Thermo Fisher Scientific

STEP*SAVER*

Instruction Manual

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For Research Use Only. Not for use in diagnostic procedures.

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This manual is a guide for use of the

Thermo Scientific STEPSAVER™ Rotor Systems

Data herein has been verified and is believed adequate for the intended use of the rotor. Because failure to follow the recommendations set forth in this manual could produce personal injury or property damage, always follow the recommendations set forth herein. Thermo Fisher Scientific does not guarantee results and assumes no obligation for the performance of rotors or other products that are not used in accordance with the instructions provided. This publication is not a license to operate under, nor a recommendation to infringe upon, any process patents.

Publications prior to the Issue Date of this manual may contain data in apparent conflict with that provided herein. Please consider all data in this manual to be the most current.

WARNING, CAUTION, and NOTE within the text of this manual are used to emphasize important and critical instructions.

WARNING informs the operator of a hazard or an unsafe practice that could result in personal injury, affect the operator's health, or contaminate the environment.

CAUTION informs the operator of an unsafe practice that could result in damage of equipment.

NOTE highlights essential information.

CAUTION and WARNING are accompanied by a hazard symbol and appear near the information they correspond to.

Important Safety Information

Certain potentially dangerous conditions are inherent to the use of all centrifuge rotors. To ensure safe operation of this rotor, anyone using it should be aware of all safe practices and take all precautions described below and throughout this manual..

WARNING

When using radioactive, toxic, or pathogenic materials, be aware of all characteristics of the materials and the hazards associated with them in the event leakage occurs during centrifugation. In the event of a rotor failure, neither the centrifuge nor the rotor can protect you from particles dispersed in the air. To protect yourself, we recommend additional precautions be taken to prevent exposure to these materials, for example, use of controlled ventilation or isolation areas.

Always be aware of the possibility of contamination when using radioactive, toxic, or pathogenic materials. Take all necessary precautions and use appropriate decontamination procedures if exposure occurs.

Never use any material capable of producing flammable or explosive vapors or creating extreme exothermic reactions.

Never exceed the maximum rated speed of the installed rotor; to do so can cause rotor failure.

Always reduce (derate) rotor speed as instructed in this manual whenever:

- the rotor speed/temperature combination exceeds the solubility of the gradient material and causes it to precipitate. See page 3-2.
- the compartment load exceeds the maximum allowable compartment load specified (average fluid density greater than 1.7 g/ml). See page 3-1.

Failure to reduce rotor speed under these conditions can cause rotor failure.

CAUTION

Do not operate or precool the rotor at the critical speed, as this will have a detrimental effect on centrifuge component life. See page 3-3.

Do not operate the rotor unless it is symmetrically balanced as described in this manual. Operating the rotor out of balance can cause damage to the centrifuge drive assembly.

Always maintain the rotor in the recommended manner. The rotor and all accessories must be clean and inspected prior to each run: do not use rotors showing signs of corrosion or cracking. See Chapter 6, Care and Maintenance.

DESCRIPTION

This manual contains information required to operate and maintain the Thermo Scientific STEP*SAVER* ™ Rotor Systems. If you require additional information regarding operation or maintenance, please contact Thermo Fisher Scientific for assistance. In the United States, call Thermo Fisher Scientific toll-free 1-866-9THERMO; outside the United States, contact the nearest Thermo Fisher Scientific office (see back cover) or your local representative for Thermo Fisher Scientific products. Thermo Fisher Scientific product information is available on our internet web site at http://www.Thermo.com .

Contents

Rotor and Cartridge Description

The STEP*SAVER* ™ Rotors are machined from a titanium forging for strength and corrosion resistance. The through holes of these rotors are bored parallel to the rotor axis. Each rotor is painted military blue. This painted coating provides surface protection and aids temperature regulation. A disc with alternating black and reflective segments is attached to the bottom of the rotor which prevents the rotor from being operated above its recommended maximum speed.

The tube cartridge sets[1] are made from an engineered plastic material. The tube cartridges streamline sample loading reducing the chance of sample loss and are color-coded for easy matching with the sample tube being used. A wide selection of cartridge sets are available for each rotor that enable various tube volumes to be processed.

Rotor Application

The STEP*SAVER* ™ Rotor Systems are used in an ultracentrifuge, primarily for density gradient separations (the design of the vertical rotor allows these separations to be done in shorter times than the conventional fixed-angle or swinging-bucket rotor). Specifically, these rotors can be used for many isopycnic and rate zonal applications. When using a STEP*SAVER*™ Rotor for density gradient separations, it is important to minimize disturbing the gradients, therefore we recommend using the slow acceleration and slow deceleration features (refer to the individual ultracentrifuge instruction manual on the use of these features).

Rotor Specifications

Table 1-1 provides the basic specifications for each of the rotors described in this manual.

Table 1-1.STEP*SAVER*™ Rotor Specifications

Description	70 V6 Rotor	65 V13 Rotor	50 V39 Rotor
Rotor Type	Vertical	Vertical	Vertical
Maximum Speed* (rpm)	70,000**	65,000**	50,000**
Temperature Range (°C)	0°C to 25°C	0°C to 25°C	0°C to 25°C
Relative Centrifugal Force (RCF) at Maximum Speed	467,420	400,671	241,831
K Factor at Maximum Speed	8.7	12.9	35.8
Number of Tube Compartments	8	8	8
ULTRACRIMP® Tube Volume (Nominal)	6.0 ml	13.5 ml	39.0 ml
Total Rotor Capacity (Nominal)	48 ml	108 ml	312 ml
Critical Speed	750 rpm	750 rpm	750 rpm
Maximum Compartment Mass***	26 grams	45 grams	161 grams
Rotor Mass (Weight)	7.6 kg (16.8 lbs)	9.7 kg (21.3 lbs)	10.3 kg (22.7 lbs)

[1]* Patent Pending

*Speed in revolutions per minute (rpm) is related to angular velocity, ω, according to the following:

$$\omega = (\text{rpm})\left(\frac{2\pi}{60}\right) = (\text{rpm})(0.10472)$$

Where ω = rad/s. All further references in this manual to speed will be designated as rpm.

**With tubes filled with a homogeneous solution having an average density of 1.7 g/ml or less. Derate speed for higher density loads.

***Maximum compartment mass includes: the sample, the sealed tube, and cartridge. (Refer to Section 3 to properly derate rotor speed when using compartment loads that exceed the design mass given.)

Rotor Systems and Accessories

Tables 1-2, 1-3, and 1-4 respectively, list the various STEP*SAVER* ™ Rotor System configurations that are available.

Note In order to seal the ULTRACRIMP® Tubes that are supplied with some of the rotor systems, you must have an ULTRACRIMP® Sealing Tool (Catalog No. 03920) and ULTRACRIMP® gauge tool (Catalog No. 03919).

To order replacement accessories, telephone 1-866-9THERMO in the United States. Outside the United States contact your local representative, distributor, or agent for Thermo Fisher Scientific products. Be sure to provide a description of the part, catalog number, plus the rotor model and serial number.

Table 1-2. STEP*SAVER*™ 70 V6 Rotor Systems

Description	Catalog Number	Quantity
STEP*SAVER*™ 70 V6 Basic Rotor includes:	79258	1
STEP*SAVER*™ 70 V6 Rotor Overspeed Decal, 70,000 rpm, extra Ultraspeed Centrifuge/Rotor Log Book Instruction Manual Rotor Stand	- 08254 52384 79231 51942	1 1 1 1 1
STEP*SAVER*™ 70 V6 6 ml ULTRACRIMP® Rotor System includes (color-coded dark blue):	79240	1
STEP*SAVER* ™ 70 V6 Basic Rotor ULTRACRIMP® Tubes, Polyallomer, 6 ml, 50/pkg Cartridge Set for 6 ml ULTRACRIMP® Tubes, 8 cartridges/set Cartridge Rack Tube Rack, 6 ml, 2/pkg	79258 79273* 79286 79211 03921	1 4 1 1 1
STEP*SAVER*™ 70 V6 2 ml ULTRACRIMP® Rotor System includes (color-coded light blue):	79274	1
STEP*SAVER* ™ 70 V6 Basic Rotor ULTRACRIMP®Tubes, Polyallomer, 2 ml, 50/pkg Cartridge Set for 2 x 2 ml ULTRACRIMP® Tubes, 8 cartridges/set Cartridge Rack Tube Rack, 2 ml, 2/pkg	79258 79251* 79289 79211 79242	1 4 1 1 1
STEP*SAVER*™ 70 V6 5.1 ml Quick-Seal®** Rotor System includes (color-coded red):	79280	1
STEP*SAVER* ™ 70 V6 Basic Rotor Cartridge Set for 5.1 ml Quick-Seal®** Tubes, 8 cartridges/set Cartridge Rack	792258 79291 79211	1 1 1

*Each package of ULTRACRIMP® tubes is supplied with an equal number of tube caps and tube plugs. To order replacement tube caps and plugs (25 per package), order Catalog No. 03999 from Thermo Fisher Scientific.

**Quick-Seal® is a trademark of Beckman Instruments, Inc

Cartridge sets can be ordered individually (1/package) for the STEP*SAVER* ™ 70 V6 Rotor as listed below: Catalog No. 79241 for the 6 ml ULTRACRIMP® Cartridge; Catalog No. 79261 for the 2x2ml ULTRACRIMP® Cartridge; and Catalog No. 79250 for the 5.1 ml Quick-Seal® Cartridge.

Table 1-3. STEP*SAVER* 65 V13 Rotor Systems

Description	Catalog Number	Quantity
STEP*SAVER*™ 65 V13 Basic Rotor includes:	79256	1
STEP*SAVER*™ 65 V13 Rotor Overspeed Decal, 65,000 rpm, extra Ultraspeed Centrifuge/Rotor Log Book Instruction Manual Rotor Stand	- 51345 52384 79231 51942	1 1 1 1 1
STEP*SAVER*™ 65 V13 13.5 ml ULTRACRIMP® Rotor System includes (color-coded dark blue):	79243	1
STEP*SAVER*™ 65 V13 Basic Rotor ULTRACRIMP® Tubes, Polyallomer, 13.5 ml, 50/pkg Cartridge Set for 13.5 ml ULTRACRIMP® Tubes, 8 cartridges/set Cartridge Rack Tube Rack, 13.5 ml, 2/pkg	79256 79246* 79296 79212 79247	1 4 1 1 1
STEP*SAVER*™ 65 V13 6 ml ULTRACRIMP® Rotor System includes (color-coded light blue):	79290	1
STEP*SAVER*™ 65 V13 Basic Rotor ULTRACRIMP® Tubes, Polyallomer, 6 ml, 50/pkg Cartridge Set for 6 ml ULTRACRIMP® Tubes, 8 cartridges/set Cartridge Rack Tube Rack, 6 ml, 2/pkg	79256 79273* 79297 79212 03921	1 4 1 1 1
STEP*SAVER*™ 65 V13 13.5 ml Quick-Seal® ** Rotor System includes (color-coded red):	79285	1
STEP*SAVER*™ 65 V13 Basic Rotor Cartridge Set for 13.5 ml Quick-Seal® ** Tubes, 8 cartridges/set Cartridge Rack	79256 79298 79212	1 1 1

*Each package of tubes is supplied with an equal number of tube caps and tube plugs. To order replacement tube caps and plugs (25 per package), order Catalog No. 03999 from Thermo Fisher Scientific.

**Quick-Seal® is a trademark of Beckman Instruments, Inc.

Cartridge sets can be ordered individually (1/package) for the STEP*SAVER* ™ 65 V13 Rotor as follows: Catalog No. 79244 for 13.5 ml ULTRACRIMP® Cartridge; Catalog No. 79260 for 6 ml ULTRACRIMP® Cartridge; and Catalog No. 79252 for 13.5 ml Quick-Seal® Cartridge.

Table 1-4. STEP*SAVER* 50 V39 Rotor Systems

Description	Catalog Number	Quantity
STEP*SAVER*™ 50 V39 Basic Rotor includes:	79254	1
STEP*SAVER*™ 50 V39 Rotor	-	1
Overspeed Decal, 50 000 rpm, extra	51349	1
Ultraspeed Centrifuge/Rotor Log Book	52384	1
Instruction Manual	79231	1
Rotor Stand	51942	1
STEP*SAVER*™ 50 V39 39 ml ULTRACRIMP® Rotor System includes (color-coded dark blue):	79245	1
STEP*SAVER*™ 50 V39 Basic Rotor	79254	1
ULTRACRIMP® Tubes, Polyallomer, 39 ml, 25/pkg	79253*	4
Cartridge Set for 39 ml ULTRACRIMP® Tubes, 8 cartridges/set	79299	1
Cartridge Rack	79288	1
Tube Rack, 39 ml, 2/pkg	79249	1
STEP*SAVER*™ 50 V39 13.5 ml ULTRACRIMP® Rotor System includes (color-coded light blue):	79277	1
STEP*SAVER*™ 50 V39 Basic Rotor	79256	1
ULTRACRIMP® Tubes, Polyallomer, 13.5 ml, 50/pkg	79273*	4
Cartridge Set for 13.5 ml ULTRACRIMP® Tubes, 8 cartridges/set	79297	1
Cartridge Rack	79212	1
Tube Rack, 6 ml, 2/pkg	03921	1

* Each package of tubes is supplied with an equal number of tube caps and tube plugs. To order replacement tube caps and plugs (25 per package), order Catalog No. 03947 from Thermo Fisher Scientific.

Cartridge sets can be ordered individually (1/package) for the various STEP*SAVER* ™ 50 V39 Rotor as follows: Catalog No. 79248 for 39 ml ULTRACRIMP® Cartridge; Catalog No. 79263 for 13.5 ml ULTRACRIMP® Cartridge; and Catalog No. 79255 for 39 ml Quick-Seal® Cartridge.

RUN PREPARATION

Read this chapter before using the Thermo Fisher Scientific STEP*SAVER* ™ Rotor Systems. It contains important safety checks that should be done before every run and includes information about the rotor that you will need when determining the chemical compatibility of your sample with the rotor.

Contents

Prerun Safety Checks

WARNING The stresses that this rotor withstands during centrifugation eventually weaken the rotor body, increasing the possibility of rotor failure. We recommend that this rotor be withdrawn from service after it has been used for 5,000 runs. Failure to do so can cause rotor failure with subsequent sample loss and damage to the rotor and/or centrifuge. If the material being processed is hazardous, the loss of sample can result in personal injury.

To ensure safe performance of the rotor, before every run you should:

a. read the Safety Information Page in the front of this manual.

b. make sure each through hole is clean and that there is no sign of corrosion.

c. be sure the rotor itself is clean and shows no sign of corrosion or cracking.

d. be sure the cartridge assemblies are clean.

Note Small hairline cracks may appear on the cartridge assembly. These cracks are normal and should be no cause for concern. However, if the cracks appear to be "growing" after subsequent use, this is an indication that the cartridge assembly needs to be replaced.

e. check the centrifuge chamber and drive spindle to be sure they are clean and free of scratches and burrs.

f. make sure the tube and cartridge assembly selected are compatible. Read the CAUTION.

CAUTION Be sure that the tube and cartridge set selected are compatible. Failure to use the proper tube and cartridge set can result in tube failure.

g. check that you have used the correct tube caps on any ULTRACRIMP® tubes used with the STEP*SAVER* ™ Rotor Systems. Read the CAUTION.

CAUTION When using ULTRACRIMP® tubes with the STEP*SAVER*™ Rotor Systems, be sure you have used the tube caps that are supplied with the ULTRACRIMP® tubes. Failure to do so can result in tube collapse and subsequent sample loss.

h. verify that the proper overspeed decal is firmly attached to the bottom of the rotor the decal should have: 13 black segments for the 70 V6 Rotor; 14 black segments for the 65 V13 Rotor; and 18 black segments for the 50 V39 Rotor (see page 6-2 for Overspeed Decal Replacement procedure).

i. check the chemical compatibility of all materials used (see Appendix A).

j. be sure the proper environment has been selected for operation; for example, controlled ventilation or isolation, if required.

Rotor Precool

If samples are routinely processed around 4°C or below, the rotor can be stored in a refrigerator or a cold room. If this is not possible, the rotor can easily be precooled in a Thermo Fisher Scientific Ultracentrifuge. Refer to the individual Thermo Fisher Scientific Ultracentrifuge Instruction Manual for precooling directions. Be careful not to precool the rotor at its critical speed (refer to Table 1-1 on page 1-2 and to the information given on page 3-3 for operation at the Critical Speed).

Chemical Compatibility

The critical components of the STEP*SAVER* ™ Rotor Systems that are apt to come in contact with solution are: the rotor body (titanium), the cartridge set (polyetherimide), and the tubes (polyallomer or polyethylene-terephthalate). ULTRACRIMP® sealing assembly components include: a flared tube cap (aluminum) and tube plug (polypropylene/polyethylene).

The chemical compatibility of rotor elements and accessory materials is given in the Appendix. Because no organized chemical resistance data exists for materials under the stress of centrifugation, this data is intended to be used only as a guide to the selection of tube materials. When in doubt, we recommend pretesting of sample lots.

Sample Preparation

Prepare the ULTRACRIMP® tubes for use following the tube filling procedure given in the ULTRACRIMP® Tube Sealing System Instruction Manual.

Note If you are using Quick-Seal®* Tubes, fill and seal them in accordance with the instructions provided by the tube manufacturer.

*Quick-Seal® is a trademark of Beckman Instruments, Inc.

SPECIAL OPERATING CONSIDERATIONS

Follow the instructions in this chapter if your sample has an average fluid density greater than 1.7 g/ml or if you are using a cesium chloride gradient. You may need to lower the speed of your run to reduce the stress on the rotor or to prevent cesium chloride from precipitating from solution.

Contents

Compartment Loads in Excess of Design Mass

A recommended design mass has been established for each ultracentrifuge rotor representing the maximum mass that each tube compartment can contain at top speed operation. To prevent rotor failure, the weight of each compartment, including specimen, cartridge, and sealed tube, should not exceed the recommended figure unless rotor speed is reduced proportionately.

Strict adherence to the maximum allowable compartment mass or reduced speed is required to prevent rotor failure. Observe the WARNING.

WARNING Always reduce (derate) rotor speed as instructed whenever the rotor speed/temperature combination exceeds the solubility of the gradient material and causes it to precipitate or when the compartment load exceeds the maximum allowable compartment load specified (average fluid density is greater than 1.7 g/ml). Failure to reduce rotor speed under these conditions can cause rotor failure, which may result in centrifuge damage.

The design mass for each rotor is given in Table 3-1. If the density is greater than 1.7 g/ml, use the following formula to determine the reduced speed:

$$\text{Reduced Speed} \sqrt{\frac{1.7}{\text{Average Fluid Density (g/ml)}}}$$

This deration formula does not apply when using gradients that can precipitate (refer to the information regarding Precautions to Prevent Precipitation of Cesium Chloride on the next page).

Table 3-1. Maximum Allowable Compartment Mass

Rotor	Maximum Rotor Speed (rpm)		Maximum Compartment Mass (grams)
STEP*SAVER*™	70 V6	70,000	26
STEP*SAVER*™	65V13	65,000	45
STEP*SAVER*™	50 V39	50,000	161

Precautions to Prevent Precipitation of Cesium Chloride

WARNING Always reduce (derate) rotor speed whenever: 1) the rotor speed/temperature combination exceeds the solubility of the gradient material and causes it to precipitate or 2) when the compartment load exceeds the maximum allowable compartment load specified (average fluid density is greater than 1.7 g/ml). Failure to reduce rotor speed under these conditions can cause rotor failure.

Reducing Speed to Prevent Precipitation

Maximum speed must be reduced for an average fluid density greater than 1.7 g/ml (square-root reduction) to prevent excessive stress in a rotor. Although the standard formula pertains to sucrose and similar gradient materials, it will not prevent precipitation of heavy crystals when material such as cesium chloride (CsCl) is used in an ultracentrifuge rotor.

Note Examples in the text are illustrated in figures 3-1 through 3-3 (STEP*SAVER* ™ 70 V6 Rotor System) only. Apply the methods explained to the curves for the other STEP*SAVER* ™ Rotor Systems.

When solid, crystalline CsCl forms, it places a density of 4 g/ml along the outside edge of each tube compartment. This density is dangerously high and can cause the rotor to fail, with subsequent sample loss. Therefore, cesium chloride solutions must be run at reduced speeds to avoid this precipitation. The allowable speed is determined by the average density of the CsCl solution and the run temperature. The curves in figure 3-1 are used to determine the maximum operating speed at 5°C and 25°C that will prevent precipitation. Figure 3-1 also includes a curve that shows the standard speed (square-root) reduction to avoid excessive stress. The standard, square-root reduction formula cannot be used when precipitation of CsCl must be considered. For example, standard speed reduction would allow you to run a solution with a homogeneous density of 1.7 g/ml to top speed (70,000 rpm); however, you can see that a cesium chloride solution will precipitate at this speed. This graph shows that the highest speed you can run a cesium chloride solution of this density (1.7 g/ml) is 60,000 rpm at 25°C or 45,000 rpm at 5°C

Note The solubility limit of cesium chloride in an aqueous solution is 1.86 g/ml at 25°C and 1.81 g/ml at 5°C.

The Gradient Shape

The curves in figures 3-2 and 3-3 show the gradient shape at equilibrium, 5°C and 25°C respectively, for tubes filled with a CsCl solution. To familiarize yourself with these curves, try the following exercises. Figure 3-2 illustrates the shape of the gradient curve at various speeds at 5°C. To find the gradient profile of a tube filled with a 1.7 g/ml homogeneous solution at 45,000 rpm at 5°C, locate the 45,000 rpm curve. The gradient profile is 1.61 g/ml at the meniscus to 1.81 g/ml at the bottom of the tube. (Use figure 3-3 to find the shape of the gradient that corresponds to 60,000 rpm at 25°C.) Interpolate to find gradient shapes at speeds other than those illustrated.

Next, use figures 3-2 and 3-3 to determine the position of a specific band of particles in the tube when run at 5°C and 25°C respectively. Using the example given on the previous page (that is, 45,000 rpm at 5°C), use figure 3-2 to locate the position of a band of particles that have a density of 1.67 g/ml. Find 1.67 on the side scale (DENSITY, g/ ml) and follow the line across until it intersects the curve at 45,000 rpm. At this point, follow the line down the graph until it intersects the bottom scale (RADIUS, cm) - in this example the line corresponds to a radius of 7.54 cm. To find this band of particles after reorientation, continue to follow the line to the VOLUME (ml) of Fluid Above Band scale; you can see that the band of particles after reorientation is at 1.8 for the 6 ml tube (or 0.63 for the 2 ml tube). This means that there will be 1.8 ml of fluid above the band and 3.9 ml below the band; therefore, measuring from the top of the meniscus, the particles will be located at 69% of the fluid column.

Note The information given is based on the use of either 6 ml or 2 ml ULTRACRIMP® tubes in the STEP*SAVER*™ 70V6 Rotor System.

Use figure 3-3 to locate a band of particles having the same density (that is, 1.67 g/ml) run at 25°C. In this example, the band of particles can be located at a radius of 7.55 cm. Continue to follow the line to the VOLUME (ml) of Fluid Above Band scale to locate the band of particles after reorientation - which is at 2.15 for the 6 ml tube (or 0.75 for the 2 ml tube). This means there is 2.15 ml above the band and 3.55 ml below the band. Again, measuring from the top of the meniscus, the particles will be located at 62% of the fluid column.

Critical Speed

WARNING Do not operate or precool the rotor at the critical speed as this will have a detrimental effect on centrifuge component life.

The critical speed is that speed at which any rotor imbalance will produce a driving frequency equal to the resonant frequency of the rotating system (that is, the rotor and the centrifuge drive). At this speed, the rotor may produce large amplitude vibrations which can be felt in the instrument frame. Mass imbalance will contribute to increased vibration intensity at the critical speed. Avoid operating the rotor at the critical speed (see Table 1-1 on page 1-2). Operation at the critical speed will have a detrimental effect on centrifuge component life.

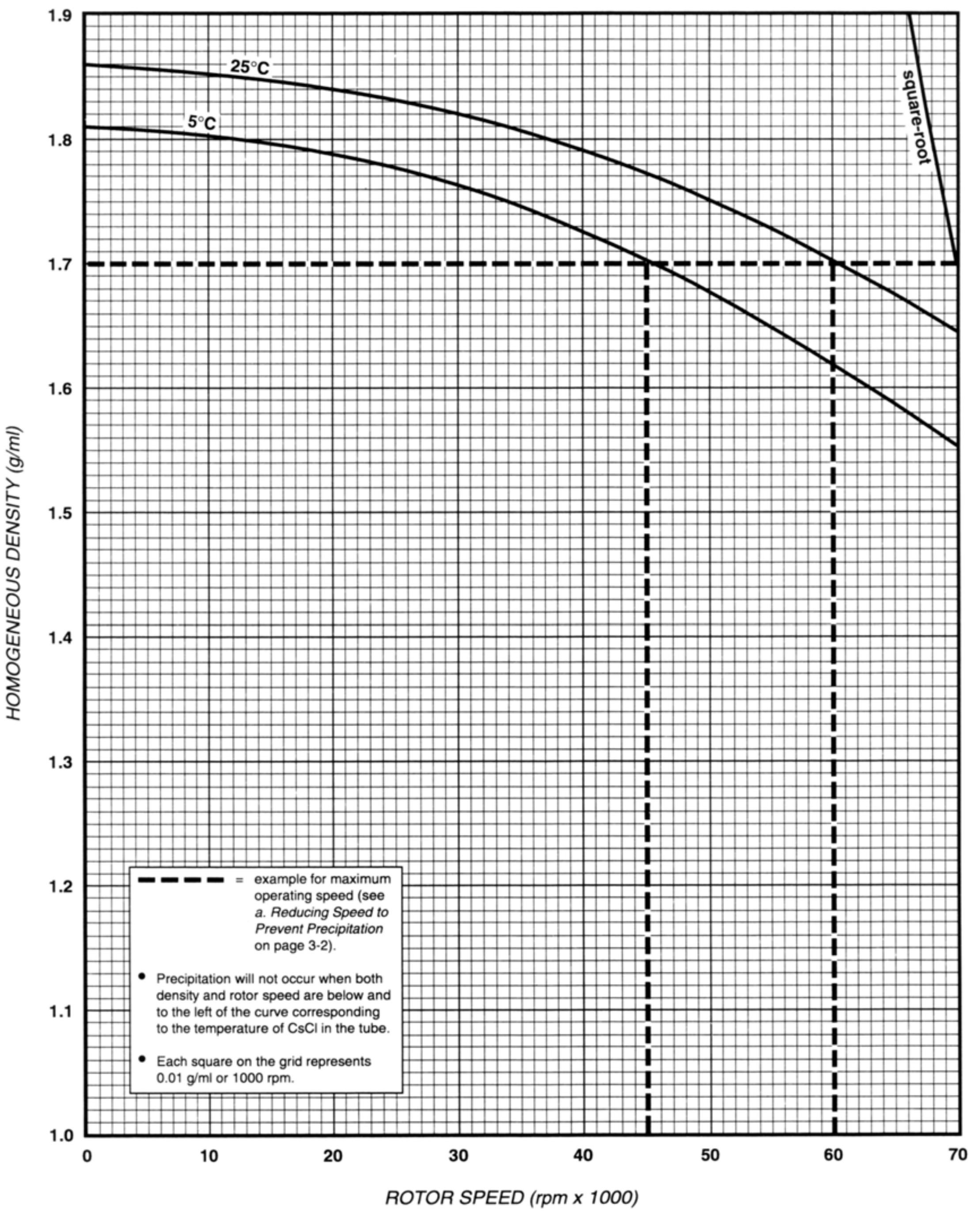

Figure 3-1. CsCl Precipitation Curves for the STEP*SAVER*™ 70 V6 Rotor Systems

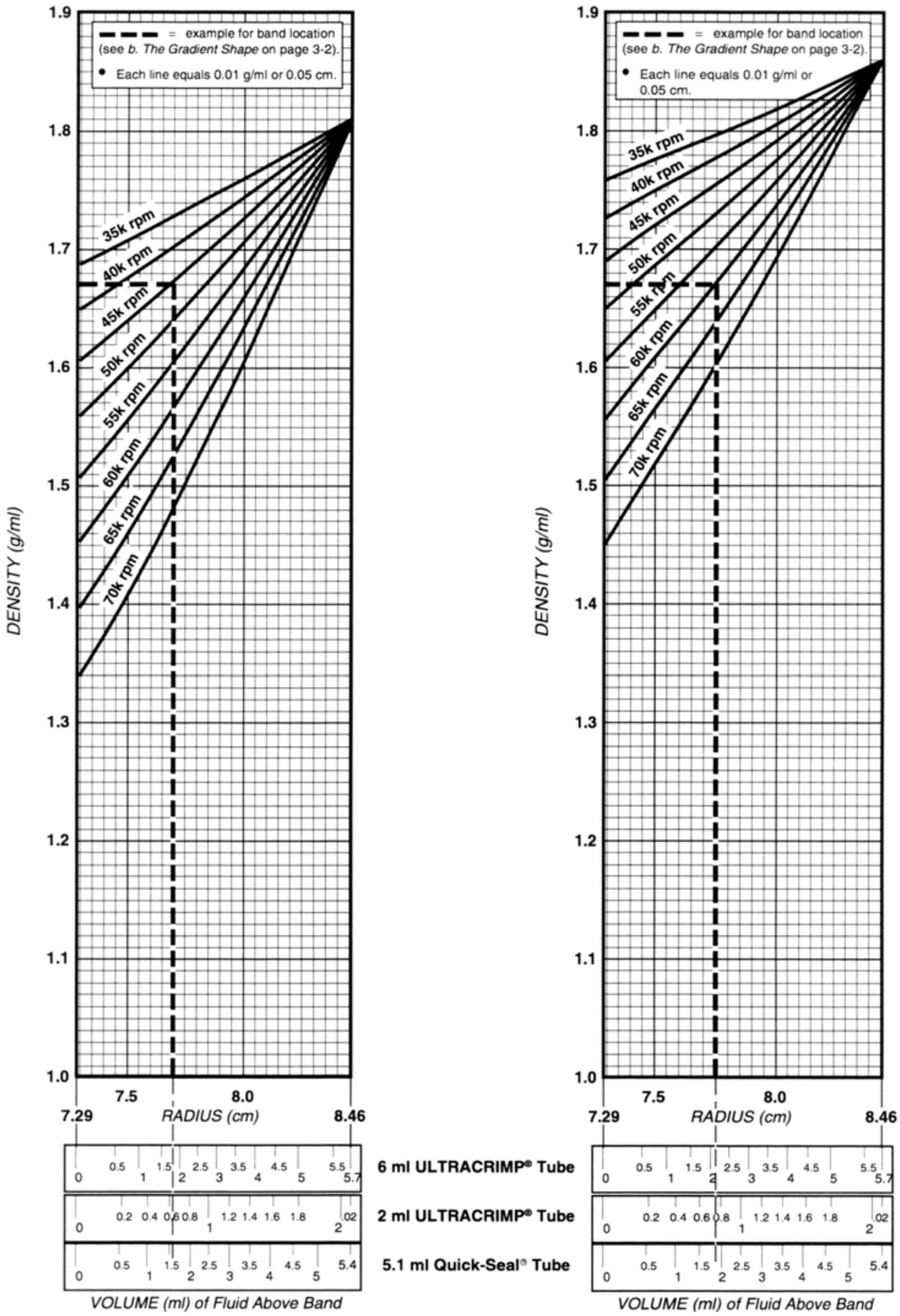

Figure 3-2. 70 V6 CsCl Density Gradient Shapes at Equilibrium (5 °C)

Figure 3-3. 70 V6 CsCl Density Gradient Shapes at Equilibrium (25 °C)

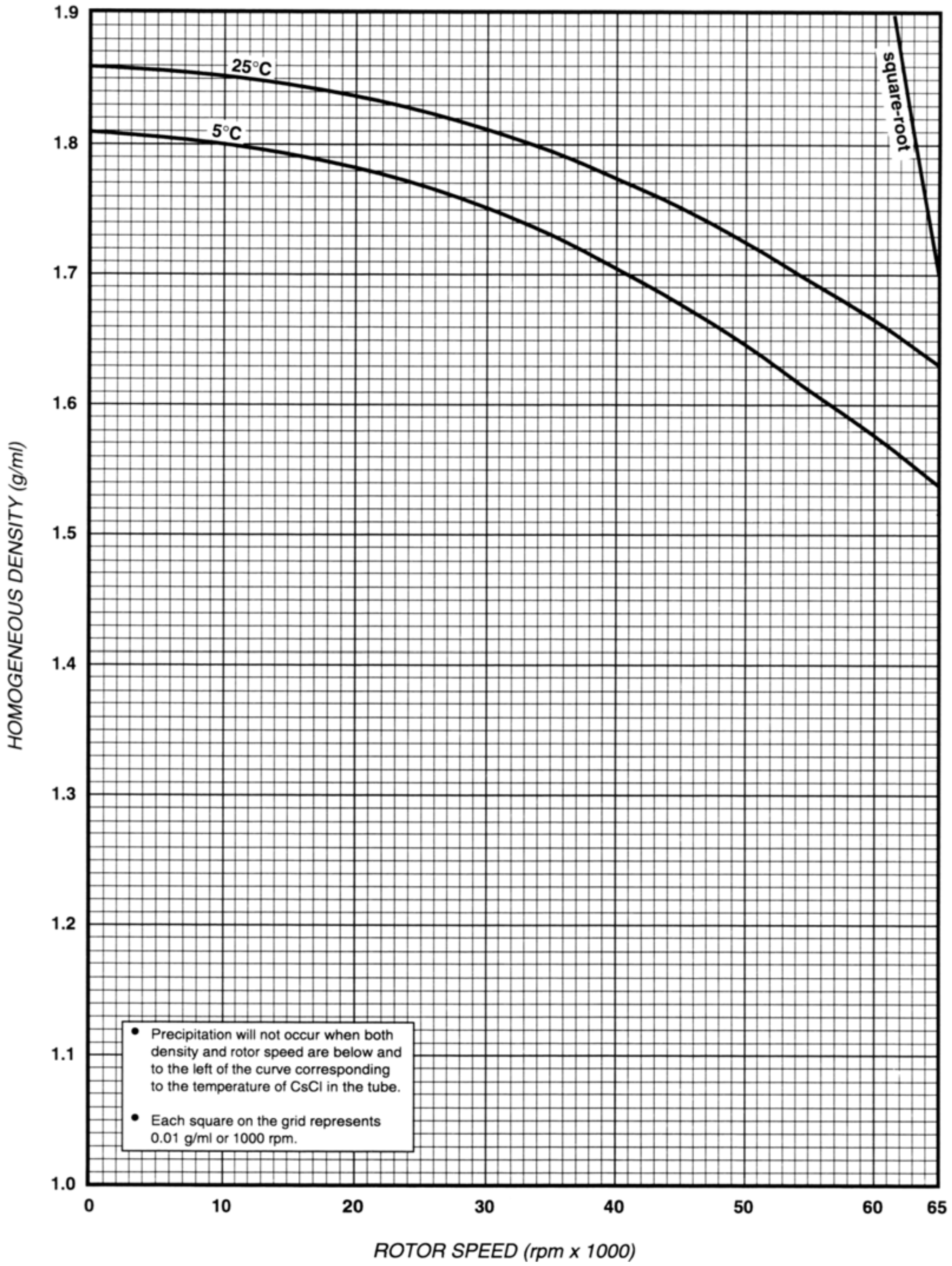

Figure 3-4. Precipitation Curves for the STEP*SAVER*™ 65 V13 Rotor System Using 13.5 ml ULTRACRIMP® or Quick-Seal® Tubes

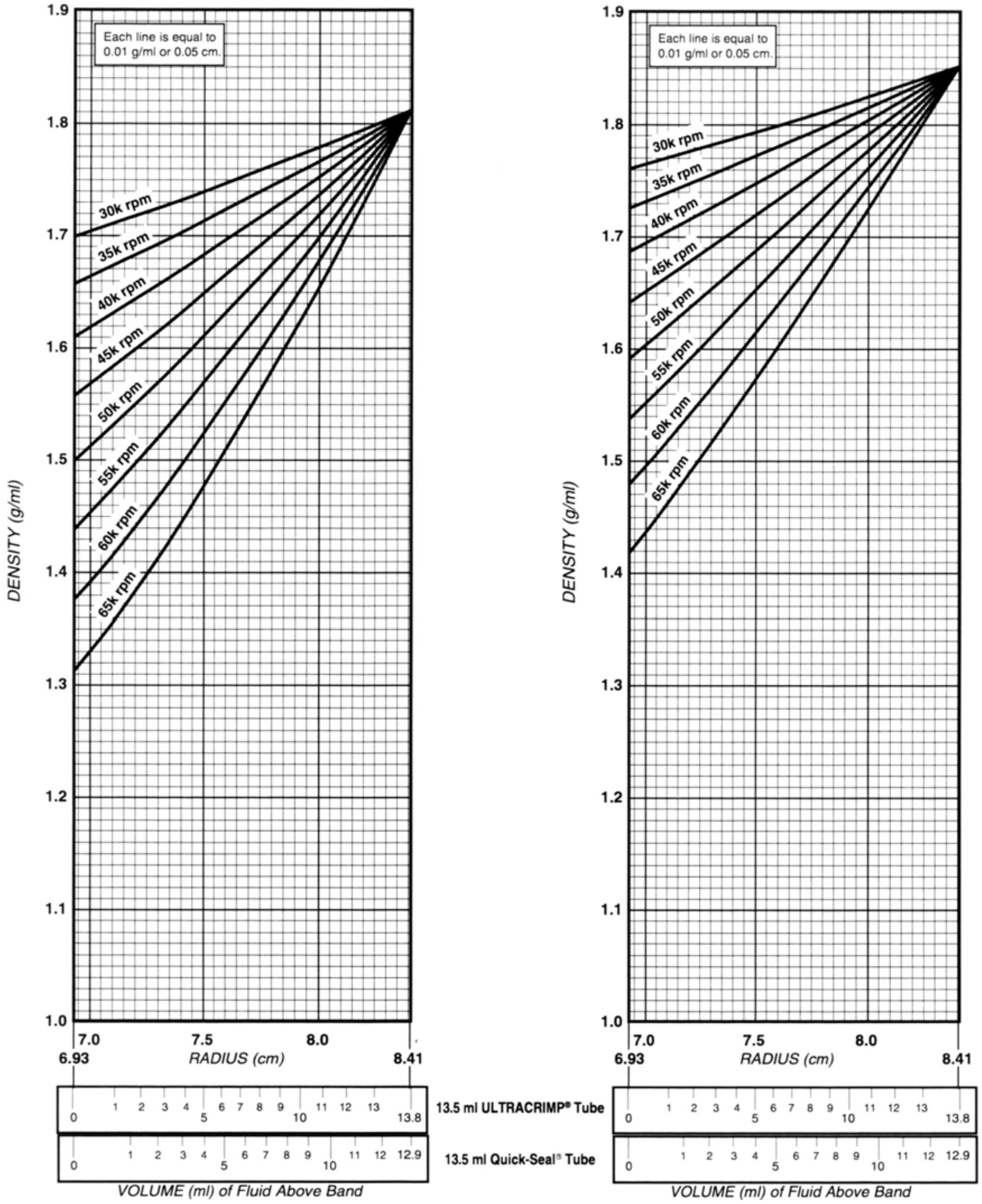

Figure 3-5. 65 V13 CsCl Density Gradient Shapes at Equilibrium (5°C)

Figure 3-6. 65 V13 CsCl Density Gradient Shapes at Equilibrium (25 °C)

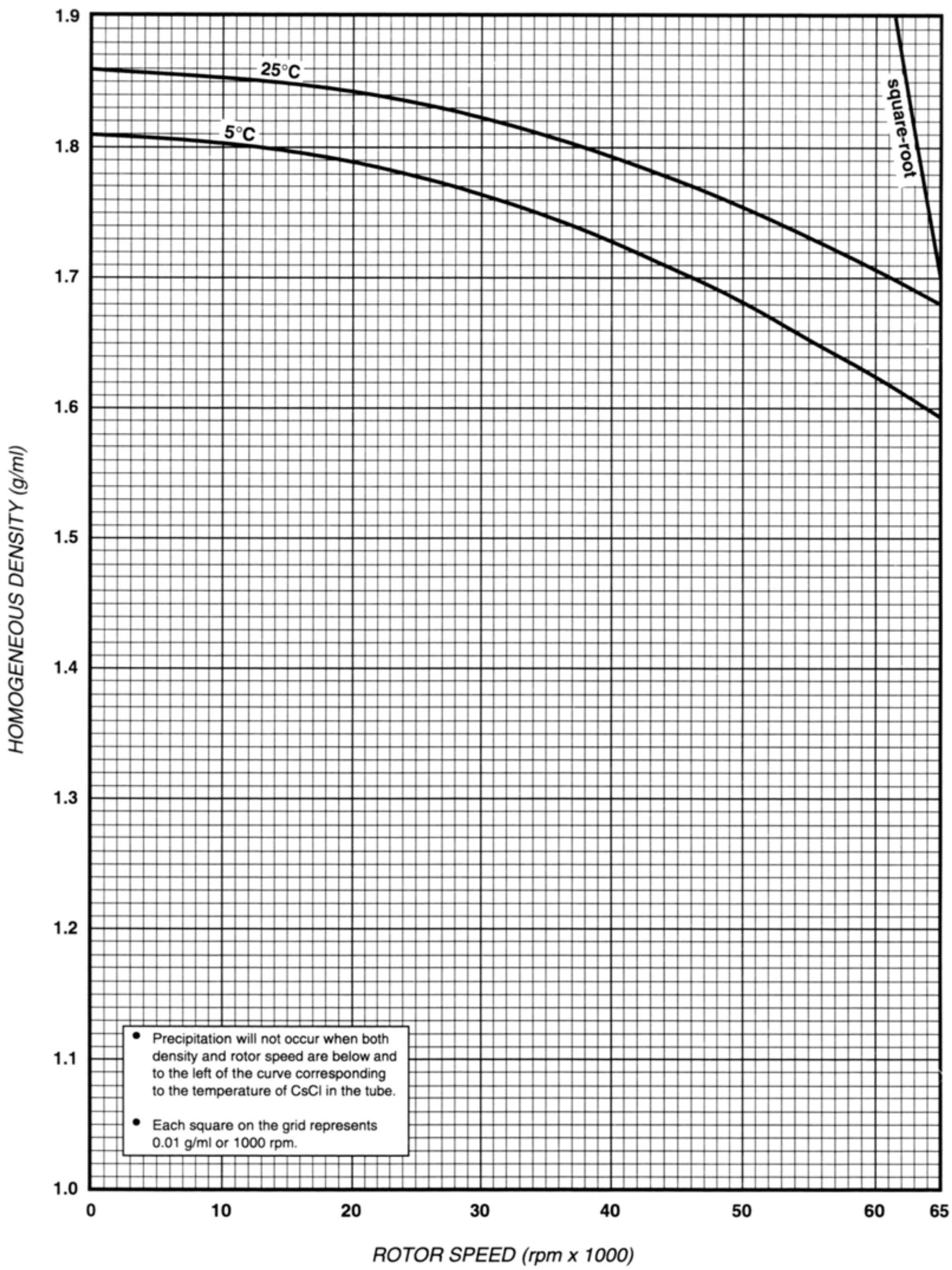

Figure 3-7. CsCl Precipitation Curves for the STEP*SAVER*™ 65 V13 Rotor System Using 6 ml ULTRACRIMP® Tubes

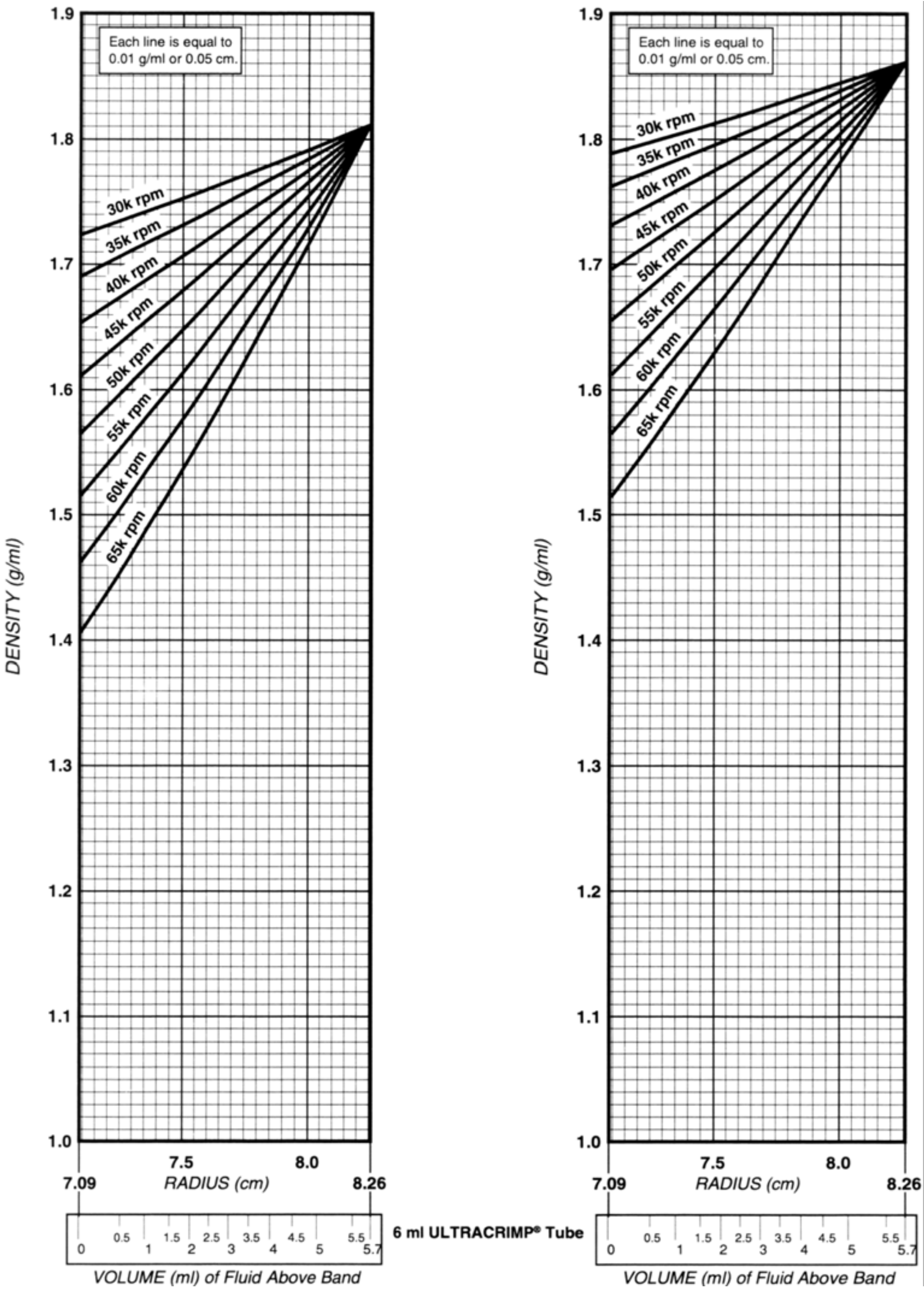

Figure 3-8. 65 V13 CsCl Density Gradient Shapes at Equilibrium (5°C)

Figure 3-9. 65 V13 CsCl Density Gradient Shapes at Equilibrium (25 °C)

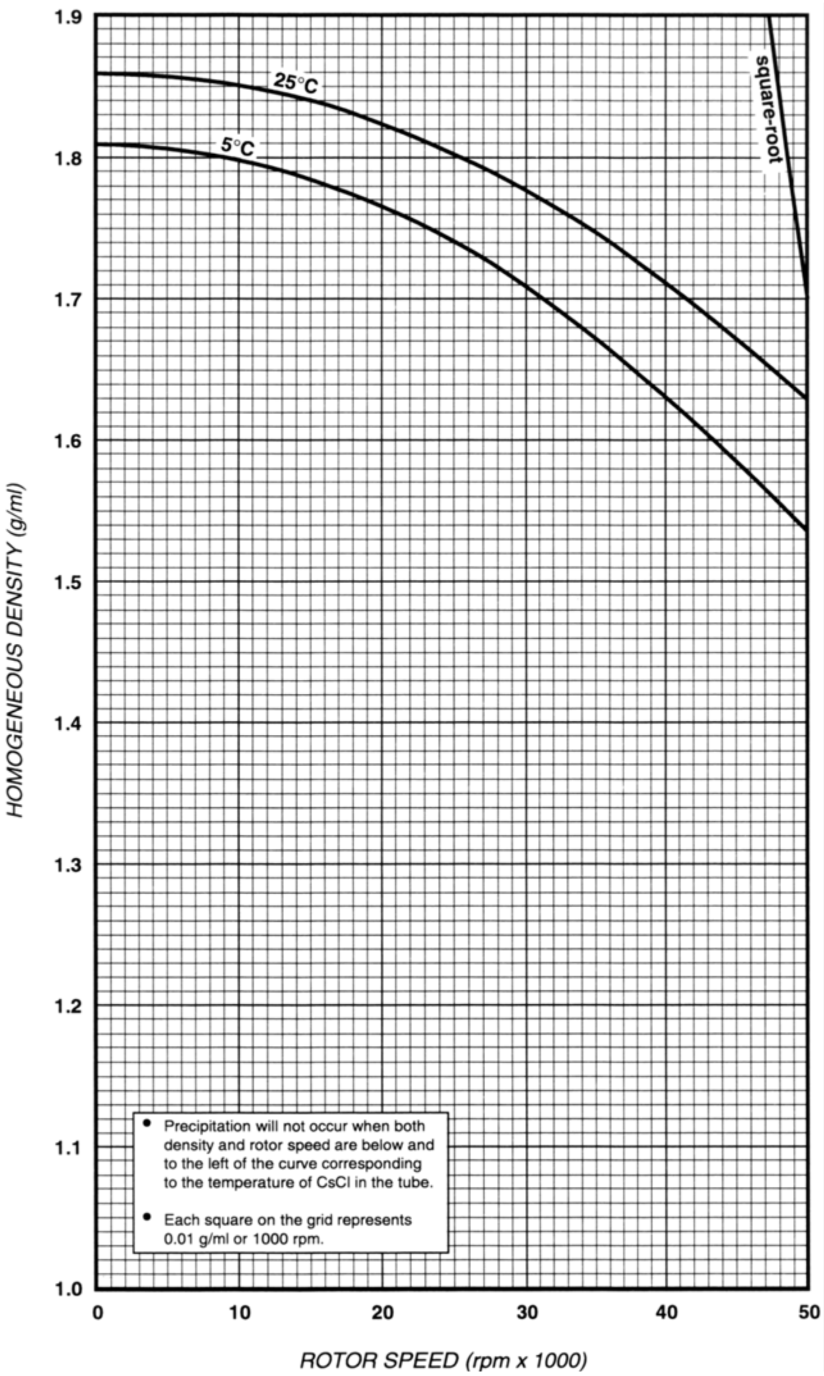

Figure 3-10. CsCl Precipitation Curves for the STEP*SAVER*™ 50 V39 Rotor System Using 39 ml ULTRACRIMP®

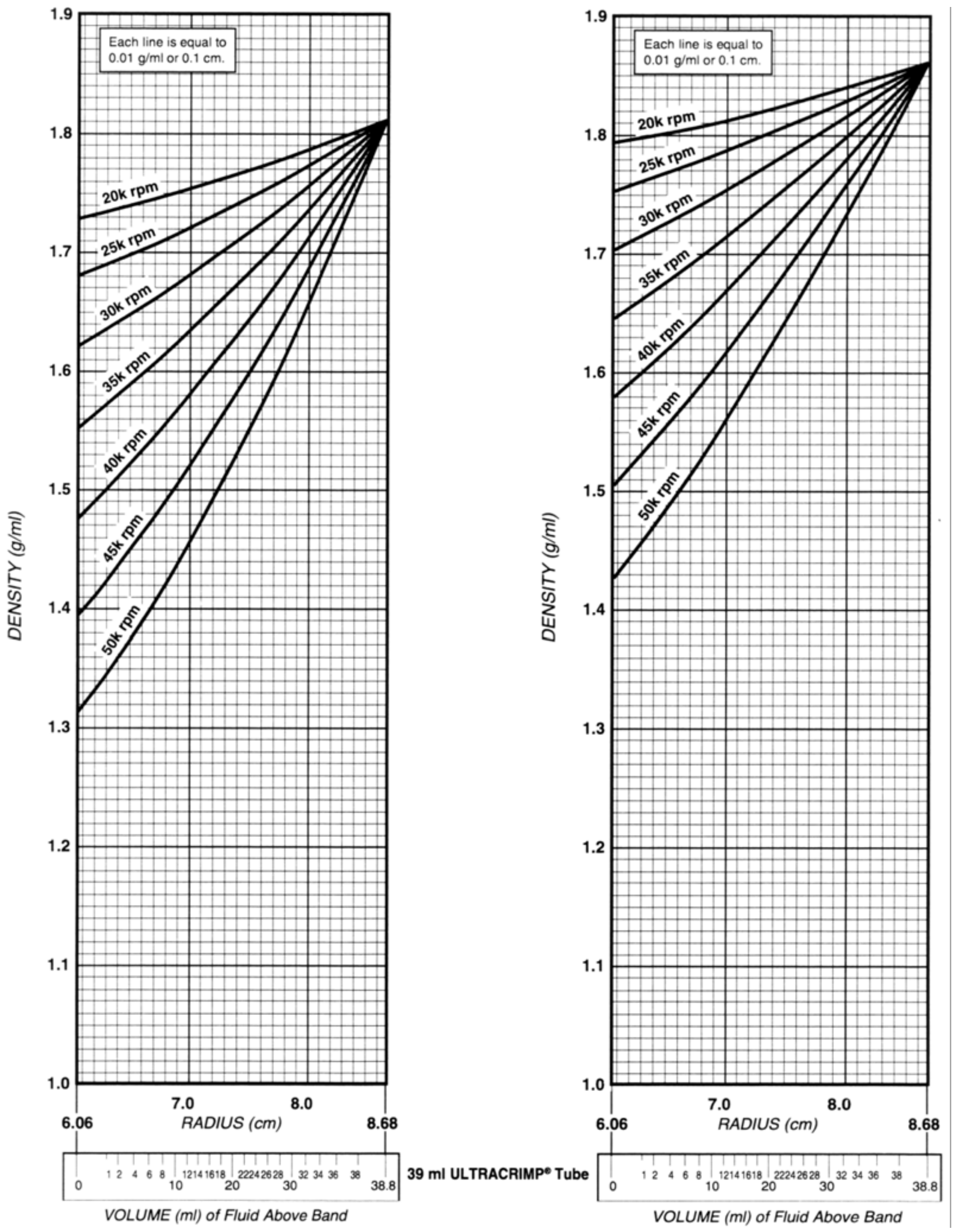

Figure 3-11. 50 V39 CsCl Density Gradient Shapes at Equilibrium (5°C)

Figure 3-12. 50 V39 CsCl Density Gradient Shapes at Equilibrium (25°C)

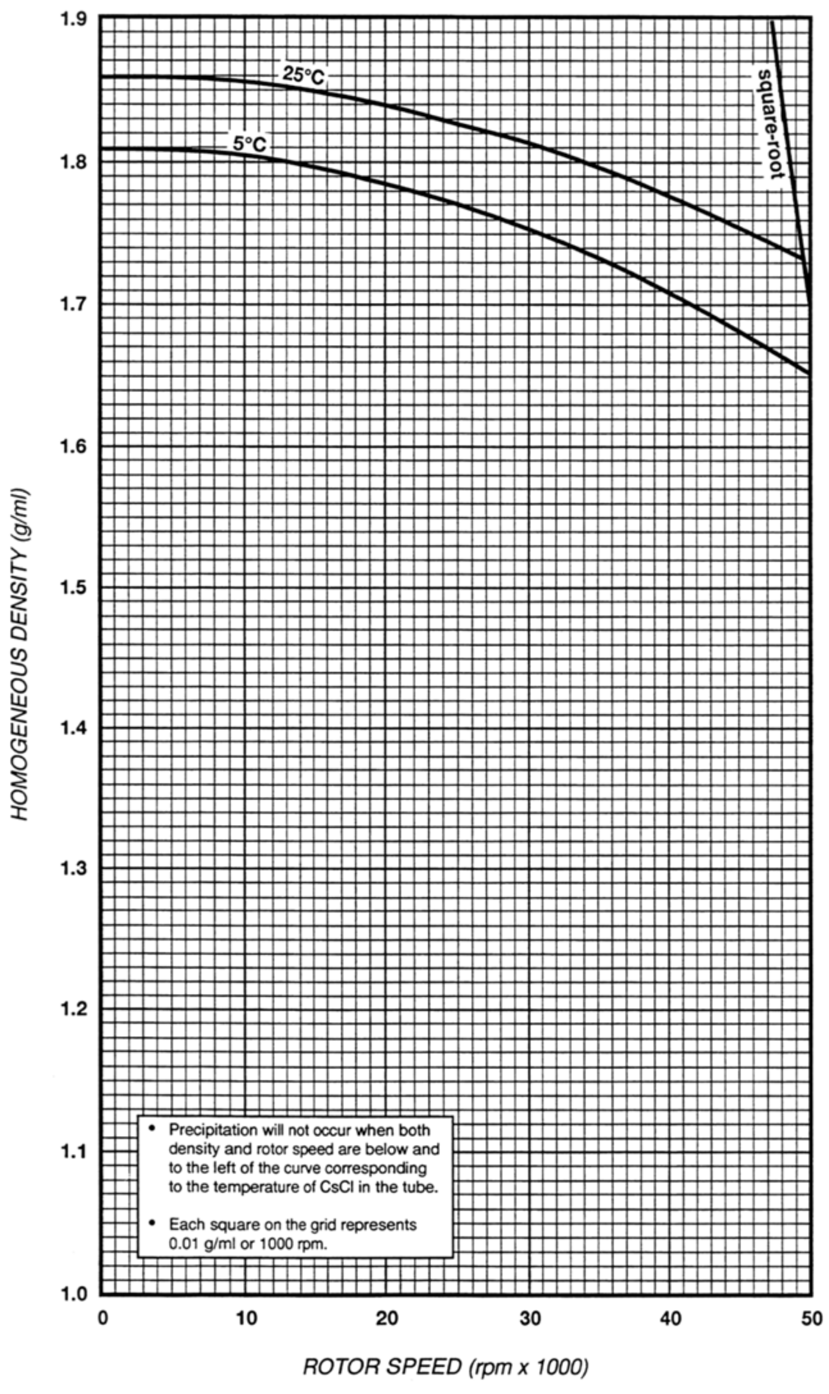

Figure 3-13. CsCl Precipitation Curves for the STEP*SAVER*™ 50 V39 Rotor System Using 13.5 ml ULTRACRIMP® Tubes

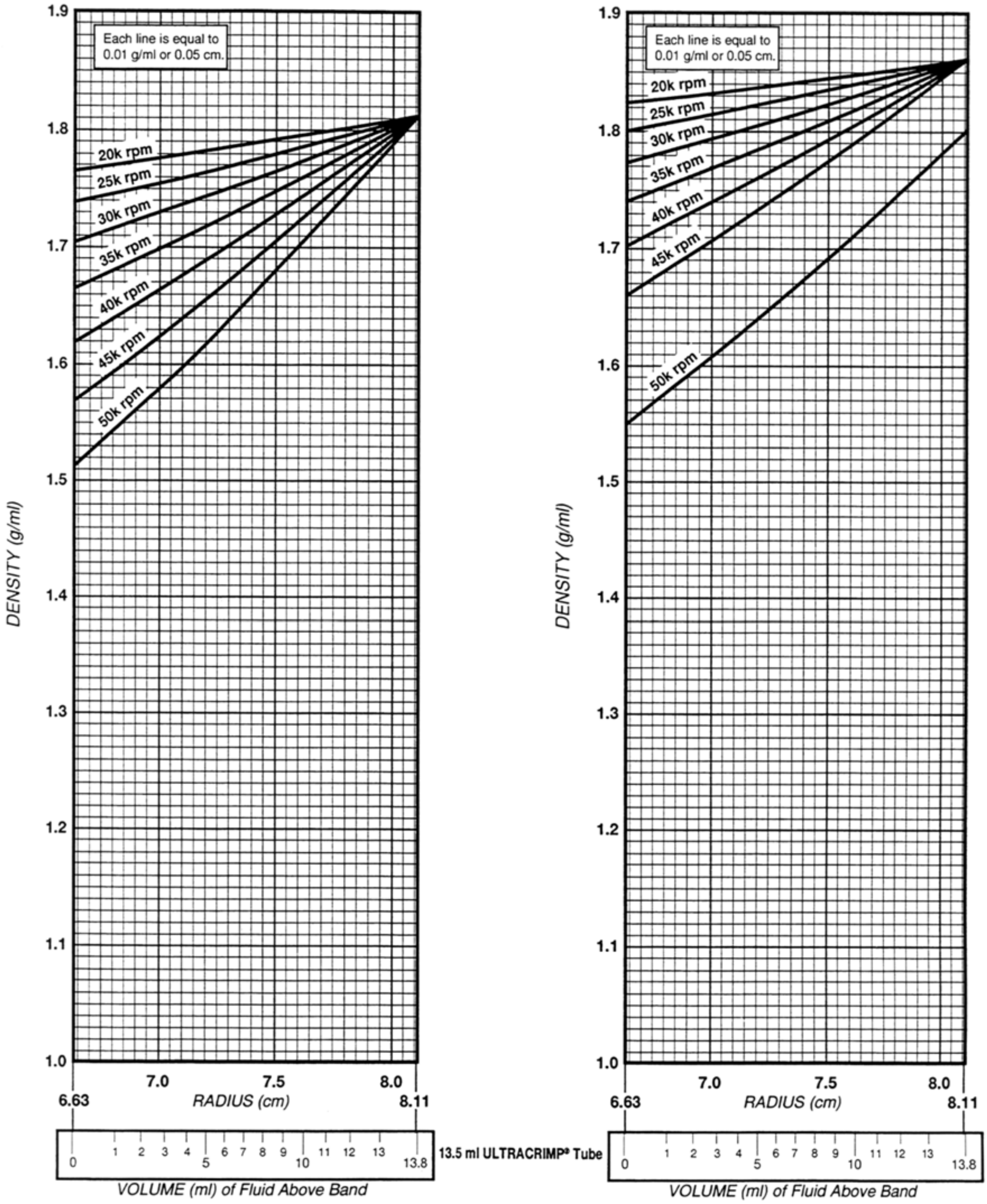

Figure 3-14. 50 V39 CsCl Density Gradient Shapes at Equilibrium (5°C)

Figure 3-15. 50 V39 CsCl Density Gradient Shapes at Equilibrium (25°C)

OPERATION

This chapter describes the operation of the rotor, including rotor balancing, rotor loading, rotor installation, acceleration and deceleration, and tube removal. Before proceeding, review the information in Chapters 2 and 3 on run preparation and special operating considerations.

Contents

Rotor Balancing

WARNING The stresses that this rotor withstands during centrifugation eventually weaken the rotor body, increasing the possibility of rotor failure. We recommend that this rotor be withdrawn from service after it has been used for 5,000 runs. Failure to do so can cause rotor failure with subsequent sample loss and damage to the rotor and/or centrifuge. If the material being processed is hazardous, the loss of sample can result in personal injury.

Always balance the rotor according to the following criteria:

k. Observe the CAUTION on the Safety Information Page in the front of this manual.

l. Pairs of tubes (in the cartridge assembly) containing a sample fluid of identical specific gravity must be placed in opposing rotor through holes. Various styles of tube/cartridge assemblies can be run at one time, however, opposing pairs of tube/cartridge assemblies must be of the same style.

m. When using less than a full complement of eight tube/cartridge assemblies, the rotor can be operated at any speed up to its maximum speed with two, four, or six samples; however, opposing pairs of tube/cartridge assemblies must be positioned as shown in Figure 4-1.

n. If an uneven number of samples is to be run, the odd sample must be counterbalanced with a tube (and cartridge assembly) that contains a solution of the same specific gravity.

Note When the rotor is operated with two, four, or six samples in opposing tube compartments, as illustrated, leave the remaining compartments empty. DO NOT put an empty cartridge in empty compartments. To do so puts unnecessary stress on the cartridge.

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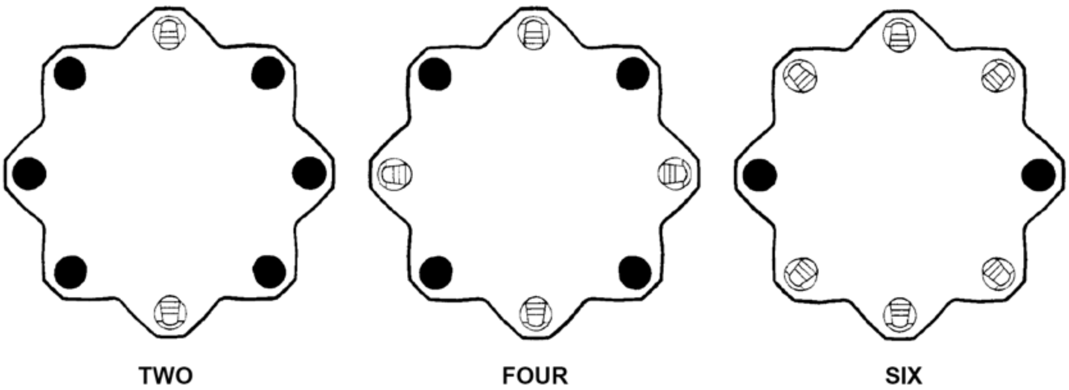

Figure 4-1. Rotor Balancing

Rotor Loading

CAUTION Inspect each tube compartment before every operation — be sure there are no nicks or scratches and that the area is clean.

If necessary, precool the rotor following the instructions given in the Thermo Scientific Ultracentrifuge Instruction Manual. The STEP*SAVER*™ Rotor Systems allow samples to be either: 1) loaded into a precooled rotor without removing the rotor from the centrifuge chamber, or 2) loaded into the rotor outside the centrifuge chamber.

Note If you are using Quick-Seal® Tubes, fill and seal them in accordance with the instructions provided with the tubes

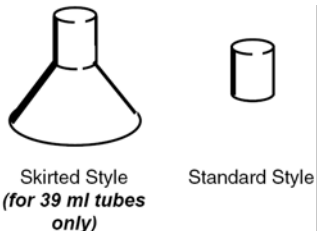

Figure 4-2. Tube Caps

Prepare ULTRACRIMP® tubes for use following the tube filling procedure given in the ULTRACRIMP® Tube Sealing System Instruction Manual. Be sure to use the correct tube caps with the STEP*SAVER*™ Rotor Systems (refer to the illustration).

1. Inspect cartridge assemblies for damage..

Note Small hairline cracks may appear on the cartridge assembly. These cracks are normal and should be no cause for concern. However, if the cracks appear to be "growing" after subsequent use, it is an indication that the cartridge assembly needs to be replaced.

2. Place a filled tube (or tubes where applicable) into the cartridge.

Note The top of each cartridge assembly is color-coded for easy identification of the rotor system used (refer to Tables 1-2,1-3, and 1-4 for color references). Only use cartridge assembly sections having the same colorcoding. Various styles of tube/cartridge assemblies can be run in the same rotor at one time, however, opposing pairs of tube/cartridge assemblies must be of the same style.

3. Close the cartridge.

CAUTION Be sure that filled cartridge assemblies are properly installed in the rotor body. Failure to do so can result in sample loss.

4. Place a filled cartridge assembly into each through hole, balancing the rotor as explained on page 4-1. A cartridge assembly is properly positioned in the rotor when the tab on the cartridge is facing toward the center of the rotor body and the top of the cartridge is seated slightly below the top surface of the rotor body. (See figure 4-3.)

Rotor Installation

Note If the rotor was loaded outside the chamber, hold the rotor vertically with both hands underneath it and move slowly and carefully to avoid disturbing the sample.

To install the rotor in the centrifuge, carefully lower it onto the drive spindle in the centrifuge rotor chamber. Check that the rotor is properly seated by gently pulling up on the rotor and noting a small amount of resistance.

Perform the run as explained in the ultracentrifuge instruction manual.

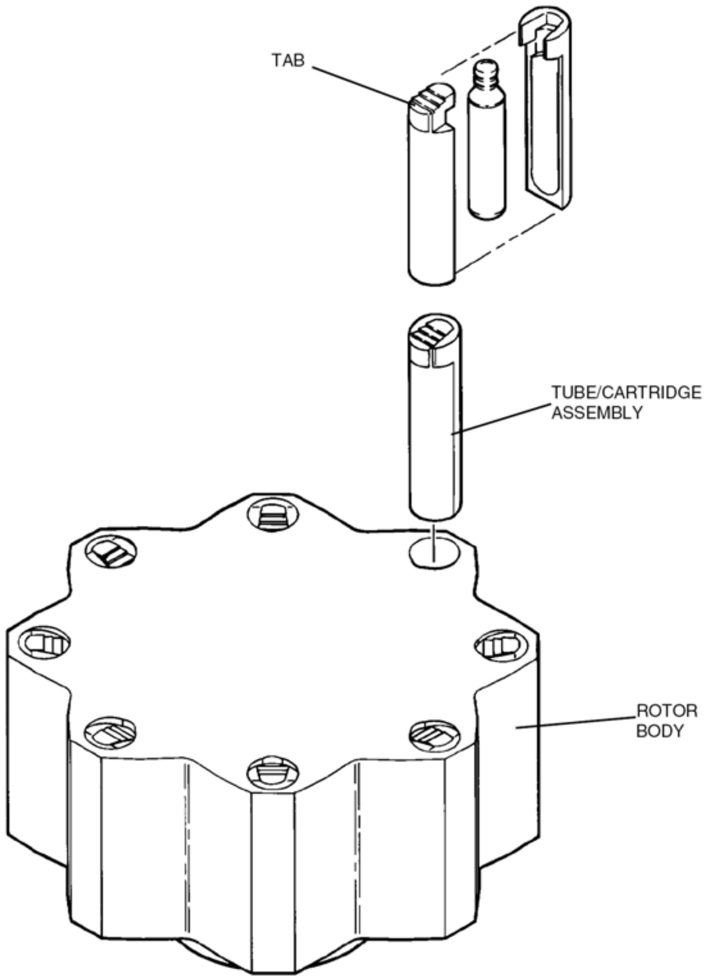

Figure 4-3. Proper Installation of the Tube/Cartridge Assembly

Acceleration and Deceleration

When using the STEP*SAVER*™ Rotors for density gradient separations, it is important to minimize disturbing the gradients, therefore we recommend using the slow acceleration and slow deceleration features. Refer to the individual ultracentrifuge instruction manual on the use of these features.

Tube Removal

1. Remove each cartridge from the rotor by gently pushing upward on the bottom of the cartridge assembly until the cartridge extends above the top edge of the rotor body and lifting the cartridge from the rotor body.
2. Remove the tube from the cartridge.
3. Unload ULTRACRIMP® tubes according to the instructions given in the ULTRACRIMP® Tube Sealing System Manual.

Note If you are using Quick-Seal®* Tubes, unload them as explained in the instructions provided by the tube manufacturer.

*Quick-Seal® is a trademark of Beckman, Instruments, Inc.

Centrifuge/Rotor Log Book

An Ultraspeed Centrifuge/Rotor Log Book is supplied with each rotor so that you can record all data necessary to meet the warranty stipulation that if a defective ultraspeed centrifuge rotor (or ultracentrifuge) is returned to Thermo Fisher Scientific it must be accompanied by an up-to-date history.

Each time a STEP*SAVER*™ Rotor is used, record the run in the log book as shown in Figure 4-3, Sample Centrifuge/Rotor Log Sheet.

Note It is not necessary to log cartridge assembly usage, however, you may want to note which cartridge assembly was used in the "Remarks" column of the log book.

Thermo Scientific Centrifuge and Rotor Log Book					RUN TIME (List by Rotor Used)								This log is for use with one centrifuge ONLY:
					Rotor S/N	AH-629 8731384	Rotor S/N	TV-865 9130129	Rotor S/N	T-1270 8931255	Rotor S/N	T-880 9030040	Model: ULTRA 80 Ser. No.: 9102448
Date	Operator	Rev. Count @ Run Start	TEMP	SPEED	HRS	MIN	HRS	MIN	HRS	MIN	HRS	MIN	Remarks*
09/04/91	J. JONES	00410290	4	57.0			05	30					*PLASMID PREP.*
09/05/91	B. SMITH	00429100	4	21.0	26	00							*SUCROSE GRADIENT*
09/07/91	J. JONES	00461860	21	70.0					18	00			*LIPOPROTEIN SEP.*

Sample Centrifuge/Rotor Log Sheet

TECHNICAL NOTES

This chapter contains information on the calculation of relative centrifugal force (RCF) and the sedimentation time in aqueous (non-gradient) solutions and in gradient solutions.

Contents

Relative Centrifugal Force (RCF) Determination

Relative Centrifugal Force (RCF) refers to the force during centrifugation that moves the particulate outward from the center of rotation. This force is proportional to the radial distance and the square of the rotor speed. The RCF value, also known a g force, is determined by the following formula:

$$RCF = 11.17(r)\left(\frac{rpm}{1000}\right)^2$$

when r = the radius in centimeters from the centerline of the rotor to the point in the tube where RCF value is required

and rpm = the rotor speed in revolutions per minute

Figure 5-1 (on the next page) shows the location of the minimum, average, and maximum radii. Table 5-1 gives the radii values for the different STEP*SAVER* ™ Rotor Systems. Tables A-1 through A-5, in the Appendix, provide precalculated RCF values for the different rotor system configurations. RCF values at speeds other than those listed can be calculated by using the formula above.

Note The radii values given do not take the thickness of the tube into consideration.

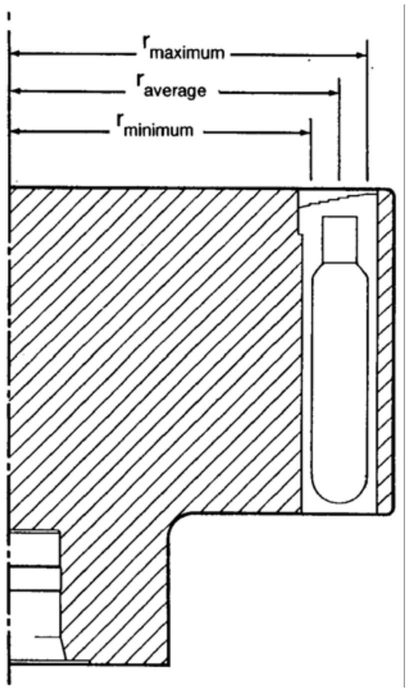

Figure 5-1. Rotor Radii

Table 5-1. Radii Values

Rotor System		$r_{maximum}$	$r_{average}$	$r_{minimum}$
STEP*SAVER*™ 70V6	6 ml ULTRACRIMP®	8.54 cm	7.875 cm	7.21cm
	2 ml x 2 ml ULTRACRIMP®	8.54 cm	7.875 cm	7.21 cm
	5.1 ml Quick-Seal®*	8.54 cm	7.875 cm	7.21 cm

Table 5-1. Radii Values

Rotor System		$r_{maximum}$	$r_{average}$	$r_{minimum}$
STEP*SAVER*™ 65 V13	13.5 ml ULTRACRIMP®	8.49 cm	7.67 cm	6.85 cm
	6 ml ULTRACRIMP®	8.33 cm	7.67 cm	7.01 cm
	13.5 ml Quick-Seal®*	8.49 cm	7.67 cm	6.85 cm
STEP*SAVER*™ 50 V39	39 ml ULTRACRIMP®	8.66 cm	7.37 cm	6.08 cm
	13.5 ml ULTRACRIMP®	8.19 cm	7.37 cm	6.55 cm

* Quick-Seal® is a trademark of Beckman Instruments, Inc.

Calculation of Sedimentation Time in Aqueous (Non-gradient) Solutions

The time required to sediment a particle in water at 20°C through the maximum rotor path length (that is, the distance between rminimum and rmaximum) can be calculated using the equation:

$$t = \frac{K}{S_{20},w}$$

where:

t = sedimentation time in hours

K = the clearing factor for the rotor (defined below)

S_{20}, w = the sedimentation coefficient for the particle of interest in water at 20°C as expressed in Svedbergs[1]

The clearing, or K factor, is defined by the equation:

$$K = (253000)\left[\text{In}\left(\frac{r_{maximum}}{r_{minimum}}\right)\right] \div \left(\frac{\text{rotor speed}}{1000}\right)^2$$

Where r_{max} and r_{min} are the maximum and minimum rotor radii, respectively, and rotor speed is expressed in rpm.

K Factors for speeds from 20,000 rpm to maximum rotor speed (in increments of 500 rpm) are listed in Appendix A.

Example: The STEP*SAVER*™ 70 V6 6 ml ULTRACRIMP® Rotor System has a K factor of 8.7 at 70,000 rpm. If the particles to be sedimented have a sedimentation coefficient of 10S, the estimated run time required at this speed will be:

$$t = \frac{8.7}{10S} \; 0.87 \text{ hours} = 0 \text{ hours, } 52 \text{ minutes}$$

[1]The sedimentation coefficient (S) in seconds, for a particle in a centrifugal field is defined by the equation S = (dx/dt) [1/(ω^2x)]; where dx/dt = sedimentation velocity of the particle in cm/s; a = rotor speed in rad/s; and x = the distance ot the particle from the axis of rotation in centimeters. Conventionally, experimentally determined values of sedimentation coefficients are multiplied by 10^{13} to convert them to Svedberg units (S), so a particle with an experimentally determined sedimentation coefficient of 10^{-11} seconds is usually referred to in the literature as a "100 S particle." Since the value determined tor the sedimentation coefficient is dependent on the density and viscosity of the solution in which centrifugation is performed, values are usually reported for the standard conditions of infinite dilution in water at 20°C, and designated S_{20}, w.

Note that the calculation assumes particles in water at 20°C. If the suspending medium is denser or more viscous than water, the sedimentation time will be greater.

Calculation of Sedimentation Time in Gradient Solutions

The time required to sediment a particle through a density gradient can be calculated using the following equation:

$$t = \frac{K}{S_{20},w}$$

where:

t = sedimentation time in hours

K = the clearing factor for the rotor (defined below)

S_{20}, w = the sedimentation coefficient for the particle of interest in water at 20°C as expressed in Svedbergs[1]Table 5-2 gives K' factors for the STEP*SAVER*™ Rotor Systems when operated at maximum speed with particles ranging in density from 1.1 g/cm^3 to 1.7 g/cm^3. In this case, the K' factors are based on the use of a 5% - 20% (w/w) linear sucrose density gradient at 5°C.

Table 5-2. K' Factors for the STEPSAVER Rotor Systems (at maximum speed)

Particle Density (g/cm3)	70 V6 6 ml ULTRACRIMP®, or 2 x 2 ml ULTRACRIMP®, or 5.1 ml Quick-Seal®*	65 V13 13.5 ml ULTRACRIMP® or 13.5 ml Quick-Seal®*	65 V13 6 ml ULTRACRIMP®	50 V39 39 ml ULTRACRIMP ®	50 V39 13.5 ml ULTRACRIMP®
1.1	48	92	55	218	150
1.2	23	44	26	115	72
1.3	20	38	23	101	62
1.4	19	35	21	95	57
1.5	18	34	20	92	55
1.6	17	33	20	218	150
1.7	17	32	19	115	72

* Quick-Seal® is a trademark of Beckman Instruments, Inc.

CARE and MAINTENANCE

This chapter provides instructions on rotor corrosion, cleaning, decontamination, inspection, overspeed decal replacement, and storage. It also includes the Service Decontamination Policy.

Contents

Corrosion

CAUTION Always maintain the rotor in the recommended manner. The rotor and all accessories must be clean and inspected prior to each run. Do not use rotors or cartridges that show signs of corrosion or cracking.

The body of the STEP*SAVER*™ Rotors are made from titanium, making it more resistant to corrosion than an aluminum rotor; however, it should be maintained and kept clean the same as an aluminum rotor. Proper care will lessen the chances of rotor failure and significantly prolong the useful life of the rotor.

Corrosion commonly refers to chemical reactions at the surface (that is, rusting or pitting) recognized by the growing areas of visible deterioration. On the other hand, stress corrosion attacks the inside of the metal as well; barely detectable surface cracks grow inward, weakening the part without visible warning. Stress corrosion applies to most commonly used alloys, even the corrosion-resistant alloys have been found susceptible.

Stress corrosion is thought to be initiated by certain combinations of stress and chemical reaction. The most common chemical causing harmful effects is chloride, whether in a solution (for example, ammonium salts) or as a subtle form as sodium chloride in hand perspiration. If the rotor is not kept clean and chemicals remain on the rotor body, corrosion will result. Also, any moisture left on the rotor for an extended period of time can initiate corrosion. Therefore, it is important to keep the rotor clean and to dry it thoroughly after use.

In general, conditions for corrosion are present in all rotor applications; proper care and maintenance will minimize its effects.

Cleaning and Decontamination

These procedures are for general cleaning purposes only. If the rotor or any components are exposed to a contaminant, they must be decontaminated first, then washed.

WARNING Always be aware of the possibility of contamination when using radioactive, toxic, or pathogenic materials. Take all necessary precautions and use appropriate decontamination procedures if exposure occurs.

Cleaning

Wash the rotor body and cartridge assemblies with warm water and mild soap or detergent at least once a week or, ideally, after each use. It is particularly important that the rotor is washed immediately after any spills have occurred. Most laboratory chemicals can be removed with a lukewarm, 1% solution of a mild, non-alkaline detergent such as a mild dishwashing liquid. Rinse the rotor and cartridge assemblies well, inside and out. After rinsing, dry the rotor and cartridge assemblies thoroughly with a soft absorbent cloth or an air blast.

Do not use strong laboratory detergents to clean the rotor surface or cartridge assemblies. Use a bristle brush to loosen encrusted material only if necessary; be careful not to scratch the rotor surface.

Sterilization and Decontamination

Rotor Body

The titanium rotor body can be sterilized by autoclaving at temperatures up to 121°C.

Cartridge Assemblies

The life of STEP*SAVER*™ Cartridge Assemblies depends on a variety of factors that include: run parameters (run speed, temperature and run time), frequency of use, chemical exposure, the cleaning and disinfection techniques used, the frequency of cleaning and disinfection plus storage of the cartridge assemblies between use.

Cartridge assemblies that are properly maintained and used as described in this manual, can be expected to provide 1000 hours of operation at the maximum rated speed of the rotor using the maximum rated sample density. (Actual cartridge assembly life can vary depending on the actual run speed and sample density used.)

As indicated above, cleaning and disinfection practices can affect the life of STEP*SAVER*™ Cartridge Assemblies. The following table gives some suggested guidelines for proper cleaning and disinfecting for the STEP*SAVER*™ Cartridge Assemblies.

Table 6-1. Cartridge Assembly Cleaning and Disinfection Techniques

Cartridge Assembly Cleaning and Disinfection Techniques	Maximum Number of Cleaning Cycles
Autoclaving - 121°C at 15 psi for 15 minutes	12
5% Hypochlorite Solution for 20 minutes	20
Dry Heat - 180°C for 4 hours	10
2% Glutaraldehyde Solution for 16 hours	12
Isopropyl Alcohol - 70% for 15 minutes	10
COUNT-OFF™1 Radioactive Decontaminant - 5% for 2 hours	10

Typically, cartridge assemblies will show signs of degradation over time - long before a failure would occur. Inspection of each cartridge assembly before use is an important step in preventing failure. Check the cartridge assembly for deformation around the window area (the cartridge assembly may be more difficult to close when a tube is in place) and crack growth. This degradation indicates that the cartridge assembly should be replaced.

Note Small hairline cracks may appear on the cartridge assembly. These cracks are normal and should be no cause for concern. However, if the cracks appear to be "growing" after subsequent use, this is also an indication that the cartridge assembly needs to be replaced.

Overspeed Decal Replacement

Before replacing the decal, be sure that the rotor is dry and at room temperature; this ensures that the new decal adheres properly.

To replace the decal:

1. Remove the existing decal from the bottom of the rotor; be careful not to scratch the rotor surface.
2. Clean the adhesive from the rotor surface using acetone or 3M GeneralAdhesive Remover #8984.
3. Wipe the surface dry with a clean, soft cloth.

Note Check that the new decal has the correct number of black segments for the rotor being used. The decal for the STEP*SAVER*™ 70 V6 Rotor should have 13 black segments; the decal for the STEP*SAVER*™ 65 V13 Rotor should have 14 black segments; and the decal for the STEP*SAVER*™ 50 V39 Rotor should have 18 black segments.

4. Peel the paper backing off the new decal. Fit the decal into the recess in the bottom of the rotor. Be sure the decal is properly centered, then press the decal firmly into place.

Storage

After the rotor has been cleaned and dried, it should be stored without the cartridges; this will keep the through-holes dry. Cartridge assemblies should be stored in the cartridge racks supplied with the rotor..

Note The cartridge assemblies can be damaged if they are stored loosely, disassembled in a drawer.

Inspection

Periodically, inspect the rotor body and cartridge assemblies for signs of: stress, including cracks, tears, and abrasions; wear; corrosion or deformation. If such problems are found, contact your representative or agent for Thermo Fisher Scientific products for information on factory inspection or replacement.

Service Decontamination Policy

If a centrifuge or rotor that has been used with radioactive or pathogenic material requires servicing by Thermo Fisher Scientific personnel, either at the customer's laboratory or at a Thermo Fisher Scientific facility, comply with the following procedures to ensure the safety of all personnel:

1. Clean the centrifuge or rotor to be serviced of all encrusted material and decontaminate it (see Maintenance Section of centrifuge or rotor instruction manual) prior to servicing by the Thermo Fisher Scientific representative or returning to the Thermo Fisher Scientific facility. There must be no radioactivity detectable by survey equipment.

   The Thermo Fisher Scientific Product Guide contains descriptions of commonly used decontamination methods and a chart showing method compatibility with various materials. The centrifuge or rotor instruction manual contains specific guidance about cleaning and decontamination methods appropriate for the product it describes.

   Clean and decontaminate your centrifuge or rotor as follows:

   For ultracentrifuges:

a. Remove rotor from the rotor chamber.

b. Decontaminate door and rotor chamber using an appropriate method.

For rotors and cartridges:

Remove the cartridge assemblies from the rotor and decontaminate using an appropriate method. If cartridge assemblies are stuck in the rotor notify Thermo Fisher Scientific representative; be prepared with the name and nature of the sample so the Thermo Fisher Scientific Chemical Hazards Officer can decide whether to authorize the rotor's return to a Thermo Fisher Scientific facility.

2. Complete and attach Decontamination Information Certificate (in the back of your rotor or instrument manual) to the centrifuge, rotor or cartridge before servicing or return to Thermo Fisher Scientific facility. If Certificate is not available, attach a written statement verifying decontamination (what was contaminant and what decontamination method was used).

If the centrifuge or rotor must be returned to a Thermo Fisher Scientific facility:

1. Contact your Thermo Fisher Scientific representative to obtain a Return Service Order Number (RSO No.); be prepared with the name and serial number of the centrifuge or rotor and the repairs required.
2. Send item(s), with the RSO No. clearly marked on the outside packaging, to the address obtained from your Thermo Fisher Scientific representative.

Note United States federal regulations require that parts and instruments must be decontaminated before being transported. Outside the United States, check local regulations.

If a centrifuge or rotor to be serviced does not have a Decontamination Information Certificate attached, and in Thermo Fisher Scientific's opinion presents a potential radioactive or biological hazard, the Thermo Fisher Scientific representative will not service the equipment until proper decontamination and certification is complete. If Thermo Fisher Scientific receives a centrifuge or rotor at its Service facilities which, in its opinion, is a radioactive or biological hazard, the sender will be contacted for instructions as to the disposition of equipment. Disposition costs will be borne by the sender.

Decontamination Information Certificates are included with these instructions. Additional certificates are available from the local Account Representative or Field Service Engineer. In the event these certificates are not available, a written statement certifying that the unit has been properly decontaminated and outlining the procedures used will be acceptable.

Note The Field Service Engineer will note on a Customer Service Repair Report if decontamination was required and, if so, what the contaminant was and what procedure was used. If no decontamination was required, it will be so stated.

Chemical Compatibility Chart

CHEMICAL / MATERIAL	ALUMINUM	ANODIC COATING for ALUMINUM	BUNA N	CELLULOSE ACETATE BUTYRATE	POLYURETHANE ROTOR PAINT	COMPOSITE Carbon Fiber/Epoxy	DELRIN®	ETHYLENE PROPYLENE	GLASS	NEOPRENE	NORYL®	NYLON	PET*, POLYCLEAR®, CLEARCRIMP® CCCLEARCRIMP®	POLYALLOMER	POLYCARBONATE	POLYESTER, GLASS THERMOSET	POLYTHERMIDE	POLYRTHYLENE	POLYPROPYLENE	POLYSULFONE	POLYVINYL CHLORIDE	RULON A®, TEFLON®	SILICONE RUBBER	STAINLESS STEEL	TITANIUM	TYGON®	VITON®
2-mercaptoethanol	S	S	U	-	S	M	S	-	S	U	S	S	U	S	S	-	S	S	S	S	U	S	S	S	S	S	S
Acetaldehyde	S	-	U	U	-	-	-	M	-	U	-	-	-	M	U	U	U	M	M	-	M	S	U	-	S	-	U
Acetone	M	S	U	U	S	U	M	S	S	U	U	S	U	S	U	U	U	S	S	U	U	S	M	M	S	U	U
Acetonitrile	S	S	U	-	S	M	S	-	S	S	U	S	U	M	U	U	-	S	M	U	U	S	S	S	S	U	U
Alconox®	U	U	S	-	S	S	S	-	S	S	S	S	S	S	M	S	S	S	S	S	S	S	S	S	S	S	U
Allyl Alcohol	-	-	-	U	-	-	S	-	-	-	-	S	-	S	S	M	S	S	S	-	M	S	-	-	S	-	-
Aluminum Chloride	U	U	S	S	S	S	U	S	S	S	S	M	S	S	S	S	-	S	S	S	S	S	M	U	U	S	S
Formic Acid (100%)	-	S	M	U	-	-	U	-	-	-	-	U	-	S	M	U	U	S	S	-	U	S	-	U	S	-	U
Ammonium Acetate	S	S	U	-	S	S	S	-	S	S	S	S	S	S	S	U	-	S	S	S	S	S	S	S	S	S	S
Ammonium Carbonate	M	S	U	S	S	S	S	S	S	S	S	S	S	S	U	U	-	S	S	S	S	S	S	M	S	S	S
Ammonium Hydroxide (10%)	U	U	S	U	S	S	M	S	S	S	S	S	-	S	U	M	S	S	S	S	S	S	S	S	S	M	S
Ammonium Hydroxide (28%)	U	U	S	U	S	U	M	S	S	S	S	S	U	S	U	M	S	S	S	S	S	S	S	S	S	M	S
Ammonium Hydroxide (conc.)	U	U	U	U	S	U	M	S	-	S	-	S	U	S	U	U	S	S	S	-	M	S	S	S	S	-	U
Ammonium Phosphate	U	-	S	-	S	S	S	S	S	S	S	S	-	S	S	M	-	S	S	S	S	S	S	M	S	S	S
Ammonium Sulfate	U	M	S	-	S	S	U	S	S	S	S	S	S	S	S	S	-	S	S	S	S	S	S	U	S	S	U
Amyl Alcohol	S	-	M	U	-	-	S	S	-	M	-	S	-	M	S	S	S	S	M	-	-	-	U	-	S	-	M
Aniline	S	S	U	U	S	U	S	M	S	U	U	U	U	U	U	U	-	S	M	U	U	S	S	S	S	U	S
Sodium Hydroxide (<1%)	U	-	M	S	S	S	-	-	S	M	S	S	-	S	M	M	S	S	S	S	S	S	M	S	S	-	U
Sodium Hydroxide (10%)	U	-	M	U	-	-	U	-	M	M	S	S	U	S	U	U	S	S	S	S	S	S	M	S	S	-	U
Barium Salts	M	U	S	-	S	S	S	S	S	S	S	S	S	S	S	M	-	S	S	S	S	S	S	M	S	S	S
Benzene	S	S	U	U	S	U	M	U	S	U	U	S	U	U	U	M	U	M	U	U	U	S	U	U	S	U	S

CHEMICAL / MATERIAL	ALUMINUM	ANODIC COATING for ALUMINUM	BUNA N	CELLULOSE ACETATE BUTYRATE	POLYURETHANE ROTOR PAINT	COMPOSITE Carbon Fiber/Epoxy	DELRIN®	ETHYLENE PROPYLENE	GLASS	NEOPRENE	NORYL®	NYLON	PET*, POLYCLEAR®, CLEARCRIMP®CCCLEARCRIMP®	POLYALLOMER	POLYCARBONATE	POLYESTER, GLASS THERMOSET	POLYTHERMIDE	POLYRTHYLENE	POLYPROPYLENE	POLYSULFONE	POLYVINYL CHLORIDE	RULON A®, TEFLON®	SILICONE RUBBER	STAINLESS STEEL	TITANIUM	TYGON®	VITON®
Benzyl Alcohol	S	-	U	U	-	-	M	M	-	M	-	S	U	U	U	U	U	U	U	-	M	S	M	-	S	-	S
Boric Acid	U	S	S	M	S	S	U	S	S	S	S	S	S	S	S	S	U	S	S	S	S	S	S	S	S	S	S
Cesium Acetate	M	-	S	-	S	S	S	-	S	S	S	S	-	S	S	-	-	S	S	S	S	S	S	M	S	S	S
Cesium Bromide	M	S	S	-	S	S	S	-	S	S	S	S	S	S	S	-	-	S	S	S	S	S	S	M	S	S	S
Cesium Chloride	M	S	S	U	S	S	S	-	S	S	S	S	S	S	S	-	-	S	S	S	S	S	S	M	S	S	S
Cesium Formate	M	S	S	-	S	S	S	-	S	S	S	S	S	S	S	-	-	S	S	S	S	S	S	M	S	S	S
Cesium Iodide	M	S	S	-	S	S	S	-	S	S	S	S	S	S	S	-	-	S	S	S	S	S	S	M	S	S	S
Cesium Sulfate	M	S	S	-	S	S	S	-	S	S	S	S	S	S	S	-	-	S	S	S	S	S	S	M	S	S	S
Chloroform	U	U	U	U	S	S	M	U	S	U	U	M	U	M	U	U	U	M	M	U	U	S	U	U	U	M	S
Chromic Acid (10%)	U	-	U	U	S	U	U	-	S	S	S	U	S	S	M	U	M	S	S	U	M	S	M	U	S	S	S
Chromic Acid (50%)	U	-	U	U	-	U	U	-	-	-	S	U	U	S	M	U	M	S	S	U	M	S	-	U	M	-	S
Cresol Mixture	S	S	U	-	-	-	S	-	S	U	U	U	U	U	U	-	-	U	U	-	U	S	S	S	S	U	S
Cyclohexane	S	S	S	-	S	S	S	U	S	U	S	S	U	U	U	M	S	M	U	M	M	S	U	M	M	U	S
Deoxycholate	S	S	S	-	S	S	S	-	S	S	S	S	S	S	S	-	-	S	S	S	S	S	S	S	S	S	S
Distilled Water	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
Dextran	M	S	S	S	S	S	S	-	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	M	S	S	S
Diethyl Ether	S	S	U	U	S	S	S	U	S	U	U	S	U	U	U	U	U	U	U	U	U	S	S	S	S	M	U
Diethyl Ketone	S	-	U	U	-	-	M	-	S	U	-	S	-	M	U	U	U	M	M	-	U	S	-	-	S	U	U
Diethylpyrocarbonate	S	S	U	-	S	S	S	-	S	S	U	S	U	S	U	-	-	S	S	S	M	S	S	S	S	S	S
Dimethylsulfoxide	S	S	U	U	S	S	S	-	S	U	S	S	U	S	U	U	-	S	S	U	U	S	S	S	S	U	U
Dioxane	M	S	U	U	S	S	M	M	S	U	U	S	U	M	U	U	-	M	M	M	U	S	S	S	S	U	U
Ferric Chloride	U	U	S	-	-	-	M	S	-	M	-	S	-	S	-	-	-	S	S	-	-	-	M	U	S	-	S
Acetic Acid (Glacial)	S	S	U	U	S	S	U	M	S	U	S	U	U	U	U	U	M	S	U	M	U	S	U	U	S	-	U
Acetic Acid (5%)	S	S	M	S	S	S	M	S	S	S	S	S	M	S	S	S	S	S	S	S	M	S	S	M	S	S	M
Acetic Acid (60%)	S	S	U	U	S	S	U	-	S	M	S	U	U	M	U	S	M	S	M	S	M	S	M	U	S	M	U
Ethyl Acetate	M	M	U	U	S	S	M	M	S	S	U	S	U	M	U	U	-	S	S	U	U	S	M	M	S	U	U
Ethyl Alcohol (50%)	S	S	S	S	S	S	M	S	S	S	S	S	U	S	U	S	S	S	S	S	S	S	S	M	S	M	U
Ethyl Alcohol (95%)	S	S	S	U	S	S	M	S	S	S	S	S	U	S	U	-	S	S	S	M	S	S	S	U	S	M	U
Ethylene Dichloride	S	-	U	U	-	-	S	M	-	U	U	S	U	U	U	U	U	U	U	-	U	S	U	-	S	-	S
Ethylene Glycol	S	S	S	S	S	S	S	S	S	S	S	S	-	S	U	S	S	S	S	S	S	S	S	M	S	M	S

CHEMICAL / MATERIAL	ALUMINUM	ANODIC COATING for ALUMINUM	BUNA N	CELLULOSE ACETATE BUTYRATE	POLYURETHANE ROTOR PAINT	COMPOSITE Carbon Fiber/Epoxy	DELRIN®	ETHYLENE PROPYLENE	GLASS	NEOPRENE	NORYL®	NYLON	PET*, POLYCLEAR®, CLEARCRIMP®CCCLEARCRIMP®	POLYALLOMER	POLYCARBONATE	POLYESTER, GLASS THERMOSET	POLYTHERMIDE	POLYRTHYLENE	POLYPROPYLENE	POLYSULFONE	POLYVINYL CHLORIDE	RULON A®, TEFLON®	SILICONE RUBBER	STAINLESS STEEL	TITANIUM	TYGON®	VITON®
Ethylene Oxide Vapor	S	-	U	-	-	U	-	-	S	U	-	S	-	S	M	-	-	S	S	S	U	S	U	S	S	S	U
Ficoll-Hypaque®	M	S	S	-	S	S	S	-	S	S	S	S	-	S	S	-	S	S	S	S	S	S	S	M	S	S	S
Hydrofluoric Acid (10%)	U	U	U	M	-	-	U	-	-	U	U	S	-	S	M	U	S	S	S	S	M	S	U	U	U	-	-
Hydrofluoric Acid (50%)	U	U	U	U	-	-	U	-	-	U	U	U	U	S	U	U	U	S	S	M	M	S	U	U	U	-	M
Hydrochloric Acid (conc.)	U	U	U	U	-	U	U	M	-	U	M	U	U	M	U	U	U	-	S	-	U	S	U	U	U	-	-
Formaldehyde (40%)	M	M	M	S	S	S	S	M	S	S	S	S	M	S	S	S	U	S	S	M	S	S	S	M	S	M	U
Glutaraldehyde	S	S	S	S	-	-	S	-	S	S	S	S	S	S	S	-	-	S	S	S	-	-	S	S	S	-	-
Glycerol	M	S	S	-	S	S	S	S	S	S	S	S	S	S	S	S	-	S	S	S	S	S	S	S	S	S	S
Guanidine Hydrochloride	U	U	S	-	S	S	S	-	S	S	S	S	S	S	S	-	-	S	S	S	S	S	S	U	S	S	S
Haemo-Sol®	S	S	S	-	-	-	S	-	S	S	S	S	S	S	S	-	-	S	S	S	S	S	S	S	S	S	S
Hexane	S	S	S	-	S	S	S	-	S	S	U	S	U	M	U	S	S	U	S	S	M	S	U	S	S	U	S
Isobutyl Alcohol	-	-	M	U	-	-	S	S	-	U	-	S	U	S	S	M	S	S	S	-	S	S	S	-	S	-	S
Isopropyl Alcohol	M	M	M	U	S	S	S	S	S	U	S	S	U	S	U	M	S	S	S	S	S	S	S	M	M	M	S
Iodoacetic Acid	S	S	M	-	S	S	S	-	S	M	S	S	M	S	S	-	M	S	S	S	S	S	M	S	S	M	M
Potassium Bromide	U	S	S	-	S	S	S	-	S	S	S	S	S	S	S	S	S	S	S	-	S	S	S	M	S	S	S
Potassium Carbonate	M	U	S	S	S	S	S	-	S	S	S	S	S	S	U	S	S	S	S	S	S	S	S	S	S	S	S
Potassium Chloride	U	S	S	-	S	S	S	S	S	S	S	S	S	S	S	-	S	S	S	S	S	S	S	U	S	S	S
Potassium Hydroxide (5%)	U	U	S	S	S	S	M	-	S	S	S	S	-	S	U	S	S	S	S	S	S	S	M	U	M	S	U
Potassium Hydroxide (conc.)	U	U	M	U	-	-	M	-	M	S	S	-	U	M	U	U	U	S	M	-	M	U	-	U	U	-	U
Potassium Permanganate	S	S	S	-	S	S	S	-	S	S	S	U	S	S	S	M	-	S	M	S	U	S	S	M	S	U	S
Calcium Chloride	M	U	S	S	S	S	S	S	S	S	S	S	S	S	M	S	-	S	S	S	S	S	S	M	S	S	S
Calcium Hypochlorite	M	-	U	-	S	M	M	S	-	M	-	S	-	S	M	S	-	S	S	S	M	S	M	U	S	-	S
Kerosene	S	S	S	-	S	S	S	U	S	M	U	S	U	M	M	S	-	M	M	M	S	S	U	S	S	U	S
Sodium Chloride (10%)	S	-	S	S	S	S	S	S	-	-	-	S	S	S	S	S	-	S	S	S	S	-	S	S	M	-	S
Sodium Chloride (sat'd)	U	-	S	U	S	S	S	-	-	-	-	S	S	S	S	S	-	S	S	-	S	-	S	S	M	-	S
Carbon Tetrachloride	U	U	M	S	S	U	M	U	S	U	U	S	U	M	U	S	S	M	M	S	M	M	M	M	U	S	S
Aqua Regia	U	-	U	U	-	-	U	-	-	-	-	-	U	U	U	U	U	U	U	-	-	-	-	-	S	-	M
Solution 555 (20%)	S	S	S	-	-	-	S	-	S	S	S	S	S	S	S	-	-	S	S	S	-	S	S	S	S	S	S
Magnesium Chloride	M	S	S	-	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	M	S	S	S
Mercaptoacetic Acid	U	S	U	-	S	M	S	-	S	M	S	U	U	U	U	-	S	U	U	S	M	S	U	S	S	S	S

CHEMICAL / MATERIAL	ALUMINUM	ANODIC COATING for ALUMINUM	BUNA N	CELLULOSE ACETATE BUTYRATE	POLYURETHANE ROTOR PAINT	COMPOSITE Carbon Fiber/Epoxy	DELRIN®	ETHYLENE PROPYLENE	GLASS	NEOPRENE	NORYL®	NYLON	PET*, POLYCLEAR®, CLEARCRIMP®CCCLEARCRIMP®	POLYALLOMER	POLYCARBONATE	POLYESTER, GLASS THERMOSET	POLYTHERMIDE	POLYRTHYLENE	POLYPROPYLENE	POLYSULFONE	POLYVINYL CHLORIDE	RULON A®, TEFLON®	SILICONE RUBBER	STAINLESS STEEL	TITANIUM	TYGON®	VITON®
Methyl Alcohol	S	S	S	U	S	S	M	S	S	S	S	S	U	S	U	M	S	S	S	S	S	S	S	M	S	M	U
Methylene Chloride	U	U	U	U	M	S	S	U	S	U	U	S	U	U	U	U	U	M	U	U	U	S	S	M	U	S	U
Methyl Ethyl Ketone	S	S	U	U	S	S	M	S	S	U	U	S	U	S	U	U	U	S	S	U	U	S	S	S	S	U	U
Metrizamide®	M	S	S	-	S	S	S	-	S	S	S	S	-	S	S	-	-	S	S	S	S	S	S	M	S	S	S
Lactic Acid (100%)	-	-	S	-	-	-	-	-	-	M	S	U	-	S	S	S	M	S	S	-	M	S	M	S	S	-	S
Lactic Acid (20%)	-	-	S	S	-	-	-	-	-	M	S	M	-	S	S	S	S	S	S	S	M	S	M	S	S	-	S
N-Butyl Alcohol	S	-	S	U	-	-	S	-	-	S	M	-	U	S	M	S	S	S	S	M	M	S	M	-	S	-	S
N-Butyl Phthalate	S	S	U	-	S	S	S	-	S	U	U	S	U	U	U	M	-	U	U	S	U	S	M	M	S	U	S
N, N-Dimethylformamide	S	S	S	U	S	M	S	-	S	S	U	S	U	S	U	U	-	S	S	U	U	S	M	S	S	S	U
Sodium Borate	M	S	S	S	S	S	S	S	S	S	S	U	S	S	S	S	-	S	S	S	S	S	S	M	S	S	S
Sodium Bromide	U	S	S	-	S	S	S	-	S	S	S	S	S	S	S	S	-	S	S	S	S	S	S	M	S	S	S
Sodium Carbonate (2%)	M	U	S	S	S	S	S	S	S	S	S	S	S	S	U	S	S	S	S	S	S	S	S	S	S	S	S
Sodium Dodecyl Sulfate	S	S	S	-	S	S	S	-	S	S	S	S	S	S	S	-	S	S	S	S	S	S	S	S	S	S	S
Sodium Hypochlorite (5%)	U	U	M	S	S	M	U	S	S	M	S	S	S	M	S	S	S	S	M	S	S	S	M	U	S	M	S
Sodium Iodide	M	S	S	-	S	S	S	-	S	S	S	S	S	S	S	-	-	S	S	S	S	S	S	M	S	S	S
Sodium Nitrate	S	S	S	-	S	S	S	S	S	S	S	S	S	S	S	S	-	S	S	S	S	S	U	S	S	S	S
Sodium Sulfate	U	S	S	-	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	M	S	S	S
Sodium Sulfide	S	-	S	S	-	-	-	S	-	-	-	S	S	S	U	U	-	-	S	-	-	-	S	S	M	-	S
Sodium Sulfite	S	S	S	-	S	S	S	S	M	S	S	S	S	S	S	M	-	S	S	S	S	S	S	S	S	S	S
Nickel Salts	U	S	S	S	S	S	-	S	S	S	-	-	S	S	S	S	-	S	S	S	S	S	S	M	S	S	S
Oils (Petroleum)	S	S	S	-	-	-	S	U	S	S	S	S	U	U	M	S	M	U	U	S	S	S	U	S	S	S	S
Oils (Other)	S	-	S	-	-	-	S	M	S	S	S	S	U	S	S	S	S	U	S	S	S	S	-	S	S	M	S
Oleic Acid	S	-	U	S	S	S	U	U	S	U	S	S	M	S	S	S	S	S	S	S	S	S	M	U	S	M	M
Oxalic Acid	U	U	M	S	S	S	U	S	S	S	S	S	U	S	U	S	S	S	S	S	S	S	S	U	M	S	S
Perchloric Acid (10%)	U	-	U	-	S	U	U	-	S	M	M	-	-	M	U	M	S	M	M	-	M	S	U	-	S	-	S
Perchloric Acid (70%)	U	U	U	-	-	U	U	-	S	U	M	U	U	M	U	U	U	M	M	U	M	S	U	U	S	U	S
Phenol (5%)	U	S	U	-	S	M	M	-	S	U	M	U	U	S	U	M	S	M	S	U	U	S	U	M	M	M	S
Phenol (50%)	U	S	U	-	S	U	M	-	S	U	M	U	U	U	U	U	S	U	M	U	U	S	U	U	U	M	S
Phosphoric Acid (10%)	U	U	M	S	S	S	U	S	S	S	S	U	-	S	S	S	S	S	S	S	S	S	U	M	U	S	S
Phosphoric Acid (conc.)	U	U	M	M	-	-	U	S	-	M	S	U	U	M	M	S	S	S	M	S	M	S	U	M	U	-	S

CHEMICAL / MATERIAL	ALUMINUM	ANODIC COATING for ALUMINUM	BUNA N	CELLULOSE ACETATE BUTYRATE	POLYURETHANE ROTOR PAINT	COMPOSITE Carbon Fiber/Epoxy	DELRIN®	ETHYLENE PROPYLENE	GLASS	NEOPRENE	NORYL®	NYLON	PET*, POLYCLEAR®, CLEARCRIMP®CCCLEARCRIMP®	POLYALLOMER	POLYCARBONATE	POLYESTER, GLASS THERMOSET	POLYTHERMIDE	POLYRTHYLENE	POLYPROPYLENE	POLYSULFONE	POLYVINYL CHLORIDE	RULON A®, TEFLON®	SILICONE RUBBER	STAINLESS STEEL	TITANIUM	TYGON®	VITON®
Physiologic Media (Serum, Urine)	M	S	S	S	-	-	S	-	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
Picric Acid	S	S	U	-	S	M	S	S	S	M	S	U	S	S	S	U	S	S	S	S	U	S	U	M	S	M	S
Pyridine (50%)	U	S	U	U	S	U	U	-	U	S	S	U	U	M	U	U	-	U	S	M	U	S	S	U	U	U	U
Rubidium Bromide	M	S	S	-	S	S	S	-	S	S	S	S	S	S	S	-	-	S	S	S	S	S	S	M	S	S	S
Rubidium Chloride	M	S	S	-	S	S	S	-	S	S	S	S	S	S	S	-	-	S	S	S	S	S	S	M	S	S	S
Sucrose	M	S	S	-	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
Sucrose, Alkaline	M	S	S	-	S	S	S	-	S	S	S	S	S	S	U	S	S	S	S	S	S	S	S	M	S	S	S
Sulfosalicylic Acid	U	U	S	S	S	S	S	-	S	S	S	U	S	S	S	-	S	S	S	-	S	S	S	U	S	S	S
Nitric Acid (10%)	U	S	U	S	S	U	U	-	S	U	S	U	-	S	S	S	S	S	S	S	S	S	M	S	S	S	S
Nitric Acid (50%)	U	S	U	M	S	U	U	-	S	U	S	U	U	M	M	U	M	M	M	S	S	S	U	S	S	M	S
Nitric Acid (95%)	U	-	U	U	-	U	U	-	-	U	U	U	U	M	U	U	U	U	M	U	U	S	U	S	S	-	S
Hydrochloric Acid (10%)	U	U	M	S	S	S	U	-	S	S	S	U	U	S	U	S	S	S	S	S	S	S	S	U	M	S	S
Hydrochloric Acid (50%)	U	U	U	U	S	U	U	-	S	M	S	U	U	M	U	U	S	S	S	S	M	S	M	U	U	M	M
Sulfuric Acid (10%)	M	U	U	S	S	U	U	-	S	S	M	U	S	S	S	S	S	S	S	S	S	S	U	U	U	S	S
Sulfuric Acid (50%)	M	U	U	U	S	U	U	-	S	S	M	U	U	S	U	U	M	S	S	S	S	S	U	U	U	M	S
Sulfuric Acid (conc.)	M	U	U	U	-	U	U	M	-	-	M	U	U	S	U	U	U	M	S	U	M	S	U	U	U	-	S
Stearic Acid	S	-	S	-	-	-	S	M	S	S	S	S	-	S	S	S	S	S	S	S	S	S	M	M	S	S	S
Tetrahydrofuran	S	S	U	U	S	U	U	M	S	U	U	S	U	U	U	-	M	U	U	U	U	S	U	S	S	U	U
Toluene	S	S	U	U	S	S	M	U	S	U	U	S	U	U	U	S	U	M	U	U	U	S	U	S	U	U	M
Trichloroacetic Acid	U	U	U	-	S	S	U	M	S	U	S	U	U	S	M	-	M	S	S	U	U	S	U	U	U	M	U
Trichloroethane	S	-	U	-	-	-	M	U	-	U	-	S	U	U	U	U	U	U	U	U	U	S	U	-	S	-	S
Trichloroethylene	-	-	U	U	-	-	-	U	-	U	-	S	U	U	U	U	U	U	U	U	U	S	U	-	U	-	S
Trisodium Phosphate	-	-	-	S	-	-	M	-	-	-	-	-	-	S	-	-	S	S	S	-	-	S	-	-	S	-	S
Tris Buffer (neutral pH)	U	S	S	S	S	S	S	-	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
Triton X-100®	S	S	S	-	S	S	S	-	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
Urea	S	-	U	S	S	S	S	-	-	-	-	S	S	S	M	S	S	S	S	-	S	S	S	M	S	-	S
Hydrogen Peroxide (10%)	U	U	M	S	S	U	U	-	S	S	S	U	S	S	S	M	U	S	S	S	S	S	S	M	S	U	S
Hydrogen Peroxide (3%)	S	M	S	S	S	-	S	-	S	S	S	S	S	S	S	S	M	S	S	S	S	S	S	S	S	S	S
Xylene	S	S	U	S	S	S	M	U	S	U	U	U	U	U	U	M	U	M	U	U	U	S	U	M	S	U	S
Zinc Chloride	U	U	S	S	S	S	U	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	U	S	S	S

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Zinc Sulfate	U	S	S	-	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
Citric Acid (10%)	M	S	S	M	S	S	M	S	S	S	S	S	S	S	S	S	M	S	S	S	S	S	S	S	S	S	S

*Polyethyleneterephthalate

Key

S Satisfactory

M = Moderate attack, may be satisfactory for use in centrifuge depending on length of exposure, speed involved, etc.; suggest testing under actual conditions of use.

U Unsatisfactory, not recommended.

-- Performance unknown; suggest testing, using sample to avoid loss of valuable material.

Chemical resistance data is included only as a guide to product use. Because no organized chemical resistance data exists for materials under the stress of centrifugation, when in doubt we recommend pretesting sample lots.

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