Operating Instructions

for the

ISOTEC Pressure Transducer

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Fehler! Unbekanntes Schalterargument. **Preliminary notes**

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MANUFACTURER: Pressure transducer head: Healthdyne, Irvine, USA Connecting cable with plug adapter: HSE

Fehler! Unbekanntes Schalterargument. **Application**

The ISOTEC pressure transducer marketed by HSE is intended for use in experimental laboratories for pressure measurement in the range of arterial blood pressure (-50 to +300 mm Hg). It is not suitable for clinical use on humans.

Fehler! Unbekanntes Schalterargument. **Introduction**

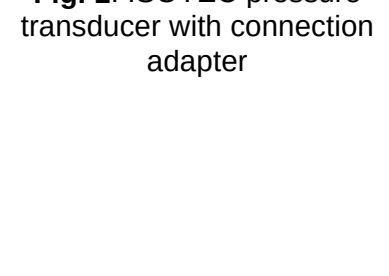

Fig. 1: ISOTEC pressure transducer with connection adapter

The ISOTEC pressure transducer serves for measuring arterial blood pressure. The pressure range is between -50 and 300 mm Hg. It is originally manufactured as a disposable item in the clinical field. The reason for being disposable is due not to technical reasons but for reasons of hygiene and safety. The construction of the transducer permits its use over long periods without failure provided no sterilisation is required. If the measuring head is used and maintained with due care it has really an unlimited life.

For use in the experimental apparatus for isolated organs it represents a low-priced and robust alternative to conventional pressure transducers. If the transducer should at any time become damaged, e.g. through overloading of the measuring system, then another price advantage comes into play: you replace the low-cost measuring head and continue to use to expensive connecting cable with adapter. You can make the replacement yourself without requiring any special calibration procedure. The measuring heads are manufacturer using an automatic laser calibration procedure and are adjusted accurately to the standard sensitivity for arterial blood pressure transducers (5 ìV/V/mmHg).

Compared with other disposable transducers available on the market the ISOTEC pressure transducer offers an important advantage: it is equipped with a clear dome which can readily be filled without air bubbles and can be checked in this respect. A further advantage of the ISOTEC transducer is that it incorporates a rigid measuring system. The volume displacement is very small, only 0.04 mm^3/100 mm Hg. This makes it possible to produce accurate traces of steep pressure signals even with thin catheters.

Fehler! Unbekanntes Schalterargument. **Unpacking, components, useful accessories**

Fehler! Unbekanntes Schalterargument..Fehler! Unbekanntes Schalterargument. **Unpacking**

Open the packing carefully and make sure that nothing drops to the floor, especially not the transducer head; this could break off one of the thin connecting tubes. Check the parts actually received against the details on the delivery note. If anything is missing, search first through the packing material before you complain to the supplier. Small parts can easily be overlooked in the voluminous packing material.

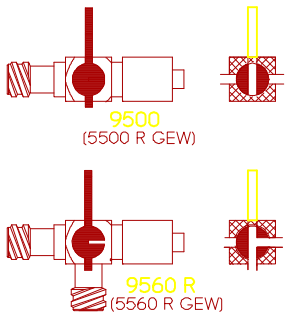

Fig. 2: Recommended metal stopcock, on the right the bores of the stopcock plug

Fehler! Unbekanntes Schalterargument..Fehler! Unbekanntes Schalterargument. **Components of the pressure transducer and useful accessories**

The complete ISOTEC pressure transducer consists of the transducer head with dome, and the connecting cable with the adapter and a plug suitable for the electromanometer or bridge amplifier which you are using.

The connecting components supplied by the transducer manufacturer (plastic 3-way and shut-off stopcocks) are not very strong and cannot be re-used many times. Metal stopcocks are better for continuous use. We recommend metal stopcocks with locking thread (Fig. 2, Shut-off stopcock 9500 and 3-way stopcock 9560 R).

WARNING, important note: use only stopcocks with locking thread at the female Luer connection! (Fig. 2). Stopcocks with sharp-edged locking flanges are unsuitable. When tightening the locking device the sharp edges immediately damage the plastic nut on the dome which can not be replaced.

Fig. 3: Stand with mounted ISOTEC pressure transducer

For correct pressure measurement it is necessary that the pressure transducer is always mounted at a clearly defined position. For this reason all apparatus produced by HSE are provided with suitable holders. When the pressure transducer is supplied together with the apparatus the holder is already mounted in the position suitable for the transducer ordered. If no transducer is supplied with the equipment these holders are intended for an ISOTEC pressure transducer unless otherwise specified in the order.

When using the ISOTEC pressure transducer separate from an apparatus it is recommended to use the stand as shown in Fig. 3. A vertical rod is screwed into a stable triangular cast iron foot and a spherical joint with height adjustment is mounted on the rod. The moving part of the spherical joint carries suitable clamps for the ISOTEC transducer. A pressure transducer mounted in this way can be tilted in all directions and is located in a defined and stable position after all clamping screws

have been tightened.

Fehler! Unbekanntes Schalterargument..Fehler! Unbekanntes Schalterargument. **Fitting the measuring head on the connecting cable**

N O T E: place the measuring head carefully on the plug adapter; do not bend the contact pins!

The ISOTEC transducer is normally supplied already mounted in position and ready for use. The measuring head is fitted on the adapter with cable and a plug suitable for your electromanometer or bridge amplifier. If in your particular case the head has not yet been fitted you can readily do this yourself.

In addition to the ISOTEC measuring head you require a connecting cable with adapter and a countersunk screw M3x10 (DIN 965) as well as a suitable Phillips head screwdriver Size 1.

Before you place the measuring head on the adapter, check the four thin gold-plated pin contacts inside the measuring head case. These must not be bent and must project inwards straight and parallel to the inner wall. If this is not the case, you should carefully try to straighten the bent contact pins, using strong forceps for example. If you are unable to do this, or if a pin breaks off during this operation, then the measuring head is damaged and can no longer be used. The necessary 4-pole electrical connection to this measuring head is then no longer possible. You can discard the measuring head and have to purchase a new one.

After you have fitted the measuring head successfully to the adapter you must carefully screw in the security screw (countersunk screw M3x10) into the angular opening at the side of the measuring head case which secures the head against slipping out.
WARNING: do not fit the screw at an angle as this damages the thread!

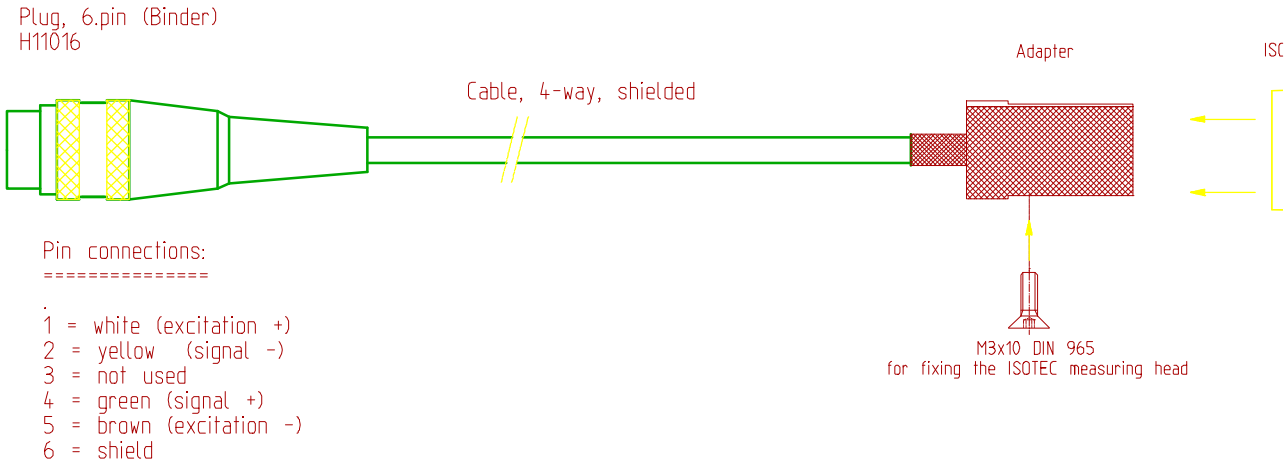

Fig. 4: Fitting the ISOTEC measuring head to the adapter of the connecting cable.

N O T E: the original ISOTEC cable supplied previously (no longer available) does not have the security screw. The adapters of those cables were fitted with a locking clip.

Fehler! Unbekanntes Schalterargument. **Application**

Fehler! Unbekanntes Schalterargument..Fehler! Unbekanntes Schalterargument. **Connection and filling without air bubbles**

The **electrical** connection is made through the connecting cable using a plug suitable for your amplifier. If you do not use an HSE bridge amplifier, check that the bridge supply voltage is within the permitted range (5 - 10 Volt, d.c. or a.c. up to about 5 kHz).

The **connection of the dome** is made via two small stopcocks through catheter tubing **(Fig. 5)**. You are strongly advised to use the metal stopcocks recommended **(Fig. 2)**. Metal stopcocks with sharp-edged locking flanges must on no account be used as they are completely unsuitable. When tightening up the locking device the sharp edges immediately damage the thread of the plastic nut on the dome which can not be replaced.

If you connect up the dome as shown in Fig. 5, the side connection of the 3-way stopcock is free and available for washing. Both the dome and the catheter can when necessary be washed through using a syringe placed at this point.

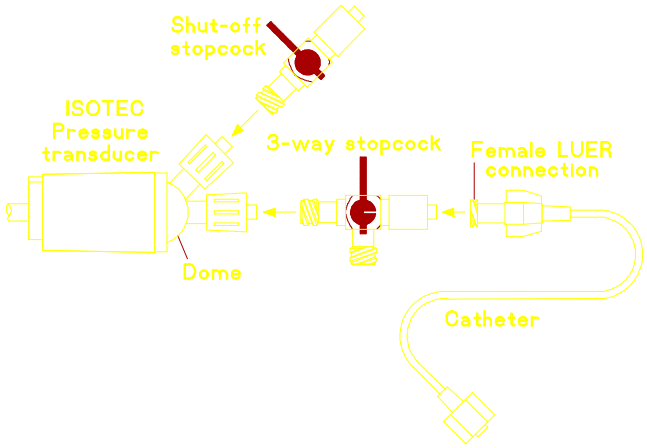

Fig. 5: Connection to the dome

WARNING: before washing the dome with a syringe the **shut-off** stopcock at the other dome connection must be **opened!**

Polyethylene tubing (PE) is suitable for use as catheter tubing. The selection of the correct tubing material and its dimensions are particularly important when recording **"fast"** pressure signals. For undistorted transmission from the pressure source to the dome you should use a catheter which is as short and as stiff as possible. Polyethylene catheters (1 mm i.d., 2 mm o.d.) are suitable.

The catheter should be secured in position and should not be left hanging or resting on the bench so that it can move freely. In case of rythmic signals (arterial blood pressure) the catheter or parts of it may start to oscillate, causing distortion in the pressure trace. The catheter must also be protected against shock and vibrations. These, or any movement of the catheter, lead to disturbing artifacts in the measured pressure trace.

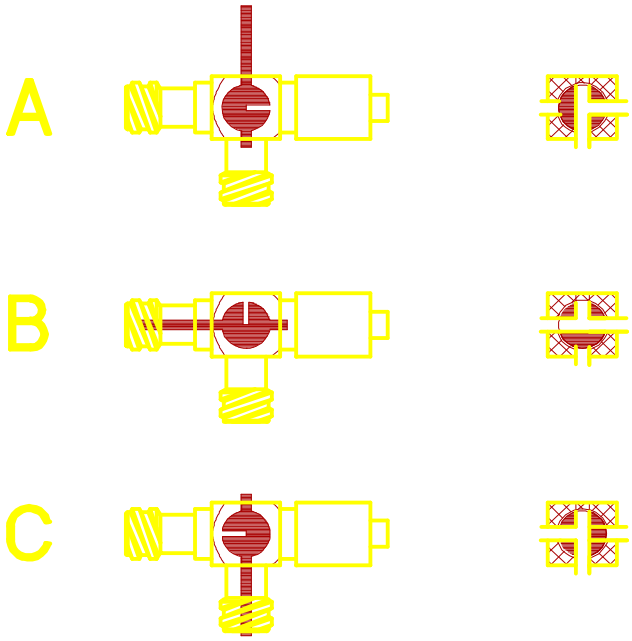

Fig. 6: Plug positions of the 3-way stopcock and the bores in the stopcock plug

Important for an exact reproduction of **"fast"** pressure signals is not only the correct choice of the connecting parts (see above) but also that the entire transmission system is fitted free from air bubbles. A critical point is the invisible **"dead"** bore inside the stopcock plugs (see Fig. 6). Even with optimum choice of catheter, a minute air bubble which may e.g. be hidden and invisible in the plug of the 3-way cock, can make it impossible to evaluate steep pressure rises. The pressure trace is generally rounded and sudden pressure changes produce oscillations in the pressure trace.

There are different ways of filling the entire system so that it is free from air bubbles. When the pressure transducer is used in an experimental setup it is generally filled with perfusion solution. In this case it is possible to use the solution under pressure directly for filling by suitably setting the two stopcocks. Where this is not possible, filling takes place using a syringe placed against the side arm of the 3-way stopcock.

N O T E: when using the perfusion solution for filling you should remember that this solution is a good substrate for the growth of algae, especially when the apparatus is located in bright light. The perfusion solution should be washed out with distilled water not later than the end of the experiment. If you do not take this precaution you will sooner or later find dark deposits in the dome which can no longer be removed by washing.

Observe the filling sequence suggested below. By proceeding as indicated you will ensure that the **"dead"** bores of the 3-way stopcock plug are also free from air bubbles.

Filling the system using perfusate under pressure:

- Remove the ISOTEC from the holder and hold it in the hand; the free branch of the 3-way stopcock should point upwards.
- Set the 3-way stopcock so that the catheter is filled with perfusate (Fig. 6 A) which escapes at the side arm of the 3-way stopcock.
- Set the 3-way stopcock so that the catheter is connected to the dome (Fig. 6 B).
- Rotate the pressure transducer so that the side arm of the dome with the shut-off cock points vertically upwards.
- Open the shut-off cock. The dome should now fill from the bottom upwards without air bubbles being trapped.
- Close the shut-off cock when all bubbles have been washed out. If small bubbles remain attached inside the dome you should continue washing while at the same time tapping the transducer. Do not use a very hard object (pencil, ball pen, handle of small screwdriver or similar). Do not make any scratches on the dome!

Filling the system with a syringe:

WARNING: avoid excess pressure when filling the dome with the syringe! **Open the shut-off stopcock before operating the syringe!**

You require a filled syringe with Luer taper. Syringe size: 10 to 20 ml. Check that the syringe is compatible with this liquid.

For filling it is necessary that the catheter tubing connected to the 3-way stopcock is open at the other end and that any liquid escaping here can flow out freely without producing any appreciable back-pressure.

- Remove the ISOTEC from its holder and hold it in the hand.
- Open the shut-off stopcock!
- Place the filled syringe on the open side arm of the 3-way stopcock and set the stopcock so that the syringe is connected to the catheter (Fig. 6 A).
- Slowly fill stopcock and catheter with the syringe.
- **IMPORTANT:** check before the next step that the shut-off cock is open!
- Rotate the pressure transducer so that the side arm of the dome with the shut-off cock points vertically upwards.
- Turn the 3-way stopcock so that the dome can be filled with the syringe (Fig. 6 C).
- Now slowly fill the dome.
- Close the shut-off stopcock only when all bubbles have been washed out. If any bubbles remain attached inside the dome you should continue washing while at the same time tapping the transducer. Do not use a very hard object (pencil, ball pen, handle of small screwdriver or similar). Do not make any scratches on the dome!
- Set the 3-way stopcock to the measurement position (Fig. 6 B).

Fehler! Unbekanntes Schalterargument..Fehler! Unbekanntes Schalterargument. **Zero adjustment**

Zero adjustment (on the bridge amplifier used) corrects inaccuracies in the transducer system when the pressure equals zero. Measurement errors caused by unsuitably positioned pressure transducers should not be corrected by zero adjustment. You should therefore ensure that the pressure transducer is always mounted at the correct height. The measurement point and the pressure transducer should be at the same level. A low transducer position increases the measurement, a high position reduces it.

The zero should be adjusted before each measurement and should where appropriate be repeated during longer measurements.

Move the 3-way stopcock so that the dome is connected with the open branch of the 3-way stopcock (Fig. 6 C). This ensures pressure equilibration with the surrounding atmosphere. There is no load on the measurement diaphragm. Now check the pressure indication on your measuring instrument or recorder and readjust the appropriate control (null, zero, zero adjustment, bridge balance, etc.) if required. Note the information in the Operating Instructions for the instrument.

This completes the zero adjustment. Return the 3-way stopcock to its previous position (Fig. 6 B).

Note that the pressure transducer must be in the measurement position during zero adjustment.

Fehler! Unbekanntes Schalterargument..Fehler! Unbekanntes Schalterargument. **Calibration**

ISOTEC pressure transducers are factory calibrated during manufacture according to the details in the technical data. During calibration in use the sensitivity of the entire measurement system (pressure transducer, bridge amplifier, pressure indicator, recorder) is adjusted. This is essential in order to produce accurate results which can be evaluated. Calibration is also important to identify possible instrument faults.

For calibration you require a pressure standard with an adjustment range from 0 to about 100 - 300 mm Hg. Particularly suitable instruments available from HSE are the well-established calibration units KAL 84 H (0 - 199.9 mm Hg), KAL 84 SH (0 - 300.0 mm Hg) or the Gauer pressure calibrator Type 367 (0 - 300 mm Hg and 0 - 30 cm H_20).

For calibration the calibration pressure generated by the calibrator is applied to the pressure transducer instead of the measured pressure. The pressure output of the calibrator is connected to the free end of the shut-off stopcock. First carry out a zero adjustment and then apply a defined pressure, e.g. 100 mm Hg. Then check the resulting deflection on the pressure indication or on the recorder, and where necessary make the appropriate corrections in the gain. Proceed as described in the instrument operating instructions.

After calibration has been completed, check that the transmission system is still free from air bubbles. If there is any doubt, wash the system through again in order to remove any air which may have entered the system.

Fehler! Unbekanntes Schalterargument..Fehler! Unbekanntes Schalterargument. **Care and maintenance**

Since the dome of the ISOTEC pressure transducer is permanently connected to the measuring head and cannot be replaced it is necessary to pay special attention to its care.

- Wash dome and stopcocks regularly with distilled water after each experiment.
- Any blood which has entered the dome must be washed out immediately if at all possible. Do not wait until it has deposited on the walls. If required use a mild detergent for washing or a solution with a laboratory cleaner, e.g. RBS 35 or MUCASOL.
- External dirt on the pressure transducer and on the connecting cable should be wiped off e.g. with a cloth moistened with cleaning solution (see above), a gauze pack or similar.
- Ensure that no liquid finds its way into the transducer case.
- The transparent dome should not be rubbed dry as this would cause scratches.
- **IMPORTANT:** never immerse the pressure transducer in a liquid!

Fehler! Unbekanntes Schalterargument. **Technical details**

Fehler! Unbekanntes Schalterargument..Fehler! Unbekanntes Schalterargument. **Construction and operation of the measuring head**

The ISOTEC transducer has a piezo-resistive sensor system. This is based on an etched silicon diaphragm in which a Wheatstone bridge circuit has been formed by diffusion. The silicon chip also carries various resistors required for correcting the linearity and the temperature drift. The sensor is calibrated by a laser during manufacture to conform to the specified data.

The actual sensor is located underneath the white surface in the dome. The electrical connections take the form of thin pins which project downwards into the inside of the transducer. The electrical insulation between sensor diaphragm and liquid in the dome is ensured by a highly insulating thin plastic foil. The space between plastic foil and sensor diaphragm is filled with Silicone paste. This ensures delay-free pressure transfer to the diaphragm, resulting in the good dynamic characteristics of the transducer.

Fehler! Unbekanntes Schalterargument..Fehler! Unbekanntes Schalterargument. **Frequency response**

Fig. 7 shows the frequency response of the ISOTEC pressure transducer. The measurements were made with a polyethylene tubing catheter, internal dia. 0.9 mm, external dia. 2 mm, length 60 cm. The stopcocks used are as shown in Fig. 5. Special care was taken during the measurement to avoid any bubbles remaining in the system. The graph shows that frequencies in the pressure signal between 0 and about 10 Hz are evaluated without any large amplitude errors. The graph then rises sharply, reaches a peak at 23 Hz, and falls off rapidly. Frequency components above 50 Hz are effectively lost.

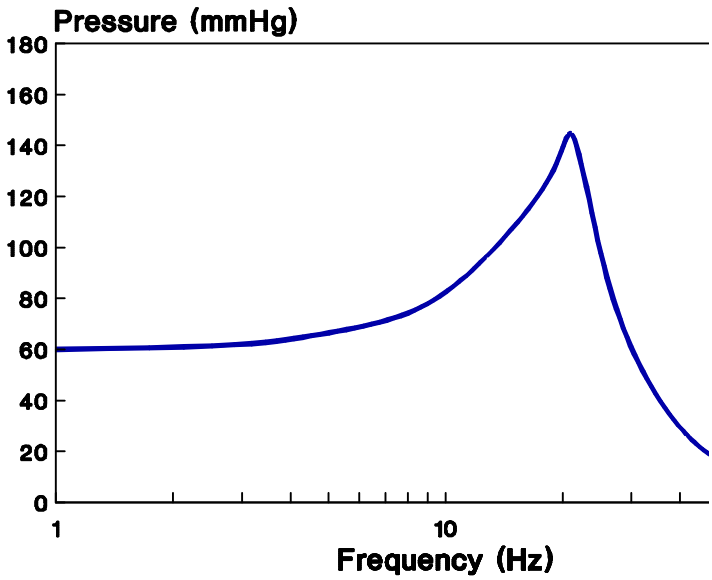

Fig. 7: Frequency response of the ISOTEC pressure transducer with tubing catheter.

Fehler! Unbekanntes Schalterargument..Fehler! Unbekanntes Schalterargument. **Electrical connection**

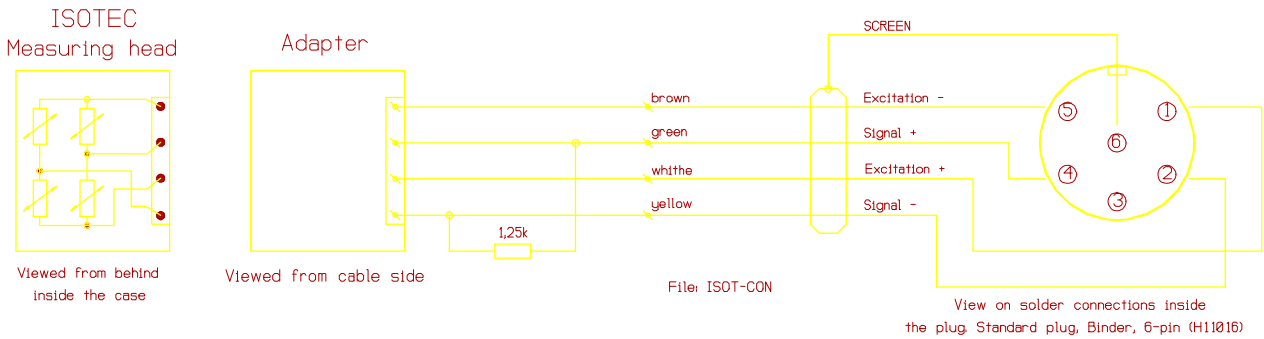

Fig. 8: Electrical connection of the ISOTEC pressure transducer. A different plug can be fitted to special order.

Fig. 8 shows the connection diagram of the ISOTEC pressure transducer. The measuring head with dome and sensor element is plugged on to the adapter via four plug pins. Soldered to the other end of the cable (approx. 3.5 m long, screened) is the plug suitable for your bridge amplifier. This is a 6-pin Binder round miniature plug if a different plug is not specified. The Appendix summarises a whole range of different plugs and the corresponding pin connections for bridge amplifiers of different manufacturers. If necessary you can yourself solder on the plug suitable for your bridge amplifier or have a plug fitted by a technician.

WARNING: **do not interchange** the connections for **excitation and signal output!** If the connections are interchanged the pressure transducer does operate but no longer conforms necessarily to the technical data. In particular the sensitivity and the temperature stability of zero and gain are worse than the values shown under Technical Data.

The exact values of the four resistances of the sensor element in the pressure measurement head are not fully specified; the technical data do however give approximate values.

N O T E on polarity; if the deflection on the bridge amplifier is in the wrong direction after the plug has been replaced, you must interchange either the two connections for the excitation (+ and -) or the two connections for the signal (+ and -).

Fehler! Unbekanntes Schalterargument. **Faults, causes and remedies**

Fault	***Causes, remedy***
When used for the first time the amplifier can not be zeroed:	• Possibly wrong pin connections, check against the bridge amplifier used. • Plug connections of measuring head faulty, perhaps connecting pins bent.
The zero error is very large and can not be fully compensated:	• There is a pressure in the dome due to stopcocks being closed. Open at least one stopcock so that there is atmospheric pressure inside the dome.
The zero is not stable. Stability is poor and does not agree with the technical data:	• The transducer head is subject to large temperature fluctuations, e.g. light from an incandescent bulb or direct sunlight or a cold draught or .... • There may be moisture in the plug connection of the transducer head, e.g. from washing or cleaning. As a remedy the head should be taken off the adapter and all parts dried carefully. WARNING: do not bend the connecting pins in the transducer head! • The transducer head or the pressure diaphragm has been damaged through washing with an unsuitable liquid. • If the fault appears after fitting a different plug there is a suspicion that the connections for excitation and signal have been interchanged.
The signal trace is not steady and "wanders":	• There are movement artifacts on the catheter. As a remedy, secure the catheter in a fixed position.
The signal trace is rounded; expected "fast" pressure rises and drops are flattened:	• The transmission system (catheter, stopcocks, dome) is not free from air bubbles. • The catheter tubing is not suitable (material too soft, lumen too large, lumen too small, too long).
The pressure trace shows unexpected "overshoots" on sudden pressure changes:	

CE

	V/V/mmHg
Accuracy:	better than ±1.5% of reading or ±1 mm Hg (whichever is larger), as total overall error covering the individual errors in linearity, hysteresis, reproducibility and sensitivity
Bridge supply voltage:	5 - 10 V d.c. or a.c. (up to 5 kHz) max.
Zero error:	±30 mm Hg max.
Temperature coefficients:	
Zero:	±0.25 mm Hg/°C max.
Sensitivity:	±0.08%/°C max.
Zero drift:	±1 mm Hg/8h max.
Operating temperature:	10 to 40°C
Storage temperature:	-25 to +70°C
Volume displacement:	< 0.04 mm3/100 mm Hg
Input resistance:	> 500 Ohm
Output resistance:	< 900 Ohm
Leakage current:	< 10 ìA a.c. at 115 V 60 Hz

Fehler! Unbekanntes Schalterargument. **Appendix: Plugs and plug connections**