Model 443 and Model 483 Slab Dryer

Instruction Manual

BIO-RAD

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SECTION 1
INTRODUCTION

Bio-Rad's slab dryers, the smaller Model 443 and the high capacity Model 483, produce perfectly flat, dried gels with a smooth glossy surface, and provide excellent preservation of high resolution gels from such applications as SDS-PAGE,* 2-D, DNA sequencing and IEF. High percentage or gradient gels (hard to dry gels) also dry crack-free when the instructions in this manual are followed.

*Abbreviations: SDS-PAGE (sodium dodecyl sulfate-polyacrylamide gel electrophoresis), 2-D (two-dimensional electrophoresis) and IEF (isoelectric focusing).

SECTION 2
SOME THEORY AND OBSERVATIONS ON GEL DRYING

2.1 Measurement of Vacuum

Vacuum is commonly measured in " Hg (inches of mercury), in torr or mm Hg (these are equivalent units), or μm (microns or micrometers). By definition, a perfect vacuum at sea level is equal to 0 torr or 29.92" Hg negative pressure.

An important concept when measuring vacuums is the distinction between gauge pressure and absolute pressure. Absolute pressure is measured relative to atmospheric pressure at sea level. In terms of absolute pressure, values from 0 up to 760 torr indicate vacuums, with 0 torr being a perfect vacuum and 760 torr being 1 atm pressure. However, standard gauges are generally designed with a diaphragm vented to the environment on one side, and the measuring port on the other. By definition 1 atm at sea level is 0 gauge pressure. Vacuums are considered to be negative pressures with 29.92" Hg being a perfect vacuum. The relationship between gauge pressure and absolute pressure is:

$$\text{Absolute Pressure} = 1\ \text{atm} + \text{Gauge Pressure}$$

Note that the units must be consistent, and that the gauge pressure is a negative value, even though the face of the gauge does not say so.

Conversion between torr and " Hg is made using the following relationship:

$$y\ \text{torr} = 760 - (x\ \text{inches Hg})\ (25.4\ \text{mm/inch})$$

In practical terms, this means that the larger the " Hg, the better the vacuum, but the smaller the torr or mm Hg or μm, the better the vacuum. Using this information, the weakest vacuum specified with the PROTEAN™ II dryers is 25" Hg or 125 torr. At this level, homogeneous gels of 12.5% T or less should dry smooth and crack-free. However, experience has shown that hard to dry gels (gels >14% T or gradient gels of any acrylamide concentration) require a much stronger vacuum to dry satisfactorily. We recommend a vacuum of at least 28" Hg (48.8 torr) or better for these types of gels, and we guarantee crack-free drying of these gels only if these vacuum conditions are provided. If these hard to dry gels are dried between two pieces of cellophane membrane, then vacuum of .010 mm or 10 μm or better must be provided.

Note:
Some laboratories use a manometer, which can be filled with any suitable liquid. The units here would be cm of pressure for the liquid used. This method of measuring vacuum will not be discussed further, since it is not common and since conversion to any of the above units would depend on the liquid used.

2.2 Vacuum Pump Specifications

The PROTEAN II dryers generally dry 10% or 12% gels without cracking in a little over an hour using "house vacuum." House vacuum systems in most institutions are large water aspirator vacuum pumps with a variable specification of 20 to 23" Hg. Of course, as the vacuum is used during the day, the actual vacuum pressure will vary, often sinking to less than 20" Hg. This variation in the vacuum can cause gels to crack, even though the vacuum seal does not break at the dryer.

In-lab water aspirators connected to a sink faucet rarely obtain a vacuum better than 20" Hg, and are **not recommended** for gel drying. If this is the only vacuum source available, drying gels will take longer. If gels crack using the 80° heat setting, the 60° setting should be tried.

For the best results, an oil (mechanical) vacuum pump is recommended. The vacuum attained by these pumps is generally 10 μm (0.01 torr) or better. The capacity of an oil vacuum pump used for drying gels should be 20 to 30 liters/min or more. A freeze-dryer or lyophilizer pump is also excellent, and convenient, because the vacuum trap is built in. Some kind of trap should be used with oil vacuum pumps, to protect the pump. Otherwise, the methanol, acetic acid, and water, or other chemicals from the gel, will travel directly into the pump and cause serious damage. A simple trap to set up in the lab consists of a 2 liter side arm flask set into a bucket of dry ice bits. The dry ice has to be replenished often enough to keep all vapors leaving the gel frozen in the side arm flask. The oil in the pump should be checked frequently, and changed as necessary.

Finally, only vacuum tubing should be used to connect the gel dryer to the trap and pump. If non-vacuum tubing is used, it may collapse. Then no water vapor can pass out of the gel and dryer, and the gel will dry very slowly or not at all.

2.3 Factors Affecting Gel Drying

The function of the vacuum in drying gels is two-fold. Lowering the pressure around the gel enhances evaporation of the bound liquid. The vacuum also serves to hold the gel rigidly in place. Once the vacuum seal is made, the silicone sheet over the gel keeps it flat and prevents any shrinkage or distortion from occurring during the drying process. If the vacuum is weak, the dehydration process takes longer. Also, with less pressure holding the gel in place, there is more likelihood that movement in the gel can occur, leading to gel cracking.

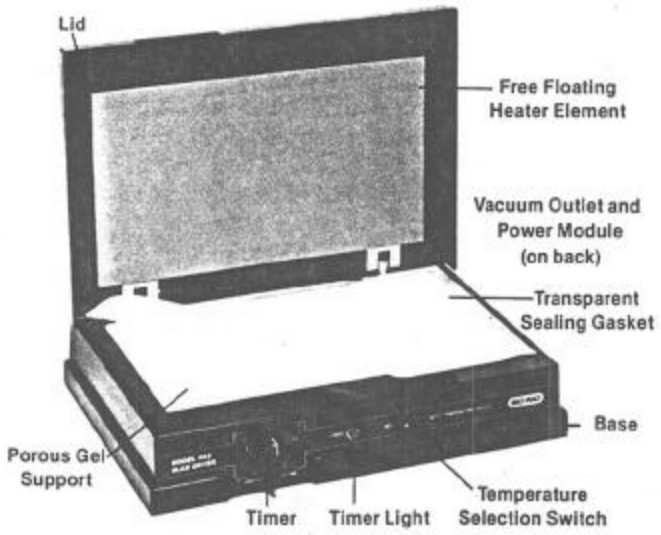
According to thermodynamics, fluid can be maintained in the vapor phase with the proper combination of vacuum and temperature. Theoretically, as shown in the Mollier Diagram,[1] the higher the temperature used, the weaker the vacuum that can be used. The diagram shows that at 60°C water will remain in the vapor phase at vacuums greater than 26" Hg. At 80°C water will remain in the vapor phase at vacuums greater than 25" Hg. At lower vacuums or temperatures, some fluid will remain in liquid form. This implies that if the vacuum is not very good (e.g. 20" Hg instead of 25" Hg), then if the temperature is raised, the gel will still dry nicely. However, the problem with this in practice is that at higher temperatures, the gel will be under high thermal stress. That is, the water vapor pressure will increase and push against the gel matrix as the water vaporizes. If the vacuum is insufficient to hold the gel in place, the gel matrix will distort and crack.

It should also be noted that if polymerization is poor (too fast or too slow), or uneven (due to impurities in the chemicals used), it is more likely that mechanical and thermal stresses on the gel during drying will cause cracking.

Reference

1. Reynolds, W. C. and Perkins, H. C., **Engineering Thermodynamics**, 2nd edition, McGraw Hill, 602 (1977).

SECTION 3
DESCRIPTION OF MAJOR PARTS



3.1 Free-Floating Heater Element

The gel is dried by controlled heat, evenly distributed on the top surface of the gel. The heater element is suspended from the lid. As the gel dries, the weight of the element presses down on the gel so that good contact with the gel is assured. The heater maintains the temperature at a constant 80°C for rapid drying, or at 60°C for gels impregnated with fluors for autoradiography. The heater circuit also contains an overheat protection, in the form of a third thermostat set at 95°C, to prevent cracking due to too rapid drying.

3.2 Transparent Sealing Gasket

The gels can be viewed clearly through the transparent sealing gasket during the drying cycle. The transparency of the gasket allows you to determine when the gels are dry. Gels can be checked without breaking the vacuum seal simply by opening the lid. The gasket can be easily removed from the dryer for cleaning or replacement.

3.3 Porous Gel Support

The vacuum is distributed evenly over the entire drying surface by the porous gel support, the pores of which average 120 μm in size. The liquid in the gel is pulled directly down (not at an angle). The application of heat from above combined with the evenly distributed vacuum dries the gel to a smooth flat sheen. Soft IEF gels dry with high resolution separations clearly preserved, because the evenly distributed vacuum prevents any sideways stretching or distortion of the gel.

3.4 Dryer Body

The tough polycarbonate body houses the dryer components, all of which are selected for durability. It also protects the user from the heat generated during drying. Finally, it protects the drying surface and circuitry from outside damage. This design, and our high quality control standards, assure a long, trouble-free life for the unit.

SECTION 4
EQUIPMENT

4.1 Specifications

Dryer body:	Polycarbonate	
Gel support plate:	Porous polypropylene, average 120 μm pore size	
Sealing gasket:	Transparent silicone rubber	
Heating element:	2.5 W/in², 0.4 W/cm²	
Vacuum source:	User must provide a vacuum source of at least 125 torr (25 inches Hg). We guarantee crack-free drying when a mechanical oil vacuum pump is used. We recommend a pump with a rating of 10 μm or better and a capacity of 20 l/min or better.	
	Model 443	**Model 483**
Drying surface:	20 × 35 cm	35 × 45 cm
Weight:	3.8 kg	5.4 kg
Dimensions:	10 × 43 × 30 cm	10 × 53 × 46 cm

4.2 Instruments and Accessories

Catalog Number	Description	Country
Model 443 (20 × 35 cm drying area)		
165-1960	**Slab Dryer,** 100V	Japan
165-1961	**Slab Dryer,** 120V	U.S., Canada
165-1962	**Slab Dryer,** 220V	Europe
165-1963	**Slab Dryer,** 240V	UK, Australia
165-1968	**Porous Gel Support,** 20 × 35 cm	
165-1969	**Transparent Sealing Gasket,** 23 × 38 cm	
165-0922	**Cellophane Membrane Backing,** 18 × 34 cm (50 sheets)	
165-0929	**3 MM Filter Paper,** 18 × 34 cm (25 sheets)	
Model 483 (35 × 45 cm drying area)		
165-1964	**Slab Dryer,** 100V	Japan
165-1965	**Slab Dryer,** 120V	U.S., Canada
165-1966	**Slab Dryer,** 220V	Europe
165-1967	**Slab Dryer,** 240V	UK, Australia
165-1970	**Porous Gel Support,** 35 × 45 cm	
165-1971	**Transparent Sealing Gasket,** 38 × 49 cm	
165-0963	**Cellophane Membrane Backing,** 34 × 45 cm (50 sheets)	
165-0969	**3 MM Filter Paper,** 35 × 45 cm (25 sheets)	

4.3 Replacement Power Cord

Power cords are provided unattached to the unit. The power cords are specific by plug type for each country. If a power cord needs replacement, please order according to the following table.

Catalog Number	Country
167-9000	Austria, Belgium, France, Germany and The Netherlands
167-9001	Switzerland
167-9002	England
167-9003	Italy
167-9004	Australia
167-9005	U.S., Canada, and Japan
167-9006	Denmark

SECTION 5
PROCEDURE FOR DRYING GELS WITHOUT CRACKING

5.1 Gels ⩽ 14% Constant Concentration Acrylamide, Including IEF Gels

(Refer to Figure 5.1)

1. Open the dryer and lay aside the transparent sealing gasket. Rinse the transparent gasket with water as necessary to remove particles or other fibrous materials, to assure a good vacuum seal.
2. Soak a piece of filter paper with distilled water. Briefly drain off excess water and place the filter paper in place on the porous support.
3. Position the gel on the filter paper.

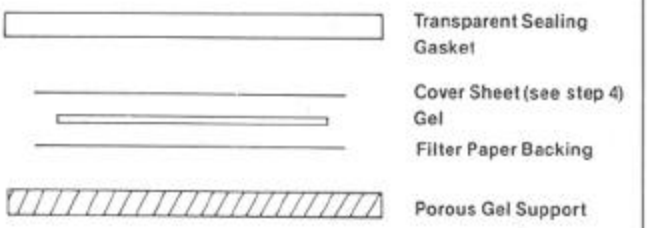


Fig. 5.1. Arrangement for drying protein gels.

Note:
For gels of low acrylamide concentration, slide the dry filter paper, cut to size, into the container with and under the gel. Drain the solution off the gel / filter paper and place the filter paper with the gel on the porous gel support in the dryer.

4. Cover the gel in one of three ways:
   a. Cover the gel directly with the transparent sealing gasket.
   b. Cover the gel first with a recommended nonporous plastic film, such as Saran Wrap!™ especially for autoradiography. This will protect the sealing gasket from radiation and from any effects of MeOH or HOAc and give the gel a smoother surface.
   c. Cover the gel with the cellophane membrane backing, after wetting the membrane in distilled water.

   For all three, remove any air bubbles by carefully smoothing the cover with your fingers. With (a) or (b) the transparent sealing gasket or the plastic film will peel off after drying is complete, leaving the gel with a shiny, slightly textured surface [more pronounced with (a)]. With (c) the cellophane membrane backing adheres to the gel and will not peel off. The gel surface will be perfectly smooth and shiny. Any excess cellophane may be trimmed away with a razor blade. Note also that the gel cover cannot extend beyond the edges of the porous gel support. Otherwise the vacuum seal will be inadequate and the gel will crack (see Figure 5.1).
5. Lay the transparent sealing gasket over the gel and close the lid. Turn on the vacuum.
6. The gasket will seal and a vacuum will be formed. It is easier to get a seal by using the lid to press down all around the edge of the gasket, rather than by using your hands.
7. Select the temperature desired by pushing on the side of the temperature select switch. Choose 80°C for normal rapid drying. Choose 60°C if the gel contains fluors for autoradiography.
8. Set the drying time by turning the timer past 1 and then selecting the time desired. Use Table 6.1 as a guide. It lists the drying times required for gels of various concentrations and thicknesses.
9. When the timer turns off the heating element (indicator light will go out), open the lid to cool the gel. When the gasket is cool to the touch, turn off the vacuum and remove the gel. Note that the cellophane membrane backing will tend to adhere to the transparent sealing gasket. Therefore, open the gasket carefully and peel the cellophane off the gasket, so that the gel does not start to pull away from the filter paper. Allowing the gel to cool will help maintain the flat, uncurled appearance of the gel. It will also minimize the structural stresses caused by a quick environmental change from negative pressure and heat.

Note:
It is very important that the gel be completely dry before the vacuum is released. Otherwise the gel is likely to crack. See the discussion under "Drying Time" for methods of determining whether the gel is dry.

Saran Wrap™ is a trademark of the Dow Chemical Company.

5.2 Gels ⩾ 15% Acrylamide or Gradient Gels

Soak these gels in 500 ml of a 3% glycerol (w/v), 40% MeOH, 10% HOAc solution for about 3 hours with constant gentle agitation. Continue with the procedure in Section 5.1, starting with step 1, except that in step 4 the gel **must** be covered with the cellophane membrane backing, (Step 4.c.) to assure that no cracks form during or after drying. If the gradient is very steep, cracking can be prevented by increasing the glycerol concentration, up to 10%. If the gel is not covered with the cellophane membrane, at 10% glycerol it will remain sticky.

5.3 Sequencing Gels

(Refer to Figure 5.2)

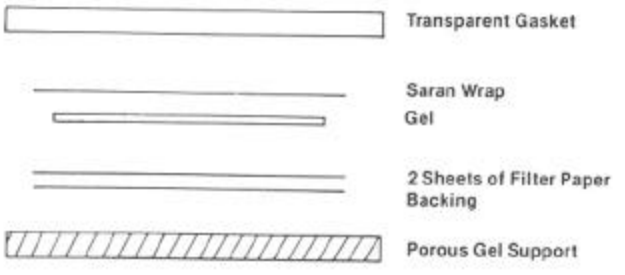


Fig. 5.2. Arrangement for drying sequencing gels.

1. After electrophoresis, separate the glass plates so that the gel is attached to one of the plates. This is usually done by siliconizing one of the plates so it can be removed easily. Distortions, folds, or bubbles under the gel must be removed by squirting running buffer over and under the gel. ^{35}S labeled gels require fixing in 10% methanol and 10% acetic acid for 10–15 minutes [Biggin, et al., *Proc. Nat. Acad. Sci. U.S.A.*, **80**, 3963 (1983)].
2. Place a fresh dry sheet of the thick filter paper over the gel.
3. Rub the filter paper on top of the gel with a small test tube to insure uniform adhesion of the gel to the filter paper backing.
4. Trim the filter paper to the appropriate dimensions for autoradiography, as necessary.
5. Peel filter paper with the adhered gel away from the glass plate.
   a. For gels ≤ 15%T, this can be done by simply peeling the paper up and away.
   b. For gels >15%T, invert the glass plate/gel/paper sandwich and place it on a smooth tabletop. Gradually slide the sandwich off the edge of the table while peeling down the filter paper backing. The gel should stick well enough to the paper that it will part from the glass. High percentage gels are peeled off in this way (inverted), so gravity is in your favor.
6. Place filter paper backing/gel sandwich on a bench, gel up, and cover the gel with Saran Wrap. Stretch out the Saran Wrap, and smooth out any bubbles. Trim Saran Wrap to slightly over size.
7. Place the gel sandwich, Saran Wrap up, on the porous gel support in the dryer.
8. Align all layers within the borders of the porous gel support.
9. Cover the gel with the transparent sealing gasket, close the lid, and turn on the vacuum. The transparent sealing gasket will seal and a vacuum will be formed.
10. Set the thermostat at 80°C. When using scintillant fluors, set the thermostat at 60°C.
11. To begin drying, turn the timer past 1 and set it for the desired drying time (usually 20 to 40 minutes). See Table 6.1.

5.4 Autoradiography

(Refer to Figure 5.2)

Gels dried prior to autoradiography generally require a nonporous plastic film as a gel cover. If the transparent sealing gasket is used directly, it may become contaminated with the radioactive label. Also, "hot" gels dried with Saran Wrap will, for most radioactive labels, expose x-ray film directly through the Saran Wrap. If necessary, the Saran Wrap can be peeled away and discarded as radioactive waste.

If the dryer is used for radioactive gels, the porous gel support can become radioactive too. Therefore, for radioactive gels, Bio-Rad recommends two sheets of fresh filter paper backing between the gel and porous gel support. The gel adheres to the top sheet, and the lower sheet of filter paper acts to:

1. Reduce the amount of radioactive label that could contaminate the porous gel support.
2. Prevent a contaminated porous gel support from cross contaminating the gel and its filter paper backing.

If you are drying radioactive gels, handle the porous gel support and dryer as potentially radioactive. You might want to purchase an extra porous gel support for your non-radioactive gels.

5.5 Transmission Densitometry

(Refer to Figure 5.3)

1. For gels ≥15% T, equilibrate the gel in the glycerol solution as described in Section 5.2.
2. Lay a sheet of filter paper moistened with water on the porous gel support.

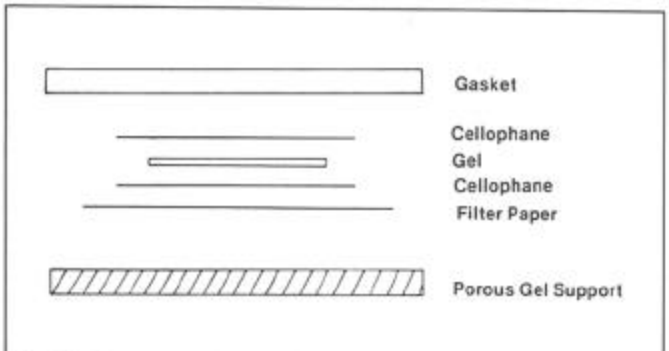


Fig. 5.3. Arrangement for drying gels for transmission densitometry.

3. Moisten one piece of cellophane membrane backing in the glycerol, 40% methanol, 10% acetic acid solution the gel is in and lay it on the filter paper. Smooth out any air bubbles.
4. Lay the gel on the cellophane. Or, transfer the gel to the dryer on the bottom sheet of cellophane membrane backing, as in Section 5.1, step 3, note.

5. Cover the gel with another sheet of cellophane membrane backing wetted in the same solution. Smooth out any bubbles carefully so that good contact is made between the gel and both pieces of cellophane.

6. Continue the procedure starting with Section 5.1, step 5.

SECTION 6
DRYING TIME

Drying time is a function of temperature, vacuum, gel porosity, and gel thickness. Use Table 6.1 as a general guide for drying times at 80°C. Increase the time by 100% if the 60°C setting is used, or if gels are being prepared for transmission densitometry.

If the vacuum is released before the gels are completely dry, cracking will likely occur. Thin (0.25 mm – 0.75 mm) gels such as sequencing gels require much less drying time, and very rarely crack. High percentage protein gels (≥15%), thick gels (≥ 1.5 mm), and gradient gels will require longer drying times, and may crack if optimal conditions are not met. If the procedures outlined above are followed, your gel will not crack.

In general, gels are not harmed by excessive drying times (with the exception of gels containing scintillant fluors). The following table provides some basic drying times for various gel concentrations at a vacuum of 125 torr and a temperature of 80°C.

Table 6.1. Drying Times

Gel Concentrations	Slab Thickness	Time at 80°C
3–10%	0.375 mm	20 min.
10–20%	0.375 mm	20 min.
3–10%	0.5 mm	30 min.
10–20%	0.5 mm	40 min.
3–10%	0.75 mm	40–60 min.
10–20%	0.75 mm	1–2 hr.
3–10%	1.5 mm	2 hr.
10–20%	1.5 mm	2–3 hr.
3–10%	3.0 mm	3 hr.
10–20%	3.0 mm	3–4 hr.
5 to 30% gradient	0.75 mm	3 hr.
5 to 30% gradient	1.5 mm	3 hr.

To determine whether your gel is dry:

a. Note its appearance at the start of drying. The initial hydrated thickness of the gel will cause the transparent sealing gasket to assume the shape of the gel once the vacuum seal is formed. During drying, as the liquid permeating the gel is removed, the gel will thin. When drying is complete, the gasket will be perfectly flat for gels ≤ 10%T, and will still retain a slight gel shape for gels >10%T. Gradient gels, depending on the % range, will be flat at one end and show some gel shape at the other.

b. The gasket area over the gel will be cooler to the touch than the gasket over the porous gel support after the heater has reached drying temperature (9 minutes after timer was turned on). When the gel is dry, the gasket over it will be the same temperature as the gasket over the porous gel support.

SECTION 7
TROUBLESHOOTING GUIDE

Problem	Trouble Check
No power	1. Check to assure the unit is plugged into a live outlet. 2. Unplug the dryer and check the fuse. The fuse is located on the back of the unit and is removed by sliding open the access port to the power entry module on the back and pulling on the tab to pop out the fuse. Replacement fuses are listed in Table 8.1. 3. Make sure the selector card in the power entry module reads the appropriate voltage (see Section 8.2).
No vacuum seal	1. Check the vacuum source. It should be at least 125 torr or 25 inches of Hg. 2. Check to be sure the filter paper, gel and gel cover are aligned within the edges of the porous gel support to assure proper sealing of the transparent sealing gasket. 3. Check that the edge of the dryer base is smooth and clean, and that the sealing gasket is clean, with no particles along the seal area. 4. If you are prevented from obtaining a vacuum due to warping of the porous support, turn it over. If the porous support is hot, and cold wet filter paper is placed on it, it will warp. The reverse side is smooth and serves equally well to dry gels. It will flatten again when the temperature has equalized.
Vacuum loss	1. Check to be sure the filter paper, gel and gel cover are aligned within the edges of the porous gel support to assure proper sealing of the silicone gasket. 2. Check transparent gasket for worn, weak or cracked areas. Replace it if it shows signs of wear. Pull a vacuum on the unit in the absence of a gel and turn off the vacuum. A seal should be maintained for 30 seconds or more. If not, replace the gasket. 3. Check the edge of the dryer around the porous gel support for physical flaws or indentations. The edge must be kept perfectly smooth to maintain a good vacuum. The gasket must be clean.
Gels crack	1. Vacuum has been released before gel is dry. Gel will be sticky in consistency. 2. Vacuum not sufficient to thoroughly dry gels in recommended drying time. Requires stronger vacuum source, alignment of filter paper, etc., or new silicone gasket. Vacuum must be at least 125 torr. Make sure porous gel support has not become clogged (see Section 8.1). 3. A nonporous cellophane or Saran Wrap has been used in densitometry or autoradiography. Switch to porous cellophane, and soak cellophane in 3% glycerol, 40% methanol, 10% acetic acid solution. 4. Glycerol concentration too low. Increase glycerol concentration in pre-drying treatment to 5% (w/v).

If this guide is not sufficient, call 1-800-4-BIORAD or your local Bio-Rad representative for technical advice on the use or performance of your slab dryer.

SECTION 8
MAINTENANCE

8.1 Cleaning and Replacement of Parts

Your dryer will give you years of trouble free service. However, the porous gel support and the transparent sealing gasket may need replacement after extended use. The porous gel support can become clogged and, if this occurs, it can be scrubbed with a bottle brush. If this does not unclog it, it must be replaced. The transparent sealing gasket can wear and dry with age, and crack, and should be replaced if it does not hold a seal for 30 seconds after the vacuum is turned off. The gasket can be removed for rinsing with water and replaced, e.g. to eliminate filter paper fibers which adhere to the gasket where no plastic film cover is used. Wipe the dryer body with a damp cloth to clean it. Do not use solvents, concentrated acids or bases with the unit.

8.2 Changing the Dryer Voltage

The circuitry in the unit can handle any of the voltages in use around the world. This is accomplished by use of a voltage card, which contains pins to connect the unit in terms of the particular voltage. The card is inserted in the unit under the fuse (in the back). If the unit is moved to a region of different voltage, it can be adapted to that voltage by opening the power module (slide access port open), removing the fuse (pull on tab to pop it out), and pulling out the card, which has a hole in its edge, with a pair of pliers. Inspect the card, noting the 4 different voltage limits printed in 4 different orientations on the card. To select the desired voltage, orient the card so that the proper voltage faces up and out (so you can read it normally), and reinsert the card into the power entry module. Replace the fuse (check to make sure of the correct amperage for the new voltage in Table 8.1), close the power module and attach the power cord appropriate for that location. Your dryer is ready for the different voltage. The dryer meets safety requirements for electrical instrumentation of every country in the world.

8.3 Vacuum Source

The vacuum source for the dryer must also be serviced properly. We advise the use of a trap. A dry ice / ethanol "cold finger" can be used. Other traps can be used, except corrosive compounds such as NaOH which will damage the vacuum pump vanes. If you use the dryer frequently and have an in-lab mechanical pump, we recommend changing the pump oil frequently, to protect it from the corrosive effects of the water vapor and methanol.

Table 8.1. Replacement Fuses

Dryer	Voltage	Replacement Fuse Amp
Model 443	100	3.0
	120	3.0
	220	1.5
	240	1.5
Model 483	100	6.0
	120	6.0
	220	3.0
	240	3.0