INSTRUMENTATION
TECHNICAL SERVICES, INC.

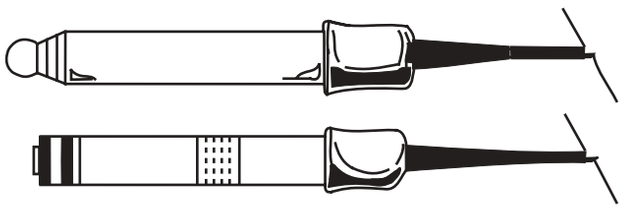
Electrode Selection Chart

An introduction to and explanation of the basic types of electrode:

1.) Combination or Electrode Pair

Combination

Best electrode for most laboratory or field applications with exceptions noted below. Most popular type.



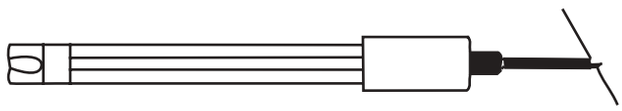
Electrode Pair

Best choice for following special applications:

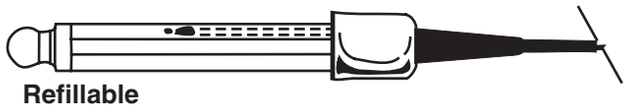
1. Colloidal suspensions
2. Samples containing Iodides
3. Samples that are high in solids
4. Viscous solutions
5. Samples requiring specific ion determinations

2.) Fill Solution (Gel-Filled or Refillable)

Gel-Filled



Need almost no maintenance. Polymer body for high durability. Moderate accuracy (±.05 pH units). Limited life (6 months to 1 year). Should not be immersed for long periods of time. Most often used for field or industrial applications.



Refillable

1. Higher maintenance
2. Glass body, typically
3. High accuracy (±.01 pH unit)
4. Longer Life (1 year or more)
5. Most often used in laboratory applications

3.) Junction type

Single Junction Ag/AgCl (Silver-Based)

Best electrode for most laboratory or field applications with exceptions noted below.

Double Junction or Calomel (Mercury-Based)

Used when samples react with the silver in an Ag/AgCl electrode. Best choice for solutions containing:

1. Proteins, sulfides or heavy metal ions
2. Strong reducing ions
3. Tris buffer

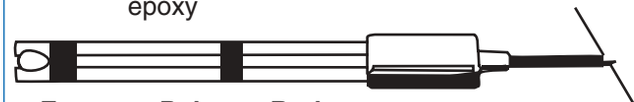
Calomel (Hg/HgCl) electrodes are often recommended in situations where an Ag/AgCl filling solution would interact with your sample. Calomel is a very stable reference at constant temperatures and is often used in laboratory applications. It has less temperature stability than Ag/AgCl and breaks down above 60°C (140°F). Ag/AgCl double junction electrodes now offer the same advantage as Calomel (Hg/HgCl) electrodes, without the latter's heat stability limitations.

4.) Body Construction (Glass, Epoxy or Polymer)

Glass Body

Most often used in laboratory applications. Best choice for solutions containing:

1. Proteins and other compounds with high surface tension
2. Highly corrosive materials
3. Organics or solvents which might attack epoxy



Epoxy or Polymer Body

More durable than glass. Best electrode for most field applications. Usually gel-filled.

Electrode Selection Chart

In order to select the proper electrode for a particular application, the following parameters should be evaluated:

Considerations	Explanation
Physical Dimensions of Electrode and Bulb	Electrodes are available in various lengths and bulb shapes for different uses such as general purpose, in test tubes, on flat surfaces or for puncturing soft, moist surfaces.
Type of Sample	If sample will react with Ag/AgCl reference, Double Junction reference should be used.
Type of Liquid Junction	Any ceramic, Teflon® or polypropylene junction can be used for most applications. The types are: Pin Ceramic—low junction flowrate. Annular or Coaxial Ceramic—higher flowrate with greater surface area to prevent clogging. Teflon® or polypropylene—higher flowrate, hard to clog. Sleeve junction—highest flow rate for hard-to-measure or easily clogging samples such as high purity water or dirty, viscous samples.
pH of Sample	At high pH (>12), special glass may be required to minimize error due to interference by sodium ions. High pH glass can be used over the entire pH scale, but has a higher resistance than standard glass.
Resistance of Electrode	The higher the resistance of the electrode, the more difficult it is to get a proper measurement. Meters with an input impedance of at least 10^{12} ohms should be used whenever possible. The input impedance of the meter should be greater than 1000 times the resistance of the electrode. Resistance of electrodes doubles for every 8°C (144°F) drop in temperature; therefore, at low temperatures, this can become important.
Connector and Cable Length	Standard electrodes come with a BNC or U.S. standard connector and between three quarters of a meter and one meter (2½ to 3 ft.) of cable. Make sure this is compatible with the meter you are using. If not, adaptors and other cable lengths are available.
Mounting	Electrodes should be mounted vertically into the sample if possible. Do not mount less than 15° from horizontal.

Note: *Longer production lead time is required for non-standard electrode configurations.*

Introduction to Electrode Selection

With so many electrodes available, how do I select the right one for my application?

One group or even a few electrodes cannot fill all the various applications that may be encountered.

The first question to ask is where will the electrode be used. Is it for the laboratory, the field or an industrial process environment? Once that is answered, then the physical dimensions of the electrode and the bulb style must be chosen. Electrodes are available in various lengths and bulb shapes for different uses, such as general purpose, test tubes, flat surfaces or puncturing moist surfaces. Also, if it is an industrial electrode, the proper mounting configuration must be chosen, such as insertion or submersion.

What other parameters do I need to consider in choosing the proper electrode?

The first choice to make is whether to use a combination electrode or an electrode pair. A combination electrode is best for most laboratory or field applications, with certain exceptions. It is the most popular type of electrode and the easiest to use. An electrode pair is the better choice for dealing with:
1) colloidal suspensions, 2) iodides in the sample,
3) high percentage of solids in the fluid,
4) viscous solutions, 5) making specific ion determinations, and 6) high purity water.

What are an electrode pair and a combination electrode?

An electrode pair consists of two electrodes: the reference electrode and the measuring electrode. A combination electrode combines these two elements into one electrode. All pH measurements are made using either an electrode pair or a combination electrode.

What are gel-filled and refillable electrodes?

Electrodes are either refillable or gel-filled. Gel-filled electrodes require almost no maintenance, and their polymer bodies exhibit excellent durability. However, gel fills also have only moderate accuracy (±0.05 pH units) and a limited life span (6 months to 1 year). They should not be immersed for long periods of time. Refillable electrodes require periodic refilling with an appropriate filling solution. They require higher maintenance, typically have breakable glass bodies, but also have higher accuracy (±0.01 pH unit), longer life, and are most often used in laboratory applications.

How do I select the electrode's body construction?

The glass body electrode is most often used in laboratory applications. It is the best choice for solutions containing proteins and other compounds with high surface tension, highly corrosive materials, and organics or solvents which might attack a polymer body. Polymer-bodied electrodes are more durable than glass ones. They are the better choice for field applications and are most often gel-filled.

What is the junction of an electrode?

The junction of a reference electrode or combination electrode is a permeable membrane through which a filling solution slowly escapes (called the liquid junction). The junction can come in several forms, but its principal function is to allow small quantities of the reference electrode's fill solution to slowly leak or migrate into the sample being measured.

What are the types of junctions and how do I select among them?

Junctions can be categorized both by number and type. Any ceramic or fluorocarbon polymer junction can be used for most applications. The differences are as follows: Pin ceramic — low flow rate. Annular or coaxial ceramic — higher flow rate with greater surface area to prevent clogging. Fluorocarbon polymer — higher flow rate, hard to clog. Sleeve junction — highest flow rate for hard-to-measure or easily clogging samples such as high purity water or dirty, viscous samples. Electrodes can use either single, double or triple junctions. Single junction electrodes with Ag/AgCl internal components are the best electrodes for many field or laboratory applications with the exceptions noted below. Double junction or triple junction electrodes provide protection when used with samples that can react with the silver in Ag/AgCl electrodes. They are the best choice for solutions containing proteins, sulfides, heavy metal ions, strong reducing ions, or tris buffers. If you're in doubt, a double junction should be used.

What are calomel electrodes?

Calomel (Hg/HgCl) reference electrodes are often recommended in situations where an Ag/AgCl filling solution would interact with the process fluid. Calomel is a very stable reference material at constant temperatures, and is often used in laboratory applications. It has less temperature stability than Ag/AgCl, and breaks down above 60°C(140°F). Ag/AgCl double junction electrodes offer the same advantage as calomel electrodes without the heat limitations.

How does the pH of the sample affect electrode selection?

At high pH (>12), special glass may be required to minimize error due to interference by sodium ions. Such high pH glass can be used over the entire pH scale, but it has a higher resistance than does standard glass.

What are the various types of connectors that are available on electrodes?

The main connectors available are BNC and U.S. standard connectors. Make sure that the connectors are compatible with the meter that you are using. If not, adaptors for other connector and meter types are available.