High-Pressure and High-Temperature Probes for Electrochemical Potential, pH, ORP, and Conductivity Measurements

Corr Instruments, LLC
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San Antonio, TX 78229
Needs for High-Pressure (HP) and High-Temperature (HT) Probes

- Nuclear Power Industry
- Geothermal Plants
- Carbon Sequestration Programs
- Oil and Gas
- Chemical Processing Plants
- Pulp and Paper
Needs in Nuclear Power Systems

- **BWR Reactor**
  - up to 290 °C, ~1500 psig

- **PWR Reactor**
  - 260 to 320 °C, 1500 to 1800 psig
  - Up to 280 °C, ~1200 psig
Needs in Geothermal Plants

Geothermal Reservoir
Up to 700 °F (370 °C)
Courtesy: Geothermal Education Office
http://geothermal.marin.org/geopresentation/sld037.htm
Needs in Carbon Sequestration Program

Courtesy: U.S. DEPARTMENT OF ENERGY
HT and HP Reference Probes
T up to 305 °C, P up to 7500 psig
HT and HP Reference Probes
(External Type, Ag/AgCl Is Away from Heated Reactor)

b (Insertion tube length) = up to 21”

Ag-AgCl electrode is at near-ambient T

3/8” OD Insertion tube (1/4” OD for special probe only)

Mounting fitting with 1/4”, 3/8”, or 1/2” NPT (1/8” NPT for 1/4” OD tube only)

Liquid junction

L2 (Insertion depth) (L2>0.5”)

PTFE tube filled with KCl Solution

Corr Fitting (with Queon seal inside)
HT and HP Reference Probes
(Internal Type, Ag/AgCl Is Inside Heated Reactor)

- Corr Fitting (with Queon seal inside)
- Ag-AgCl electrode is at reactor T
- 3/8” OD Insertion tube (1/4” OD for special probe only)
- Mounting fitting with 1/4”, 3/8”, or 1/2” NPT (1/8” NPT for 1/4” OD tube only)
- PTFE tube filled with KCl Solution
- L2 (Insertion depth) (L2>0.5”)
- Liquid junction

b (Insertion tube length) = up to 12”
HT and HP ZrO$_2$-based pH Probes
T=80 to 150 °C, 100 to 220 °C, or 180 to 343 °C, Depending on Models
P up to 4000 psig at T < 190 °C
HT and HP ZrO$_2$-Based pH Probes

- Corr fitting (Queon Seal Inside)
- 1/2” OD Insertion tube (3/8” OD for special probe only)
- Mounting fitting with 3/8” or ½” NPT (¼” NPT for 3/8” OD tube only)
- ZrO$_2$ tube
- Internal reference material
- b (Insertion tube length) = 7 to 20”
- L2 (Insertion depth) (L2>1”)

Note: The diagram illustrates the components of a HT and HP ZrO$_2$-Based pH Probe, including the Corr fitting, 1/2” OD Insertion tube, Mounting fitting, ZrO$_2$ tube, and Internal reference material. The diagram also indicates the insertion tube length and insertion depth requirements.
HP Glass-Based pH Probes
T=1 to 80 °C; P =0 to 2000 psig (or up to 7500 psig without CO₂ or H₂S)
1/2” OD Insertion tube (3/8” OD for special probe only)

Corr fitting (Queon Seal Inside)

Mounting fitting with 3/8” or ½” NPT (¼” NPT for 3/8” OD tube only)

b (Insertion tube length) =7 to 18”

Sensing glass

L2 (Insertion depth) (L2>0.5”)

HP Glass-Based pH Probes
HT and HP Conductivity Probes for Low Conductivity

$T = 0 \text{ to } 305 \degree C; P \text{ up to } 7500 \text{ psig}; \text{Conduc} < 100 \mu S/cm$
HT and HP Conductivity Probes for Low Conductivity

T = 0 to 305 °C; P up to 7500 psig; Conduc < 100 μS/cm
HT and HP Conductivity Probes for High Conductivity

T = 0 to 305 °C; P up to 7500 psig; Conduc up to 150 mS/cm
HT and HP Conductivity Probes for High Conductivity

T = 0 to 305 °C; P up to 7500 psig; Conduc up to 150 mS/cm

- 316 SS fitting with ¼”, 3/8” or ½” male NPT
- 3/8” OD insertion tube
- Drain holes
- Pt electrodes
- PTFE cell
- L3 (Cell length) ~2.0”
- L2 (Insertion depth) To be fixed by user (L2 > L3)
- Must be in liquid

Cell constant > 5
HT and HP Oxidation/Reduction Potential (ORP) Probes
T = 0 to 305 °C; P up to 7500 psig
HT and HP Oxidation/Reduction Potential (ORP) Probes

- **Corr fitting** (Queon Seal Inside)
- **Insulation**
- **Pt electrode**
- **3/8” OD Insertion tube** (1/4” OD for special probe only)
- **Mounting fitting with 1/4”, 3/8”, or ½” NPT** (1/8” NPT for ¼” OD tube only)
- **b (Insertion tube length) = 7 to 21”**
- **L2 (Insertion depth)** (L2 > 0.5”)**
High-Temperature Counter Electrode

\( P = 0 \text{ to } 3750 \text{ psig; } T = 0 \text{ to } 400 \degree C \)

Corr fitting
(Queon Seal Inside)

3/8” OD Insertion Tube
(1/4” OD for special probe only)

High temperature insulation

Pt electrode

User can spot-weld a platinum sheet here to increase surface area (not supplied)

Mounting Fitting with 1/4”, 3/8”, or ½” NPT (1/8” NPT for 1/4” OD tube only)

Mounting Fitting with 1/4”, 3/8”, or ½” NPT (1/8” NPT for 1/4” OD tube only)

L2 (Insertion depth)
To be fixed by user (L2>1”)

b (Insertion Tube length)= 17 to 30”
High-Temperature Electrode Holder for Working Electrodes

P = up to 4000 psig; T = 0 to 350 oC, depending on models

b (Insertion Tube length)= 17 to 30"

L2 (Insertion depth) To be fixed by user (L2>2”)

Passive metal (SS or C-276) lead wires with short exposed length

High temperature insulation

Corr fitting (Queon Seal Inside)

3/8” OD Insertion Tube (1/4” OD for special probes with one electrode only)

Mounting Fitting with 1/4”, 3/8”, or ½” NPT (1/8” NPT for 1/4” OD tube only)

1 to 4 Working Electrode Specimens spot-welded to passive wires by user (Not Supplied)
Important Probe Components—Queon™ Seals for High Temperatures and High Pressures

Queon Seal can be made into various shapes

Queon Seal is particularly suitable for packing gland
# Properties of Queon™ Seals and Comparison with PTFE (Teflon®) Seals

<table>
<thead>
<tr>
<th></th>
<th>Queon Seal</th>
<th>Teflon Seal</th>
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</thead>
<tbody>
<tr>
<td>Continuous Working T</td>
<td>-185 to 343°C (-300 to 650°F) Maintains integrity after exposure to heat</td>
<td>-185 to 232°C (-300 to 450°F) Becomes loose after exposure to heat</td>
</tr>
<tr>
<td>Temperature Cycling</td>
<td>Withstand rapid heating to 343°C (650°F) and rapid cooling to 25°C (77°F)</td>
<td>Leak develops after slow cooling from 232°C (450°F)</td>
</tr>
<tr>
<td>Chemical Stability</td>
<td>Excellent in water/steam or high pH solutions in packing gland at 343°C (650°F)</td>
<td>Excellent</td>
</tr>
</tbody>
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## Testing Results in Compression Fittings

<table>
<thead>
<tr>
<th>Sealed Rod or Tube Size in Packing Gland</th>
<th>Before Baking (cc He/sec at 25°C)</th>
<th>After 320°C (cc He/sec at 25°C)</th>
<th>Electrical Resistance at 5000 V (ohm)</th>
<th>Maximum Pressure at 25°C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Queon</td>
<td>Teflon</td>
<td>Queon</td>
<td>Teflon</td>
</tr>
<tr>
<td>6.35-mm OD steel rod</td>
<td>2x10⁻⁸</td>
<td>2x10⁻⁸</td>
<td>2x10¹²</td>
<td>13000 psi/90 MPa</td>
</tr>
<tr>
<td>1-mm OD steel wire</td>
<td>Similar to Queon</td>
<td>2x10⁻⁸</td>
<td>Leak after Baking</td>
<td>Similar to Queon</td>
</tr>
<tr>
<td>3.18-mm OD steel rod</td>
<td>-----</td>
<td>2x10⁻⁸</td>
<td>2x10¹²</td>
<td>13000 psi/90 MPa</td>
</tr>
</tbody>
</table>

*Teflon seals leaked after baking and cannot withstand any pressure.
Typical Installations of HP and HT Probes in Reactors/Autoclaves
Combination pH or ORP Probes
(Reference probe can be bent for installation)

Ref Probe

pH Probe Or ORP Probe
(Never bend pH probes)

Soft sealant

Mounting Fitting (3/4” or larger NPT)

1/4” OD

3/8” OD

L0

L2
Type A Probes
Insertion Depth Is One-Time Adjustable by Users

- Insertion tube length: \( b \)
- Insertion depth: \( L_2 \) (one-time adjustable by users)

Mounting fitting with 1/4”, 3/8”, or 1/2” NPT
(1/8” NPT for 1/4” OD tube only)

- Corr Fitting (with Queon seal inside)
- Metal seal (position on tube not re-adjustable)
- 3/8” OD insertion tube (1/4” OD for special probe only)

L2 (Insertion depth)
(L2 is one-time adjustable by users)
Type B Probes
Insertion Depth Is Fully Adjustable by Users
(P< 3000 psig only)

- Corr Fitting (with Queon seal inside)
- Soft seal (position on tube re-adjustable)
- 3/8” OD insertion tube (1/4” OD for special probe only)
- Mounting fitting with 1/4”, 3/8”, or 1/2” NPT
- b (Insertion tube length)
- L2 (Insertion depth) (L2>0.5”) (L2 is fully adjustable by users)
Type C Probes
Insertion Depth Is Not Adjustable by Users

Corr fitting
(Queon Seal Inside)

Mounting fitting with 3/8"
or ½” NPT
(¼” NPT for 3/8” OD tube only)

L2 (Insertion depth)
(L2 is fixed at factory)
Back up slides

Typical Curves
Connections
Meters
Data acquisition
HT and HP Level Probes
T = 0 to 305 °C ; P up to 5000 psig

b (Insertion tube length)
PTE coating
C-276 electrodes (1 to 4 electrodes)
Drain holes for probe
fitting with male NPT
tubing
L2 (Insertion depth)
To be fixed by user
L3 (Distance between electrodes)