mag-safe / shell-safe / double-safe

Monitoring devices for Magnetic Coupled Pumps

1. mag-safe

Temperature rise in sealless magnetic driven pumps

In sealless pumps with magnet coupling and metallic containment shells, eddy currents are generated which cause temperature rise of the pumped liquid inside the containment shell. This heat must be dissipated through an internal cooling flow.

Also, below minimum flow, the temperature will rise remarkably.

Dry running is the worst of these flow related conditions. The heat built up in the containment shell can cause a temperature rise of more than 200 °C (392 °F) within seconds, this can cause demagnetization of the magnet coupling if the temperature is not reliably monitored.

Sleeve bearing, allowable temperature

Sealless pumps require sleeve bearings which work in the pumped liquid. The sleeve bearing material in DICKOW-pumps is generally Silicon Carbide with diamond like carbon coating, providing dry running capability. The widely used term "process lubricated bearing" is not quite correct, since many pumped fluids (e.g. LPG) have no lubrication abilities.

Similar to the situation between the faces of mechanical seals, a stable fluid film is required between the slide faces. If temperature rise in the magnet end causes vaporization of the pumped liquid, this fluid film breaks down and the sleeve bearing runs dry and fails sooner or later. Although, the DLC coating can accept dry running in an empty pump because no hydraulic loads are acting, it cannot save the bearings if dry running occurs under upset operating conditions. Only a reliable temperature monitoring can avoid such upset conditions. When handling volatile liquids, the relation between temperature and pressure in the magnet end and the boiling point of the liquid should be considered in any case.

Function

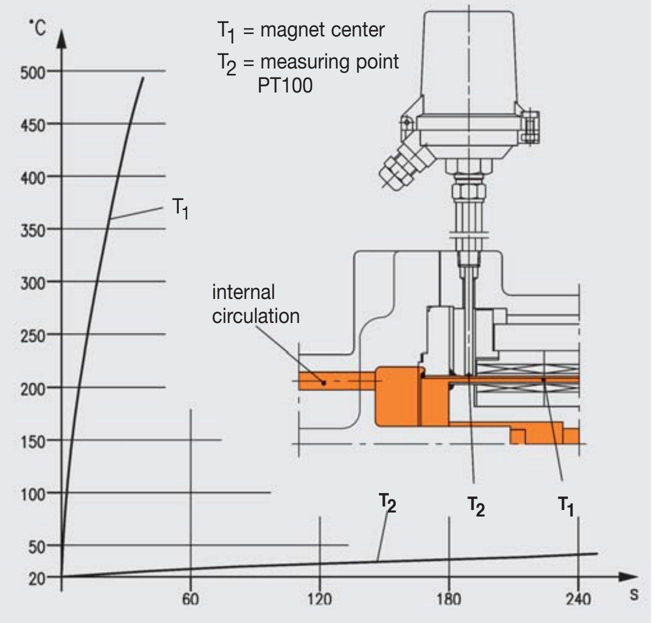
The most common temperature monitoring systems are PT100-elements. The disadvantage of these elements is the location outside of the magnets.

This is proved by the test results shown in the graph below. The graph shows the temperature rise (T_2) at the PT100 and the temperature rise (T_1) in the center of the magnets during dry running of a pump over a period of 4 minutes.

In the center of the magnets the temperature rises very fast and can reach, depending on the magnetic losses, over 200 °C already after a few seconds. The temperature reading at the PT100 after 4 minutes is 40 °C (105 °F) only.

These results prove that the PT100-probe cannot act as a dry running protection.

To obtain reliable readings from the PT100-probe, the pump must be vented respectively properly filled with pumped liquid and the internal circulation flow must transport the heat from the magnet center to the measuring spot of the PT100. This is provided in our NM-pumps with circulation from discharge to discharge by rotor back vanes and the PT100 located at the return of the internal cooling flow (after passing the magnet area).



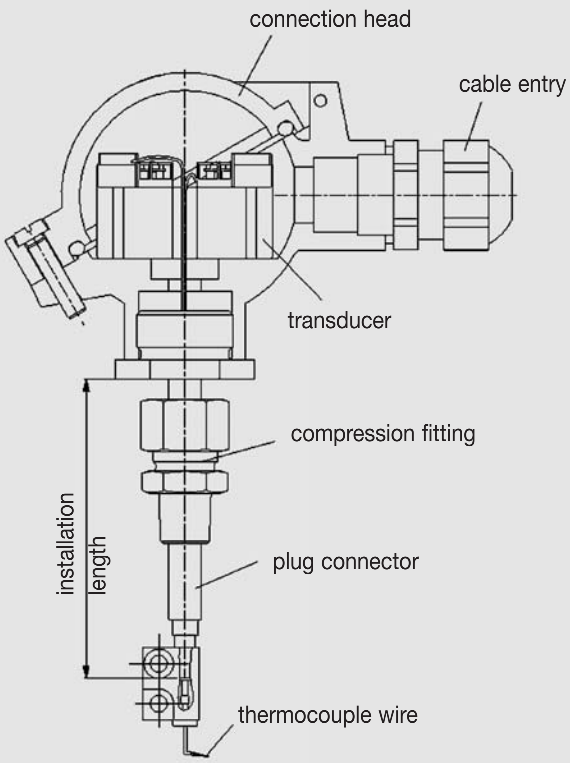
Temperature profile during dry running

Design

The mag-safe is developed and designed for monitoring DICKOW-sealless pumps with metallic containment shells and preventing serious pump failures.

The thermocouple wire is spot-welded to the containment shell surface and forms a thermocouple.

Contrary to the PT100, the mag-safe reads the temperature in the center of the magnets between shell and magnets. Temperature changes in the thermocouple generate voltage changes. The transducer converts these changes into a linear output signal of 4 to 20 mA.



mag-safe

Advantages / protective function

<table>
<tr><th>problem</th><th>symptoms</th><th>possible affects</th><th>protection through mag-safe</th></tr>
<tr><td>dry running</td><td rowspan="7">temperature rise, hot containment shell surface</td><td>damage of sleeve bearings, demagnetization of the magnets</td><td rowspan="7">alarm or immediate shut-off if the allowable temperature limit is exceeded</td></tr>
<tr><td>closed discharge valve, clogged circulation channels, operation below minimum flow</td><td rowspan="3">volatile liquids:
vaporization of liquid in sleeve bearing area,
failure of bearings through dry run

non-volatile liquids:
demagnetization of magnets through overheat</td></tr>
<tr><td>decoupled magnets</td></tr>
<tr><td rowspan="2">dry running through exceeded boiling point in containment shell area</td></tr>
<tr><td rowspan="2">vaporization of liquid in sleeve bearing area,
failure of bearings through dry run</td></tr>
<tr><td rowspan="2">solids/sediments between rotor and containment shell</td></tr>
<tr><td>rupture of the containment shell, leakage</td></tr>
<tr><td>worn out antifriction bearings</td><td>increased vibrations and noise level</td><td>rupture of the containment shell through rubbing of drive rotor</td><td>shut-off when connection wire is cut</td></tr>
</table>

The mag-safe is highly recommended for handling boiling liquids, for liquids which tend to polymerize if a certain temperature is exceeded and for service conditions where no monitoring of antifriction bearings is provided.

Technical data

The **mag-safe** is - according to DIN EN 50020 chapter 5.4 - a simple electrical equipment and is not subject to the EU-Directive 94/9/EG.

Measuring range:	-50 °C up to +300 °C
Minimum speed pump:	> 300 min^{-1}; lower speeds will lead to heavy fluctuating temperature indications (> 10K) resp. mA-signals.
Ambient temperature:	-40 °C up to +75 °C

Transmitter

Classification:	Exia IIC T5 / T6, ATEX II 1G
Type-examination-certificate:	TÜV 07 ATEX 347151 X

Cable entry

Material:	Brass nickel-plated; gasket EPDM, clamping cage polyamide
Classification:	Ex II 2G Exe II
Type-examination-certificate:	PTB 04 ATEX 1112 X

Connection head

Material:	Aluminium-diecasting; magnesium content ≤ 3%
Protection class:	IP65

Thermocouple

The thermocouple on which the measurement is based, consists of containment shell material 1.4571 or 2.4610 and of alloyed standard wire constantan.

Temperature / voltage output signal

input [mV]	output [mA]	temperature [°C]
-3,150	4,00	-50
-2,700	4,46	-40
-2,250	4,91	-30
-1,800	5,37	-20
-1,350	5,83	-10
-0,900	6,29	0
-0,450	6,74	10
0,000	7,20	20
0,450	7,66	30
0,900	8,12	40
1,350	8,57	50
1,800	9,03	60
2,250	9,49	70
2,700	9,94	80
3,150	10,40	90
3,600	10,86	100
4,050	11,32	110
4,500	11,77	120

input [mV]	output [mA]	temperature [°C]
4,950	12,23	130
5,400	12,69	140
5,850	13,14	150
6,300	13,60	160
6,750	14,06	170
7,200	14,52	180
7,650	14,97	190
8,100	15,43	200
8,550	15,89	210
9,000	16,34	220
9,450	16,80	230
9,900	17,26	240
10,350	17,72	250
10,800	18,17	260
11,250	18,63	270
11,700	19,09	280
12,150	19,54	290
12,600	20,00	300

2. shell-safe

Why containment shell monitoring shell-safe?

Monitoring of non-metallic containment shells, in particular ceramic shells, is up to now not available for the end user. A temperature sensor alone does not make sense, because there is no magnet loss generated and no temperature increase occurs.

Monitoring of a containment shell failure and the associated considerable damage of all rotating components due to loose ceramic parts is still not possible.

In order to meet the increasing safety requirements of the associated industries, the containment shell monitor shell-safe has been developed.

Ceramic shell with shell-safe film

Construction

The shell-safe consists of a very thin Kapton film with embedded nickel wire. This film is affixed to the containment shell and covers the total tube area of the containment shell. Via a connecting block attached to the flange and a plug connector, a contact is established to a transmitter placed in the connection head.

Flange, containment shell and the intermediate gasket are glued together and form a single component.

Hazardous area protection

The shell-safe is an intrinsically safe electrical equipment according to EN 60079-11 and therefore subject to the regulations of Explosion Proof Directive 94/9/EC. A conformity assessment procedure through a notified body has been performed. A type-examination certificate is available. The shell-safe is ATEX-tagged.

The shell-safe, an intrinsically safe equipment with the marking Exib, can be used in hazardous areas as a device for category 2 in zone 1.

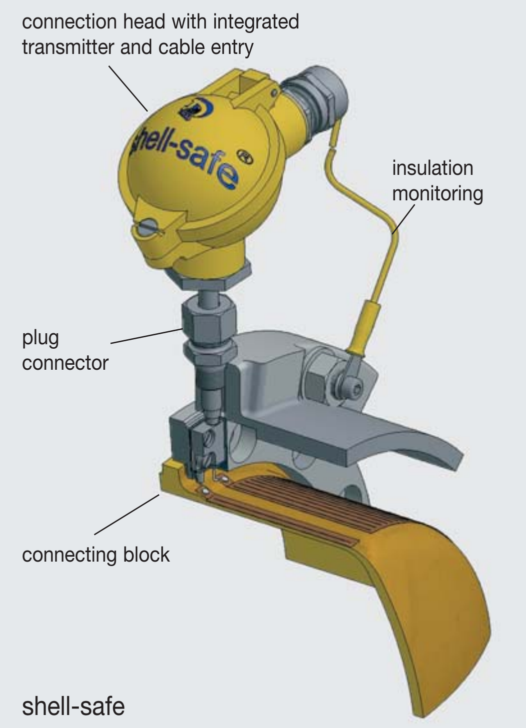
Head transmitter and cable entry are subject to a separate conformity assessment procedure.

Function

The transmitter monitors - by means of resistance measurement - the circuit of the nickel wire as well as the insulation of this wire and of the connection to surrounding casing parts and containment shell.

Consequently, there are two independent measuring circuits which are individually monitored: If the nickel wire is damaged or cut through, the electrical resistance increases to infinity and activates an alarm when exceeding the set value. In order to ensure that the alarm is also issued if the cut nickel wire should short-circuit itself over the surrounding parts, the insulation resistance is additionally monitored. If the value falls below the set point, the second measuring circuit activates also an alarm.

The temperature-dependent specific resistance of the nickel wire serves as indicator for the surface temperature of the total surface area. This allows additional monitoring of the outer containment shell temperature with an accuracy of +/- 5K.



shell-safe

Technical data

The **shell-safe** meets the requirements of the ATEX directive 94/9/EC and is approved for use in zones 1 and 2.

Classification:	II 2 G Ex ib IIC T4
Type-examination-certificate:	PTB 15 ATEX 2009
Ambient temperature:	-40 °C up to +40 °C
Temperature range of containment shell:	-40 °C up to +175 °C

Transmitter

Type:	Krohne Inor OPTITEMP TT 51 C Ex
Classification:	II 1 G Ex ia IIC T6…T4 Ga
Type-examination-certificate:	KIWA 14 ATEX 0004 X Issue: 2

Cable entry

Type:	Pflitsch UNI Ex Dicht
Classification:	II 2 G Ex e IIC Gb
Type-examination-certificate:	PTB 14 ATEX 1011 X

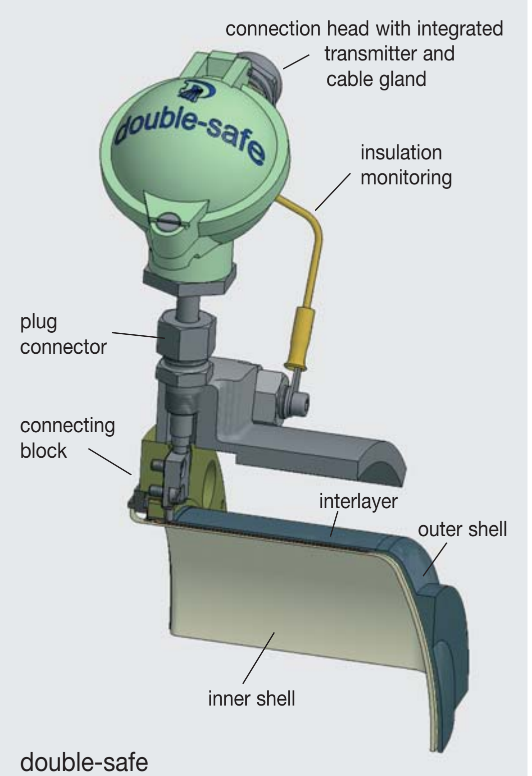
Connection head

Material:	Aluminium-diecasting; magnesium content ≤ 3%
Protection:	IP65

3. Double containment shell with double-safe

When handling highly hazardous and toxic liquids, increased safety requirements are playing an increasingly important role. The trend is to provide a second barrier for such liquids, this avoids product leakage in case of containment shell damage. Apart from the well known secondary seals according to 84.SE.19 which form together with the bearing bracket a secondary containment, DICKOW developed a patented double containment shell (DE 10 2012 019 423 B3, European patent pending).

This containment shell can be defined for the first time as a real second barrier because inner shell as well as outer shell are designed for the maximum permissible operating conditions. As soon as one shell should be defective through unforeseen operating conditions, a complete containment by the second shell is guaranteed.



double-safe

Advantages over the solutions available on the market up to now:

- No air between inner and outer shell in the pipe section.
- No external liquid required for cooling the outer shell.
- Interlayer material of high thermal conductivity, high specific electric resistance and chemical corrosion resistance.
- Eddy current losses of the outer shell are led through the interlayer to the inside and dissipated through the internal circulation flow.
- An interwoven insulated thermocouple wire serves to monitor the interspace and is led to a plug connector at the containment shell flange.
- Monitoring options:
  - wire break through contact of inner or outer magnets.
  - damage of wire through corrosive attack of pumped liquid in case of defective inner shell.
- No further connections on the containment shell flange required.
- No expensive monitoring equipment necessary for the interspace.
- Interlayer cannot escape in case of a containment shell damage. No health risk and no requirement of checking the compatibility with the pumped liquid.
- Inner and outer shell are friction-locked together.

Additional temperature monitoring of the outer containment shell with PT100 or mag-safe is possible respectively recommended.

Hazardous area protection

The double containment shell is a simple electrical equipment according to EN 60079-11 and not subject to the regulations of the Explosion Proof Directive 94/9/EC. A conformity assessment procedure through a notified body is not required. The double containment shell has no ATEX-marking.

In connection with an intrinsically safe circuit, the double containment shell can be used in hazardous areas.

Head transmitter and cable entry are subject to a separate conformity assessment procedure.

Function

The transmitter monitors - by means of resistance measurement - the circuit of the thermocouple wire as well as the insulation of this wire and of the connection to surrounding casing parts.

Consequently, there are two independent measuring circuits which are individually monitored:
If the thermocouple wire is damaged or cut through, the electrical resistance increases to infinity and activates an alarm when exceeding the set value. In order to ensure that the alarm is also issued if the cut thermocouple wire should short-circuit itself over the surrounding parts, the insulation resistance is additionally monitored. If the value falls below the set point, the second measuring circuit activates also an alarm.

Technical data

According to EN 60079-11, the **double-safe** is a simple electrical device and therefore requires no Ex-marking.

Ambient temperature:	-40 °C up to +40 °C
Temperature range of containment shell:	-40 °C up to +175 °C

Transmitter

Type:	Krohne Inor OPTITEMP TT 51 C Ex
Classification:	II 1 G Ex ia IIC T6…T4 Ga
Type-examination-certificate:	KIWA 14 ATEX 0004 X Issue: 2

Cable entry

Type:	Pflitsch UNI Ex Dicht
Classification:	II 2 G Ex e IIC Gb
Type-examination-certificate:	PTB 14 ATEX 1011 X

Connection head

Material:	Aluminium-diecasting; magnesium content ≤ 3%
Protection:	IP65

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