Cell for Ring-Disk Electrodes

Operator's Manual

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Cell for Ring-Disk Electrodes

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Part number 988-00012

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If You Have Problems

Please visit our service and support page at www.gamry.com/service-support/.

This page contains information on installation, software updates, and training. It also contains links to the latest available documentation. If you are unable to locate the information you need from our website, you can contact us via email using the link provided on our website. Alternatively, you can contact us one of the following ways:

Internet	www.gamry.com/service-support/
Telephone	(215) 682-9330 9:00 AM–5:00 PM US Eastern Standard Time
	(877) 367-4267 Toll-free US & Canada Only

Replacement parts for this kit are available from Gamry Instruments, Inc. Optional parts may be available from Gamry Instruments, or from third-party vendors. Contact your local Gamry sales representative to discuss any special requirements or accessories that you need.

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Introduction

Gamry Instruments designed the Cell kit for use with the RDE710 Rotating Electrode and Disk and Cylinder electrodes.

A reference electrode is ***not*** included in the cell kit. Requirements for this electrode vary too much from user to user to make its inclusion in the standard kit practical. Gamry Instruments sells three types of reference electrodes (SCE, Ag|AgCl, and $Hg|Hg_2SO_4$) that are suitable for use with your EuroCell kit. Order your reference electrode separately.

The Cell uses five standard ports to implement its required functions. You can customize the cell by rearranging some of Gamry's standard fittings, or making or buying additional fittings, electrodes, sensors, or adapters.

Too often, temperature control is neglected in designing electrochemical experiments. Temperature is an important variable in the rate of both heterogeneous and homogeneous chemical reactions. Comparing test results recorded at different can be vital in gaining a full understanding of a chemical system. For these reasons, Gamry sells a special jacketed version of the Cell body. When this cell is connected to a circulating water bath, accurate temperature control of your experiments becomes possible.

Chemical Compatibility of the Cell

The components in the Cell were selected to be as chemically inert as possible. In normal use the only materials in contact with the test solution are:

- borosilicate glass (Pyrex® or equivalent),
- unfired glass frit,
- PTFE,
- polyethylene,
- ACE Glass's FETFE O-ring material

Chemical resistance tables for most of these materials are available (try searching the Internet). One exception is FETFE, which is an elastomer proprietary to ACE Glass, which consists of PTFE particles in a fluorinated rubber base similar to Viton®. According to ACE Glass, it offers *slightly* better chemical resistance than Viton®.

The black ACE-Thred™ fittings supplied with the cell do not normally come in contact with the cell electrolyte. These are nylon fittings, so you can use nylon's properties (which are generally available) as an indication of these fitting's suitability for use in any specific chemical environment.

Caution: The nylon bushings in the ACE-Thred™ fittings and the FETFE O-rings may not be suitable for use in some electrolytes (particularly non-aqueous media). If you need better chemical resistance than that offered using the standard ACE-Thred™ components, ACE Glass (www.aceglass.com) can provide replacement fittings made from PTFE and Kalrez®, which are extremely resistant to chemical attack. Contact Gamry Instruments if you need help selecting the proper replacement fittings.

Gamry's Cell for Ring Disk Electrodes was not designed for use in electrolytes that dissolve glass (extremely basic solutions or HF-containing solutions).

Caution: The glass components in the cell and the glass frits used in the reference bridge tube are not suitable for use with extremely basic solutions or solutions containing hydrofluoric acid. We do not know of any substitute cell components that will completely overcome this limitation. If you need to work with solutions that will damage the Cell, we recommend that you design and build an all-plastic cell.

The simple construction of the polyethylene stoppers used to seal the unused port makes them easily adaptable as a vent for purge gas: you simply poke a hole in the flat surface of the stopper. While they provide chemical resistance to most aqueous electrolytes, they may not be a good choice for use with some aggressive solvents. If polyethylene is not suitable for your application, glass and PTFE stoppers are available from most laboratory supply houses. If you use these "more solid" stoppers, don't forget the need to vent purge gas from the cell.

Unpacking and Checking a Cell Kit

This section is primarily intended for the user who has just received a new Cell Kit.

Checking for Shipping Damage

Your new Cell kit was shipped disassembled to minimize shipping damage. All of the pieces have been carefully packaged in anticipation of rough handling in shipment. Unfortunately, no matter how carefully glass pieces are packaged, damage will sometimes occur.

When you first receive your Cell kit, please check it for any signs of shipping damage. Be especially careful if the shipping container shows signs of rough handling.

Obviously, the glass pieces are the most susceptible to damage. Check the glass pieces for chipping and small cracks as well as for major damage.

If any parts were broken in shipment, please contact our US facility or your local Gamry representative as soon as possible. In most cases, Gamry should have replacement parts in stock. Please retain the shipment's packaging material for a possible claim against the shipping company.

Warning: Do not use any glass parts that are chipped or cracked. Any damage to glass increases the probability of additional damage. Broken glass can have extremely sharp edges that represent a significant safety hazard. Injuries from broken glass can be quite severe.

Parts List

Please check the contents of your kit versus the Cell kit packing list in Table 1. When shipped, all of the Cell kit components should be labeled with their Gamry Instruments, Inc. part number.

If you are checking the completeness of an older kit, you can identify the components by name using the illustrations in Figure 1 later in this manual.

Table 1: RDE Cell Kit Packing List

Quantity	Part Number	Description
1	930-00033	Adapter, 14/20 to #7 ACE-Thred™ with Hose Barb
1	930-00035	Fritted Tube for Counter Electrode Isolation, 7 mm
1	930-00040	Bubbler, ACE-Thred™ to glass frit
3	930-00042	Glass frit with PTFE heat-shrink tube
1	930-00044	Reference Electrode Bridge Tube, with glass frit
1	935-00005	Adapter, 24/40 to 8 mm tube
2	935-00052	#7 ACE-Thred™ nylon bushing with 2 FETFE O-rings
1	935-00053	#11 ACE-Thred™ nylon bushing with FETFE O-ring
1	935-00054	#7 to ¼" ACE Safe hose connector
1	935-00056	Platinum wire counter electrode (15 cm)

5	935-00059	Polyethylene stoppers for 14/20 Joint
1	970-00050	Cell body
1	975-00006	Three-pronged clamp
1	975-00010	Clamp, regular holder for RDE only
1	988-00012	Manual

Contact us as soon as possible if any of the parts are missing. The contact information for our US facility is on the first pages of this manual. If you are outside the US, you may want to contact your local Gamry representative.

Assembly of and Use of Your Cell Kit

This section of the manual tells you how to assemble and use a Cell kit in its standard configuration.

This "standard" cell configuration has:

- A standard cell body for use at room temperature
- A rotating electrode in the central 24/40 standard taper port (sold separately),
- A three-way gas purge/blanket/vent adapter in one 14/20 standard taper port
- A graphite-rod counter electrode in one #7 ACE-Thred™ port
- A reference electrode (sold separately) and bridge tube in one #7 ACE-Thred™ port
- One unused 14/20 standard-taper port (may be closed with a stopper)

This is one of many possible cell configurations. Feel free to customize your Cell. You are only limited by your imagination and the number and size of the ports available on the top of the cell.

Cell Assembly: General Information

Figure 1 shows an assembled cell.

If you are assembling your Cell kit for the first time, you may want to assemble the entire cell dry first. After you are comfortable with the process of assembling, you can fill the cell with a test solution and run real tests.

We recommend that you start the assembly of your cell by clamping the cell body in a three-fingered clamp attached to a ring stand. Gamry sells a ring stand kit which can be purchased using part number 990-00202. Alternatively, these can be purchased from any supplier of laboratory equipment. The cell body is not stable when laid on a flat surface such as a laboratory bench and can easily roll off a bench onto the floor with cell-shattering results. Gamry Instruments can always use additional sales, but we'd hate to have them come in the form of replacement cell bodies!

Caution: Always assume that the cell body will roll a substantial distance if laid down on a flat surface. Guard against it rolling off your test bench. Gamry's optional Cell Stand Kit (part # 990-00202) for the EuroCell can be very useful in preventing this type of accident.

Three of the ports on the Cell are standard-taper ground-glass joints. Never grease these joints.

Caution: In vacuum work in a chemical laboratory, ground-glass joints are often greased. This is unnecessary with the Cell and may even cause problems if the grease gets into the test solution or on an electrode. **Never grease** any of the ground glass joints on your Cell.

Figure 1. The Standard Configuration of a RDE Cell.

Pay careful attention to cell cleanliness. In most electrochemical testing situations, contaminants in the cell and test solution can lead to poorly reproducible results. If you touch the cell components with your fingers, you can inadvertently add salts and organic compounds to your cell solution. We recommend that you carefully clean the cell components using good laboratory practice. After the components are clean, avoid touching their wetted surfaces.

The Cell includes a number of ACE-Thred™ connectors used for a wide variety of functions. #7 ACE-Thred™ connectors are particularly common. ACE-Thred™ fittings are designed to seal cylindrical objects into the cell. These objects can include glass tubes, glass plugs, thermometers, and plastic electrode bodies. ACE-Thred™ connections are designed to be tightened with finger-pressure only.

Warning: ACE-Thred™ fittings should always be tightened "finger-tight". Never use tools such as a wrench or pliers to tighten an ACE-Thred™ fitting. Over-tightening a fitting can break the cell. In extreme cases this can cause personal danger because broken glass can have very sharp edges.

A given ACE-Thred™ size can only accommodate objects with a specific diameter. A #7 ACE-Thred™ is specified to work with object with a diameter between 6.5 mm and 7.5 mm. If you need to add non-standard options to your Cell kit, make sure you are aware of this restriction.

Gas-flow Overview and Terminology

The Gas Bubbler Assembly may or may not be required for your experiment. Most of the cases in which you use it involve the removal of atmospheric oxygen from the test solution.

You can remove oxygen from your test solution by bubbling nitrogen, or another electrochemically inert gas, through the solution. This process is often (imprecisely) called de-aeration. It is more correctly called de-oxygenation. Other commonly used terms for the process of oxygen removal are gas-purging or sparging. At least 15 minutes of vigorous bubbling with nitrogen is required to remove most of the oxygen from a test solution.

Bubbling gas through your test solution can cause noise while you are running your experiment. To avoid this noise, you can stop gas purging during the data-acquisition phase of your experiment. Instead, you can flow the inert gas over the top of the test solution, often referred to as “blanketing” the cell. In general, blanketing is used after solution purging, where blanketing prevents acquiring new oxygen from the gas above the solution.

Many modern electrochemical test systems include automatic control of gas flow in their experimental sequencing. This is true of Gamry Instruments’ Pulse Voltammetry and Physical Electrochemistry systems. These systems generate a digital signal that is intended to control a solenoid valve, which in turn routes gas flow to the cell. Gamry’s VistaShield™ Faraday cage, when equipped with its Purge and Stir option, provides a complete solution for purge-gas control.

Pre-saturation of the Purge Gas

Bubbling dry purge gas through your cell electrolyte can cause significant evaporation of the electrolyte’s solvent during the purge process. This can be a significant source of error in some experiments. This problem can often be avoided by pre-saturation of the purge gas with the electrolyte prior to it entering the cell. This is commonly done using a “gas washing bottle,” which can be obtained at most laboratory supply companies.

The Cell kit does not include a gas washing bottle, for they are already available in many laboratories.

Cell Gas Bubbler Assembly

The standard gas bubbler assembly consists of four pieces: the Gas Flow Adapter, the Gas Bubbler Tube, a #7 ACE-Thred™ nut, and an ACE-Thred™-To-Hose adapter. A photograph of these pieces can be seen in Figure 2.

Figure 2. Gas Bubbler Assembly

Figure 2 is representative of the Gas Bubbler used for purge only (no blanketing). A plastic hose-barb is shown connected to the Gas Bubbler Tube, using the ACE-Thred™-To-Hose adapter. The other end of this hose is connected to a source of purge gas.

At Gamry, we often refer to the gas bubbler assembly as a three-way adapter, because it can be used to implement three functions: purge, blanket, and vent.

The vent function is critical. Regardless of whether gas is flowing through or over the test solution, you must provide a way for it leave the cell. If you, do not, the gas may not flow, or worse, the cell may burst apart unexpectedly. Not providing a vent for the escape of purge gas is a very common and often dangerous "mistake" made when setting up an electrochemical cell.

Warning: If you use purge of blanket gas, you ***must*** provide a vent for the gas to escape the cell. EuroCell was not designed to withstand gas pressure! Failure to vent the cell can cause damage to the cell, uncontrolled loss of electrolyte from the cell, and risk of personal injury to the cell's operator.

In normal use, the Gas Flow Adapter is installed in one of the 14/20 ground-glass ports on your Cell. The Gas Bubbler Tube, with an O-ring installed as shown in Figure 2, is slid into a #7 ACE-Thred™ port on top of the Gas Flow Adapter. When you are satisfied with position of the Gas Bubbler Tube, tighten the ACE-Thred™ nut.

Attaching Gas Tubing to the Cell

The position of the Gas Bubbler Tube is normally adjusted so its orifice end sits in the cell's electrolyte. The hose barb on the side of the Gas Flow Adapter can be used as a vent or as an inlet for blanket gas.

Warning: Your gas flow system should include a needle valve to control the gas flow rate. Make all gas tubing connections to the cell with this valve **turned all the way off**. Making connection with a cell filled with electrolyte or adding electrolyte to a system when the gas flow is on can lead to severe accidents. Excessive gas flow can damage the cell and result in a loss of electrolyte. In extreme cases, this can represent a significant safety hazard.

Connect the gas-flow system and add the cell electrolyte before the needle valve is turned on. Open the valve slowly, while you watch the bubbles in the cell. Bubbling should not be vigorous enough to splash large quantities of electrolyte on the cell walls.

In addition to the needle valve, a three-way valve is very useful in purge and blanket gas control. Three-way valves are available in both electrically switched and manual versions. A three-way valve switches one gas stream so it flows from a single inlet to one of two outlets.

If your system includes a three-way valve for switched purge and blanket gas control, we recommend that you:

- Connect the purge gas to the ACE-Thred™-To-Hose adapter on top of the Gas Bubbler Tube
- Connect the blanket gas to the hose barb on the side of the Gas Flow Adapter
- Use the spare port to provide a vent. A small hole poked into one of the polyethylene stoppers in the cell kit is generally a sufficient vent.

If you do not have a three-way gas-control valve, you can switch from purge mode to blanket mode manually. Connect the gas flow to the ACE-Thred™-To-Hose adapter. When you want to purge, loosen the ACE-Thred™ nut holding the Gas Bubbler tube in place, slide the Gas Bubbler Tube deeply into the cell so its orifice is in the cell solution, then retighten the ACE-Thred™ fitting. When you want to blanket, slide the Gas Bubbler Tube far out of the cell, so its orifice is above the solution. When you use the cell in this way, the hose barb port on the Gas Flow Adapter provides a convenient vent.

Counter Electrode Assembly

Counter Electrode Overview and Terminology

The counter electrode in a three-electrode electrochemical experiment is generally an inert metal or carbon electrode that provides a source or sink of electrons to the cell. Another term used for this electrode in the auxiliary electrode.

The electrochemist is generally not interested in the reactions that occur at the counter electrode. One exception is when the reactions at the counter electrode produce a soluble product that can diffuse to the working electrode and interfere with its operation. In this case, the electrochemist may want a diffusion barrier to isolate the counter electrode compartment from the rest of the cell. A glass frit is commonly used as an isolation barrier.

High-Density Graphite Counter Electrodes

Your Cell kit comes with a high-density graphite rod counter electrode (150 mm long × approx. 6.3 mm dia.). It fits nicely in a #7 ACE-Thred™ port. The Gamry Instruments part number for replacement graphite rods is 935-00014.

To use this graphite rod as the counter electrode in the Cell, slide the O-ring from the ACE-Thred™ port directly onto the graphite rod and place the rod into the port, until the desired length of the rod is immersed in the electrolyte.

The graphite rod that is shipped with your Cell is spectroscopic grade. It is very pure and therefore is unlikely to be a significant source of contamination in your initial experiment. However, the rod is somewhat porous and can adsorb substances present in your test solution. If you reuse a graphite rod, it can contaminate your test solution. The effect is small, and you are unlikely to see it unless the test solution changes drastically between tests.

Cell Counter Electrode: Optional Isolated Assembly

In the standard configuration of the Cell, the counter electrode is a graphite rod, which is immersed directly in the test solution.

In some cases, you may want your counter electrode isolated from the bulk solution by a glass frit. Gamry Instruments sells an Isolated Counter Electrode kit (Part Number 990-00194) that works with both the Cell and the PTC1 Paint Test Cell kit.

There are two pieces in this isolated counter electrode kit:

- A fritted isolation tube
- 150 mm of platinum wire.

A complete counter electrode assembly (without the platinum wire) is shown in Figure 3. Note the placement of the required O-ring between the nut and the fritted end of the tube.

Figure 3. Counter Electrode Isolation Tube

The fritted tube is slid into a #7 ACE-Thred™ port on the cell. Slide the platinum wire into the isolation tube. The lower end of the platinum wire must be in contact with electrolyte. A sharp bend in the platinum wire at the upper rim of the isolation tube can help prevent loss of contact between the electrolyte and the platinum. When the counter electrode wire is clipped to the platinum wire below this bend, gravity helps keep the counter electrode in place.

Reference Electrode and Bridge Tube

Overview and Terminology

Most modern electrochemical measurements are performed using a three-electrode potentiostat. The cell includes a reference electrode that has a constant electrochemical potential. All working-electrode potentials are measured with respect to this reference electrode.

In many cases, placing the reference electrode directly in the test electrolyte can be a problem. Examples include:

- When the reference electrode is large, making it inconvenient to use in a small volume
- When the reference electrode's filling solution will contaminate the electrolyte
- When the cell is heated and you do not want the reference potential to change with cell temperature

To avoid these problems, Cell always uses a bridge tube to locate the reference electrode above the cell. The bridge tube is a glass tube filled with electrolyte that provides a conductive path from the cell electrolyte to the tip of the reference electrode. The electrolyte in the bridge tube is usually identical to the cell electrolyte, but in some cases a different electrolyte may be necessary.

A bridge tube is similar, but not identical, to a Luggin capillary. A Luggin capillary attempts to move the "sensing point" of the reference electrode close to the working electrode's surface. The bridge tube in Cell has too large a tip for it to qualify as a true Luggin capillary.

The bridge tube in Cell is particularly convenient, because it terminates in an unfired glass frit, which makes filling the bridge tube easy yet doesn't add a lot of resistance to the reference electrode circuit. Most other bridge tube or Luggin capillary designs either have excessive resistance causing noisy data, potentiostat oscillation, or are difficult to fill with electrolyte.

Bridge Tube and Reference Electrode Assembly

Figure 4 shows the Cell Bridge Tube and Reference Electrode. Note the placement of the O-rings. These O-rings are critical in sealing the ACE-Thred™ fittings holding this assembly together.

Figure 4. Reference Electrode Bridge Tube

The Cell does not include a reference electrode, because different tests may call for different reference electrode types. The reference electrode shown in Figure 4 is Gamry's standard saturated calomel reference electrode (SCE) P/N 930-00003. Gamry also offers an Ag|AgCl reference (P/N 930-00015) and a $Hg|Hg_2SO_4$ reference (P/N 930-00029). Contact your local Gamry sales representative if you need a new or a replacement electrode.

The Cell can be used with third-party reference electrodes, if the reference electrode diameter is between 9 and 10.5 mm.

To fill, assemble, and install the bridge tube and reference electrode:

1. Place an O-ring and #7 ACE-Thred™ fitting on the middle section of the bridge tube (see Figure 4).
2. Place an O-ring and #11 ACE-Thred™ fitting on the reference electrode (see Figure 4).
3. Pour electrolyte into the larger diameter end of the bridge tube, leaving about 2.5 cm between the bottom of the ACE-Thred™ and the top of the electrolyte.
4. Place the reference electrode, tip first, into the larger end of the bridge tube and tighten the #11 ACE-Thred™ fitting until it is finger tight and the reference electrode is held in place.
5. Place the smaller end of the bridge tube into one of ACE-Thred™ ports on your Cell.
6. Adjust the height of the bridge tube so that its tip will be in the electrolyte and close to the working electrode.
7. Tighten the bridge tube's #7 ACE-Thred™ fitting until it is finger-tight and the bridge tube is held firmly in place.

Bridge Tube and Reference Electrode: Maintenance and Care

The unfired glass-frit tips used on both the reference electrode and the bridge tube are subject to cracking when allowed to go from a wetted to a dry state.

Caution: Do not allow the glass frits on the reference electrode or the bridge tube to dry out. They are likely to crack, greatly increasing the flow of bridge-tube or reference filling solution into your cell. If the frit does dry out, we recommend that you replace it.

Your Cell kit contains three replacement frits with heat-shrinkable PTFE sleeves. Use one of these whenever you need to replace a damaged frit.

Whenever possible store the bridge tube tip in the electrolyte used in your system. Place the bridge tube tip down, in a flask containing the electrolyte you use in your tests.

If you cannot keep the frit wetted with electrolyte, you can store the bridge tube tip in the solvent that it will be exposed to during testing. In aqueous testing, always use high quality de-ionized or distilled water. The glass frits have a very large surface area which absorbs contaminants from impure solvents.

Periodically, it may be necessary to replace the glass frits on the reference electrode and bridge tube. The Cell comes with three spare glass frits with heat-shrinkable PTFE tubing.

To replace the frit of the bridge tube:

1. Make sure the bridge tube is clean and dry.
2. Cut the old frit off with a sharp blade, taking care not to cut yourself.

Warning: Be careful when cutting off the old fit, to prevent injury. Never cut towards your body.

3. Turn the tube upside down and place the PTFE sleeve over the end of the tube.
4. Insert the piece of glass frit in the sleeve and then heat the sleeve with a heat gun to shrink the PTFE sleeve around the glass frit.

Warning: Heat guns can burn your skin. Be careful!

5. Trim the sleeve to be flush with the exposed end of the glass frit.

A similar procedure can be accomplished with the reference electrode, however it may be difficult to empty. Instead, just turn it upside down and keep the solution away from the tip.

The reference electrode is also supplied with a clear plastic sleeve covering a fill hole in its glass body. This fill hole serves two purposes:

- It allows you to refill the electrode with saturated KCl if the liquid level in the electrode drops.
- It also provides a vent, so the filling solution flows slowly out of the electrode.

In normal use, we recommend that the fill hole be kept slightly open. When storing the electrode, the fill hole should be closed.

If the electrode or the bridge tube has been stored in a pure, poorly conductive solvent, the glass-frit tip must refill with ions prior to use. In the case of the reference electrode, half an hour with the vent hole open should suffice. In the case of the Bridge Tube, half a hour with a vented reference electrode in place should also be sufficient.

Gamry's Reference electrodes are shipped with a black plastic sleeve covering the electrode tip. This tip is effective in keeping the reference electrode's glass-frit tip wet. A plastic sleeve on one side of Bridge Tube's glass-frit tip will not keep the bridge tube tip wet, unless the tube is filled with solvent or electrolyte.

Caution: Do not use a plastic sleeve to cover the Bridge Tube's glass-frit tip, unless the other side of the tip is covered with solvent or electrolyte. If the tip dries out, it is likely to crack, causing irreproducible results in your electrochemical tests.

Spare Port

The normal Cell configuration includes a spare 14/20 port. If you never ever use this port, you can cap it with one of the 14/20 plastic stoppers included in your cell kit. Remember to poke a vent hole in this stopper if you will have gas flowing into your cell and there is no other gas vent available.

You can also use this spare port for customizing your system. A few examples are listed below.

Addition of corrosive agents

In many experiments, you record a baseline curve before you add a vital reactant to the cell. You then add that reactant, stir the cell, then record another curve. Many of Gamry's analysis packages allow you to subtract the baseline curve from the data curve. The resulting curve shows only electrochemistry related to this reactant.

Another common use for added reactant is current-versus-concentration studies.

To add reactant, remove the stopper, add the reactant, then replace the stopper.

Temperature Sensing and Control

The rate of almost all chemical reactions is strongly temperature-dependent. For this reason, you may want to either measure or control the temperature of your cell.

Ace Glass has thermometer adapters that are designed to mount a standard lab thermometer to a 14/20 ground-glass joint. One example is Ace part number 5028-26. This is a convenient way to add temperature measurement to your system.

In many cases, temperature must be controlled, not measured. One way to do this is:

1. Purchase the jacketed option for the Cell. This is a special cell body (Gamry part number 930-00041) that allows a flowing temperature-transfer fluid to encase the cell.
2. Plumb the jacket on the cell to a recirculating constant-temperature bath.
3. If the bath offers remote temperature sensing, place a sensor in the spare port of the cell. This may require purchase of another option (for example an RTD-to-14/20-port adapter).

4. In some cases, Gamry's software supports setting automatically the temperature. Add the controlled temperature to the experiment's Setup window, and the software controls the temperature bath via an RS-232 port. In other cases, a modified script is required.

Addition of a pH electrode

Another possible use for the space port is addition of a pH electrode. Again, an adapter is required.

Getting a Stir Bar into the Cell

If you want to magnetically stir, and you forget to add a stir bar to your cell, you can add it using the spare port.

Moving the Pieces About

There are several circumstances in which the standard cell configuration may not work. One is a larger-than-normal working or reference electrode.

There is no requirement that any electrode or adapter mount in any specific port. However, the main port (24/40 joint) has the largest diameter of all the ports.

Electrode Connections

If you are using your Cell with a Gamry Instruments potentiostat, make the following connections to the electrodes.

The Reference Electrode lead plugs into the white pin jack on the cell cable.

The green and blue leads from the cell cable are attached to the Working Electrode. Cell currents in a Cell experiment are often large enough that you should clip the blue and green leads separately to the working electrode.

Some potentiostats may not include a blue clip lead. In this case, connect only the green lead to the Working Electrode.

The red lead on the cell cable clips to the Counter Electrode.

Make sure that the long black lead on the cell cable cannot touch any other cell connection. You may find that connection of this lead to a source of earth ground, such as a water pipe, will reduce noise in your experimental results.

If you are measuring very small currents, you may find that a metal enclosure completely surrounding your cell will further reduce noise. In this case, connect the shield, known as a Faraday cage, to an earth ground. Then connect the black lead from the cell cable to the Faraday shield.

Gamry's VistaShield™ is a versatile, easy-to-use Faraday cage that was designed to work well with the Cell kit. When equipped with a Purge and Stir option, it provides a complete electrochemical corrosion test stand, well integrated with Gamry's cells, potentiostats, and software systems.

Always double-check your cell connections. Even an experienced experimentalist will occasionally leave one of the cell cable leads lying on the desktop.

Troubleshooting

By far, the most common source of problems is lack of a connection between a cell lead and the cell electrolyte. The lack of connection can be between the potentiostat and the electrode, or between the electrode and the electrolyte.

One very common and often embarrassing error is to forget to connect one of the cell leads! Always double-check your cell connections.

A more subtle problem is a gas bubble blocking an electrode's access to the electrolyte. Places where this can happen include:

- Purge gas or gaseous reaction products collecting on the face of the working electrode.
- The counter electrode wire is not in the solution.
- If you have a counter isolation tube, it can fail to fill with electrolyte.
- The Reference Bridge tube contains a bubble between the reference electrode and the electrolyte.
- A bubble collects on the glass frit at the end of the reference electrode.

Another common problem is two electrodes shorting together (coming into mutual electrical contact). This can occur within the cell (especially with a bare-wire counter electrode). It can also occur between the cell cable connections.

This section of the manual is organized as a list of problems that you may encounter. Following each problem is a list of some possible causes for that problem. Neither the list of problems nor the list of their causes is comprehensive.

This troubleshooting guide only applies if you are running a potentiostatic experiment on the cell. Galvanostatic experiments show different symptoms.

Very small current or no current when you run an experiment but no overload indication

- The working electrode (green) lead in the cell cable is not connected to the cell properly.
- There is a gas bubble completely blocking the face of the working electrode.

  Stop the experiment, fix the error, and restart. The working electrode is not damaged.

Very small current or no current when you run an experiment, with a control amplifier overload

- The counter electrode (red) lead in the cell cable is not connected to the cell properly.
- The counter electrode is partially pulled out of the cell.
- If your cell includes a counter electrode isolation tube, it has not filled with electrolyte.

  Stop the experiment, fix the error, and restart. The working electrode is not damaged.

Full-scale current and voltage when you run an experiment, many overloads

- The reference electrode (white) lead in the cell cable is not connected to the cell properly.
- The working sense (blue) lead in the cell cable is not connected to the cell properly.
- You have incorrect experimental settings (e.g., wrong potential).

- Two of your electrodes are shorted together.
- There is a gas bubble in the Luggin capillary.

  Large currents have passed through the working electrode. It may need to be resurfaced or replaced.

Noisy Cell Current—overloads may be present

- Your de-oxygenation gas is still bubbling through the solution.
- You have a high impedance in the reference electrode path.
- There is a gas bubble in the Reference Bridge Tube.
- You are picking up noise: try a Faraday cage.

Excess back pressure required to bubble deoxygenation gas

- No vent is available for the gas to escape.

Poor Experimental Reproducibility

- A variable amount of test solution is leaking underneath the PTFE Compression Gasket. It does not have to actually reach the inside of the sample holder tube to have an effect.
- Your cell, solution, or working electrode surface has a contamination problem. Carefully clean the cell and components. Avoid touching the wetted surfaces of these parts.
- Contaminants are entering the cell from the graphite counter electrode.
- Your electrochemical system is inherently irreproducible. This is often true of localized corrosion phenomena.

Specifications

Cell

Volume	175 mL maximum	
	125 mL minimum	
Port Types	One 24/40 standard taper ground-glass joint	
	Two 14/20 standard taper ground-glass joint	
	Two #7 ACE-Thred™ ports	

Reference Electrode

Size	9 to 11 mm diameter	(using the standard bridge tube)

Working Electrode

Diameter	7 to 9 mm	(using the adapter supplied with the cell)
Length	50 mm minimum	(using large cell volumes)

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