MultiPort

Electrochemical Cell Kit

Operator's Manual

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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. Do not ask us to supply metal samples in materials other than C1018 Mild Steel. See the Introduction section of this manual for a source of metal samples.

Disclaimer

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Table of Contents

Introduction

The Gamry Instruments MultiPort™ Cell Kit was designed for simple, reliable operation. The cell is normally used to run electrochemical tests on standard cylindrical metal specimens. You can also customize the cell for use with other sample types.

A commercial source of suitable cylindrical specimens is the P/N 410 series from Alabama Specialty Products. They have cylindrical samples available in several hundred different metals. They can be contacted at:

Metal Samples Co., Inc.
152 Metal Samples Road
P.O. Box 8
Munford, AL 36268 USA

Telephone: (256) 358-4202
Fax: (256) 358-4515
Email: msc@alspi.com

Your Corrosion Cell kit was shipped with one Metal Samples, Inc. P/N 410 Series samples. The sample material is C1018 mild steel.

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 MultiPort uses four of the seven 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 temperatures can be vital in gaining a full understanding of a chemical system. For these reasons, Gamry sells a special jacketed version of the MultiPort cell body. When this cell is connected to a circulating water bath, accurate temperature control of your experiments becomes possible.

Chemical Compatibility of the MultiPort Cell Kit

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

- The corrosion sample
- 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 a 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 MultiPort 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, do not forget the need to vent purge gas from the cell.

Unpacking and Checking Your MultiPort Cell Kit

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

Checking for Shipping Damage

Your MultiPort Cell Kit is shipped disassembled to prevent 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 sometimes occurs.

When you first receive your MultiPort 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 Corrosion Cell packing list in Table 1. When shipped, all of the Corrosion 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 Figures 1 and 2 later in this manual.

Table 1
MultiPort Cell Kit Packing List

Quantity	Gamry Part Number	Description
1	988-13	Manual, MultiPort Cell Kit
1	930-53/930-54	Cell Bottom, (standard/jacketed with hose barb adapters through #11 bushings)
1	930-52	Cell Top, (incl. three #7 bushings with O-rings)
1	935-18	Cell Flange Clamp
1	935-77	PTFE encapsulated silicone O-ring for flange
1	930-55	Reference Electrode Bridge tube with glass-frit tip (incl. #11 bushing with O-ring)
1	930-50	Adapter SJ28 to #7 (with bushing and O-ring)
1	935-73	Clamp, SJ28 Ball Joint
1	930-48	Gas Dispersion Tube
1	935-3	12” Graphite Rod, Counter Electrode
1	935-5	Adapter, 24/40 to 8 mm Tube, PTFE
1	930-51	Tube, Cylindrical Specimen Holder, Pyrex
1	820-51	Rod, Cylindrical Specimen Holder, Stainless Steel
1	820-1	Compression Gasket, PTFE
1	820-4	Centering Washer, Polypropylene
1	850-5	Standoff, Hex 8-32 x 1/2", S. Steel
1	820-5	Cylindrical Specimen, C1018 Mild Steel
5	935-76	Polyethylene Stoppers for 24/40 Joint
2	935-74	Polyethylene Stoppers for 24/40 Joint
1	935-53	#11 Bushing, with O-ring
3	930-42	Spare Glass Frit with PTFE sleeve

Contact us as soon as possible if any of the parts are missing. Our address and phone numbers are immediately following the title page of this manual.

Assembly

This section of the manual tells you how to assemble the kit's components into a complete MultiPort Cell. The descriptions are based on a "standard" cell configuration consisting of a cylindrical-metal sample working electrode, a graphite-rod counter electrode, a single-junction reference electrode in a reference bridge tube, and a gas dispersion tube.

Your kit was shipped to you with one C1018 mild-steel metal sample. Use this sample to try out the assembly of your cell as you read this section of the manual.

Feel free to customize your cell configuration. You are only limited by your imagination and the number and size of the ports available on the top of the cell.

General Information

A diagram of an assembled cell is shown in Figure 1. The basic setup makes use of four of the seven available ports (five of the seven ports are clearly visible in the figure). A more detailed diagram of the working-electrode assembly is shown in Figure 2.

If you are assembling your MultiPort Cell for the first time, you may want to assembly the entire cell dry first. After you are comfortable with the cell's assembly, you can fill the cell with a test solution and run real tests.

Three of the ports on the cell top are 24/40 ground-glass female joints, one is a 15/28 ground-glass female ball joint, and the other three are #7 glass thread joints. The central (24/40) port is used for the Sample Holder (the Working Electrode). The ball joint is intended for use with the included adapter and bridge tube for the reference electrode. The included gas dispersion tube (bubbler) fits either of the remaining 24/40 joints, and the counter electrode is intended for one of the #7 glass thread joints.

Caution: In vacuum work in a chemical laboratory, ground-glass joints are often greased. This is unnecessary with the MultiPort, 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 MultiPort.

The base of the MultiPort is flat. The cell can stand up on a lab bench as long as it is not subject to accidental jostling. If you are concerned that it might be knocked over, clamp the cell to a ring stand, available from laboratory supply houses.

Caution: The cell can be damaged and valuable data can be lost if the cell topples over. Ensure that the cell is stable on your work surface.

Pay careful attention to cell cleanliness. In many corrosion-testing situations, contaminants in the cell and test solution are not a problem if you take minimal precautions. In other cases, trace contaminants can lead to poorly reproducible results. One example is a study of corrosion in tap water.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.

Figure 1
Assembled Cell: Standard (left) and Jacketed (right) Versions

The MultiPort 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™ fittings 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 specific diameter objects. 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 MultiPort kit, make sure you are aware of this restriction, for this joint type is two of the three "spare" ports.

Main Cell Assembly

Assembly of the cell starts with placing the Cell Top onto the Cell Bottom, with the O-ring in the O-ring grove on the Cell Bottom flange.

The Cell Clamp holds the top and bottom together. This clamp is a draw type. With the draw portion released, fit the clamp around the flange, then fit and secure the clamp on the hooks and push the bar back to bring the ends together. If necessary the clamp can be loosend or tightened either by fingers or using a flat-head screwdriver.

Caution: The cell requires very modest clamping force. If you have difficulty closing the clamp, loosen the bar and try again. **Do not force** the clamp or tighten it beyond what is necessary to keep the top from sliding or rotating against the bottom (and even that degree is unnecessary in many cases). Overtightening can result in damage to the cell.

Figure 2
Main Cell Assembly

Bridge Tube and Reference Electrode

The Bridge tube fits any of the #7 ports on the top, but it is designed for the #7-to-15/28 adapter included. It can be adjusted in depth and position. Generally position it with the tip near the sample but not touching. Always use the included ball-joint clamp, for the joint is not stable without it.

The bridge tube allows the reference electrode to be placed outside the test solution, isolating it from thermal-gradient experiments and more caustic test solutions. Ensure that the bridge tube is filled to the tip with a conductive solution (the test solution when possible) for ideal performance of the reference electrode.

Insert the reference electrode into the #11 thread at the upper end of the bridge tube. The reference electrode must contact the test solution inside the tube. Various reference electrodes that work with this system are available; contact us for details.

Figure 3
Reference Bridge Tube

Counter Electrode

The Counter Electrode is a rod of very-high-density graphite.

To fit the counter electrode to the cell, first roll on one of the small black washers. With the washer on, feed the counter through any of the available #7 ports on the top and secure with a bushing. Leave at least half an inch exposed for electrical contact.

The graphite rod that is shipped with your MultiPort Cell Kit is spectroscopic grade. It is very pure and is therefore 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. If this is a concern to you, consider a platinum counter electrode, possibly with a fritted glass tube (available from us) to isolate it further from the test solution.

Gas-flow Overview and Terminology

The Gas Dispersion Tube 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.

Oxygen is an electrochemically active gas. Its reduction can act as the cathodic half-reaction in a corrosion reaction. You probably want to remove oxygen from the solution whenever the real-world corrosion system that you are modeling is oxygen-free.

Remove oxygen from the test solution by bubbling nitrogen, or another electrochemically inert gas, through the solution. This process is often (imprecisely) called *deaeration*. It is more correctly called *deoxygenation*. At least half an hour 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, 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' PV and PHE software. These sets of software 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 a Purge and Stir option, provides a complete solution for purge gas control.

Pre-saturation of the Purge Gas

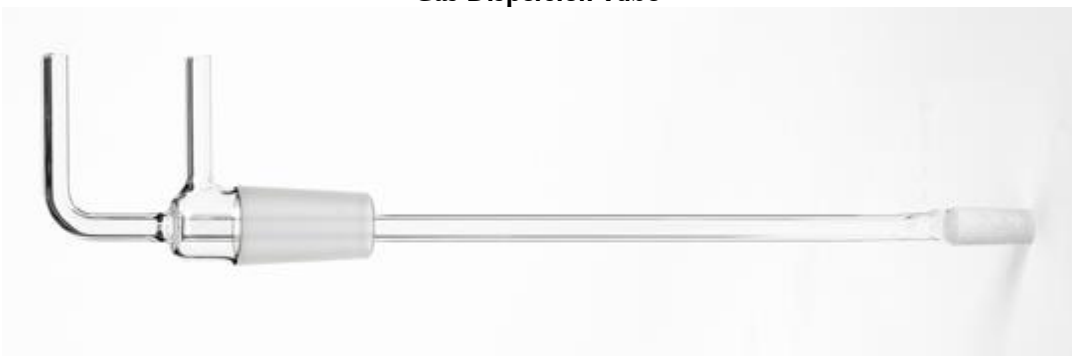
Bubbling dry purge gas through your cell electrolyte can cause significant evaporation of the electrolyte's solvent during the purge process. This can be a significant source of error in some experiments. This problem can often be avoided by pre-saturation of the purge gas with the electrolyte prior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

The MultiPort does not include a gas washing bottle, because they are already available in many laboratories.

Gas Dispersion Tube

In the MultiPort, gas-flow control is via a gas dispersion tube that fits a 24/40 standard taper. 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.

Figure 4
Gas Dispersion Tube



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. The MultiPort 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.

Attaching Gas Tubing to the Cell

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 top adapter on of the Gas Dispersion Tube.
- Connect the blanket gas to the lower adapter of the Gas Dispersion Tube.
- 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 by switching the tubing from the top to bottom hose barb.

Sample Holder Assembly

The Sample Holder is generally the last part inserted into the cell. If you are deoxygenating your test solution, do so before placing the Test Sample into the solution.

Take great care to insure that the surface of your test sample is not altered prior to the test. Avoid contacting the sample with your fingers. You may want to degrease the metal sample mounted on the Sample Holder just prior to starting your test.

Sample surface finish and other sample preparation are critical if you want to obtain reproducible results. Consult the corrosion measurement literature for details about the handling of corrosion test specimens. Most of the surface preparation techniques used for weight-loss coupons are also applicable to electrochemical test specimens.

A diagram of an assembled Sample Holder can be seen in Figure 5. A threaded rod is used to hold the assembly together and to provide electrical contact with the metal sample. The PTFE Compression Gasket is used to prevent leakage of solution into the interior of the glass rod. The sealing surfaces of this gasket must be smooth or a good seal cannot be obtained.

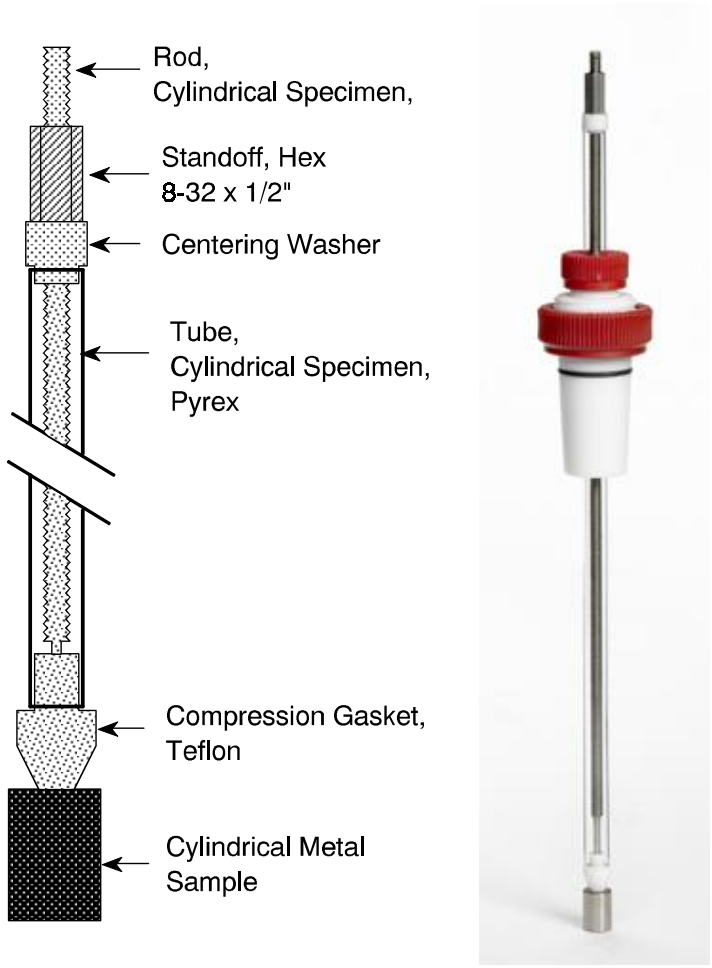
Put together the assembly loosely before tightening the Hex Standoff. Consult the diagram in Figure 5 for the position of the Sample Holder components. The centering washer has a small protrusion on one surface; the other surface is flat. The side with the protrusion side faces into the glass tube.

Tighten the Hex Standoff at the top of the assembly while you hold the metal sample on the other end. Only tighten the assembly finger-tight.

Caution: Never use a wrench to tighten the Sample Holder Assembly. Doing so can damage the PTFE Compression Gasket or even break the glass tube.

A **small** amount of bending in the glass tube may occur when you tighten the assembly. This is normal and no cause for concern.

Figure 5
Sample Holder Assembly (pictured with 24/40 port adapter)



Inserting the Sample Holder into the Cell

1. Place the assembled Sample Holder into the 8 mm PTFE-tubing adapter.

2. Loosen the smaller of the two knurled nuts on the adapter.

3. From the bottom of the adapter, slide the top of the Sample Holder into the adapter's central hole. The Hex Standoff and Centering Washer should easily pass through the adapter.

4. Leave approximately 8 cm of the of the glass tube extending below the adapter. When you have the tube at the desired position, tighten the smaller knurled nut again.

5. Insert the PTFE adapter into the central hole in the Cell Top. Be careful that the sample doesn't hit the bridge tube.

6. Once you insert the sample holder, watch the glass tube to see that it does not fill with the test solution. You are interested in the electrochemical behavior of your sample, not that of the stainless-steel rod holding the sample in place. Leaks can be the result of:

- A damaged PTFE Compression Gasket
- A scratch or other imperfection in the sealing surface on the sample
- A chip on the end of the Glass Tube

The larger knurled nut on the adapter is used when it is time to remove the adapter. Without this nut, it is difficult to grab the adapter firmly enough pull it out of the Cell Top. By turning the nut so that it presses against the top of the cell, you can easily remove the adapter, no matter how deeply it is in the cell top.

Electrode Connections

If you are using your MultiPort 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 MultiPort 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 MultiPort 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.

Customizing Your Cell

The MultiPort was designed to have options available even while fully accommodating the ASTM G5 standard. There are seven total ports and only three or four necessary for most experiments (five or six for full ASTM G5 compliance with opposed counter electrodes and a thermometer or temperature probe). With anywhere from one to four spare access ports and a two-piece cell design, customization options are myriad. Some common modifications to experiments are mentioned 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.

In either case the additional ports allow you to make changes to the solution easily.

Temperature Sensing and Control

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

Many thermometers will fit the standard bushing for a #7 thread. This is an 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 corrosion cell. This is a special cell body 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).

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. 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.

Selected Specifications

Cell

Volume	1000 mL standard operating volume		
Port Type	24/40 standard taper	15/28 socket	#7 glass thread
Number of Ports	3	1	3

Working Electrode

Threaded Hole	US 3-48 Coarse Thread
Area under Gasket	0.03 $in.^2$ nominal 0.20 cm^2 nominal

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 amp 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 is 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 Reference Bridge Tube.

  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 path is available for the gas to escape.

Poor Experimental Reproducibility

- A variable amount of test solution is leaking under the PTFE Compression Gasket. The solution 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; often true of localized corrosion phenomena.

Index

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