

DURAG

D-R 290

Dust and Opacity Monitor



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***This description is valid for devices as from year of construction 07/2006
and as from program version D-R 290 MK P-3.21 / D-R 290 AW P-4.35 / D-R 290 AZ P-4.24***

1 Applications

The Durag D-R 290 opacity monitor can be used for continuous emissions monitoring in smokestacks, exhaust ducts, and other similar applications.

The system can be used to determine the efficacy of the air filtering system by monitoring the remaining dust quantities. The D-R 290 also insures that unacceptably high smoke and dust emissions are immediately determined. This makes it possible to intervene in the plant's processes immediately and make sure that the legal requirements are not exceeded.

This type of opacity monitor is necessary for the legal and economically sound operation of power plants, heating plants and other industrial large boiler facilities. These systems are also critical for use in the chemical and cement industries where careful monitoring of the industrial processes is a criterion for problem-free operation.

The measuring system is designed, made and tested for application in not explosive zones.

Durag opacity monitors have functioned successfully for years in applications where dust emissions could have potentially damaging environmental pollution effects. The data they collect is incorruptible, precisely reproducible, unaffected by seasonal changes or weather conditions, and functions easily in either automatic or manual operation. These systems have been used for applications in refineries and other facilities of the petrochemical industry, in waste-burning facilities and many others.

2 Basic Features

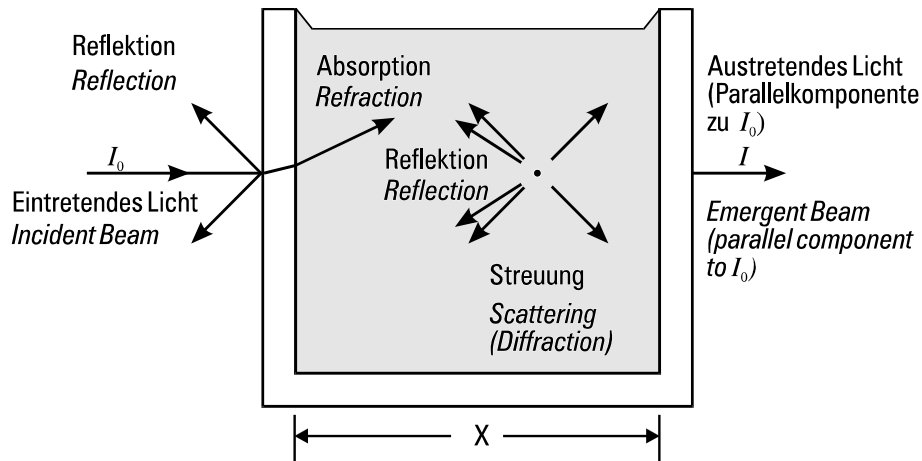
- Continuous, *in situ* measurement directly in the exhaust stream without disruption or dust sampling.
- Semi-conductor light source is long lasting.
- The wide spectrum of the Super-Wide Band Diode (SWBD) optimizes system accuracy because the measurements are more stable than those made with conventional LEDs.
- Modern microprocessor technology and software allow digital information processing.
- LCD shows measurements as opacity or extinction, calibrated in mg/m³.
- Automatic control cycle corrects values for window contamination.
- Purge air system protects the reflector and heated exit window making maintenance less frequent.
- External control panel with digital display makes installation and operation simple.
- Hermetically sealed optics and electronics prevent dust or smoke from damaging internal system components. Two analog outputs with selectable measuring ranges on each system.

Optional

- Fail-safe shutter system protects the measuring head and reflector.
- BUS - Ports
- additional display unit on-site
- Bus-interfaces
- Temperature compensation of the measuring value

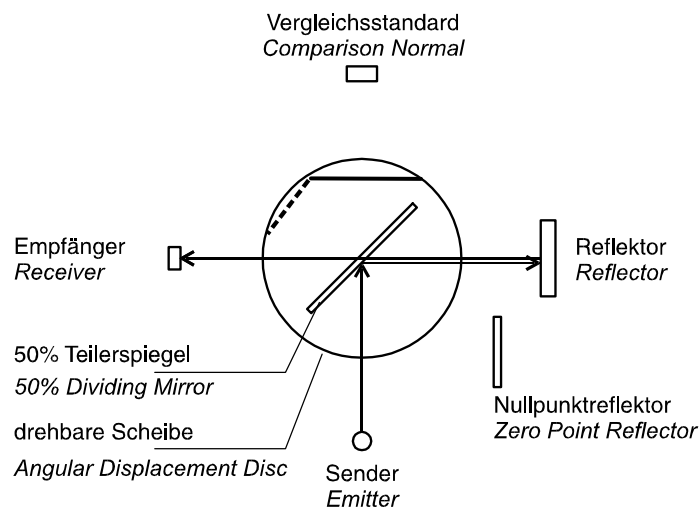
3 Operating Principles

The Durag D-R 290 opacity monitor is designed to utilize the principles of light transmission. The measuring head and reflector are mounted opposite one another. Using the auto collimation principle, the light beam traverses the distance to be measured twice. This significantly increases the sensitivity of the measurements made by the system.



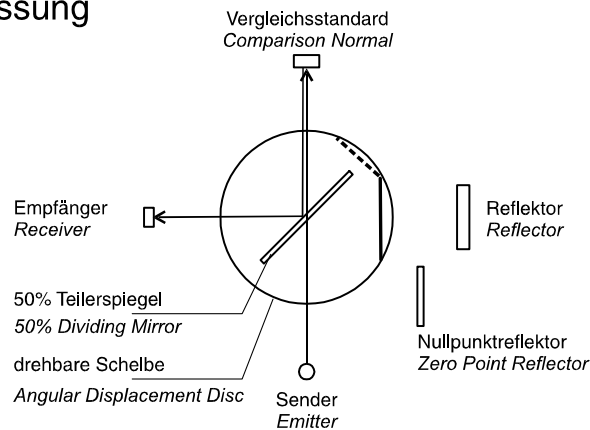
The reflector then sends the light beam across the distance a second time. The light beam loses intensity proportionally to the particle concentration of the air. The light beam has a significantly larger diameter than the reflector surface. This makes alignment easier and reduces measurement errors caused by possible heat-induced shifts in the measuring head or reflector mounting flanges.

Messung Measuring



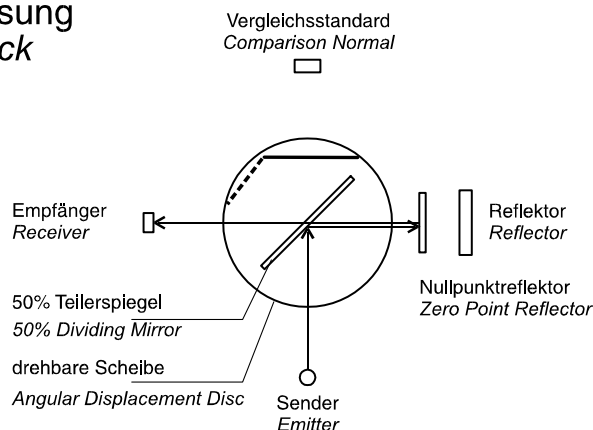
The unavoidable drifts in light intensity that result from aging of the light source or temperature changes are automatically compensated by the monitor. The 2 kHz modulated light is split into both a measurement light beam and a comparison normal. An optical receiver (photo element) alternately reads these light beams. The selection of the light paths is driven by a stepper motor.

Vergleichs-Messung Comparison



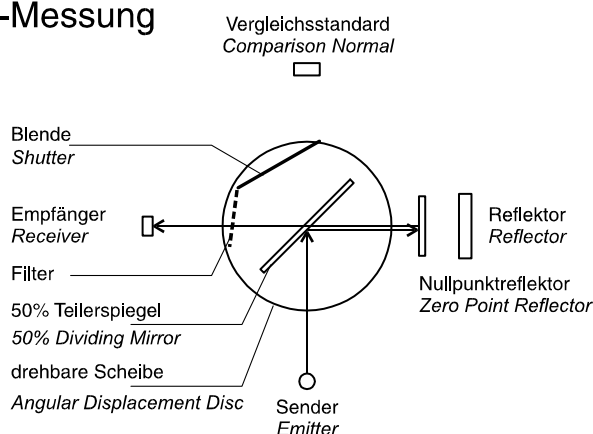
The comparison normal light beam travels across the built-in comparison normal calibration path. Every 2 minutes, the measuring beam is interrupted by the stepper motor to allow a two second measurement of the comparison normal by the photoelement. This value is digitized and used as the calibration point for the next 2-minute cycle. The same amplifier is used for both light beam readings.

Nullpunkt-Messung Zero point check



To make sure the D-R 290 system is operating properly, a control cycle runs at regular intervals, which can be set to occur every 1-99 hours or can be initiated by the data logger. This cycle automatically measures and displays the zero point value, the level of window contamination on the optical surfaces, and check point. The results of the subsequent measurements are then corrected by the extent of the measured contamination. If the window contamination exceeds a certain percentage which is adjustable, a warning message will be displayed (relay output). The succeeding digital control panel systems then calculate the transmission intensity based on the light it receives and the intensity of the comparison normal beam. This data is then used in the calculation of the opacity or the extinction value. The extinction can be calibrated and is displayed in mg/m^3 . The result is then both displayed and given as an analog current output signal.

Referenzpunkt-Messung Span check



3.1 Transmission Measuring Principle

If a light shines through a smoke stack or dust exhaust duct, this light beam will become weaker as the dust density increases.

The measurement is based on the value difference between a reference light beam (the comparison normal) and the measurement beam that is exposed to the effects of the dust particles. The computer then calculated the ratio of the measurement beam to the comparison normal beam, as shown in equation 1.

$$\frac{I}{I_0} \quad \text{Eq.1}$$

The measurement of the loss in light intensity is T , the degree of transmission. The ratio between the sent light and the received light is given as a percent value, as shown in equation 2.

$$\frac{I}{I_0} \cdot 100\% = T \quad \text{Eq.2}$$

Subtracting the transmission measurement from one gives the opacity value. Opacity is the default measurement mode of the D-R 290, since this results in an increasingly strong signal at the detector as the dust density diminishes.

$$100\% - \frac{I}{I_0} \cdot 100\% = Op \quad \text{Eq.3}$$

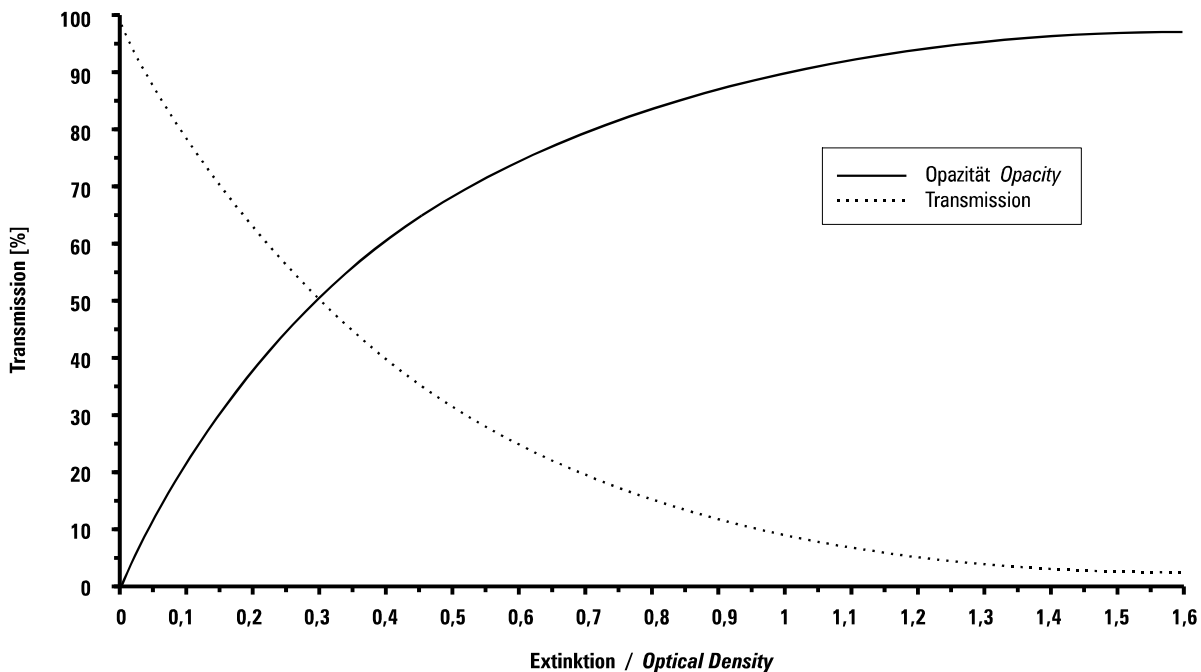


Fig. 1: Relationship between Extinction, Transmission and Opacity

Because the D-R 290 operates on the auto collimation principle, the light beam being measured crosses the measurement region twice. This means that the measurement light beam will lose the same percentage of intensity on each pass through the dust particles in the exhaust air.

The final evaluation of the measurement, however, should be calculated as if the light beam were crossing the stack exit once.

3.2 Opacity Calculation at the Stack exit

Op = Single pass opacity at the measurement point.

Op1 = Double pass opacity at the measurement point measured using the auto collimation principle.

Op2 = Single pass opacity at the stack exit.

L1 = Diameter of the stack at the measurement point.

L2 = Diameter of the stack at the stack exit.

$$Op1 = 1 - (1 - Op)^2 \quad \text{Eq.4}$$

If both losses of light intensity from the measurement beam passes are taken into account, the following equation (Eq. 5) can be used to calculate the opacity at the stack exit:

$$Op2 = 1 - (1 - Op1)^{\frac{L2}{2 \cdot L1}} \quad \text{Eq.5}$$

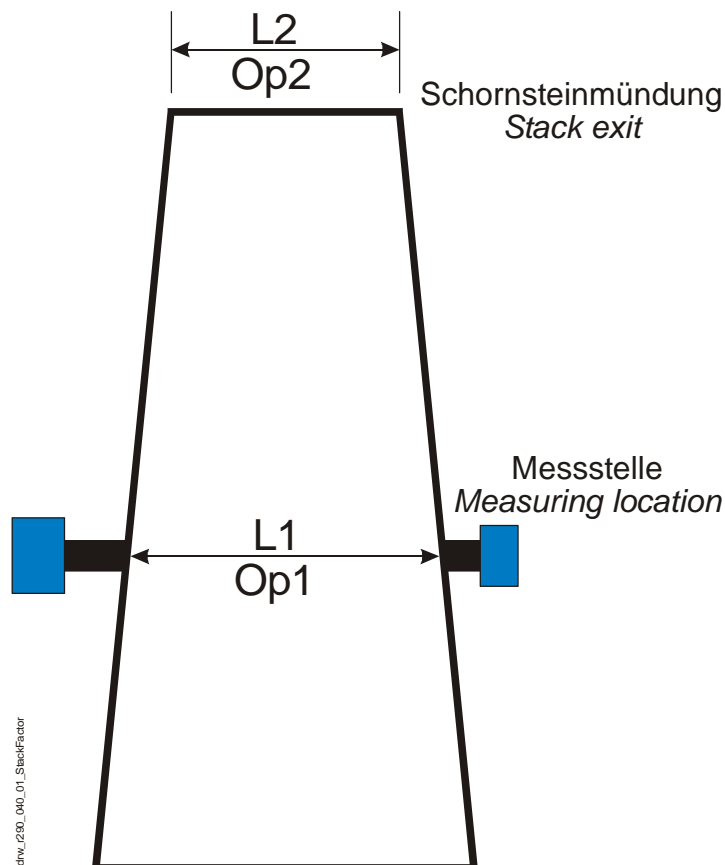


Fig. 2: Reference locations for determining opacity

Since the data must be evaluated as if the measured light beam crossed the stack opening only once, it is possible to correct the measuring accordingly with the D-R 290 measuring system.

For this, the stack correction factor $L1/L2$ must be entered into the evaluation unit. This value can be set as shown in section 6.4 Operation of the D-R 290 AW2 evaluation unit. The set stack correction factor is used in all opacity measurement ranges on both measurement channels.

For example:

Measurement location	= 6,00m	= L1
Stack exit	= 5,10m	= L2
Stack correction factor	= $\frac{L2}{L1}$	= $\frac{5,10m}{6,00m} \approx 0,850$

The default setting for the stack correction factor is 1. This setting will display the opacity at the measurement point as if the measured light beam crossed the stack only once (single-pass value).

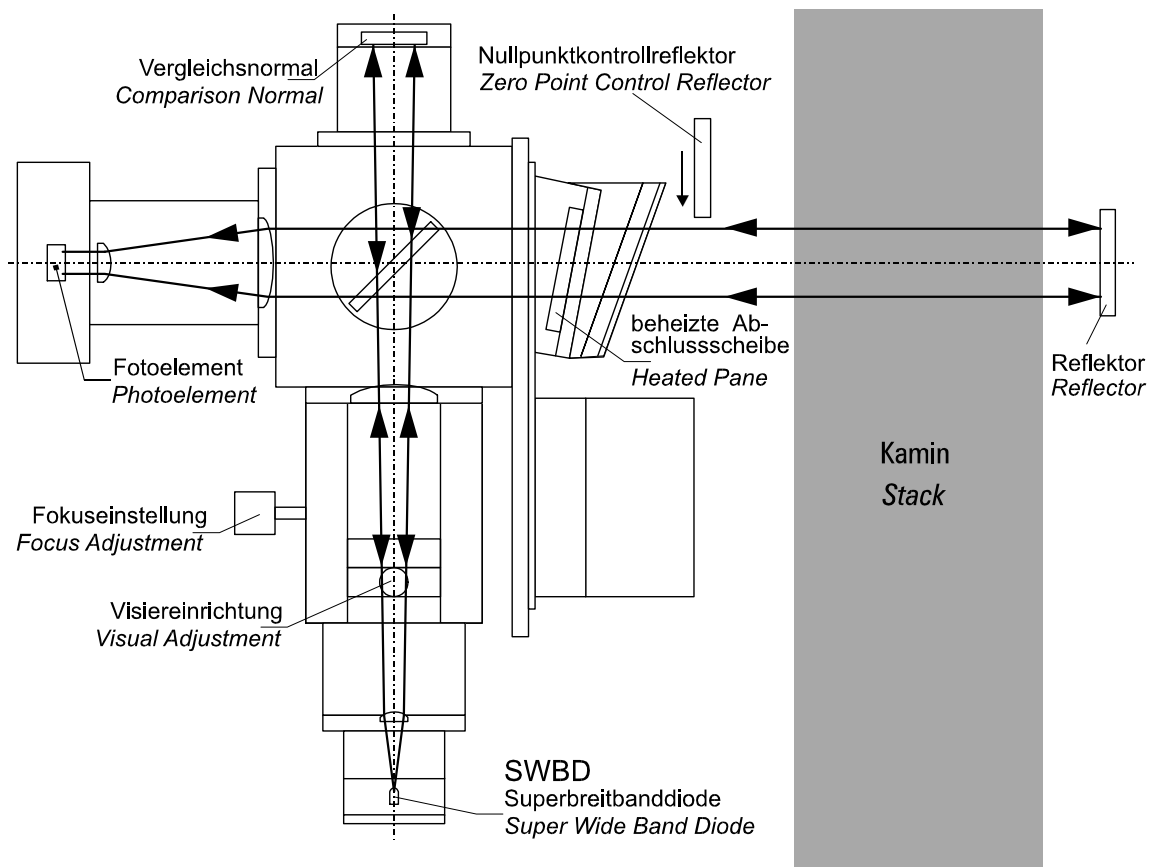


Fig. 3: Optical Diagram D-R 290

3.3 Extinction Measurement Principle

If a beam of light shines through a flue gas channel or dust extraction line, the light intensity will attenuate as the dust concentration increases. This loss of light intensity is caused by absorption and diffraction, collectively referred to as extinction. Generally, the light intensity I decreases exponentially as the path length L increases.

$$I = I_0 \cdot e^{-K \cdot L} \quad \text{Eq.6}$$

In calculating the measured dust intensity, I_0 is the constant for the emitted light intensity and L is the constant value of the measured path length. The value of the extinction constant K can then be determined. In general, the dust concentration (in mg/m^3) has a linear relationship to extinction. A number of parameters, however, may vary depending on the different installations including size of the dust particles and composition of the particles, as characterised by specific weight, refraction index, and absorption constant for the light wavelength used. Moreover, both in fireplaces and in dust-producing installations, e.g. in the cement industry, the load of the facility will affect the size of the dust particles. The way wet filtering systems (steam and condensation nucleus) work and the respective filtering output will also influence the particulate exhaust significantly. For this reason, the relationship between the extinction value the monitor displays and the actual dust emissions should be determined through gravimetric measurement.

$$E = \ln \frac{1}{T} = \frac{I_0}{I} \quad \text{Eq.7}$$

Solving equation 6 allows the derivation of the extinction constant K as shown below:

$$K = -\frac{1}{L} \ln \frac{I}{I_0} = \frac{1}{L} \ln \frac{I_0}{I} \quad \text{Eq.8}$$

In order to obtain a linear relationship between the extinction constant K and thus also for the dust concentration S , the logarithms of both the measurement and the comparison light beams are found.

The dust concentration S is as follows:

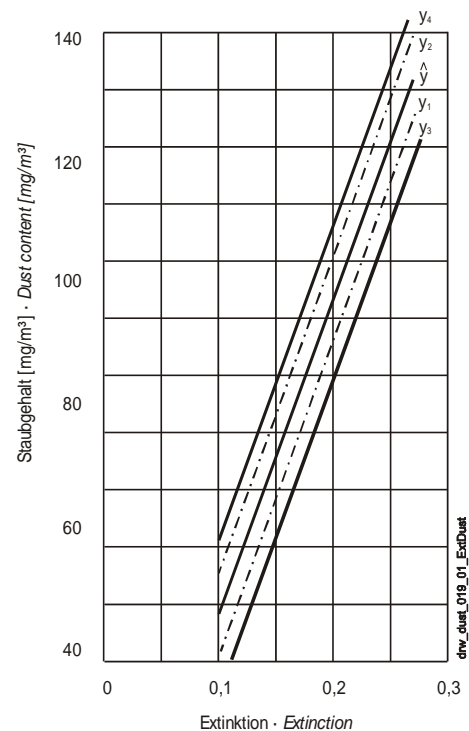
$$S = c \cdot K = \frac{c}{L} \ln \frac{I_0}{I} \quad \text{Eq.9}$$

$I_0 =$	Emitted light	$K =$	Extinction coefficient
$I =$	Received light	$E =$	Extinction
$L =$	Measuring path length (for Auto collimation * 2)	$c =$	Dust constant

For the reasons above, dust constant c must be determined by gravimetric measurement. The necessary measurement must be carried out at the expected plant loads and the expected filter settings of the respective plant. When changing fuel types, checking the measurements is necessary. Only when these comparison values are available can the extinction values in respect to the particulate emissions be correctly evaluated. As dust concentration readings are subject to fluctuations, most favourable are statistical methods for determining the calibration curve for the relationship between extinction and dust concentration.

See DIN 1319 p. 3 'Fundamentals of Measuring Techniques' and DIN 55302 p.1 and 2 'Statistic evaluation procedures, frequency distribution, mean value and scattering', as well as VDI 2066 'Dust measuring in streaming gases'.

The compensating straight-line, which is drawn through the measuring points, is established to the 'smallest quadratic error' method. It is also designated as regression straight-line (\hat{Y}). The (Y_1 , Y_2) lines represent the reliability range, i.e., the mean value of extinction x obtained over a long period lies with a probability of 95% between Y_1 and Y_2 . Two further lines (Y_3 , Y_4) define the tolerance range. This means that as a result of many gravimetric dust measurements at the indicated extinction value x , at least 75% of the spot-checked dust contents will lie with 95% probability in the tolerance range between Y_3 and Y_4 .



4 System Components

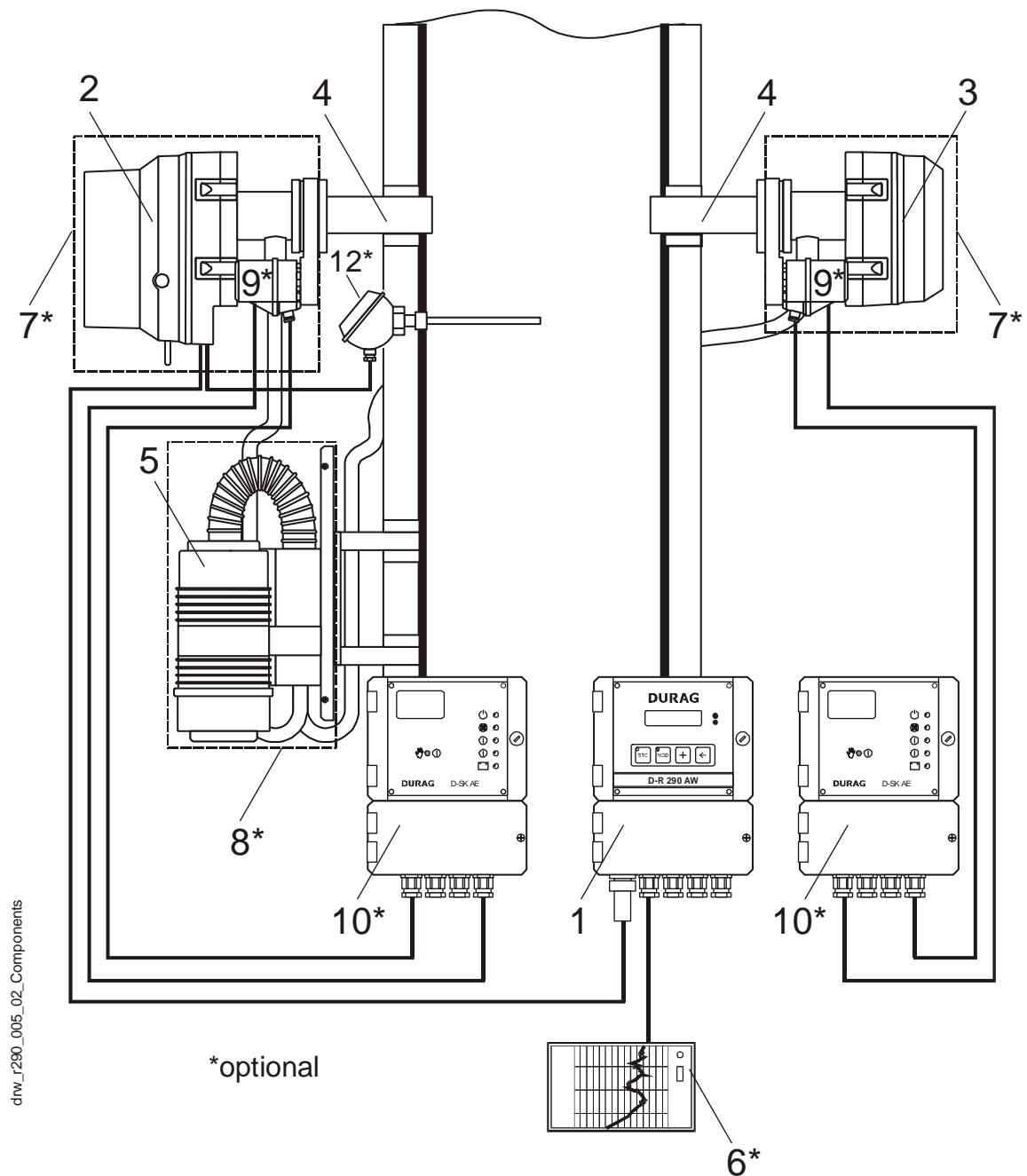


Fig. 4: System components

Standard

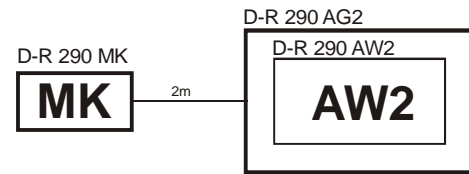
- 1 Control unit D-R 290 AW2
- 2 Measuring head D-R 290 MK
- 3 Reflector D-R 290 R
- 4 Mounting flange
- 5 Purge air unit D-R 290 GN

* Optional

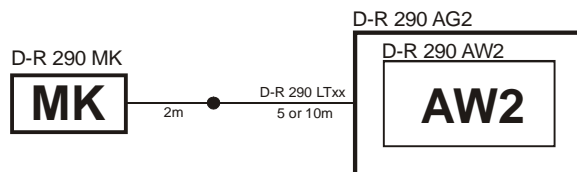
- 6 Recorder
- 7 Weather hoods
- 8 Weather hoods for purge air blower
- 9 Fail-safe shutters
- 10 Fail-safe shutter control electronics
- 11 Weather hoods for D-R 290 AW2 / AZ2
- 12 Temperature transmitter for normalization

4.1 Possible Combinations of the Control System D-R 290

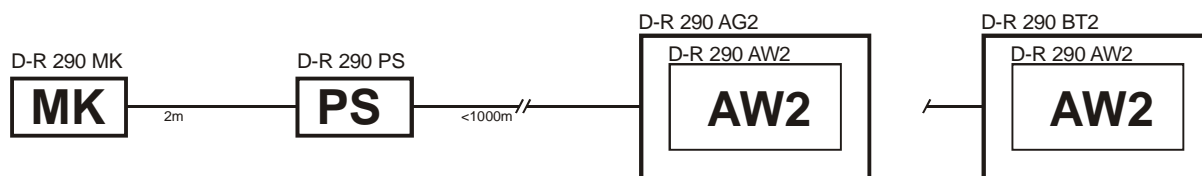
Evaluation unit at the control point in the wall mount housing (Standard)



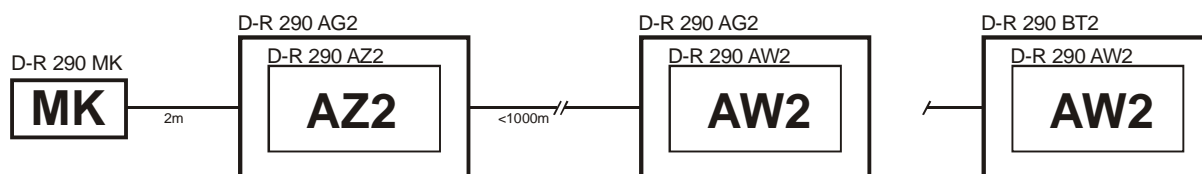
Evaluation unit with a 5 or 10 m extension cable



Evaluation unit in the wall mount housing or the circuit board housing, moved up to 1000 m away from it with the help of the local supply unit D-R 290 PS



Display unit D-R 290 AZ2 at the control point in the wall mount housing, evaluation unit in the wall mount housing or the circuit board housing, moved up to 1000 m away from it



Evaluation unit without housing, can be connected to the measuring head via 2 m adapter cables for testing purposes



If it should be possible to operate the control system D-R 290 from the control panel as well, the control system can be expanded with the display unit D-R 290 AZ2 or the local supply unit D-R 290 PS. The distance between the local unit and the evaluation unit in the control panel can be as long as 1,000 meters. The wiring should be done with a twisted cable of a conductor diameter of 0.20 mm² (conforming to AWG No. 24).

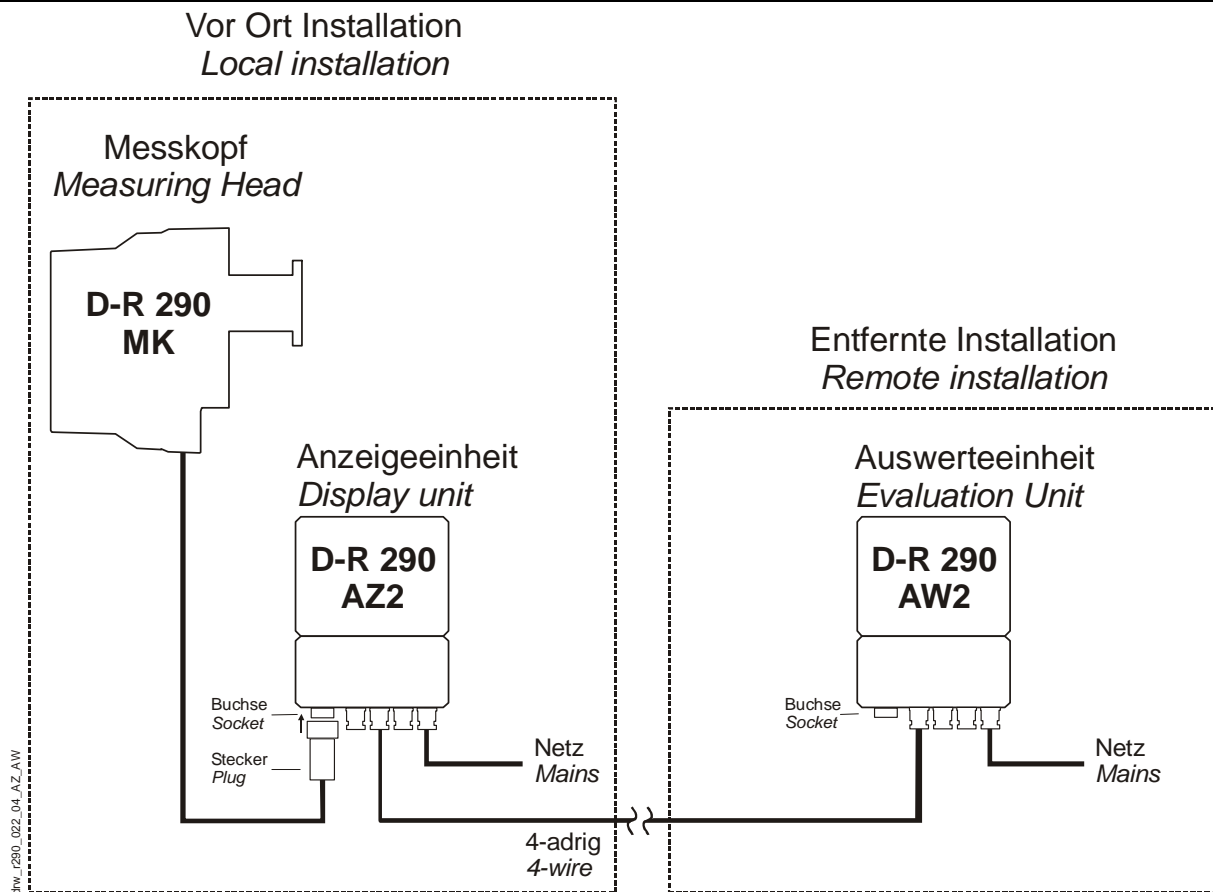


Fig. 5: System with display and evaluation unit

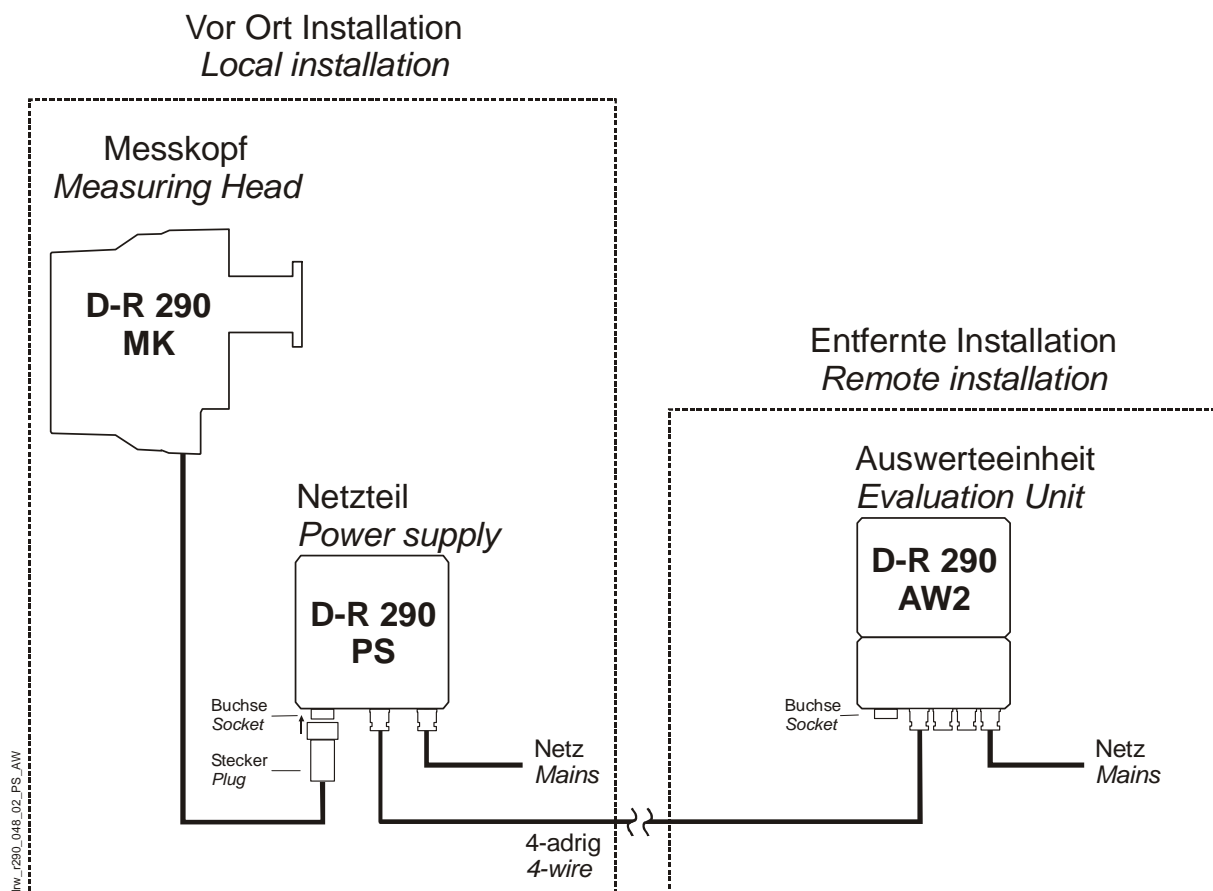


Fig. 6: System with local power supply and evaluation unit

4.2 Possible Combinations of the Control System D-R 290

For various measuring path lengths from 1 m up to 18 m different systems are available.
The systems differ in the housing design and in the used reflector material.

The following designs are available:

D-R 290, pitch diameter 100 mm

D-R 290-150, pitch diameter 150 mm for larger measuring path lengths

System	Measuring Head	Reflector	Path length	Pitch
D-R 290 System 1	D-R 290 M	D-R 290 R1	1 up to 2,25 m	100 mm
D-R 290 System 2	D-R 290 M	D-R 290 R2	1,5 m up to approx. 8 m	100 mm
D-R 290 System 3	D-R 290 M-150	D-R 290 R3-150	1,5 m up to 12 m	150 mm
D-R 290 System 4	D-R 290 M4-150	D-R 290 R3-150	1,5 m up to 18 m	150 mm

The manual in hand is valid for system 1 and 2 with 100 mm pitch diameter (see Dimensional Drawing: Welding pipe with adjustment flange, Fig. 9, for reference).

For system 3 and 4 with 150 mm pitch diameter a separate manual D-R 290-150 is available.

5 Installation of the Measuring System

5.1 Selection of the Measuring Location

The technical conditions at the different boilers or dust extraction plants, ducts or smoke gas chimneys vary widely. It is recommended to have the measuring institute in charge (e.g. TÜV) determine the appropriate measuring location.

Make sure that the dust or flue gas distribution in the D-R 290 measuring location is as homogenous as possible. Also ensure that the temperature at this location does not go below the dew point of the flue gases. The light beam should pass through the flue or duct horizontally.

The planned measuring location must have adequate mounting possibilities for the reflector, the purge air units and, if applicable, the fail-safe shutters. There must be room for the optic head and the reflector to swivel. If the system is installed outdoors, space must be available for the protective weather hoods of the measuring system and the purge air units.

The measuring location should be positioned in a straight section of the duct, as far from upstream or downstream turns as possible. Changes in flue or duct diameter should also be avoided near the measuring location. This means a distance **3xD** (equal to 3 times the internal stack diameter at the measuring location) should be free from bends or diameter changes on either side of the measuring location. If such a location is unavailable at any point in the exhaust system, the distance meeting these requirements before the opacity monitor location should be longer than the distance downstream. If the stack is non-circular, the diameter **D** should be the hydraulic diameter of the duct.

$$D = \frac{4F}{U}$$

F = Area
 U = Circumference

Eq. 10

If the measuring location will lie between the filter and the exhaust fan, the site should be located as close as possible to the fan system and not near the filter. Vibrations at the mounting location in this situation are often unavoidable. If the vibrations at full load are strong enough to affect the mechanical mounting of the equipment or the operation of the optics and electronics, a different mounting location must be selected away from the vibrations of the filter and blower system.

The selected measuring location must be safely accessible. This applies not only to system start-up and calibration work, but also for later maintenance and service of the opacity monitoring equipment. If the D-R 290 will operate on flue gas ducts or stacks where there is a backpressure, a failure of the purge air unit may result in damage or destruction of the optic head and/or reflector.

Installation of fail-safe shutters offers effective protection against this type of damage. The D-R 290 opacity monitor is designed to permit mounting of a D-SK 290 fail-safe shutter between the welded pipe and the optic and reflector heads. These fail-safe shutters mechanically block the opening between the monitor heads and the exhaust gas in the event of an emergency. This feature will securely protect the opacity monitor in the event of a power supply or purge air failure until the problem is resolved.

5.2 Mounting

For the installation of the optic head and the reflector, installation flanges with welded pipe sockets for installation in steel channels must be provided as a standard. Thickly insulated stacks, brick-lined chimneys, and high exhaust temperatures require that the flanges be modified accordingly. Such flanges can be manufactured by the construction or projected by DURAG; longer pipes require larger pipe diameter. Two versions of the installation flange are available:

Flange type	Material	
Standard installation flange	St. 37, carbon steel	material 1.0037
Special order flange	V4A stainless steel	material 1.4571

The pipes and installation flanges must be precisely aligned. This is best done by guiding a pipe with maximally 58 mm outer diameter through the openings in the stack wall. Slip the installation flanges onto this pipe and weld them to the stack wall. When the guide pipe is then removed, the installation flanges should be properly aligned. They must be in a straight line and the flat surfaces of the flanges should be parallel to one another. This adjustment must be within + 1° of accuracy. The red dot on the installation flange must always be on top.

If the walls are thin, gusset plates must be installed for reinforcement. For stacks with flue gas temperatures of over 250°C (482 °F), insulation should be installed. Use of fail-safe shutters is also recommended.

When mounting the optic head and reflector to the installation flange, the following sequence must be strictly observed as shown in figure 5:

1. rubber collar
2. 24 spring washers (alternating direction)
3. purge air flange
4. half-round washer
5. self-locking nut

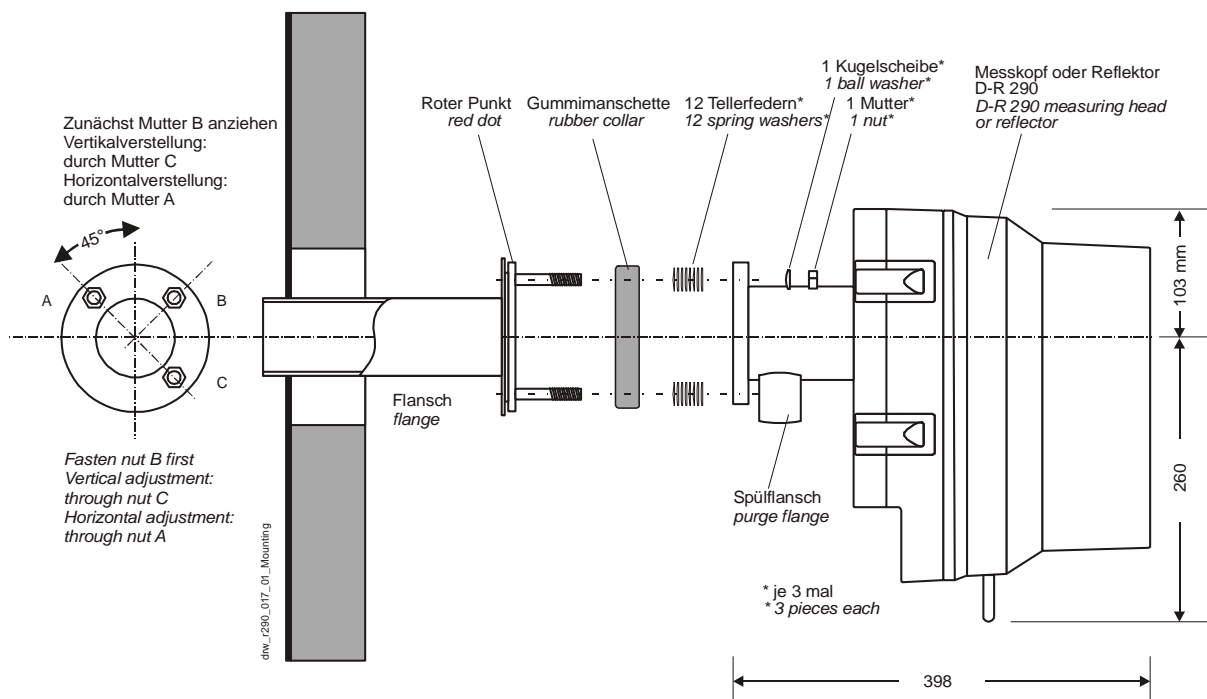


Fig. 7: Mounting on the alignment flange

Optische Messeinheit
Optical measuring unit

Reflektoreinheit
Reflector unit

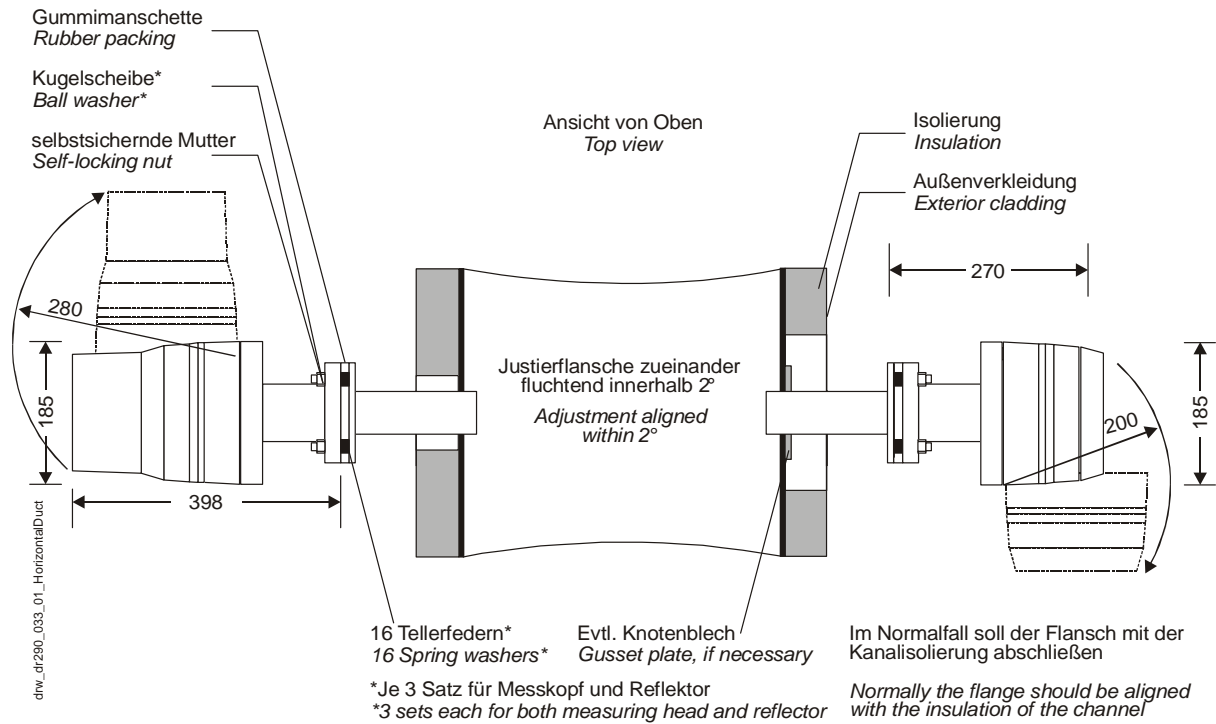


Fig. 8: Sample mounting on a horizontal duct

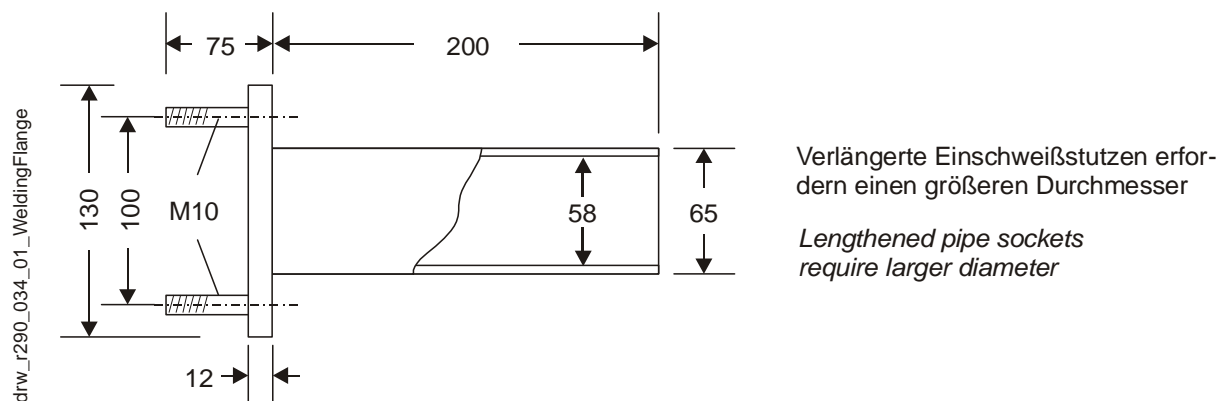


Fig. 9: Dimensional Drawing: Welding pipe with adjustment flange

Important Note:

The red dot on the installation flange must be on top.

5.3 Optical adjustment

After mounting on the stack the measuring system has to be adjusted optically. If known the measuring system is adjusted to the given path length in the factory. So the measuring system has not to be opened to do further adjustments.

If the measuring system is not adjusted to the appropriate path length or the path length has changed a clear path procedure has to be carried out first (see chapter 12.2 Clear path procedure).

The adjustment should be done in the following sequence:

1. Connect the measuring head to the evaluation unit (power on). After power up the D-R 290 performs a control cycle. Afterwards the system changes to measuring mode and is ready for operation.
2. If the measuring head and the reflector have been mounted like it is shown on Fig. 7:, the 3 nuts on the reflector flange can be tightened. First tighten the nut B on the measuring head.
3. Now the measuring head has to be justified optically. For this an optical sight is available at the measuring head that can be found on the right side behind a viewing window. The projection of the reflector (light spot) has to be set that it is in the center of the sight. Nut B has to be tightened first. When tightening the nut A, the measuring head inclines to the axis B - C and the figure in the image display moves in a vertical direction. When tightening or loosening the nut C, the measuring head pivots at the axis A - B and the figure in the image display moves in a horizontal direction.
4. Disconnect the measuring head from the evaluation unit after the alignment (power off).
5. Connect the measuring head to the evaluation unit (power on). After power up the D-R 290 performs a control cycle. Afterwards the system is ready for operation.

6 D-R 290 AW2 Evaluation Unit

6.1 D-R 290 AG2 Wall mount housing

If the evaluation unit D-R 290 AW2 is operated at the site, a compact splash-proof aluminium housing (Identification: D-R 290 AG2) of the protection type IP 65 can be used for the installation of the control system D-R 290 AW2 at the measurement location.

In the housing the keys and the LC-Display in the front panel of the evaluation unit are protected by a transparent cover that can be swivelled to the left.

The connection terminals are located in a part of the housing (lower housing part) that can be opened separately. 7 cable glands (2x M20, 5x M16) are available for the connection of the lines. The cable glands M20 are suitable for cable diameters between 7 mm and 13 mm. The cable glands M16 can be used for cable diameters between 4.5 mm and 10 mm.

The measuring head and the evaluation unit in the housing are connected with a 2m long cable and plug. Lengthening is possible for maximum 10m.

The inserted part has to be removed from the housing before the housing is mounted (after the 4 fastening screws have been removed). Then, the housing can be opened. In order to do so, the turning bolt lock on the right of the housing has to be opened with a screwdriver (turn it to the left), and the mounting frame with the clear-view hood that can be swivelled to the left is opened.

Colour: Housing unit and connection room traffic blue RAL 5017.

Diameter of the fastening drillings 6.5 mm.

Hole distance 162 (top) / 166 (bottom) x 220 mm.

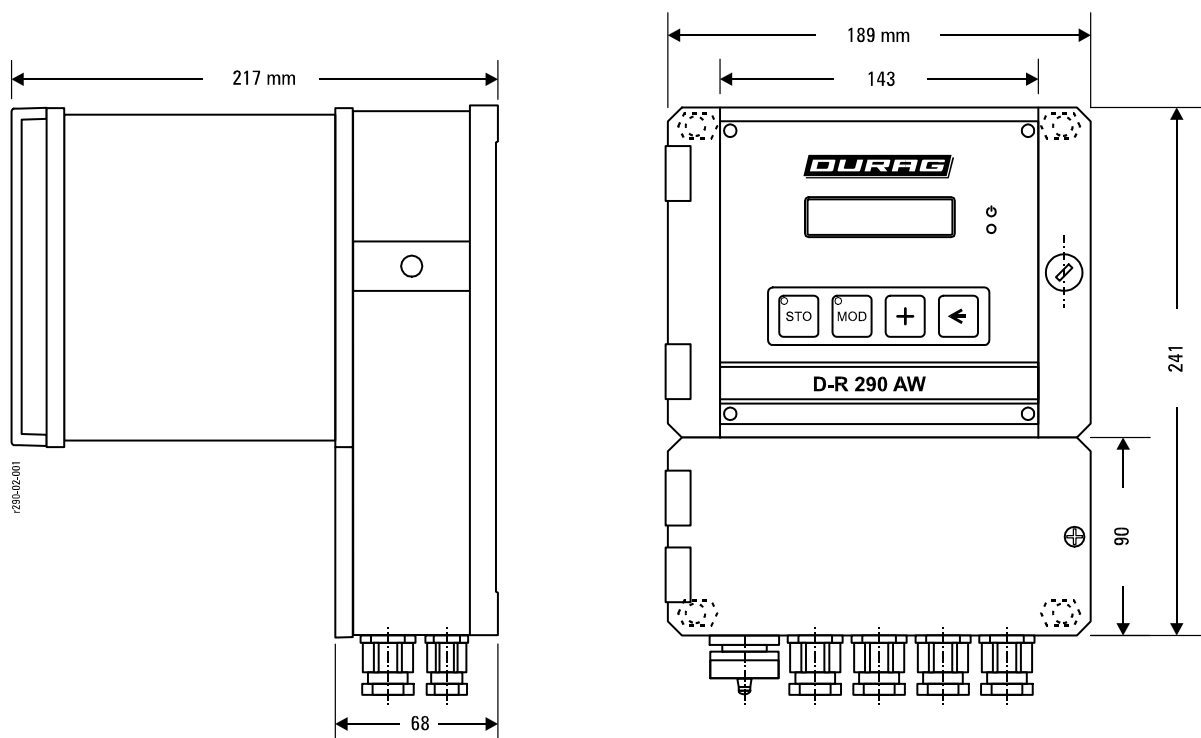


Fig. 10: Dimensional drawing: D-R 290 AG2 housing

6.2 D-R 290 BT2 Rack mount housing

If the evaluation unit D-R 290 AW2 is remote operated e.g. in a control room, a compact rack mount housing (Identification: D-R 290 BT2) of the protection type IP 20 can be used for the installation of the control system D-R 290 AW2.

In the housing the keys and the LC-Display in the front panel of the evaluation unit are protected by a transparent cover that can be swivelled to the left.

The connection terminals are located at the rear side of the housing.

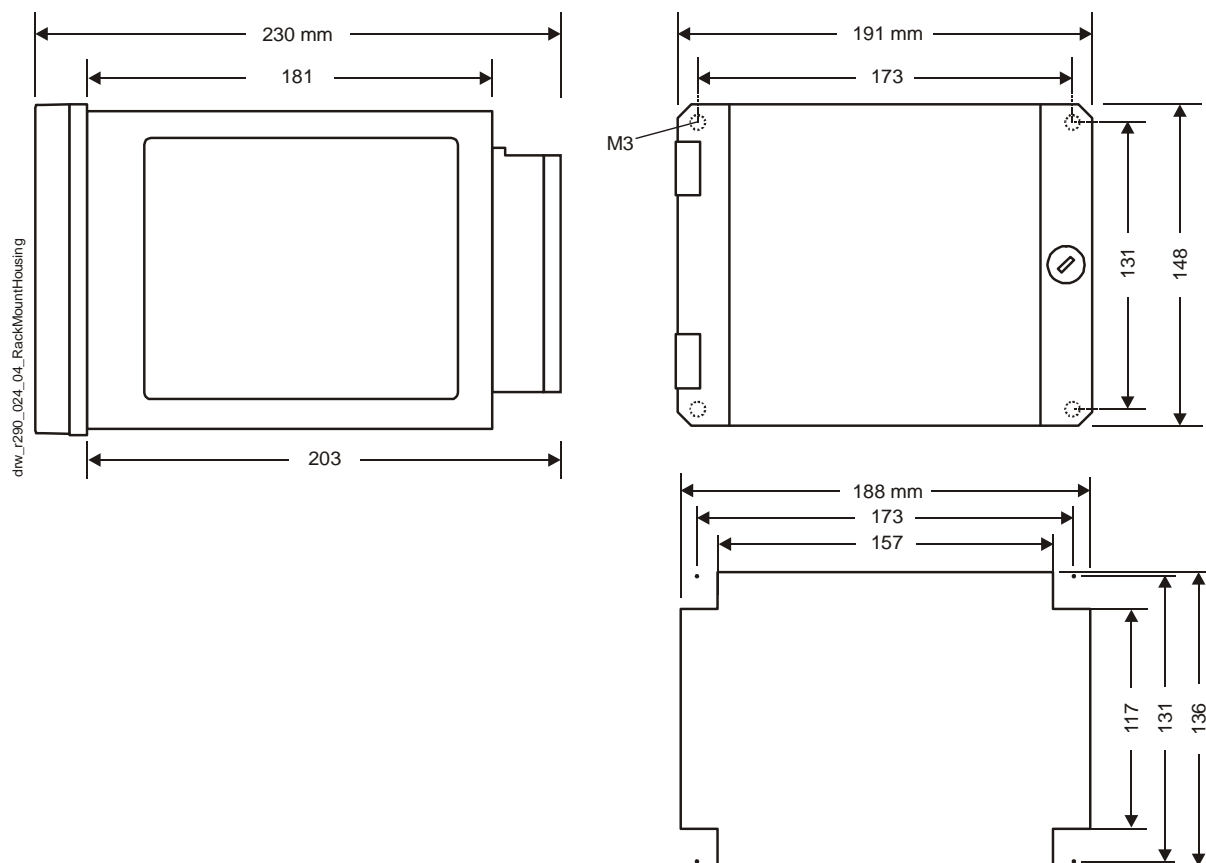


Fig. 11: Dimensional drawing: Rack mount housing D-R 290 BT2

6.3 D-R 290 AW2 Electrical Connection

If the evaluation unit D-R 290 AW2 is operated at the site in the housing D-R 290 AG2 or in the rack mount housing D-R 290 BT2, the electrical connection in the housing terminal either at the rear side is done via a 66-pin terminal strip according to the column Terminal in the connection plan. The mains connection is done by a 6-pin terminal strip X1.

The measuring head and the D-R 290AW2 evaluation unit are connected by a cable with a plug-in connection (cable length about 2m).

Cables for the power supply, status signals, recorder outputs, relay contacts, and data transmission should be laid separately. The mains supply line has to be carried out in 3x1.5 mm². The wire and sheath material has to be adapted to the conditions at the particular installation location. For the fuse protection of the mains supply line a 16A automatic circuit breaker has to be installed near the measuring system. The single conductors of the mains line have to be secured to each other that they can't reach other clamps if one single conductor goes lose (e.g. binder).

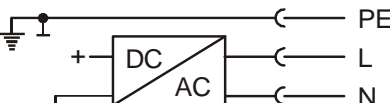
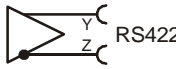

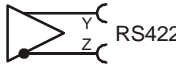
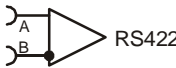



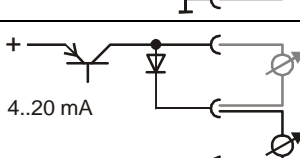
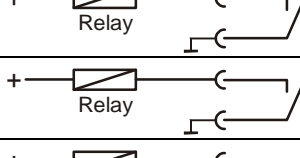
Connection between measuring head D-R 290 MK and evaluation unit D-R 290 AW2*			
Measuring head cable connection			Connection evaluation unit
Plug	Cable No.	Function	Terminal X2
Housing	Shield	Shield	Housing
B	1	+ 15 Volt	61
D	2	GND	64
C	3	- 15 Volt	62
A	4	+ 5 Volt	65
E	gn/ye	PE	63
F	6	GND	66
J	7	RS-422 Y (M)	1
H	8	RS-422 Z (M)	21
G	9	RS-422 Y (Ax)	2
M	10	RS-422 Z (Ax)	22

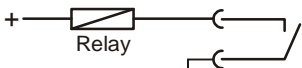
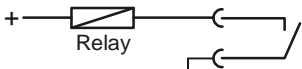
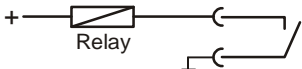
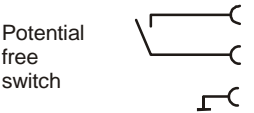
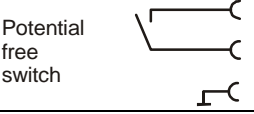
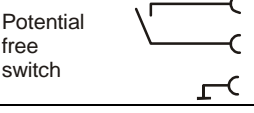
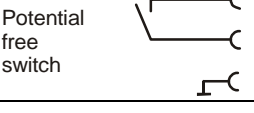
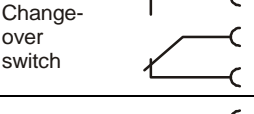
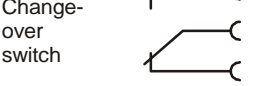
* This cable connection is pre manufactured as a standard.

ATTENTION!

The relevant VDE regulations and possibly existing additional regulations of the local Energy Supply Companies (EVU) have to be observed in all installations related to the measuring head of the device and the blowing system.

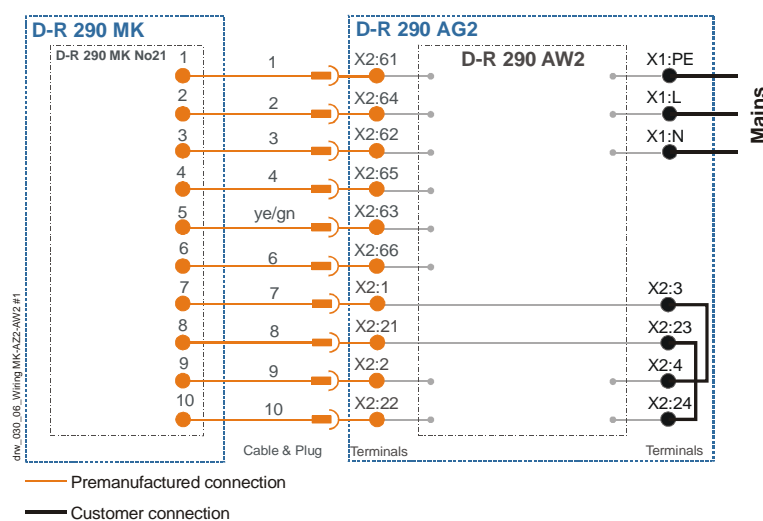
Evaluation unit D-R 290 AW2

Mains		Terminal X1		Function
		b	c	
	1	4	PE	
	2	5	L (90 - 264 V)	
	3	6	N	
Interfaces	Terminal X2			Function
	a	b	c	
		61		Supply measuring head: +15V
			64	Supply measuring head: GND
		62		Supply measuring head: -15V
			65	Supply measuring head: +5V
		63		Supply measuring head: PE
			66	Supply measuring head: GND
	1			Internal interface: RS-422 Y (MK)
		21		Internal interface: RS-422 Y (MK)
			41	PE
	2			Internal interface: RS-422 Y (AW)
		22		Internal interface: RS-422 Z (AW)
			42	PE
	3			Internal interface: RS-422 Y (MK)
		23		Internal interface: RS-422 Y (MK)
			43	PE
	4			Internal interface: RS-422 A (AW)
		24		Internal interface: RS-422 B (AW)
			44	PE
	5			D-COM02: RS-485 A
		25		D-COM02: RS-485 B
			45	PE
	6			D-COM02: RS-485 A
		26		D-COM02: RS-485 B
			46	PE
	7			4..20mA Output 1: Instrument +
		27		4..20mA Output 1: Instrument - Recorder +
			47	4..20mA Output 1: Recorder -
	8			4..20mA Output 2: Instrument +
		28		4..20mA Output 2: Instrument - Recorder +
			48	4..20mA Output 2: Recorder -
	9			Relay input 1: Input free
	10			Relay input 1: GND
		29		Relay input 2: Control cycle
		30		Relay input 2: GND
			49	Relay input 3: External error 002
			50	Relay input 3: GND

Interfaces	Terminal X2			Function
	a	b	c	
	11			Relay input 4: RANGE 2 OUT.-1
	12			Relay input 4: GND
		31		Relay input 5: RANGE 2 OUT.-2
		32		Relay input 5: GND
			51	Relay input 6: External error 003
			52	Relay input 6: GND
	13			Relay output 1: see page 27 NO
		33		Relay output 1: COM
			53	PE
	14			Relay output 2: see page 27 NO
		34		Relay output 2: COM
			54	PE
	15			Relay output 3: see page 27 NO
		35		Relay output 3: COM
			55	PE
	16			Relay output 4: see page 27 NO
		36		Relay output 4: COM
			56	PE
	17			Relay output 5: "Error" NO
		37		Relay output 5: COM
			57	Relay output 5: "no Error" NC
	18			Relay output 6: "Measurement" NO
		38		Relay output 6: COM
			58	Relay output 6: "no Measurement" NC

* For loosening the cage clamps a screwdriver with a 0.6 x 3.5 mm blade is necessary.

Fig. 12: Connection plan for the evaluation unit



**Fig. 13: Standard connection plan:
D-R 290 MK to D-R 290 AW2**

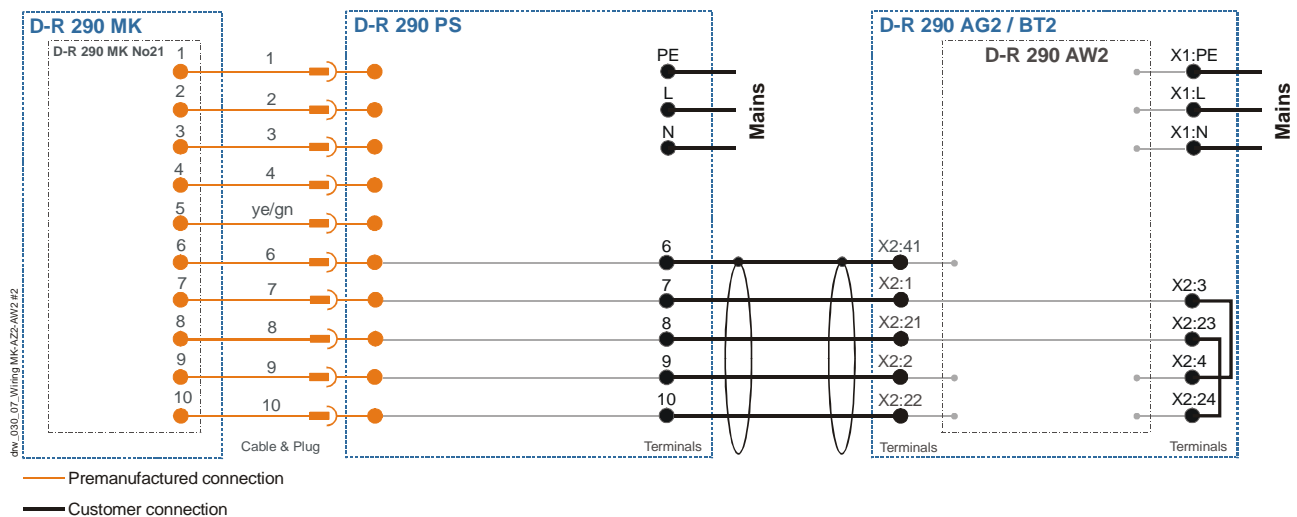


Fig. 14: Optional connection plan:
D-R 290 MK to D-R 290 PS and D-R 290 AW2

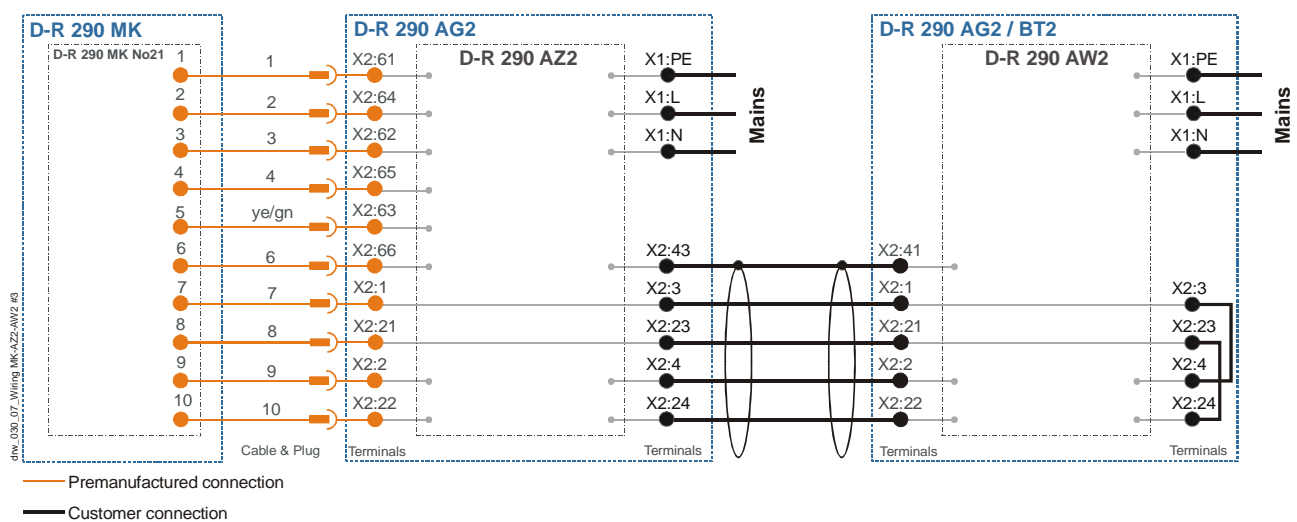


Fig. 15: Optional connection plan:
D-R 290 MK to D-R 290 AZ2 and D-R 290 AW2

The terminal bridges X2:3/4 and X2:23/24 are preassembled as a standard. However it should be checked if it matches the corresponding connection plan.





If a remote evaluation unit is wired by an installation cable it may be necessary to reconnect the wires from the internal connector of the wall mount housing D-R 290 AG from the terminals X2:1/2/21/22 and store in a safe area.

6.4 Operation of the D-R 290 AW2 evaluation unit

The D-R 290 is controlled using the four keys and the LCD on the front panel of the control unit. The following parameters, values, and functions can be called up, entered and saved:

Functions	Display: 1 st line
Current measured value of output 1	OUTPUT 1
Current measured value of output 2	OUTPUT 2
Current measured value measuring range 2 of	R2/OUT-1
Current measured value measuring range 2 of	R2/OUT-2
Set-up	SET-UP MODE
Coefficient input for mg display (Optional)	SET-UP mg/m3
Measuring range 1 output-1	RANGE 1 OUT.-1
Measuring range 2 output-1	RANGE 2 OUT.-1
Integration time for output 1	INT. TIME OUT.-1
Measuring range 1 output-2	RANGE 1 OUT.-2
Measuring range 2 output-2	RANGE 2 OUT.-2
Integration time for output 2	INT. TIME OUT.-2
Cycle time	CHECK CYCLE -> HRS
Limit value for pollution message	WINDOW ALARM
Limit value 1	LIMIT VALUE 1
Limit value 2	LIMIT VALUE 2
Control mode	CONTROL MODE
Zero point control	ZERO POINT CHECK
Pollution control	WINDOW CHECK
Reference point control	SPAN CHECK
Stack correction factor	STACK COR. FACTOR

6.5 Key functions

- Key  Puts the system into the "*data entry*" (save) mode. The LED's on the "STO" and "MOD" keys should blink in this mode. The "STO" key LED blinking alone indicates an error message.
- Key  Puts the system into the "*display parameters*" mode. The "MOD" key LED should be lit in this mode.
- Key  Pressing this key in the "*Display measured value*" mode switches the displayed value between outputs 1 and 2. The "MOD" key LED should not be lit.
In the "*Display parameters*" mode, this key will cause the next parameter to display. The "MOD" key LED will be lit.
In the "*Enter data*" mode, this will change the value of the blinking digit. LED's on both the "MOD" and "STO" keys will be lit.
- Key  This key moves the blinking cursor to the next digit in the display. It is active only in the "*data entry*" mode. The LED's on both the "MOD" and "STO" keys will be lit.
If you press the Cursor and the Plus keys simultaneously for approximately 5 seconds, the control cycle will start..

6.6 Saving/ Data entry

The D-R 290 AW2 evaluation unit has a status relay input which enables the saving of data (terminals 9 / 10).

Open: Save function disabled, closed: Save function enabled.

1. Pressing the "MOD" key takes the system out of "Measuring" mode and puts it into "display parameters" mode. The LED on the "MOD" button should light.
2. Press the "+" key until the desired value appears in the display field.
3. Press the "STO" key to switch into "data entry" mode. The LED on the "STO" key should light up.
4. One of the digits should be blinking. Pressing the "+" key will increase this number (zero will appear after reaching the number 9). Pressing the "←" key will move the blinking cursor to the next digit to the left. Again, press the "+" key until the desired number appears. When all digits have been adjusted, the cursor will automatically return to the right-most digit.
5. Pressing the "STO" key will save the newly entered value and return the system to the "display parameters" mode. The LED on the "STO" key should go out.
6. Pressing the MOD key while in the "display parameters" mode will return the system to the "measurement" mode. The "MOD" key LED will go out and the display will show the current measured value.
If the "MOD" key is pressed during the "data entry" mode before saving, the system will revert to the "measurement" mode without saving changes.
7. After changes have been made and saved, the status input relay should be opened to disable the data entry mode (terminal 9 / 10).

	Operating mode	Key sequence	Explanation	Display
1	Display measured value	<div>+ MOD</div>	Switch measured value display	Measured value Output 1 Output 2
	Display parameters		MOD - LED lights	Measured value
2	Select	<div>+</div>	Select the value you wish to view	Saved value
3	Data entry	Enable data entry. Close the status relay contact input.		Previously saved value
		<div>● STO</div>	STO - LED lights	
4	Change value	<div>+</div>	Increase the digit value	Previously saved value
5		<div>←</div>	Change digit/move blinking cursor	
		<div>● STO</div>	Save the adjusted value	Changed value
6	Display parameters	<div>● MOD</div>	STO - LED goes out	Current measured value
7	Display measured value		If the STO key has not been pressed, the changes will not be saved	
		MOD - LED goes out		
		Disable data saving. Open status relay input		

Fig. 16: Operating sequence

6.7 LC-Display

The display has two 16-character lines. All error and warning messages appear in the first line (sections 1 and 2). In the event of an error, the display will alternate between the error message (see chapter 9.7 Error Messages) and the currently selected display mode.

The display is divided into four sections.

Display during actual operation

- Section 1:** Currently selected output
- Section 2:** If the system is set to automatically run the control cycle at regular intervals, this will display the time remaining until the next control cycle.
- Section 3:** Calculated value of the current measurement.
- Section 4:** Current analog-output signal in mA, from output 1 or 2.

Section 1	Section 2
OUTPUT 1	03:48
OD 0.512	11.38mA
Section 3	Section 4

Control cycle Display

- Section 1+2:** Current control cycle
ZERO POINT CHECK, WINDOW CHECK, SPAN CHECK
- Section 3:** Calculated value in % (* = display of the automatic control cycle)
- Section 4:** Analog-output signal in mA for the current control cycle

Section 1	Section 2
ZERO POINT CHECK	
* 0.0%	4.00mA
Section 3	Section 4

6.8 Default settings

Press the “MOD” key to switch from the “measurement” mode to the parameter display. The key LED “MOD” is lit. Select the default settings by pressing the key “+”, display “SET-UP MODE”. In the entry mode you can assign the physical output sizes (measurement ranges) to the measurement value outputs and fade the control cycles in to the measurement value output 2 by using the last digit of the display. By using the second-from-last digit of the display you can assign the function of the relay outputs 1 to 4 according to the following table.

Opacity = [OP%]
 Extinction = [OD] calibration capability in mg/m³.

Display 1s digit	Output – 1 Measuring in	Output – 2 Measuring in	Control cycle at	Stack factor on
X 0 S	OD	OD	Output-1	X
X 1 S	OP%	OD	Output-1	X
X 2 S	OD	OP%	Output-1	X
X 3 S	OP%	OP%	Output-1	Output-1
X 4 S	OD	OD	Output-1 + Output-2	X
X 5 S	OP%	OD	Output-1 + Output-2	X
X 6 S	OD	OP%	Output-1 + Output-2	X
X 7 S	OP%	OP%	Output-1 + Output-2	Output-1 + Output-2
Display 10s digit	Relay 1 Function	Relay 2 Function	Relay 3 Function	Relay 4 Function
0 X S	X	X	D-SK 290 #1	D-SK 290 #2
1 X S	LV I Output -1	LV II Output -1	D-SK 290 #1	D-SK 290 #2
2 X S	LV I Output -2	LV II Output -2	D-SK 290 #1	D-SK 290 #2
3 X S	LV I Output -1	LV II Output -2	D-SK 290 #1	D-SK 290 #2
4 X S	ZP- Control	WC-Control	RP-Control	Stack factor
5 X S	ZP- Control	WC-Control	RP-Control	D-SK 290 #2
6 X S	ZP- Control	WC-Control	RP-Control	Stack factor

LV - Limit value, ZP - Zero point, WC - Window check, RP - Reference point, D-SK 290 - fail safe shutter

6.9 mg/m³ Display

The measurement results can be displayed in mg/m³ by using the firmware version D-R 290 AW2 P-4.XX (under the operational conditions).

In order to do so, the coefficient b that has been determined by a gravimetrical measuring has to be entered in the input mode (SET-UP mg/m³). The input range for the coefficient is from 0001 to 6200. If b= 0000 is entered for the coefficient, it will not be displayed in mg/m³.

If a coefficient is entered, the display will be switched automatically to the extinction measurement ranges [OD] in mg/m³.

The relationship between the dust amount display in mg/m³, the extinction, and the coefficient b is:

Extinction x b = dust amount display [mg/m³].

Example: Set measurement range 0.24 ext., coefficient b=0820
 0.24 x 0820 = 196.8 [mg/m³]

Section 1	Section 2
OUTPUT 1	03:48
mg 127.9	14.40mA
Section 3	Section 4

6.10 Limit Values

There are two adjustable limit value contacts available. In the default setting (see chapter 6.8 Default settings), the limit values will be assigned to the two measurement value outputs. The limit values can be set in 0.1 mA – steps independently of each other and throughout the whole measurement range. If the limit values are exceeded, the related relay contact will be initiated for the duration of the exceeding.

6.11 Integration Times

The integration times for the two measurement value outputs can be set independently of each other from 5 seconds to 1800 seconds in 1-second-steps for the D-R 290 (see chapter 6.6 Saving/ Data entry).

6.12 Measuring Ranges

The D-R 290 has two analogue measurement value outputs. Each of the outputs has two extinction or opacity measurement values that can be selected freely. In the default setting (see chapter 6.8 Default settings), the measurement values will be assigned to the two measurement value outputs. The measurement values can be set independently of from each other.

Opacity range: from 20 to 100 % in 1% increments.

Extinction range from 0,1 to 1,6 Ext. adjustable in 0,01 Ext. increments.

Display			Function
RANGE 1	OUT.-1	= Measuring range 1 of output 1	Measuring range 1 changeable to measuring range 2
RANGE 2	OUT.-1	= Measuring range 2 of output 1	
RANGE 1	OUT.-2	= Measuring range 1 of output 2	Measuring range 1 changeable to measuring range 2
RANGE 2	OUT.-2	= Measuring range 2 of output 2	

Activating the appropriate status relay input in measuring range 2 will switch the outputs. The output channels can measure independently either opacity or extinction.

6.13 Linearity test

The control mode is used to test the linearity according to the EPA requirements. The linearity measurement is carried out within the set measurement range for Output 1. For OP measurement ranges with the stack correction factor 1.



Fig. 17: EPA – Test filter



After selecting the control mode (display "**CONTROL MODE**"), the key "STO" is pressed for at least 10 seconds to carry out a contamination correction, if necessary, and thus the display is brought to 4 mA. Open the 4 fastening shutters at the measuring head and move the measuring head to the side. Then you can continue with the linearity measurement with the EPA - test filters. You can check the filters by plugging them into the filter casings in front of the heated disk of the measuring head.

6.14 Stack Correction Factor

If the measurements of the D-R 290 should be displayed as if the measurement beam has crossed the stack exit only once (as required by the EPA), the stack correction factor $L2 / L1$ must be entered (see chapter 3.2 Opacity Calculation at the Stack exit). The adjusted correction factor (a value between 0.5 and 2.9) will be used to measure opacity in both measurement output channels.

L1= Stack diameter at the measuring location

L2= Diameter at the stack opening

When the stack factor is selected the displayed value is shown as an analog output as well. 0.5 to 2.9 corresponding to 4.0 mA to 20.00 mA

The default setting for the stack correction factor is 1. This setting will display the opacity at the measurement point as if the measured light beam crossed the stack only once (single-pass value).

6.15 Cycle Time

In the D-R 290 system, the interval between control cycles can be set in one-hour increments from 1-99 hours ("**CHECK CYCLE -> HRS**"). At the end of the current period, the control cycle will begin automatically. At the end of the control cycle, the newly set cycle time will take effect. The display will count down the time remaining until the next control cycle.

There is also the possibility of a manual triggering of the controls during the normal measuring mode. If you press the "←" and the "+" keys simultaneously for approximately 5 seconds, the control cycle will start (the remaining time display blinks in the display of the evaluation unit).

The D-R 290 AW2 evaluation unit has a status input for the control cycle start.

Terminals 29 / 30.

- Open: The control cycle will initiate automatically as described above.
- Closed: The control cycle will not be carried out automatically, only manually (the time remaining until the next cycle will not display).
- Upon opening: The control cycle will begin.

6.16 Zero Compensation Exceeded Alarm ("**WINDOW ALARM**")

The allowable level of window contamination ("**WINDOW ALARM**") can be set in 0.1% increments from 0% to 9.9%. If the window contamination exceeds this value, the system will generate an error message. If this value is set to 0% the error message is disabled.

If the window contamination level that has been measured during the contamination control exceeds the set percentage, the message "*** **ERROR 001** ***" will be displayed. After a delay of approximately 10 seconds, an error message will be sent through the relay output.

6.17 Registering and Recording the Measured Values

The current measured value is transmitted by the D-R 290 as an analog current output signal. Regulations require a continuous record of the measured values. A line recorder (0-20mA) with a width of at least 100 mm can be used for this. We recommend one that meets section 1.0 of VDE 0410. The displayed zero point is at 20% (4 mA live zero) of the recorder scale.

The measurement values and status signals can also be sent to a computer system such as the D-MS 500 for evaluation.

6.18 Zero Point Control

With the D-R 290 a zero point control ("**ZERO POINT CHECK**") of 1:30 minutes is carried out within the set measurement range (display in %) at the beginning of the control cycle. When the zero point reflector at the measuring head has swivelled to its position, the output power will be 4 mA. It is also possible to query the zero point control manually.

6.19 Zero Contamination Measurement ("Window Check")

With the D-R 290 a contamination control ("**WINDOW CHECK**") of 1:30 minutes is carried out within the set measurement range (displayed in %) following the zero point control at the control cycle. The contamination built-up on the optical surfaces is measured and displayed. These results will be used to correct the following measurements for the level of window contamination. If the contamination level that has been measured during the contamination control exceeds the given percentage, an error message follows and the message "*** **ERROR 001** ***" is displayed. It is also possible to query the pollution manually.

6.20 Reference point control

After the contamination control, a reference point control ("**SPAN CHECK**") follows in the control cycle for approximately 1:30 minutes (display in %). A grid filter is swivelled to the reception light path via a stepper motor.

This reference value should be reproducible for each reference point control. It is also possible to query the reference value manually.

6.21 Stack Correction Factor Display

If OP %-measurement ranges have been selected for both measurement outputs in the default setting (see chapter 6.8 Default settings), the stack correction factor is displayed after the reference control in the control cycle for approximately 1:20 minutes. When the stack factor is selected the displayed value is shown as an analog output as well. 0.5 to 2.9 corresponding to 4.0 mA to 20.00 mA. It is also possible to query the stack correction factor manually.

7 Display Unit D-R 290 AZ2

If the operation and the measurement display are to be possible in the control room as well, the system D-R 290 can be expanded with the local display unit D-R 290 AZ2. A regarding connection diagram can be found in chapter 6.3 D-R 290 AW2 Electrical Connection.

If the control system D-R 290 is operated on the site with a display unit, a compact water-tight aluminium housing of the protection type IP 65 can be used for the installation of the display unit D-R 290 AZ2 at the measurement location (see chapter 6.1 D-R 290 AG2 Wall mount housing).

7.1 *Electrical Connection D-R 290 AZ2*

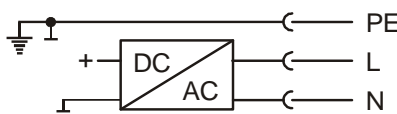
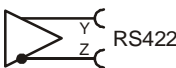

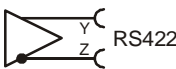
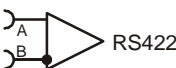



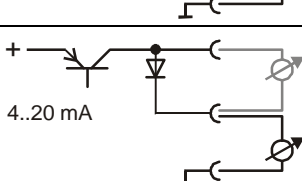
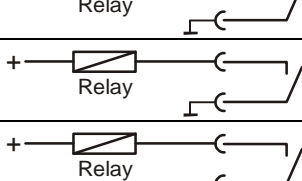
If the display unit D-R 290 AZ2 is operated in the housing D-R 290 AG2, the electrical connection in the housing terminal is done by a 66-pin terminal strip X2 according to the column Terminal of the connection plan. The mains connection is done by a 6-pin terminal strip X1.

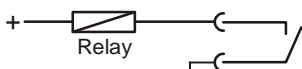
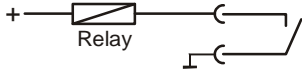
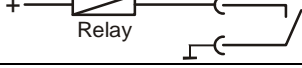
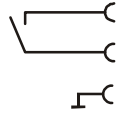
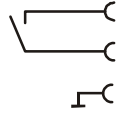
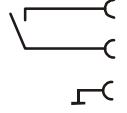
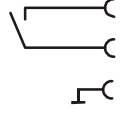
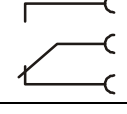
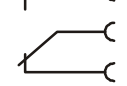
The measuring head and the D-R 290 AZ2 display unit are connected by a cable with a plug-in connection (cable length about 2 m).

Cables for the power supply, status signals, recorder outputs, relay contacts, and data transmission should be laid separately. Cables for the power supply, status signals, recorder outputs, relay contacts, and data transmission should be laid separately. The mains supply line has to be carried out in 3x1.5 mm². The wire and sheath material has to be adapted to the conditions at the particular installation location. For the fuse protection of the mains supply line a 16A automatic circuit breaker has to be installed near the measuring system. The single conductors of the mains line have to be secured to each other that they can't reach other clamps if one single conductor goes lose (e.g. binder).

The distance between the display unit and the evaluation unit can be no more than 1000 meters. The wiring for the data transmission (RS 422) should be done with a twisted cable of a conductor diameter of 0.20 mm² (corresponding to AWG No. 24).

Evaluation unit D-R 290 AZ2

Mains		Terminal X1		Function
		b	c	
	1	4	PE	
	2	5	L (90 - 264 V)	
	3	6	N	
Interfaces	Terminal X2			Function
	a	b	c	
		61		Supply measuring head: +15V
			64	Supply measuring head: GND
		62		Supply measuring head: -15V
			65	Supply measuring head: +5V
		63		Supply measuring head: PE
			66	Supply measuring head: GND
	1			Internal interface: RS-422 Y (MK)
		21		Internal interface: RS-422 Y (MK)
			41	PE
	2			Internal interface: RS-422 Y (AZ)
		22		Internal interface: RS-422 Z (AZ)
			42	PE
	3			Internal interface: RS-422 Y (MK)
		23		Internal interface: RS-422 Y (MK)
			43	PE
	4			Internal interface: RS-422 A (AZ)
		24		Internal interface: RS-422 B (AZ)
			44	PE
	5			D-COM02: RS-485 A
		25		D-COM02: RS-485 B
			45	PE
	6			D-COM02: RS-485 A
		26		D-COM02: RS-485 B
			46	PE
	7			4.. 20mA Output 1: Instrument +
		27		4.. 20mA Output 1: Instrument - Recorder +
			47	4.. 20mA Output 1: Recorder -
	8			4.. 20mA Output 2: Instrument +
		28		4.. 20mA Output 2: Instrument - Recorder +
			48	4.. 20mA Output 2: Recorder -
	9			Relay input 1: External error 100
	10			Relay input 1: GND
		29		Relay input 2: External error 200
		30		Relay input 2: GND
			49	Relay input 3: External error 300
			50	Relay input 3: GND

Interfaces	Terminal X2			Function
	a	b	c	
 Relay	11			Relay input 4: External error 400
	12			Relay input 4: GND
 Relay		31		Relay input 5: External error 500
		32		Relay input 5: GND
 Relay			51	Relay input 6: External error 600
			52	Relay input 6: GND
 Potential free switch	13			Relay output 1: Report output D-SK 290 #1 NO
		33		Relay output 1: COM
			53	PE
 Potential free switch	14			Relay output 2: Report output D-SK 290 #2 NO
		34		Relay output 2: COM
			54	PE
 Potential free switch	15			Relay output 3: Switch output D-SK 290 #1 NO
		35		Relay output 3: COM
			55	PE
 Potential free switch	16			Relay output 4: Switch output D-SK 290 #2 NO
		36		Relay output 4: COM
			56	PE
 Change-over switch	17			Relay output 5: "Error" NO
		37		Relay output 5: COM
			57	Relay output 5: "no Error" NC
 Change-over switch	18			Relay output 6: "Measurement" NO
		38		Relay output 6: COM
			58	Relay output 6: "no Measurement" NC





* For loosening the cage clamps a screwdriver with a 0.6 x 3.5 mm blade is necessary.

Fig. 18: Connection plan for the display unit

7.2 Control display unit D-R 290 AZ2

The D-R 290 is controlled using the four keys and the LCD on the front panel of the display unit. Parameters, values, and functions that have been entered and saved in the evaluation unit can be accessed.

7.3 Key functions

Key		The LED of the key "STO" flashes on error message.
Key		Puts the system into the "display parameters" mode. The "MOD" key LED should be lit in this mode.
Key		Pressing this key in the "Display measured value" mode switches the displayed value between outputs 1 and 2. The "MOD" key LED should not be lit. In the "Parameter Display" mode for the switching of the display. The LED of the "MOD" key should light up.
Key		If you press the Cursor and the Plus keys simultaneously for approximately 5 seconds, the control cycle will start.

1. Press the "MOD" key to switch from the "measurement" mode to the "parameter display" mode. The LED key "MOD" should light up.
2. Press the "+" key to display the next value in the display field.
3. Press the "MOD" key to switch back from the "parameter display" mode to the "measurement" mode. The key -LED "MOD" goes out and the current measurement value is displayed in the display field.
4. Press the "+" key in the "measurement display" mode to switch the measurement value display of the output 1 and 2.

8 Local power supply D-R 290 PS

If the operation and the measurement display are to be possible in the control room, the system D-R 290 can be expanded with the local power supply D-R 290 PS.. A regarding connection diagram can be found in chapter 6.3 D-R 290 AW2 Electrical Connection.

8.1 Electrical Connection D-R 290 PS

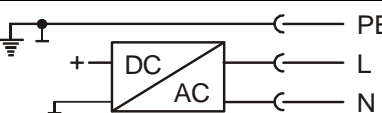
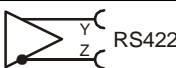

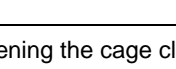
The electrical connection in the housing terminal is done by a 9-pin terminal strip according to the column Terminal of the connection plan.

The measuring head and the D-R 290 PS power supply are connected by a cable with a plug-in connection (cable length about 2 m).

Cables for the power supply, status signals, recorder outputs, relay contacts, and data transmission should be laid separately.

Cables for the power supply, status signals, recorder outputs, relay contacts, and data transmission should be laid separately. The mains supply line has to be carried out in 3x1.5 mm². The wire and sheath material has to be adapted to the conditions at the particular installation location. For the fuse protection of the mains supply line a 16A automatic circuit breaker has to be installed near the measuring system. The single conductors of the mains line have to be secured to each other that they can't reach other clamps if one single conductor goes lose (e.g. binder).

The distance between the power supply and the evaluation unit can be no more than 1000 meters. The wiring for the data transmission (RS-422) should be done with a twisted cable of a conductor diameter of 0.20 mm² (corresponding to AWG No. 24).

Local power supply D-R 290 PS			
Mains	Terminal	Function	
	gn/ye	PE	
	~	L (90 - 264 V)	
	~	N	
Interfaces	Terminal	Function	
	6	Internal interface: GND	
	7	Internal interface: RS-422 Y (MK)	
	8	Internal interface: RS-422 Y (MK)	
	9	Internal interface: RS-422 Y (AW)	
	10	Internal interface: RS-422 Z (AW)	
	gn/ye	PE	Shield

* For loosening the cage clamps a screwdriver with a 0.6 x 3.5 mm blade is necessary.

Fig. 19: Connection plan for the local power supply

9 Status Inputs and Outputs

9.1 Status Inputs D-R 290 AW2

The D-R 290 AW2 evaluation unit has six status inputs. In the default setting (see chapter 6.8 Default settings), the status inputs will be assigned.

The setting **6 X S** enables manual access to the controls by the status inputs 3 to 6. The selected control function will be carried out for the duration of the selection.

Input 1	open:	Data entry disabled.
	closed:	Data entry/saving enabled
Input 2	open:	Control cycle runs automatically.
	closed:	Control cycle does not run automatically.
	upon opening:	Control cycle begins.

X X S	6 X S
Input 3 closed: External Error 002, Error Message 002.	Zero Point Control
Input 4 open: Measurement range 1 from Output 1 enabled. closed: Measurement range 2 from Output 1 enabled.	Contamination control
Input 5 open: Measurement range 2 from Output 1 enabled. closed: Measurement range 2 from Output 2 enabled.	Reference point control
Input 6 closed: External Error 003, Error Message 003.	Stack factor

9.2 Status Outputs D-R 290 AW2

The D-R 290 AW2 evaluation unit has six potential-free status inputs, limit values, errors, control cycles, etc.

The contact outputs (make contacts) of the relay 1 to 4 are assigned in the default setting (see chapter 6.8 Default settings). The status outputs for the error message (relay 5) and the measurement (relay 6) are switch contacts and fixed defaults.

9.3 Status Inputs D-R 290 AZ2

The display unit D-R 290 AZ2 has six status inputs for external error messages (ERROR 100 to 600). In case of an error message, the error message in the top line of the LC-display changes to the current display and the key LED of the "STO" key flashes. After a delay of approximately 10 seconds, an error message will be sent through the relay output error.

The error messages 500 and 600 can be activated with the switches S1/1 (D-SK 290 #1) and S1/2 (D-SK 290 #2) on the circuit board D-R 290 AW No. 40 for the feedback of the fail-safe shutters D-SK 290.

9.4 Status Outputs D-R 290 AZ2

The display unit D-R 290 AZ2 has potential-free status outputs for the messages error, control cycle, and the control of the fail-safe shutters D-SK 290.

The status outputs for the messages are fixed defaults of switch contacts:

- Error / No Error (Relay 5)
- Measuring / No Measuring (Relay 6)

9.5 Function Test D-SK 290 with D-R 290 AW2

If the D-SK 290 function is enabled in its default settings, an automatic monitoring and function control of the operational fail-fast shutters D-SK 290 will be possible. If the control system D-R 290 is operated without any display unit, the connection will be done according to the Fig. 20 on the evaluation unit. In order to activate this function (see chapter 10.2 Switch on the Circuit Board D-R 290 AW No. 40), the switch S1/1 or S1/2 has to be set to ON. The control is done for the reference point control in the control cycle for approximately 1 minute through the switch output relay 3 / 4 of the evaluation unit "close shutter". The input 3 / 6 is activated for the feedback (shutter CLOSED). If the feedback (shutter CLOSED) is not given after approximately 2.5 seconds, the current display "SPAN CHECK" in the top line of the LC-display changes to the error message "*** ERROR 002 ***" or "*** ERROR 003 ***" and the LED of the "STO" key flashes. After a delay of 10 seconds, an error message will be sent through the relay output.

Switch S1/1: Position ON activates the relay output 3 and for the feedback the Input 3 with the error message "*** ERROR 002 ***"

Switch S1/2: Position ON activates the relay output 4 and for the feedback the Input 6 with the error message "*** ERROR 003 ***"

If the fail-save shutter outside the function control (while measurement) is closed, the error message "*** ERROR 002 ***" or "*** ERROR 003 ***" will be given and the LED of the "STO" key will flash, as well. After a delay, an error message will be sent through the relay output.

This function control by the evaluation unit will be disabled during the operation with an additional display unit D-R 290 AZ2. In this case, the automatic function control of the fail-fast shutters D-SK 290 will be carried out by the display unit D-R 290 AZ2.

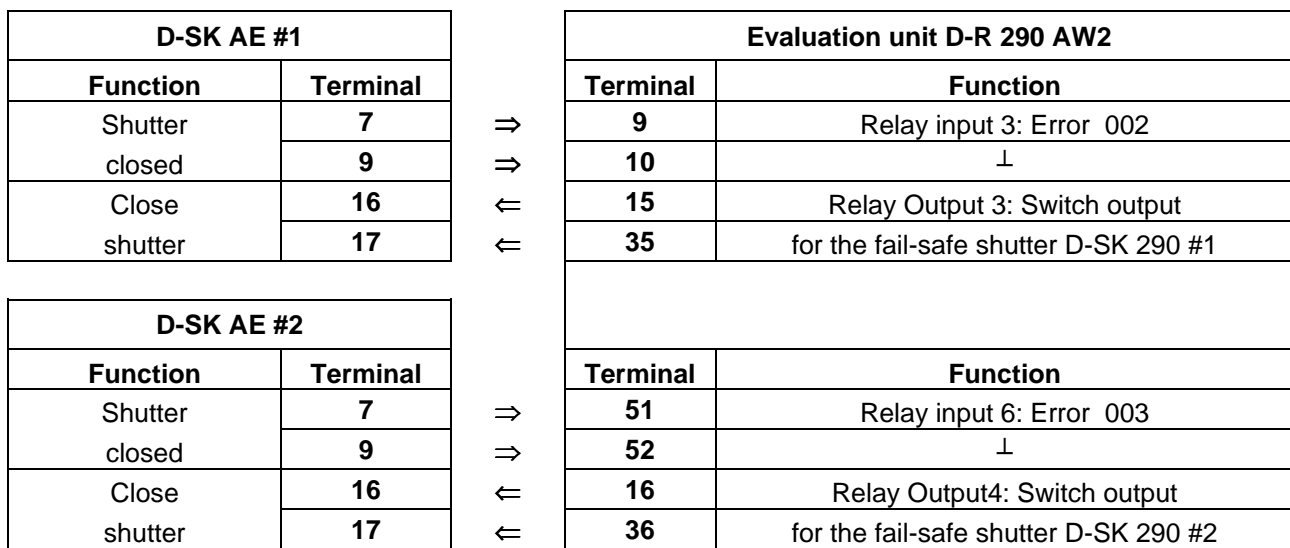


Fig. 20: Electrical Connection D-SK AE and D-R 290 AW2

9.6 Function Test D-SK 290 with D-R 290 AZ2

If the control system D-R 290 is operated with a display unit, the operational fail-fast shutters D-SK 290 can also be checked with an automatic function control. In order to activate this function (see chapter 10.2 Switch on the Circuit Board D-R 290 AW No. 40), the switch S1/1 or S1/2 on the display unit has to be set to ON. The control is done for the reference point control in the control cycle for approximately 1 minute through the switch output relay 3 / 4 “close shutter”. The input 5 / 6 is activated for the feedback (shutter CLOSED). If the feedback (shutter CLOSED) is not given after approximately 2.5 seconds, the current display “**SPAN CHECK**” in the top line of the LC-display changes to the error message “** ERROR 500 **” or “** ERROR 600 **” and the LED of the “STO” key flashes. After a delay of 10 seconds, an error message will be sent through the relay output.

Switch S1/1: Position ON activates the relay output 5 and for the feedback the Input 3 with the error message “** ERROR 500 **”.

Switch S1/2: Position ON activates the relay output 6 and for the feedback the Input 4 with the error message “** ERROR 600 **”.

If the fail-fast shutter outside the function control (while measurement) is closed, the error message “** ERROR 500 **” or “** ERROR 600 **” will be given and the LED of the “STO” key will flash, as well. After a delay, an error message will be sent through the relay output.

- Relay 1 additional message output for the triggering of the fail-fast shutter1 D-SK 290 (inverted signal to the relay output 3 “close shutter”).
- Relay 2 additional message output for the triggering of the fail-fast shutter 2 D-SK 290 (inverted signal to the relay output 4 “close shutter”).

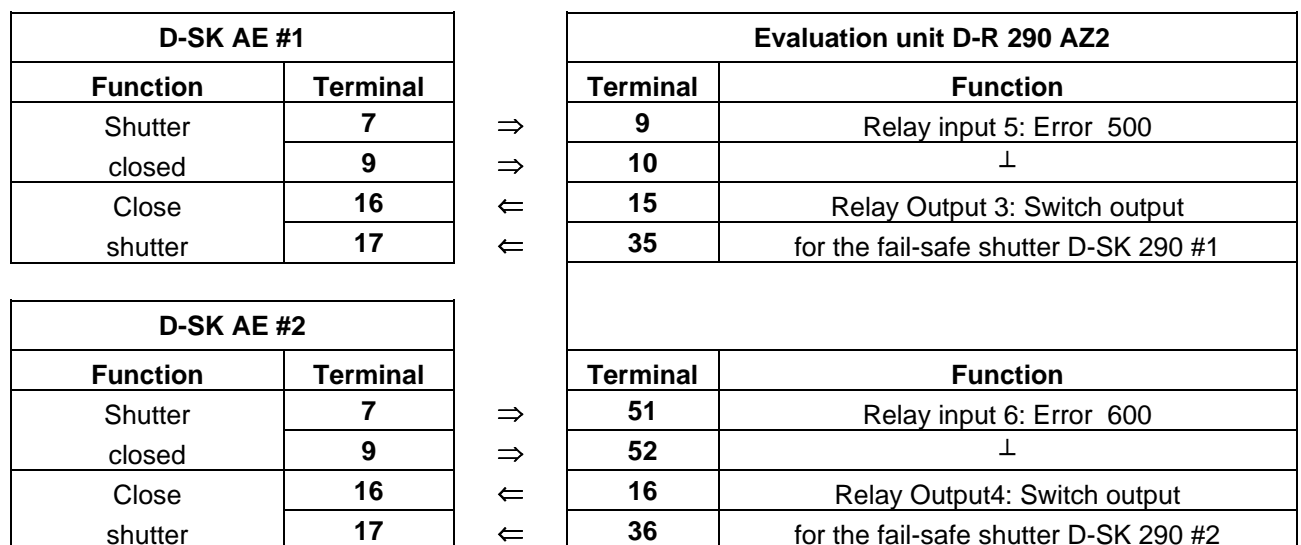


Fig. 21: Electrical Connection D-SK AE and D-R 290 AZ2

9.7 Error Messages

In case of an error message, the error message in the top line of the LC-display of the control or the display unit changes to the current display and the LED of the STO key flashes. After a delay of approximately 10 seconds, an error message will be sent through the relay output R5. In case of system errors, the additional status message OFF will be sent through the relay output R6, according to the table.

The error messages ERROR 100 to ERROR 700 are active only during operations with the display unit D-R 290 AZ2.

ERROR	LCD Display	R6	R5
Data transmission error	** ERROR 000 **	X	X
Window contamination too high	** ERROR 001 **		X
Extern Error Message 1 AW	** ERROR 002 **		X
Extern Error Message 2 AW	** ERROR 003 **		X
EEPROM error	** ERROR 004 **		X
RAM error	** ERROR 005 **	X	X
PROM error	** ERROR 006 **	X	X
AW – System error	** ERROR 007 **	X	X
TimeOut IIC-EEPROM	** ERROR 008 **		X
External Zero Point Error	** ERROR 010 **		X
Internal Zero Point Error	** ERROR 020 **		X
Comparison error	** ERROR 030 **		X
Stepper motor error	** ERROR 040 **	X	X
LED Error	** ERROR 050 **	X	X
Heated Disk Error	** ERROR 060 **		X
Measuring head – System error	** ERROR 070 **	X	X
Temperature measurement - Range overshoot	** ERROR 080 **		X
Temperature measurement - Range undershoot	** ERROR 090 **		X
Error Message Input 1 AZ	** ERROR 100 **		X
Error Message Input 2 AZ	** ERROR 200 **		X
Error Message Input 3 AZ	** ERROR 300 **		X
Error Message Input 4 AZ	** ERROR 400 **		X
Error Message Input 5 AZ	** ERROR 500 **		X
Error Message Input 6 AZ	** ERROR 600 **		X
AZ – System error	** ERROR 700 **	X	X

10 Switch Functions in the Control Display Unit

10.1 Switch on the Circuit Board D-R 290 AW No. 30

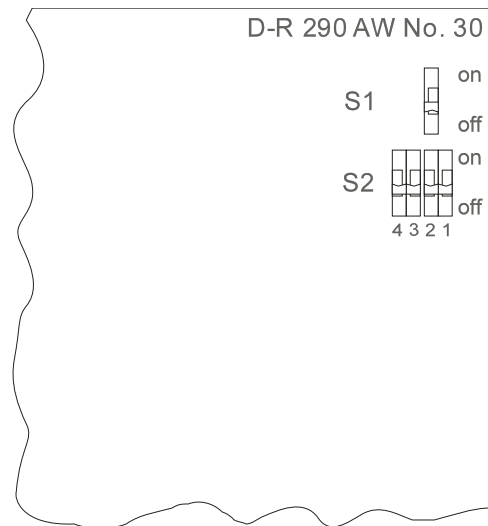


Fig. 22: Switch arrangements on the Circuit Board D-R 290 AW No. 30

Default setting of all switches is the position OFF

Switch	ON	OFF	Function D-R 290 AW2 / D-R 290 AZ2	D-R 290 AZ2
S1		X	Watchdog Timer ON	
S2/1	X		Operation with display unit D-R 290 AZ2	none
S2/2	X		TEST STEP # 16 Current outputs to 20 mA P1 + P2	
S2/3		X		
S2/2		X	Display Amplification Factor and LED-Current	
S2/3	X			
S2/2	X		Temperature compensation enabled	
S2/3	X			
S2/4	X		System Status -> load	none

Switch S1:

The function of the Watchdog Timer has been switched off: Switch S1 in ON position. The function of the Watchdog Timer has been switched on: Switch S1 in OFF position.

Switch S2/1:

If the system is optionally operated with an additional local display unit D-R 290 AZ2, the switch S1/2 in the evaluation unit has to be switched to ON in order to enable this function. The automatic function control of the fail-fast shutters D-SK 290 by the evaluation unit will be disabled during the operation with an additional display unit D-R 290 AZ2.

Switch S2/2:

In order to check / adjust the current outputs, switch the switch S2/2 to ON. Messages on the display: **"TEST STEP # 16"** (20 mA). The two current outputs of the display evaluation unit can be adjusted to 20 mA with the potentiometers P1 and P2.

If the switch S2/3 is also set to the ON position the temperature compensation is enabled.

Switch S2/3:

The current amplification factor and the LED power can be displayed in the display of the evaluation unit for service purposes. In order to enable this function, move the switch S2/3 to ON.

If the switch S2/2 is also set to the ON position the temperature compensation is enabled.

Switch S2/4:

If the switch S2/4 of the evaluation unit is in ON position and the status input 1 is closed (released for storage) before the power supply is connected, the standard data (delivery state) will be load and stored for the evaluation unit as soon as the power supply is connected. Messages on the display: **"System Status ->"**.

10.2 Switch on the Circuit Board D-R 290 AW No. 40

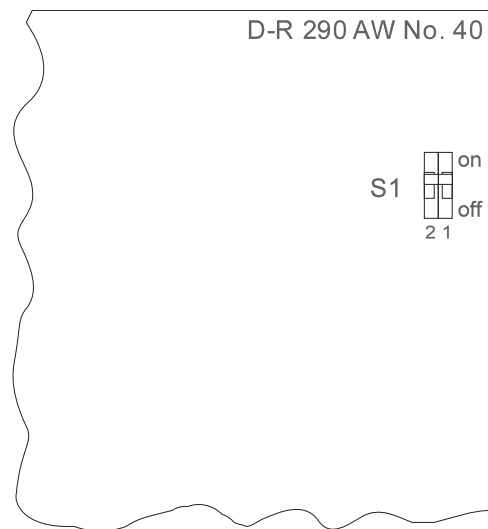


Fig. 23: Switch arrangements on the Circuit Board D-R 290 AW No. 40

Switch S1 / S2

It is possible to check the functions of the operational fail-fast shutter D-SK 290 automatically. In order to enable this function, the switch S1 on the circuit board D-R 290 AW no. 40 has to be switched to OFF. If no fail-fast shutters are available, the switch S1 have to be switched to ON.

Switch	ON	OFF	Function in D-R 290 AW2
S1/1		X	Output relay 3 has been triggered for the control and input 3 for the feedback of the fail-safe shutter D-SK 290, error message "*** ERROR 002 ***".
S1/2		X	Output relay 4 has been triggered for the control and input 6 for the feedback of the fail-safe shutter D-SK 290, error message "*** ERROR 003 ***".

Switch	ON	OFF	Function in D-R 290 AZ2
S1/1		X	Output relay 3 has been triggered for the control and input 5 for the feedback of the fail-safe shutter D-SK 290, error message "*** ERROR 500 ***".
S1/2		X	Output relay 4 has been triggered for the control and input 6 for the feedback of the fail-safe shutter D-SK 290, error message "*** ERROR 600 ***".

This function control by the evaluation unit will be disabled during the operation with an additional display unit D-R 290 AZ2. In this case, the automatic function control of the fail-fast shutters D-SK 290 can be carried out by the display unit D-R 290 AZ2 nevertheless.

11 Reflectors

The following reflectors can be used with the D-R 290 opacity monitor:

Type	Flange to flange stack distance	Model
Reflector II	Between 1.75 and 12.00 meters	Triple with optic
Reflector I	Between 1.00 and 2.25 meters	Scotchlite

The reflector should be selected according to the flange-to-flange distance across the measurement path. When mounting the system, be sure that the measuring path given when ordering is the same as the actual path length. The monitor has been calibrated for this distance before delivery. Reflectors with the same device number have to be mounted opposite each other.

12 Measuring head D-R 290 MK

12.1 Setting of the Light Intensity of the Internal Zero Point Reflector

The internal zero point reflector has to be set according to the EPA requirements so that it swings forward and reflects the same light intensity as the reflector on the smokeless control distance.

Note:

The measuring systems are set correctly corresponding to the following instruction in the factory.

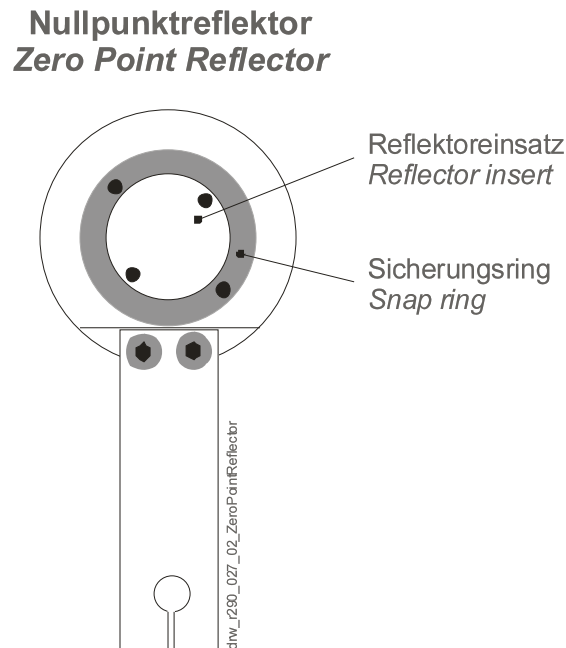
Measuring systems that are not subject to the EPA requirements do not have to be checked or set.

1. Set-up the measuring head and the reflector in a dust free room at the exact stack distance. The lengthening of the control distance that has been caused by the cone disk springs and the fail-fast shutters has to be considered as well. It should be taken care to adjust the flange for the measuring head and reflector as parallel as possible. The optical surfaces (exit windows and zero point reflector) of the measuring system have to be cleaned very careful and striation-free with an optics cloth and glass cleaning agent (see chapter 13 Maintenance).
2. Then the 4 fastening shutters at the measuring head have to be removed and the measuring head is moved to the side. Remove the 6 Allen screws for the housing lid with a 4 mm Allen wrench and remove the housing lid. Now the measuring head has to be moved back to its place and the 4 fastening shutters are closed again. The measuring head and the evaluation unit have to be connected electrically. After the starting, the D-R 290 carries out a self test and the comparison light way is tested. Display in Line 1 of the LC-Display: **"REF. LIGHT CHECK"**. After the automatic set-up of the LED-intensity, the device will be ready for set-up (the yellow LED is off).

Section 1	Section 2
REF. LIGHT CHECK	
# 046	0754
Section 3	Section 4

3. The switch **S2** on the circuit board D-R 290 MK no 20 has to be switched to the upper position **ON** ↑ and at the service switch **S6** the test functions 4 have to be set for the set-up of the light intensity. By pressing on the key **S8** "–", the reflector on the smokeless control distance will be selected. The signal voltage (ZP-External) on the control point MP2 against the mass connection of the capacitor C 37 (1000 µF / 25 V) will be read.
4. Then, the internal zero point reflector will be swung forward and the signal voltage (ZP-Internal) will be read at the control point MP2 by pressing on the key **S7** "+". The internal zero point reflector has to be set so that it swings forward and yields the same light intensity (signal voltage) like the reflector brings for the external zero point. Tolerance of the light intensity is maximum 10 %.

5. In order to set it, the snap ring at the zero point reflector has to be removed (turn to the left). The setting of the light intensity is done by turning the reflector application. If it is turned to the right, the light intensity will decrease and the signal voltage will fall. If it is turned to the left, the light intensity will increase and the signal voltage will rise. If the signal voltage (ZP-Internal) is equal to the signal voltage (ZP-External), the reflector use with the snap ring has to be fastened again (turn to the right).
6. Then an automatic adjustment has to be carried out on the dust free path length (see chapter 12.2 Clear path procedure).



12.2 Clear path procedure

The adjustment should be done in the following order:

1. Set-up the measuring head and the reflector in a dust free room at the exact stack distance. The lengthening of the path length that has been caused by the cone disk springs and the fail-fast shutters has to be considered as well. It should be taken care to adjust the flange for the measuring head and reflector as parallel as possible. The optical surfaces (exit windows and zero point reflector) of the measuring system have to be cleaned very careful and striation-free with an optics cloth and glass cleaning agent (see chapter13 Maintenance).
2. Then the 4 fastening shutters at the measuring head have to be removed and the measuring head is moved to the side. Remove the 6 Allen screws for the housing lid with a 4 mm Allen wrench and remove the housing lid. Now the measuring head has to be moved back to its place and the 4 fastening shutters are closed again. The measuring head and the evaluation unit have to be connected electrically. After the starting, the D-R 290 carries out a self test and the comparison light way is set. Display in Line 1 of the LC- Display: **"REF. LIGHT CHECK"**. After the automatic set-up of the LED-intensity, the device will be ready for set-up.
3. The switch S2 and S3 have to be switched from **OFF** to the upper position **ON** ↑. The zero point motor drives back.
Display Line 1 of the LC-Display: **"ZERO EXT. CALIB"**.

4. The measuring head has to be justified optically (see chapter 5.3 Optical adjustment). If the measuring head and the reflector have been mounted like it is shown on Fig. 7:, the 3 nuts on the reflector flange can be tightened. First tighten the nut B on the measuring head. When tightening the nut A, the measuring head inclines to the axis B - C and the figure in the image display moves in a vertical direction. When tightening or loosening the nut C, the measuring head pivots at the axis A - B and the figure in the image display moves in a horizontal direction. The metal knurled screw on the optics has to be removed (control the focus setting) and the focus has to be set with the plastic button so that a sharp image can be seen in the image display for control distances of 1 to 2.25 meters (reflector 1). For control distances of more than 2,25 meters (reflector 2), turn the plastic button to the left end. Then lock the setting with the metal knurled screw.
5. Move the switches **S2** and **S3** back to the button position **OFF ↓**, then activate the switch **S5** in the key position (towards the front part of the device) till the yellow LED (adjustment) flashes. The switch **S5** is in the central position and the yellow LED continues flashing. The storage of the adjustment values has been enabled (red LED flashes continuously). The bottom line of the display (evaluation unit) is working.
 Display Line 1: "**LED INT. CALIB**" the comparison light way is adjusted.
 Display Line 1: "**ZERO POINT CALIB**" the internal zero point is adjusted.
 Display Line 1: "**SPAN CALIB**" the reference light way is adjusted.
 Display Line 1: "**ZERO EXT. CALIB**" the external zero point is adjusted.
6. The self test will follow the set-up; the yellow LED continues flashing. In order to block the storage of the values, the switch S5 has to be moved to the back (red LED is not lit).
7. Then the measuring head and the evaluation unit have to be separated electrically (switch off voltage). The 4 fastening shutters at the measuring head have to be removed, the measuring head has to be moved to the side and the housing cover has to be mounted to its place and tightened again with the 6 Allen screws. Now the measuring head has to be moved back to its place and the 4 fastening shutters are closed again.
8. The measuring head and the evaluation unit have to be connected electrically (switch on voltage). After the start-up, the D-R 290 carries out a control cycle.

Display during adjustment

Section 1+2: Current Adjustment Function

Section 3: Enhancing Factor.

Section 4: LED - Power

Section 1	Section 2
LED INT.	CALIB
# 096	0754
Section 3	Section 4

12.3 Manual internal zero point (Window Check)

If the value needs to be adjusted after the system has done its automatic calibration, this can be done manually as well.

1. The optical surfaces (exit windows and zero point reflector) of the measuring system have to be cleaned very careful and striation-free with an optics cloth and glass cleaning agent (see chapter 13 Maintenance), and the measurement "**Window Check**" has to be selected with the keys "**MOD**" and "+" at the evaluation unit D-R 290 AW2.
2. Open the lid to the D-R 290 MK measuring head housing. On the circuit board, push switch **S4** on the 6-terminal switch **S4/4** to the **OFF** ↓ position. Put switch **S3** (calibration function) to the **ON** ↑ position. Switch **S5** must be set to "free memory access" so that the red LED lights. The first line of the display should alternate between "**OFFSET - +**" and "**WINDOW CHECK**".
3. With keys **S8** "-" (lower value) and **S7** "+" (upper value) the internal zero point can now be adjusted to 4.0 mA. Keep in mind that this corrected value will not take effect until after the integration time. Therefore, press the keys briefly and then wait at least 10 seconds before pressing a key again. The yellow LED should light when the keys are used.
4. At the end of the calibration, the switches should be set to their normal positions. Switch **S5** should be set to OFF, which will turn off the red "data entry" LED. On the slide switch **S4** the switch **S4/4** to the **ON** ↑ position. Switch **S3** should be in the **OFF** ↓ position. Place the housing lid back on the unit and tighten the fastening screws.

12.4 External Zero Point Calibration

If the value needs to be adjusted after the system has done its automatic calibration, this can be done manually as well.

1. Set-up the measuring head and the reflector in a dust free room at the exact stack distance and do the optical alignment. The optical surfaces (exit windows and zero point reflector) of the measuring system have to be cleaned very careful and striation-free with an optics cloth and glass cleaning agent (see chapter 13 Maintenance). Set a short integration time (such as 10 seconds) on the D-R 290 AW2 evaluation unit, then select the external zero point.
2. Open the housing lid to the D-R 290 MK measuring head. On the circuit board, locate the 6-terminal switch **S4** and push the **S4/5** switch to the **OFF** ↓ position and the calibration switch **S3** to the **ON** ↑ position. Switch **S5** must be set to the "allow memory access" position so that the red LED lights. The first line of the display should alternate between "**OFFSET - +**" and "**OUTPUT X**".
3. With keys **S8** "-" (lower value) and **S7** "+" (upper value) the internal zero point can now be adjusted to 4.0 mA. Keep in mind that this corrected value will not take effect until after the integration time. Therefore, press the keys briefly and then wait for the duration of the integration time before pressing a key again. The yellow LED should light when the keys are used.
4. At the end of the calibration, the switches should be returned to their normal positions. Switch **S5** should be set to OFF, which will turn off the red "enter value" LED. On the switch **S4**, push **S4/5** to the **ON** ↑ position. Switch **S3** should be put in the **OFF** ↓ position. Place the housing lid back on the unit and tighten the fastening screws. Re-enter and save the old integration time on the D-R 290 AW2 evaluation unit.

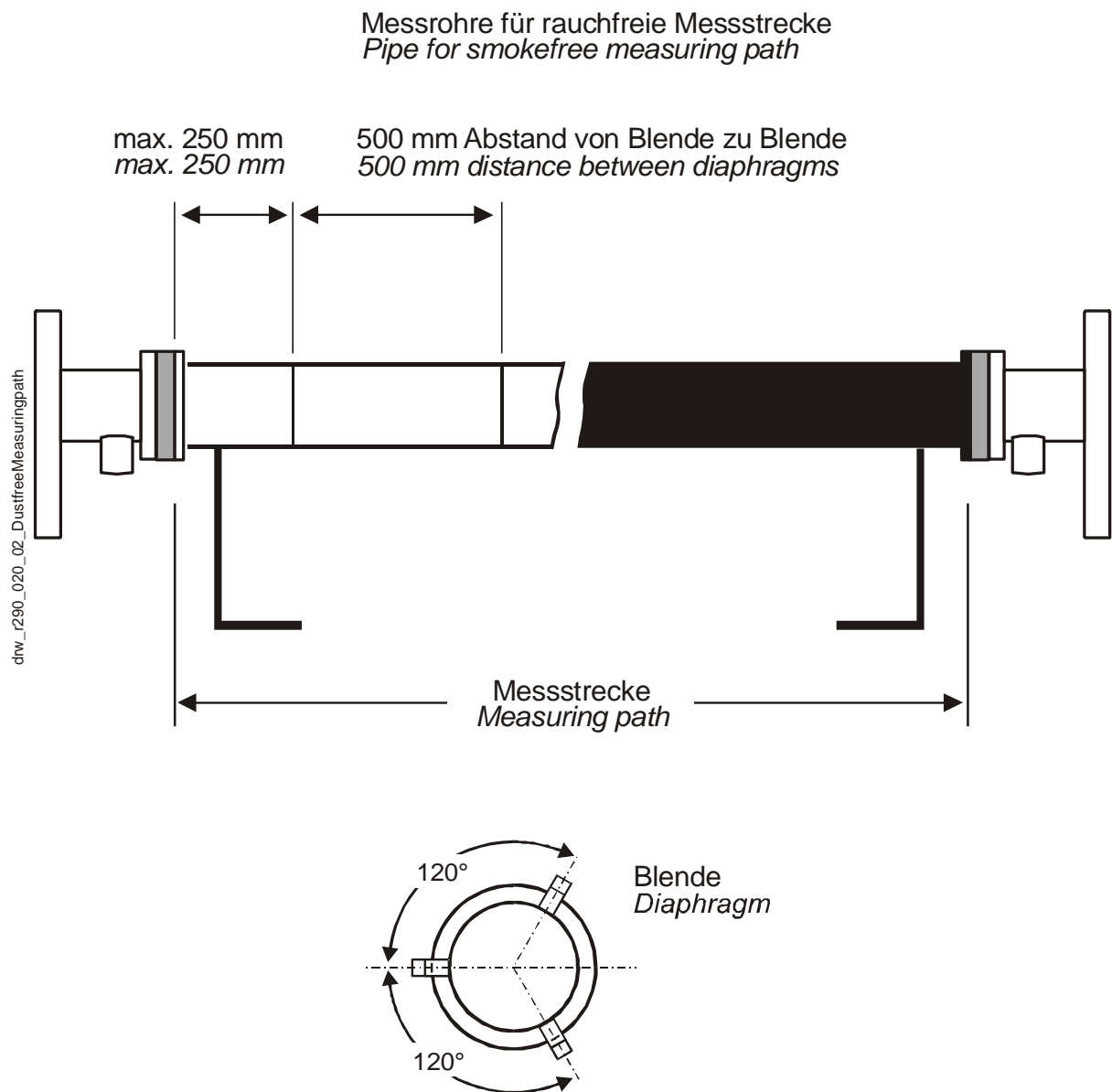


Fig. 24: Measuring pipe for clear path calibration

12.5 Temperature compensation D-R 290 TC (Option)

The dust concentration monitor D-R 290 can optionally be equipped with a temperature compensation. In this case the measured dust concentration (extinction) is calculated to the standard conditions at 0 °C with the following equation:

$$\text{Extinction}(\text{temperature compensated}) = \frac{\text{waste gas temperature} + 273,15^{\circ}\text{C}}{273,15^{\circ}\text{C}} * \text{Extinction}(\text{measured})$$

The necessary determination of the waste gas temperature is done by a additional temperature measurement input (4-pin plug) at the measuring head of the system. This input is designed as a 4..20 mA interface. Suitable temperature transmitter (transducer) with 4..20 mA output are available as accessories. The temperature measuring rang can be 0..200°C, 0..400°C o r 0..1000°C and should match the waste gas temperature.

The following figures are showing the electrical connection of temperature transmitters without and with an own power supply. 2-wire transducer can be powered directly from the measuring head with max. 30 mA.

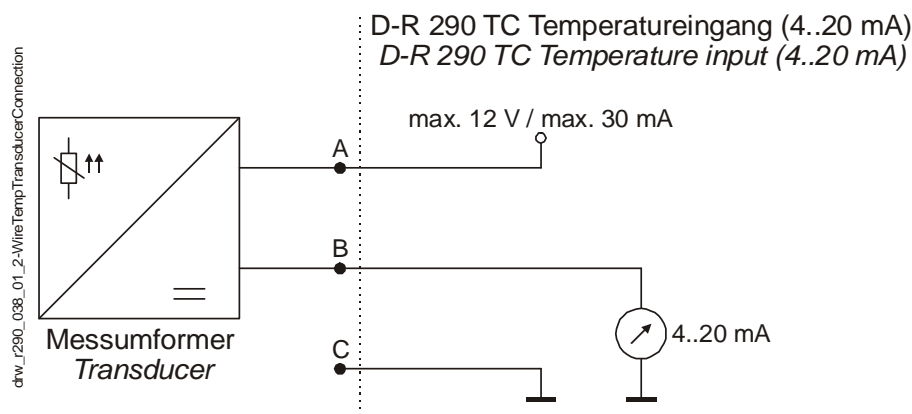


Fig. 25: Electrical connection of a 2-wire transducer (not self powered)

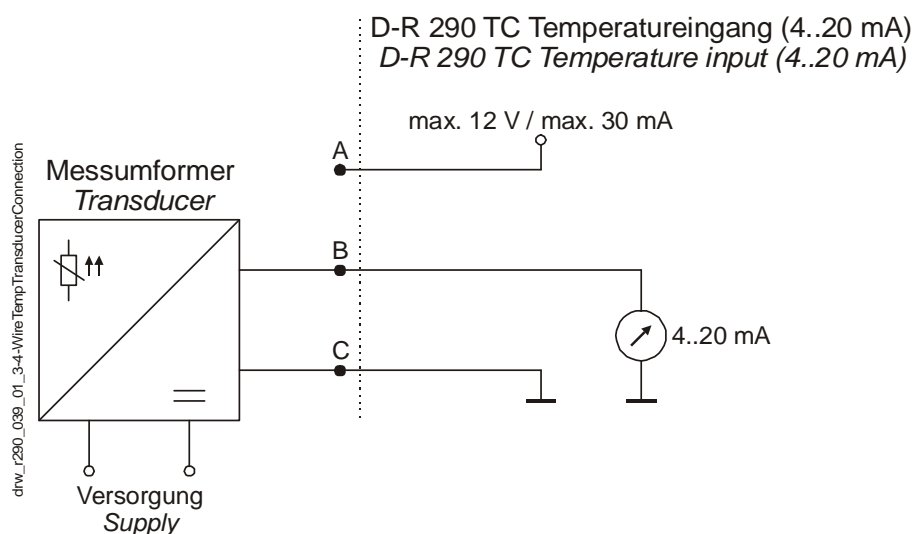


Fig. 26: Electrical connection of a 3- / 4-wire transducer (self powered)

The setting of the temperature range of the transducer has to be done at the measuring head DIL-switch S9 (see chapter 12.6 Measuring Head Switch Functions).

The temperature compensation can also be done with fixed values instead of measured temperature values. For this the temperature of the waste gas should be known and relatively constant. The temperature value can be set between 10°C and 630°C. The setting of the fixed value compensation is also done at the measuring head DIL-switch S9 (see chapter 12.6 Measuring Head Switch Functions).

In addition the temperature compensation has to be enabled at the evaluation / display unit (see chapter 10.1 Switch on the Circuit Board D-R 290 AW No. 30)

Please note that the temperature compensation results in a higher measuring range than it would be without these calculation. The following table shows an example how the extinction changes after temperature compensation with different temperatures.

Extinction without temperature compensation	Extinction after temperature compensation with				
	0 °C	100 °C	200 °C	300 °C	400 °C
0,10	0,10	0,14	0,17	0,21	0,25
0,20	0,20	0,27	0,35	0,42	0,49
0,40	0,40	0,55	0,69	0,84	0,99
0,80	0,80	1,09	1,39	1,68	1,97
1,20	1,20	1,64	2,08	2,52	2,96

12.6 Measuring Head Switch Functions

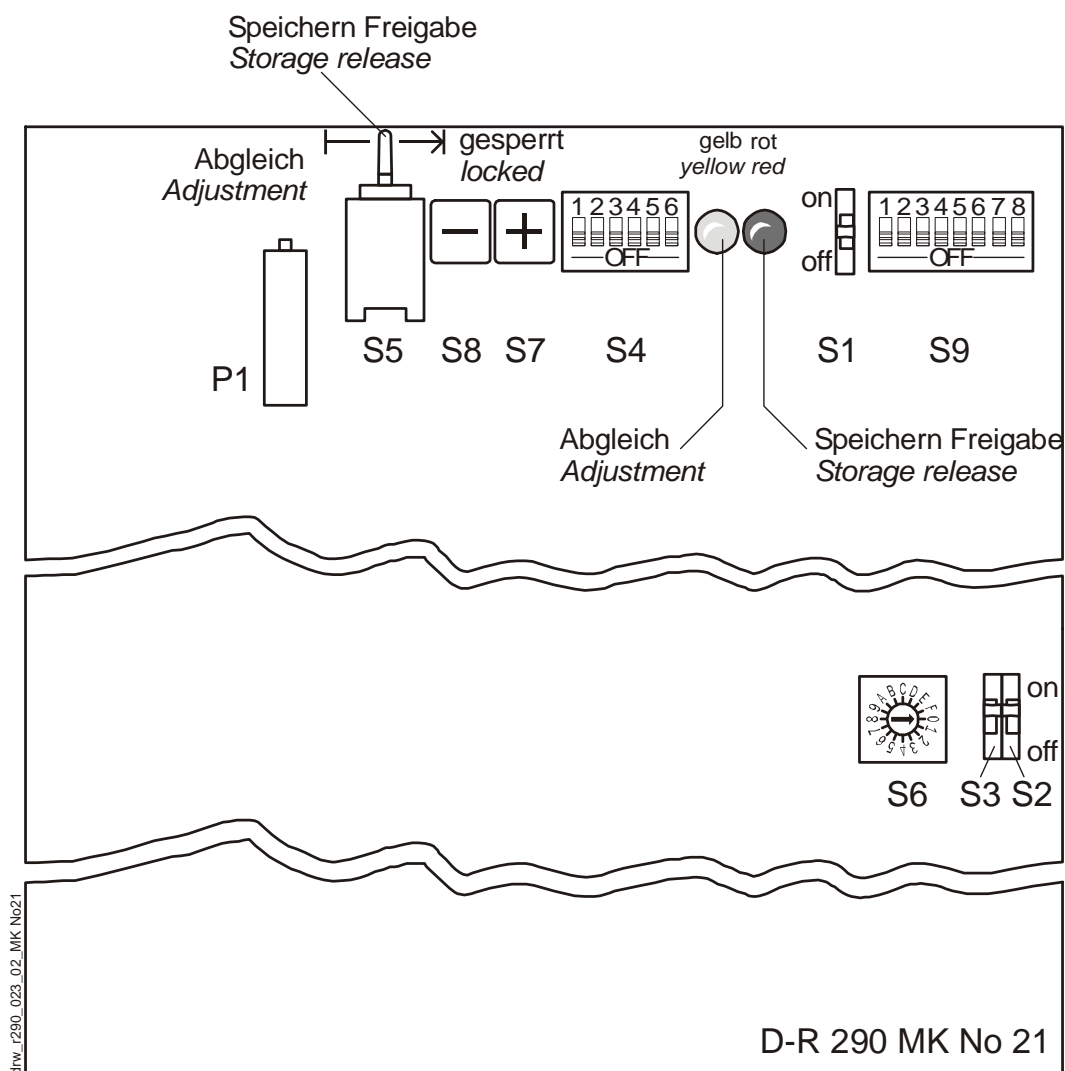


Fig. 27: Switch arrangements in the measuring head

Switch S1 - Watchdog

ON	OFF	Standard/default setting
	X	Watch Timer on

Switches S2 and S3 - Enable

	ON	OFF	Function
S2		X	Standard/default setting
S3		X	Standard/default setting
S2	X		Allow calibration when S5 is pushed
S3	X		Allow calibration when S5 is pushed
S2	X		Enable service program switch S6
S3	X		Enable calibration function switch S4

DIL- Switch S4 - Calibration

S4	ON	OFF	Standard default setting
6	X		Basic calibration disabled
5	X		OFFSET external zero point (measurement)
4	X		OFFSET internal zero point (window check)
3	X		SPAN slope
2	X		CONTROL MODE slope
1	X		OUTPUT slope

Switch S5 - Enable save

Switch S5	Function	
Pushed / active setting	Start calibration	Yellow LED blinks
Middle setting	Enable save	Red LED lights
Set to off position	Save disabled - default setting	Red LED is out

DIL-Switch S9 - Temperature compensation

S9	ON	OFF	Function
8		X	Temperature compensation with external temperature transmitter disabled - Standardeinstellung
7		X	
8		X	Temperature compensation with external temperature transmitter and measuring range 0..200°C enabled
7	X		
8	X		Temperature compensation with external temperature transmitter and measuring range 0..400°C enabled
7		X	
8	X		Temperature compensation with external temperature transmitter and measuring range 0..1000°C enabled
7	X		
6		X	Temperature compensation with fixed value 320°C disabled - default
5		X	Temperature compensation with fixed value 160°C disabled - default
4		X	Temperature compensation with fixed value 80°C disabled - default
3		X	Temperature compensation with fixed value 40°C disabled - default
2		X	Temperature compensation with fixed value 20°C disabled - default
1		X	Temperature compensation with fixed value 10°C disabled - default

* The switch positions 1..6 can be combined freely (addition). So it is possible to enable the temperature compensation with fixed values from 10°C to 630°C in 10°C steps.
If all switches are in OFF position the temperature compensation with fixed values is disabled.

** The temperature compensation with an external temperature transmitter take priority over the temperature compensation with fixed values.

13 Maintenance

The D-R 290 requires little maintenance. The periods between maintenance work will vary based on the conditions at the installation. The pressure, environmental and climatic conditions, as well as the type of measurement being conducted, will determine the maintenance frequency.

In all installations, a basic check of the equipment should be made every four weeks. This includes a check of the fail-safe shutter system, if applicable.

A maintenance routine should include the following steps:

1. Clean the external parts of the unit.
2. Check the function of the fail-safe shutters.
3. Check all seals and mounts.
4. Check the purge air system and its tubing for secure mounting and a good seal.
5. *Check the filters:* The filter cartridges can be cleaned several times before they need to be replaced. The maintenance intervals will depend on the quality of the air used.
6. Cleaning the exit windows and the zero point reflector: After opening the clamps on the housing, the measuring head and reflector can be opened. The cleaning of the optical surfaces should be done very careful and striation-free with an optics cloth and glass cleaning agent. For a better accessibility to the zero point reflector it is useful to remove the reflector from its axis.
7. Any deposits or build-ups on the mounting flanges should be removed. Contamination on the fail-safe shutter can be removed with a brush or cloth and a cleaning solvent that dries without leaving a residue (e.g. dishwashing liquid). Never use a solvent that damages aluminium.

It is advisable to make a service contract with the company DURAG for the dust concentration control device D-R 290. The commissioning of the control unit D-R 290 can be also done by the company DURAG, provided that the welding works and the electronic installations have been completed.

Warning!

Do not insert fingers into the fail-safe shutter system. Serious injury may result! Disconnect the unit by opening the connection at terminals 16 and 17 before conducting maintenance work on the D-SK AE.

14 Weather protection covers

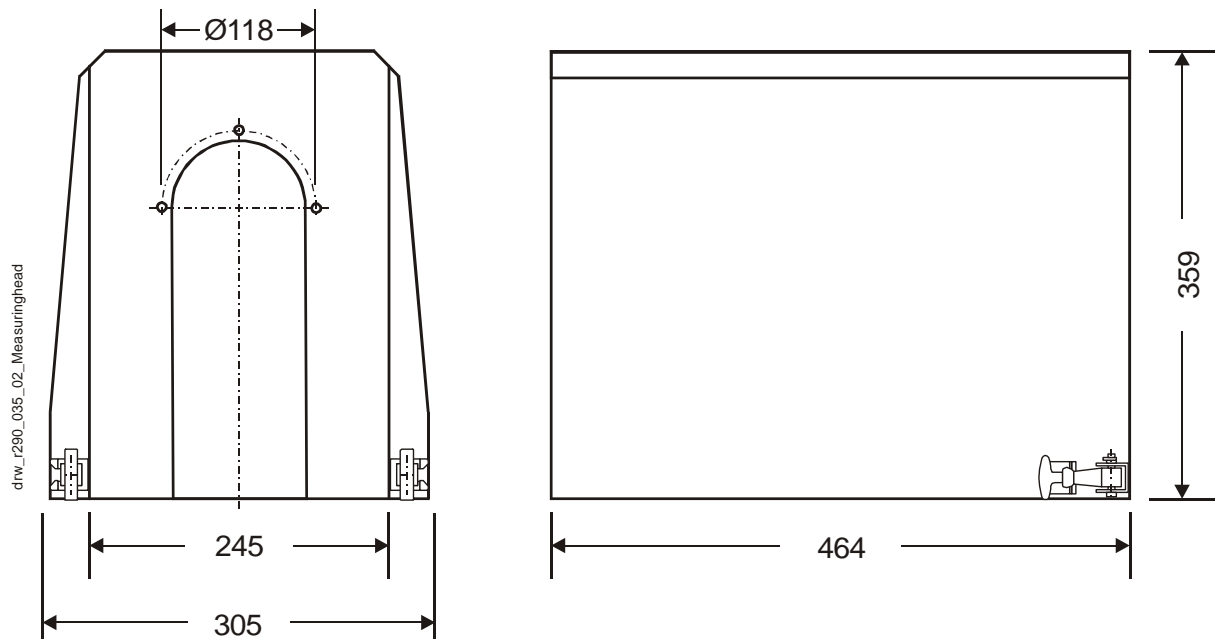


Fig. 28: Dimensional Drawing: Weather protection cover for measuring head

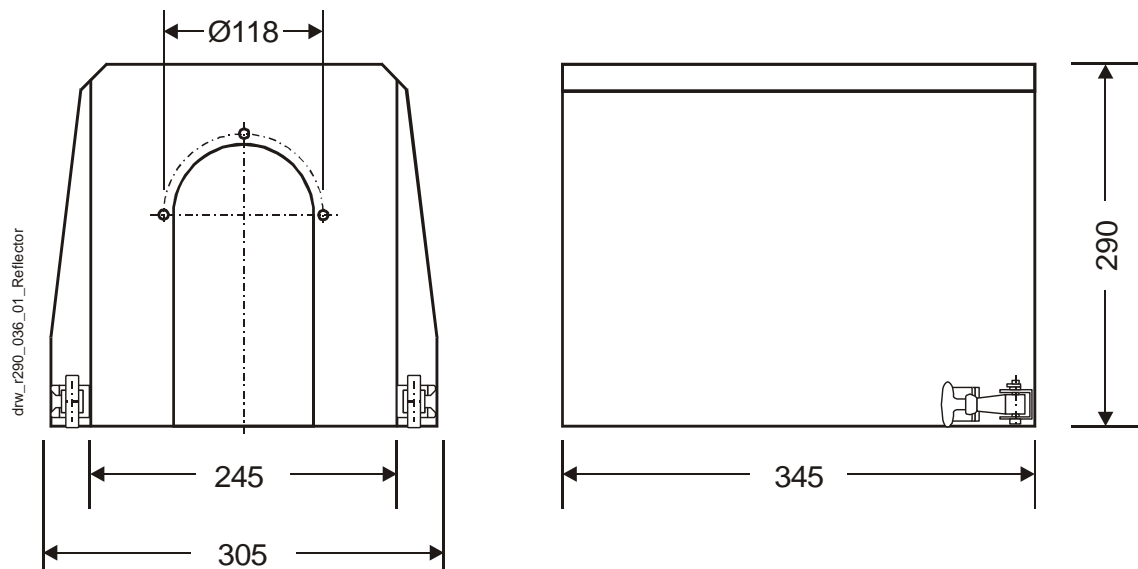


Fig. 29: Dimensional Drawing: Weather protection cover for reflector

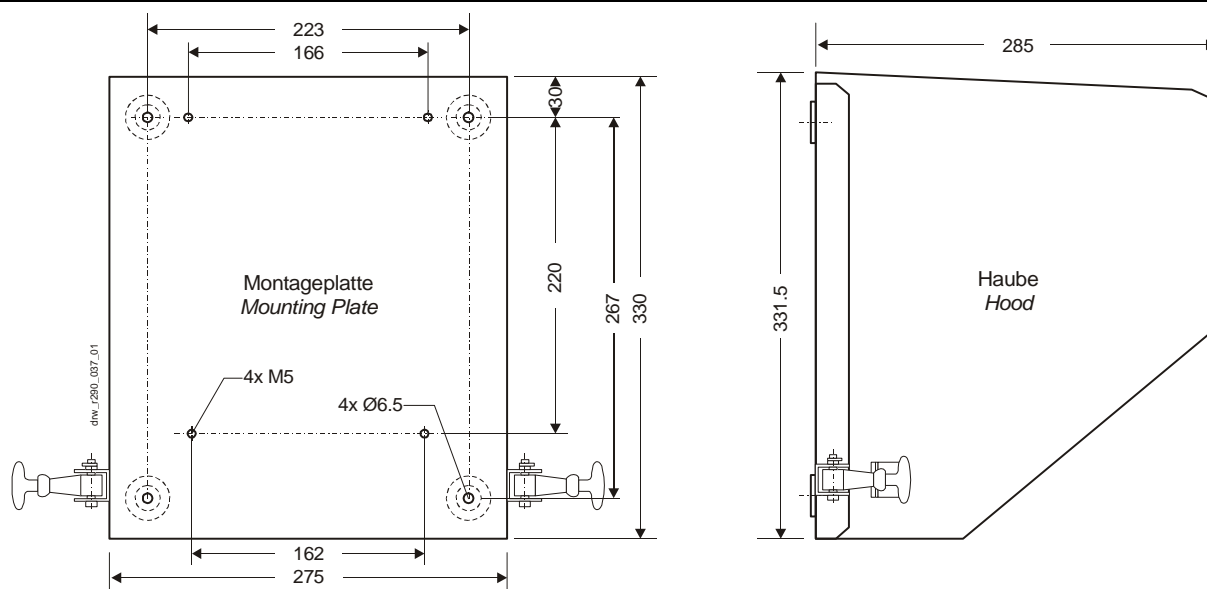


Fig. 30: Dimensional Drawing: Weather protection cover for D-R 290 AG2 (AW2/AZ2)

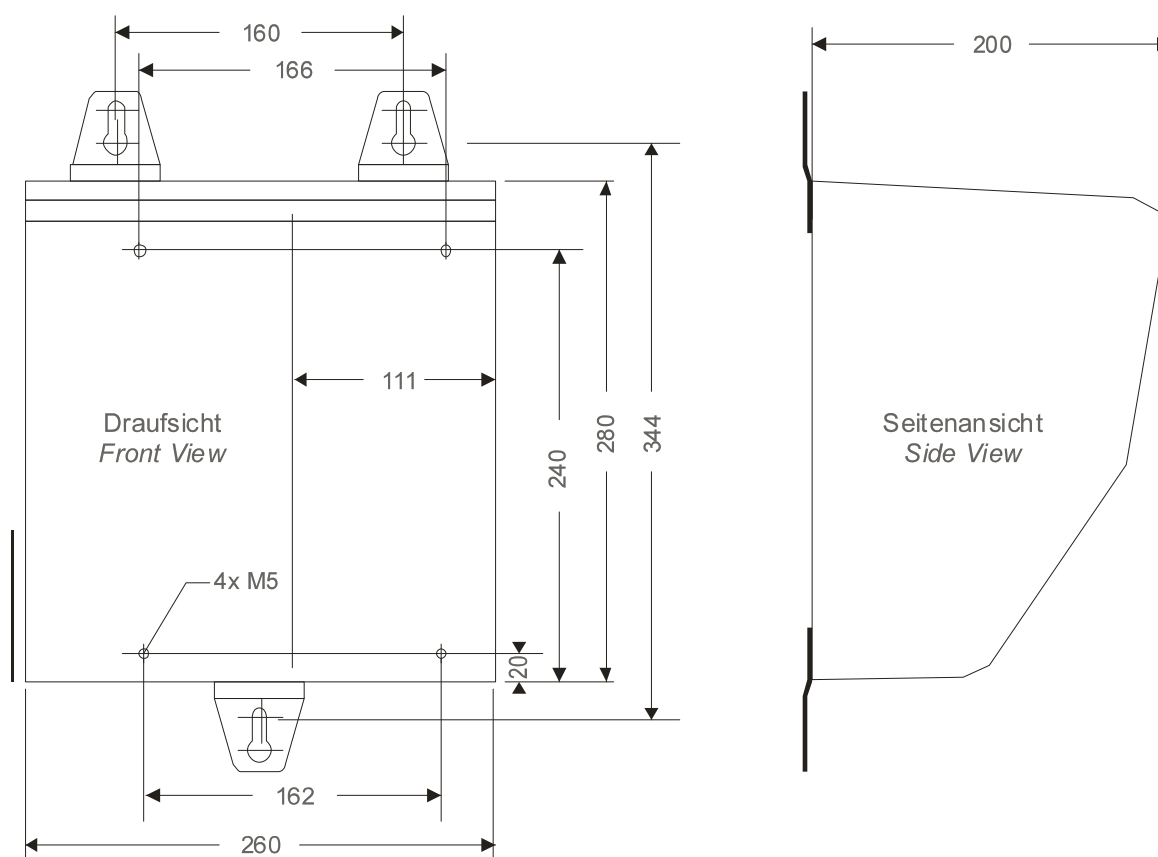


Fig. 31: Dimensional Drawing: Weather protection cover for D-SK AE

15 Purge unit

The purge air system protects the monitor from too much dirt build-up on the external optical surfaces and keeps the unit from overheating. In installations with certain stack pressure conditions, a boiler shutdown, failure of the blower fan, or system start-up may allow dirt to contaminate the unit if there is no purge air present.

When selecting the mounting location, the following conditions must be met:

- The air used should be as dry and dust-free as possible.
- The air temperature should not exceed 40°C.
- There must be enough room to allow for changing the filters (see page 46 Fig. 19)
- If the purge air unit will be mounted outdoors, a protective weather hood (Type D-WSH 290 GN) is available.

Warning ! Observe the following when doing any electrical installation:

- All work should be conducted with the power disconnected.
- The power supply voltage and frequency should match the designation on the labels.
- Connection and bridges should be done as specified on the terminal lid cover.
- Connect the ground to the PE terminal.
- Motor current protection (not included in delivery) should be mounted on the voltage side.
- Check the direction of the fan motor rotation.

WARNING

The purge air system must be turned on at all times when the D-R 290 is mounted at the measuring location. This applies even when the D-R 290 itself has been turned off. Make sure the purge air unit electrical systems are secured separately from those of the D-R 290 itself.

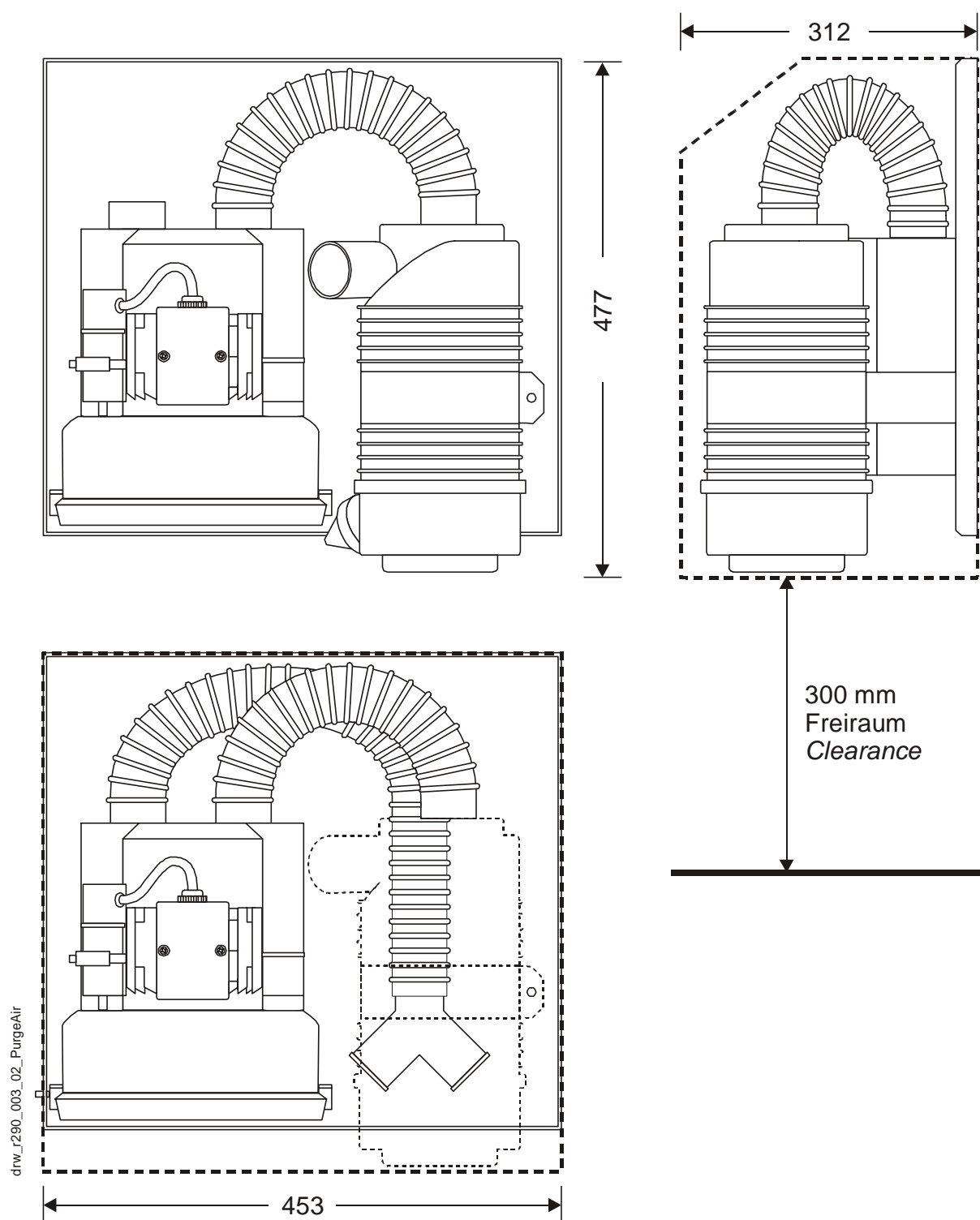


Fig. 32: Dimensional Drawing: Purge air unit

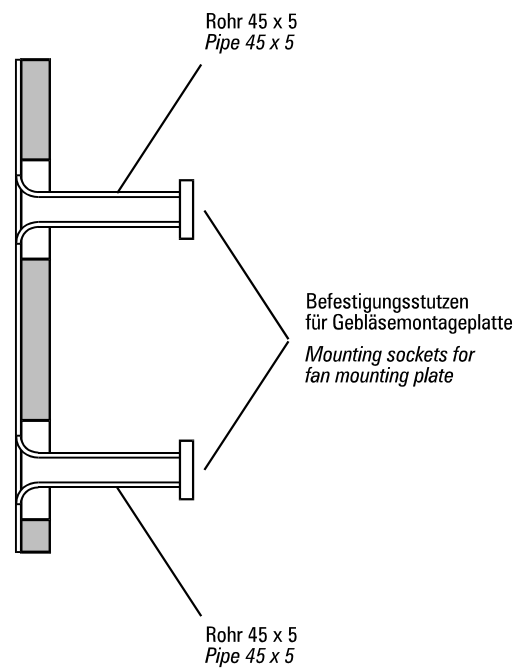
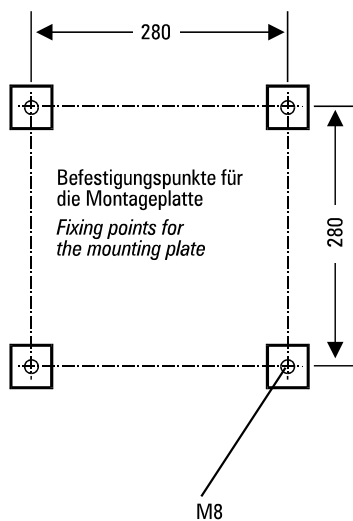
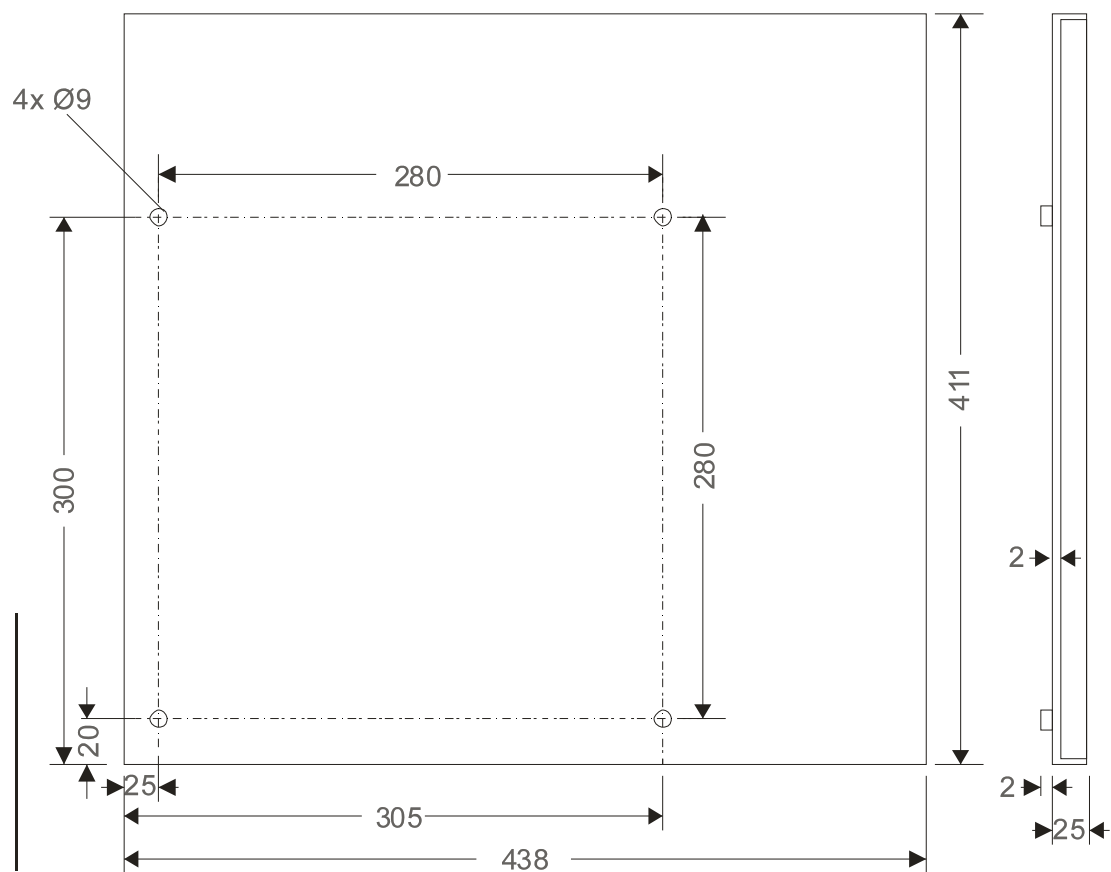


Fig. 33: Dimensional Drawing: Mounting points for the purge air blower7

15.1 Electrical Connection for the Purge Air Motor (Type ESAM)

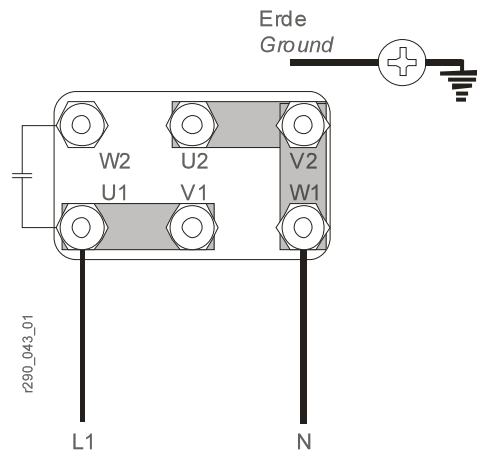


Fig. 34: Electrical connection to the Universal-purge air motor (Type ESAM) at 115V

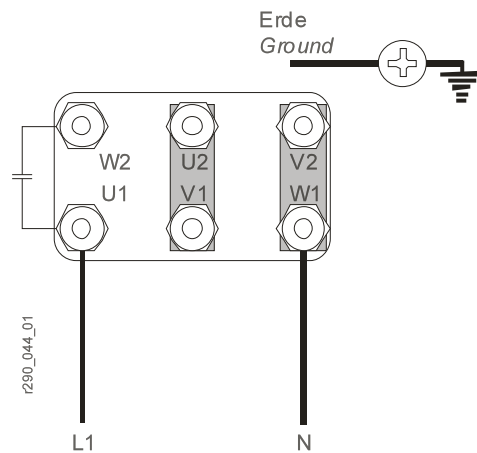


Fig. 35: Electrical connection to the Universal-purge air motor (Type ESAM) at 230V

15.2 Electrical Connection for the Purge Air Motor (Type nash_elmo)

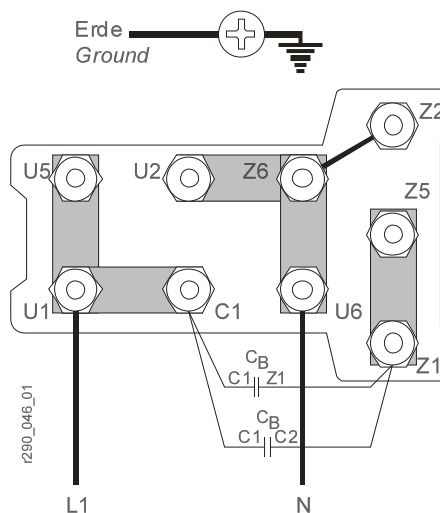


Fig. 36: Electrical connection to the Universal-purge air motor (Type nash_elmo) at 115V

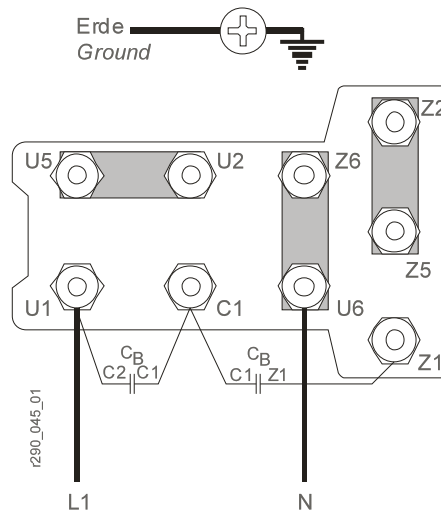


Fig. 37: Electrical connection to the Universal-purge air motor (Type nash_elmo) at 230V

16 D-SK 290 Fail-safe Shutters

If the D-R 290 monitor is intended for use on an exhaust duct or smokestack, in which a high stack-pressure is present, a failure of the purge air system can lead to serious damage or destruction of the monitor. To protect the system in such an event, D-SK 290 fail-safe shutters can be installed. The shutter system consists primarily of a motor-driven quick close shutter D-SK 290 MA and the D-SK AE control electronics with the air flow sensor F3.

The D-R 290 AV opacity monitor is designed optically and mechanically to permit mounting of a D-SK 290 fail-safe shutter between the welded pipe and the optic and reflector heads. Through the installation of the D-SK 290 fail-safe shutter it is possible in the case of malfunction (failure of power supply or purge air) to mechanically block the opening between the monitor heads and the exhaust gas. This feature will securely protect the opacity monitor in the event of a power supply or purge air failure until the problem is resolved.

Due to possible overheating, however, the D-R 290 must never be left on the stack without purge air for extended time periods.

16.1 Function

After turning on the power supply and detecting purge air, the fail-safe shutter will automatically move to the "OPEN" position.

If the power supply or the purge air supply fails, the shutter will close. For such an event, the D-SK AE electronics have several maintenance-free batteries to insure that an adequate power supply is available at all times. After the problem has been corrected, the shutter will automatically open again. The shutter "open" signal is at terminals 7 and 8 (closed connection).

The battery charge will be indicated on the red "*battery charging LED*" on the front panel. The LED will remain lit by rapid charging and will blink during normal charging. The light diodes ▼▲ show only the triggering, not the shutter position. The feedback of the shutter position is given by cam switch in the driver.

The fail-safe shutter can also be closed manually with the push button found on the front panel of the controller.

A functional check of the protection system D-SK 290 can also be done by the status input "Close shutter" (terminal 16 and 17). If the connection between the terminal 16 and 17 is opened, the shutoff shutter moves automatically to the position "CLOSED". The shutter "CLOSED" signal is given at the terminals 7 and 9 (closed connection).

The check of the proper functioning can also be done automatically.

1. By an emission calculator that is connected to the control system (for instance DURAG D-MS 285 or D-MS 500). By the status contact of the control device for the reporting of the controls.
2. By the control system D-R 290 (see chapter 9.5 Function Test D-SK 290 with D-R 290 AW2 or 9.6 Function Test D-SK 290 with D-R 290 AZ2)

16.2 Installation

A D-SK 290 fail-safe shutter system needs to be mounted on both the measuring head and the reflector flanges, each with its own D-SK AE control electronics.

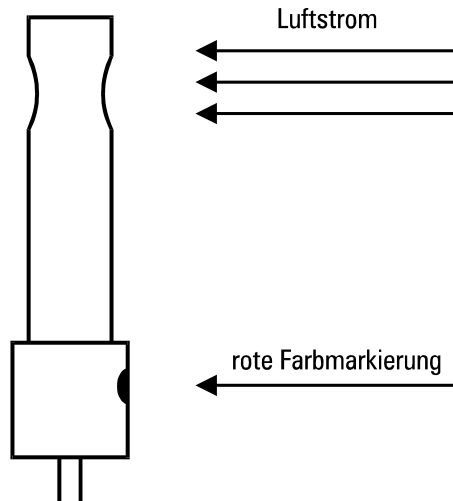
Open the status input relay between terminals 16 and 17 to close the shutter.

The D-SK AE control electronics are connected to the fail-safe shutter with a six-wire cable.

This connection should be made only after the monitor has been mounted.

In addition, an airflow sensor (F3) is connected to the control electronics D-SK AE, which is installed on the purge airflow of the control device and records the failure of the purge air.

The 6-pin cable connection (delivery length 2 meters) to the fail-fast shutter and the connection to the airflow sensor can be extended to 50 meters without any problems (airflow sensor 3-lined with a total shield).



The air current sensor should be mounted on the system after removing the cover (PG 7). The sensor should be positioned at the monitor opening such that the air current flows directly through the hole in the sensor. The red mark is meant to aid in mounting and should face away from the monitor in the direction of the air current.

Fig. 38: Airflow Sensor

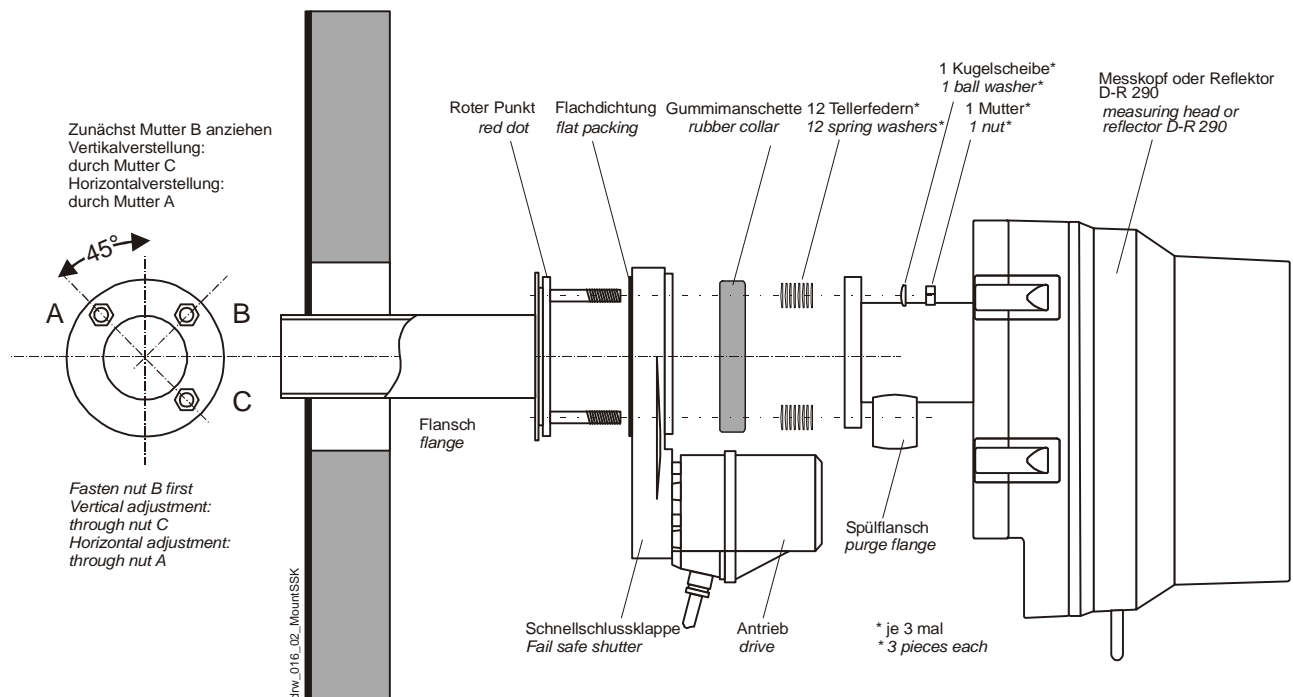


Fig. 39: D-SK 290 Mounting

Warning!

Do not insert fingers into the fail-safe shutter system. Serious injury may result! Disconnect the unit by opening the connection at terminals 16 and 17 before conducting maintenance work on the D-SK AE.

16.3 Electrical Connection D-SK AE

The electrical connection to the fail-safe shutter uses a 20-pin terminal strip in the connection box of the D-SK AE as shown in the diagram below:

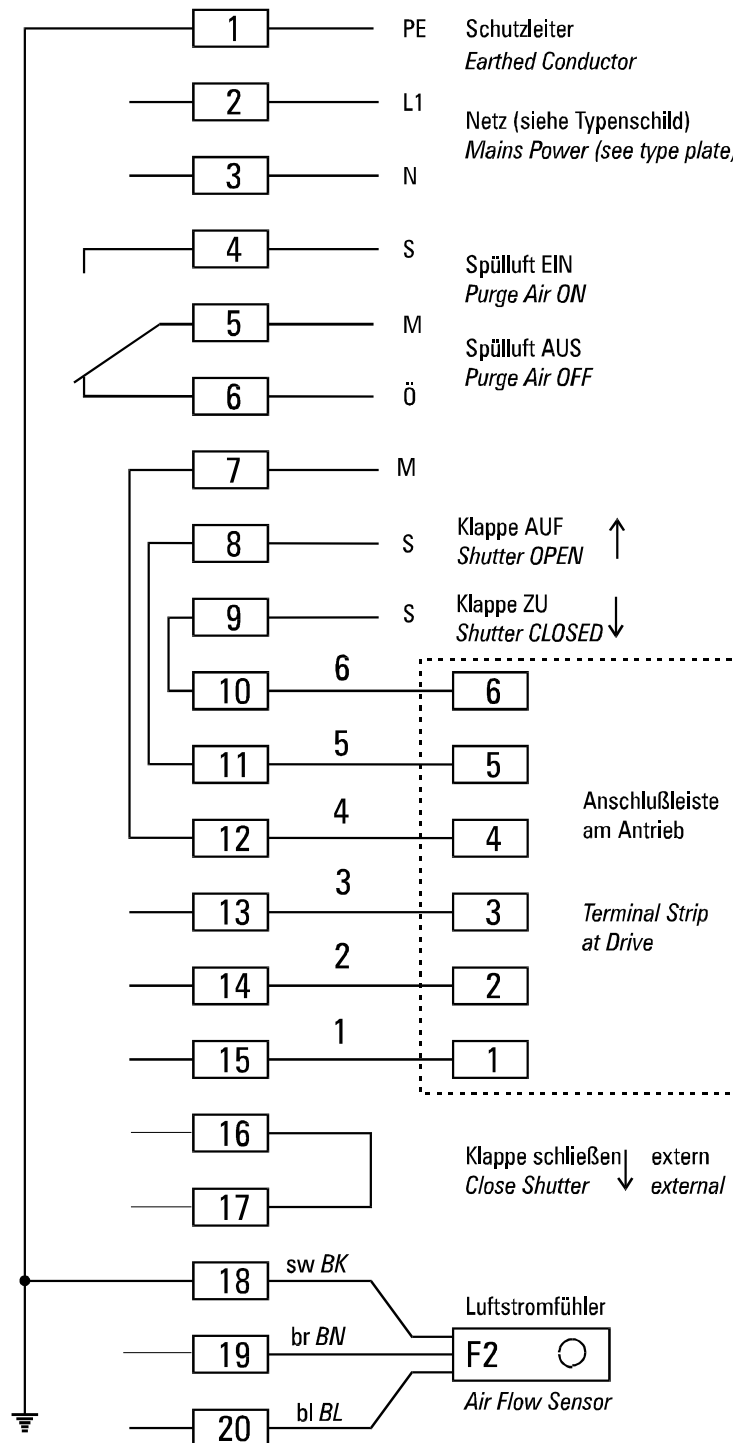


Fig. 40: Electrical Connection for the D-SK AE

The connection terminals are located in the housing in a separate part (cover in the lower housing part). 5 cable glands are available for the connection of the lines. The cable glands M20 are suitable for cable diameters between 7 mm and 13 mm. The cable glands M16 can be used for cable diameters between 4.5 mm and 10 mm.

Cables for the power supply, status signals, recorder outputs, relay contacts, and data transmission should be laid separately. The mains supply line has to be carried out in 3x1.5 mm². The wire and sheath material has to be adapted to the conditions at the particular installation location. For the fuse protection of the mains supply line a 16A automatic circuit breaker has to be installed near the measuring system. The single conductors of the mains line have to be secured to each other that they can't reach other clamps if one single conductor goes lose (e.g. binder).

16.4 Start-up

Before starting the system, the D-SK AE controller should be connected to the D-SK 290 fail-safe shutters with a six-wire cable. Then close the status input relay between terminals 16 and 17 at status input "*close shutter*".

When starting the system, the battery charge level should be checked. The battery charge will be indicated on the red "*battery charging LED*" (L5) on the front panel. The LED will remain lit by rapid charging and will blink during trickle charge (indicating that the batteries are charged). When the batteries are strongly depleted, a slow normal charging will occur first (with the LED blinking). When the batteries have reached a minimal charge level, the rapid charging procedure will begin.

If it is necessary, the batteries have to be charges before the first commissioning. In order to do so, the control electronics D-SK AE has to be connected to the power supply separately and without any fail-fast shutter.

The housing has to be opened to set the switching points and the hysteresis. The turning bolt lock on the right side of the housing has to be turned with a screwdriver (turn it to the left). Then the mounting frame that can be moved to the left will be opened with the hood for a clear view. The set-up elements can now be accessed. The potentiometer (P1) "*Airflow*" and the potentiometer (P2) "*Hysteresis*" are set to the minimum (turn the potentiometer to the right).

After main power is switched on, the unit is ready for operation. Both the yellow LED "*Stand-by*" (L1) and the red LED "*Shutter closed*" (L4) light up.

While running the purge air unit, turn the potentiometer (P1) "*Air flow*" slowly towards maximum, until the green LED (L2) "*Air flow*" lights up; then slowly turn the potentiometer ½ turn past this point (turn the potentiometer to the left). The green LED (L3) "*Shutter open*" should light up and the shutter will open automatically.

With the potentiometer (P2) "*Hysteresis*", set the hysteresis switch so that erratic switch behaviour is avoided, but without the hysteresis switch losing too much sensitivity to the air flow signals.

After the commissioning set-ups, the housing will be closed. In order to do so, the turning bolt lock on the right side of the housing has to be turned with a screwdriver (turn it to the right).

A check of the functioning of the operational fail-fast shutter can be done by a temporary shut off of the purge air supply or by a disconnection of the purge air hose.

A delay for the closing of the shutter will follow, since the airflow sensor detects the lack of the purge air only after a time constant.

If the commissioning has been carried out properly, the function of the shutter however has not been given, the installed motor power protection switch could have been triggered. To activate the motor protection switch, remove the cover of the motor after removing the two Allen screws and press the motor power protection switch back to its place.

16.5 Control Electronics D-SK AE

The control electronics D-SK AE has been placed in a compact aluminium housing with a hood for a clear view.

Colour Hue: Traffic blue RAL 5017

The front plate has been protected by a transparent cover that can be moved to the left.

The housing is water-tight and has the protection type IP 65.

Diameter of the fastening drillings 6,5 mm.

Hole distance 162 (top) / 166 (bottom) x 220 mm.

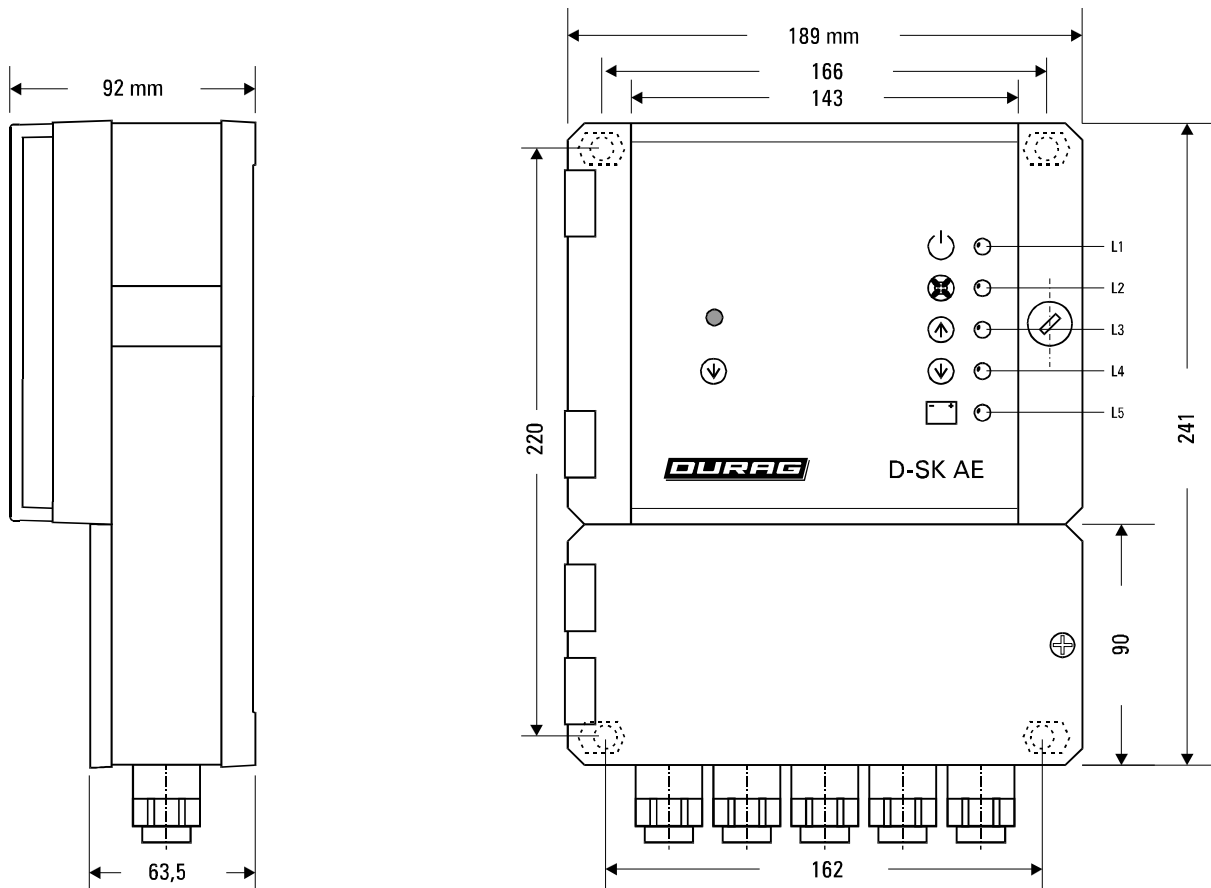


Fig. 41: Dimensional Diagram: Control electronics D-SK AE

⊗	L1	yellow	"Stand by"
⊗	L2	green	"Purge air present"
⊗	L3	green	"Shutter open"
⊗	L4	red	"Schutter closed"
⊗	L5	red	"Charge state of the batteries"

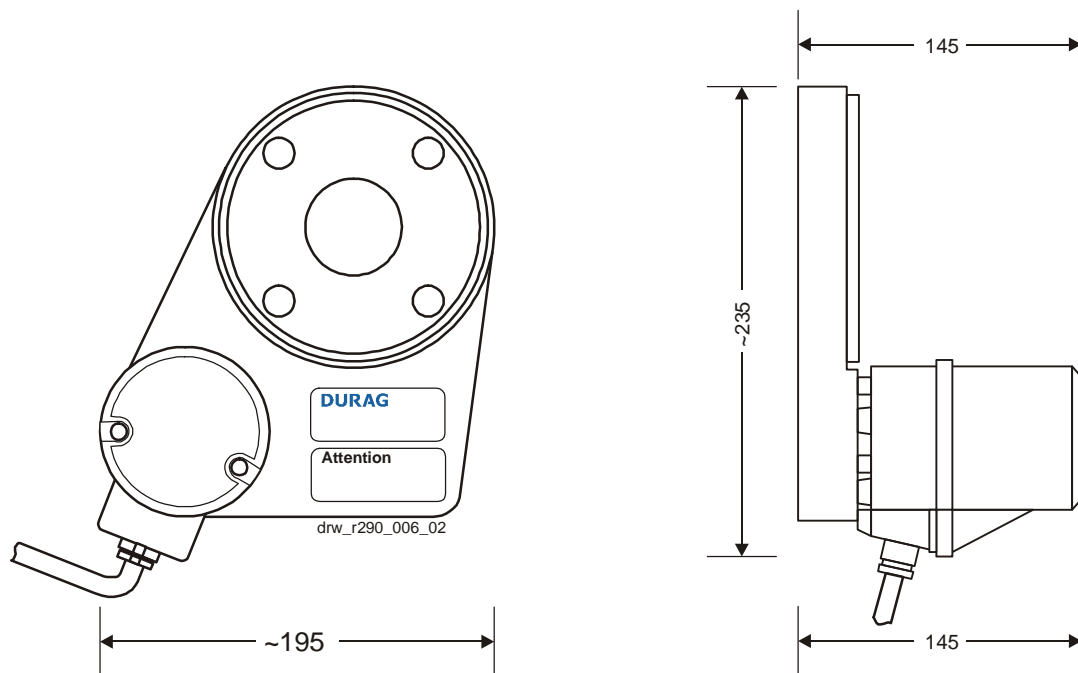


Fig. 42: Dimensional Diagram: Fail-safe shutter D-SK 290 MA

16.6 Fail-safe Shutter Maintenance

The fail-safe shutters should be tested and undergo routine maintenance on the same schedule as the opacity monitor itself.

For safety reasons, the connection (status input "Close shutter") between the terminals 16 and 17 has to be opened for the duration of the maintenance procedures. The fail-safe shutter moves automatically to "CLOSED".

Any sediments on the shutter system should be removed. A brush or cloth with cleaning solvent that dries without residue (e.g. dishwashing liquid) can be used to remove contamination. Never use a cleaning solvent that degrades aluminium.

The fail-safe shutter can also be closed manually with the push button found on the front panel of the D-SK AE controller.

Warning!

Do not insert fingers into the fail-safe shutter system. Serious injury may result! Disconnect the unit by opening the connection at terminals 16 and 17 before conducting maintenance work on the D-SK AE.

17 Technical Specifications

17.1 Technical Specifications: D-R 290

Measuring range for a one meter long measuring path:	0-200 mg/m ³ to 0-4000mg/m ³ calibrated to VDI 2066
Light source:	Super Wide Band Diode (SWBD)
Physical measuring range	
Extinction:	0..1,6 ±2% full-scale
Opacity:	0..99,9% ±2% full-scale
Measuring range adjustable	
Extinction:	between 0..0,1 and 0..1,6 free selectable
Opacity:	between 0..20% and 0..100% free selectable
	Measuring ranges can be switched
Resolution	
Extinction:	0,001
Opacity:	0,1%
Measurement path length:	1..12m
Admissible ambient temperature:	-20°C..+50°C
Admissible humidity:	≤ 95% relative humidity
Stack gas temperature:	above the dew point
Enclosure rating:	IP 65
Weight	
Measuring head:	approx. 10 kg
Reflector:	approx. 7 kg
Angle of projection:	approx. 2,8°
Angle of view:	approx. 3,9°
Max. permitted deviation from the optical axis:	±1°

17.2 Technical Specifications: D-R 290 AW2 Evaluation Unit

Output signal:	2 x 0..20mA, 4mA live zero
Maximal load:	500 Ohm
Relay outputs:	6 x Status, potential free (limit value, error, control cycle, etc.)
Maximal switch capacity:	48 V, 0.5 A
Inputs:	6x Status (Data entry enable, purge air error, 2x switch measurement range, control cycle)
Output signal integration time:	5..1800 seconds each output independently adjustable in 1 s - increments
Intersystem data communication:	RS-422 interface *
Admissible ambient temperature:	-20°C..+50°C
Enclosure rating:	IP 20 stand alone as 19" plug-in unit IP 20 in Rack mount housing D-R 290 BT2 IP 65 in Wall mount housing D-R 290 AG2
Electrical data:	
Power supply:	95..264 V, 48..62 Hz
Power consumption:	approx. 30 W

17.3 Technical Specifications: D-R 290 AZ2 Display Unit

Output signal:	2 x 0..20mA, 4mA live zero
Maximal load:	500 Ohm
Relay outputs:	6 x Status, potential free (error, control cycle, etc.)
Maximal switch capacity:	48 V, 0.5 A
Inputs:	6x Status (purge air error D-SK, etc.)
Intersystem data communication:	RS-422 interface *
Admissible ambient temperature:	-20°C..+50°C
Enclosure rating:	IP 20 stand alone as 19" plug-in unit IP 20 in Rack mount housing D-R 290 BT2 IP 65 in Wall mount housing D-R 290 AG2

Electrical data:

Power supply:	95..264 V, 48..62 Hz
Power consumption:	approx. 30 W

17.4 Technical Specifications: D-R 290 PS Connection Box

Intersystem data communication:	RS-422 interface *
Admissible ambient temperature:	-20°C..+50°C
Enclosure rating:	IP 65

Electrical data:

Power supply:	95..264 V, 48..62 Hz
Power consumption:	approx. 30 W

* The distance between the display unit / connection box and the evaluation unit can not be more than 1000 meters. The wiring should be done with a twisted cable of a conductor diameter of 0,20 mm² (corresponding to AWG No. 24).

If the D-R 290 opacity monitor is operated only with the evaluation unit D-R 290 AW2, the maximum distance between the measuring head and the evaluation unit will be 12 meters.

17.5 Technical Specifications: D-R 290 GN Purge Air Unit

Supply voltage:	115 / 230 V, 50 / 60 Hz *
Power consumption:	0,4 kW, at 50 Hz 0,5 kW, at 60 Hz
Airflow rate at 0 mbar:	approx. 80/90 m ³ /h
Enclosure rating:	IP 55
Dimensions:	approx. 350mm x 550mm x 500mm
Weight:	approx. 12 kg

* Other voltages and frequencies available upon request.

** The purge air system includes 10 m of hose.

17.6 Technical Specifications: D-SK AE Control Electronics

Power supply:	115 / 230 V \pm 10%, 48..62 Hz
Fuse:	0,1 A, slow blow
Power consumption:	approx. 10 VA
Motor driver:	24 Volt DC
Enclosure rating:	IP 65
Weight:	approx. 3,5 kg
Admissible ambient temperature:	-20°C..+50°C

Contacts:

1 contact shutter "closed"
1 contact shutter "open"
1 contact switch "purge air" present / failure
All contacts potential-free, switching performance of maximum 250 Volt 100 VA for ohm charge

Display messages:

5 Display-LED's for the messages:
"Stand by"
"Purge air present"
"Shutter open"
"Shutter closed"
"Charge state of the batteries"

The LED charge state will remain lit by rapid charging and will blink during trickle charging.

Sensitivity:

Can be set; starting from approximately 5 m/s airflow speed. Switch hysteresis can be set.

17.7 Technical Specifications: D-SK 290 MA Mechanics

Motor driver:	24 V DC driver with built-in motor overload switch
Torque:	8 Nm
Running time OPEN/CLOSED:	approx. 2 seconds
Shutter:	Stainless steel 1.4571
Housing:	Aluminium
Enclosure rating:	IP 65
Weight:	approx. 4,5 kg
Admissible ambient temperature:	-20°C..+50°C

18 Standard Delivery: Bill of Materials

D-R 290 Standard model	Description	Part number	Qty
	D-R 290 Standard, Complete system	D-R 290	1
Consists of:			
1	Evaluation unit	D-R 290 AW2	1
2	Wall mount housing for the evaluation unit	D-R 290 AG2	1
3	Measuring head D-R 290	D-R 290 MK	1
4	Reflector D-R 290	D-R 290 RI / II	1
5	Purge air unit	D-R 290 GN	1
6	Welding flange	D-R 290 E	2

18.1 Optional Accessories

Optional Accessories	Description	Part number	Qty
1	Safety device (Fail safe shutter)	D-SK 290	1 Set
2	Measured value recorder		1
3	Weather protection hood for Measuring head	D-WSH 290 M	1
4	Weather protection hood for Reflector	D-WSH 290 R	1
5	Weather protection hood for evaluation unit	D-WSH 290 AW2	1
6	Weather protection hood for purge air unit	D-WSH 290 GN	1
7	Display unit	D-R 290 AZ2	1
8	Rack mount housing	D-R 290 BT2	1
9	Temperature compensation	D-R 290 TC	1
10	Temperature transmitter 0..200°C	D-R 290 TM-x200	1
11	Temperature transmitter 0..400°C	D-R 290 TM-x400	1

19 Spare parts

Art.- Code	Bezeichnung	Description
Montage		Mounting
BR290MONTAGET	Satz Einbauszubehör bestehend aus 96 Tellerfedern, 6 Kugelscheiben und 6 Sechskantmuttern	Set Mounting Accessories, consisting of 96 cone disk springs, 6 spherical washers and 6 self locking nuts
ndifeder20x10,2	Tellerfeder B20 DIN 2093	Cone Disk Spring B20 DIN 2093
nus10,5mmD6319	Kugelscheibe C10 DIN 6319	Spherical Washer C10 DIN 6319
nmuM10D985	Sechskantmutter M10 DIN 985	Self locking hex. Nut M10 DIN 985
ndibindstPG9	Bindverschraubung PG 9	blind screw PG 9
morgmschette216	Dichtungsmanschetten 20 x 120 x 3	rubber seal 20 x 120 x 3
Messkopf / Reflektor		Measuring Head / Reflector
BR290SBDIODE	Superbreitbanddiode	Super Wide Band Diode
BR290MKLP20	Zentralplatine	Main board
BR290MKLP30	Steckkarte Lichtschränke	PC board with light barrier
BR290MKLP10	Fotoelement mit Platine	Photo element with PCB
mdiheizsch42mm	Heizscheibe	Heated Disk
BR290NPR	Nullpunktreфлектор intern	Internal Zero Point Reflector
mdimotorPK243	Schrittmotor	Stepper Motor
BR290RE1	Reflektoreinsatz Typ I (1,0 - 2,25 m)	Reflector Insert Type I (1.0 - 2.25 m)
BR290RE2	Reflektoreinsatz Typ II (1,75-12,0 m)	Reflector Insert Type II (1.75-12.0 m)
Auswerte- / Anzeigeeinheit		Evaluation / Display Unit
BR290AWLP30	CPU Karte	CPU Board
BR290AWLP40	Relaiskarte	Relay Board
BR290AWLP20	Anzeige / Eingabe	Display / Data Entry
BR290AWLP10	Interne Rückwand	Internal Backplane
BR290AWLP60	Externe Rückwand (im Wandgehäuse)	External Backplane (in wall mount housing)
wdinetzMAP40	Netzteil	Power supply
psia02000t	Sicherung 2 A, pro 10 Stck.	Fuse 2 A, per 10 pcs.
Spüllufteinheit		Purge Air Unit
wdifilter7505	Filtergehäuse FPG05 7505	Filter Housing FPG05 7505
wdilfP77-5631	Filterpatrone P77-5308 für FPG05 7505	Filter Cartridge P77-5308 for FPG05 7505
wdiluftsch216	Luftschlauch für Gebläse, Durchmesser 40 mm, Preis per Meter	Air Hose for blower, diameter. 40 mm, price per meter
wdischelle216	Schlauchschele, Durchmesser 40 mm	Hose Band clip for air hose, (diameter 40 mm)
Zubehör		Accessories
wdisrolle35069	Rolle Registrierpapier für Linienschreiber	Roll register paper for line recorder

Federal Gazette



Issued Thursday, May 15th, 2003

Federal Environmental Agency

Announcement

on the Standard Federal Practice

for the Monitoring of Emissions

dated April 22nd, 2003

I.

Approved Measuring Devices

for Continuous Emission Measurement

With reference to number 3 of the guidelines for uniform practice in monitoring emissions - circular letter of the Federal Ministry for the Environment dated June 8th, 1998 - the suitability of the following measuring device is announced on behalf of the Environmental Ministry:

1 Particulate Emissions (Dust concentration)

1.1 D - R 290

Manufacturer:

DURAG Industrie Elektronik GmbH & Co KG, 22453 Hamburg

Suitability:

For 13th and 27th BImSchV (large furnaces and crematories) and TA Luft

Measuring ranges during the suitability test:

0-0.1 Extinction, approx. 0-16 mg/m³ at 2x5 m path length and

0-0.2 / 0-0.5 / 0-1.6 Extinction and 0-100 % Opacity

Limitation:

The measuring device can only be used when a drop below the dew point can be excluded.

Note:

The dust concentration is measured in wet waste gas under operating conditions.

Test report:

TUV Cologne / Berlin Brandenburg No 936 / 801017 / A dated Jan 31st, 2003

DURAG

EG-Konformitätserklärung *EC Declaration of Conformity*

Hersteller <i>Manufacturer</i>	DURAG Industrie-Elektronik GmbH & Co KG
Anschrift <i>Address</i>	Kollastr. 105, D22453 Hamburg
Produktbezeichnung <i>Product description</i>	Staubkonzentrations- und Opazitätsmessgerät D-R 290 <i>Dust Concentration and Opacity Monitor D-R 290</i>

Das bezeichnete Produkt stimmt mit den Vorschriften folgender Europäischer Richtlinie überein, vorausgesetzt, dass es installiert, gewartet und entsprechend seiner Bestimmung eingesetzt wird. Die einschlägigen Vorschriften und Hinweise aus der Bedienungsanleitung sind zu beachten.

The described product complies with the following provisions of Council Directive, provided that it is installed, maintained and used in applications for which it was made, in accordance with relevant installation standards and manufacturer's instructions.

Richtlinie des Rates 89/336/EWG (EMV), geändert durch 91/263/EWG, 92/31/EWG und 93/68/EWG
Council Directive 89/336/EEC (EMC), changed by 91/263/EEC, 92/31/EEC and 93/68/EEC

Wir bestätigen die Konformität des oben bezeichneten Produktes entsprechend den Normen:

We confirm the conformity of the above mentioned product according to the standards:

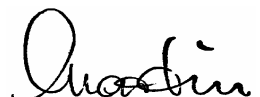
EN 61326-1 (1998)
EN 61 000-6-2 (1999)

EN 61 010-1 (2001)

Aussteller <i>Issuer</i>	DURAG Industrie Elektronik GmbH & Co KG
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Ort, Datum <i>Place, date</i>	Hamburg, 17.08.2001
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Rechtsverbindliche
Unterschrift
*Legally binding
Signature*


(Prof. Dr.-Ing. Martin)