

Instructions For Use

SW 28 and SW 28.1 Swinging-Bucket Rotors

For Use in Beckman Coulter
Class H, R, and S
Preparative Ultracentrifuges



PN L5-TB-069PB
November 2012



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SW 28 and SW 28.1 Swinging-Bucket Rotors

PN L5-TB-069PB (November 2012)

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Safety Notice

Read all product manuals and consult with Beckman Coulter-trained personnel before attempting to use this equipment. Do not attempt to perform any procedure before carefully reading all instructions. Always follow product labeling and manufacturer's recommendations. If in doubt as to how to proceed in any situation, contact your Beckman Coulter Representative.

Alerts for Warning, Caution, and Note

WARNING

WARNING indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.

CAUTION

CAUTION indicates a potentially hazardous situation, which, if not avoided, may result in minor or moderate injury. It may also be used to alert against unsafe practices.

NOTE NOTE is used to call attention to notable information that should be followed during installation, use, or servicing of this equipment.

Safety Information for the SW 28 and SW 28.1 Rotors

Handle body fluids with care because they can transmit disease. No known test offers complete assurance that such fluids are free of micro-organisms. Some of the most virulent—Hepatitis (B and C) viruses, HIV (I–V), atypical mycobacteria, and certain systemic fungi—further emphasize the need for aerosol protection. Handle other infectious samples according to good laboratory procedures and methods to prevent spread of disease. Because spills may generate aerosols, observe proper safety precautions for aerosol containment. Do not run toxic, pathogenic, or radioactive materials in these rotors without taking appropriate safety precautions. Biosafe containment should be used when Risk Group II materials (as identified in the World Health Organization *Laboratory Biosafety Manual*) are handled; materials of a higher group require more than one level of protection.

The rotors and accessories are not designed for use with materials capable of developing flammable or explosive vapors. Do not centrifuge such materials in nor handle or store them near the centrifuge

Although rotor components and accessories made by other manufacturers may fit in the SW 28 and SW 28.1 rotors, their safety in these rotors cannot be ascertained by Beckman Coulter. Use of other manufacturers' components or accessories in these rotors may void the rotor warranty and should be prohibited by your laboratory safety officer. Only the components and accessories listed in this publication should be used in these rotors.

Safety Notice

Safety Information for the SW 28 and SW 28.1 Rotors

Hook all six buckets, loaded or empty, to the rotor for every run. Make sure that filled containers are loaded symmetrically into the rotor and that opposing tubes are filled to the same level with liquid of the same density. Make sure that buckets containing Quick-Seal tubes have the proper floating spacers inserted (if applicable) before installing the bucket cap.

If disassembly reveals evidence of leakage, you should assume that some fluid escaped the rotor. Apply appropriate decontamination procedures to the centrifuge and accessories.

Never exceed the maximum rated speed of the rotor and labware in use. Refer to the section on [Run Speeds](#), and derate the run speed as appropriate.

Do not use sharp tools on the rotor that could cause scratches in the rotor surface. Corrosion begins in scratches and may open fissures in the rotor with continued use.

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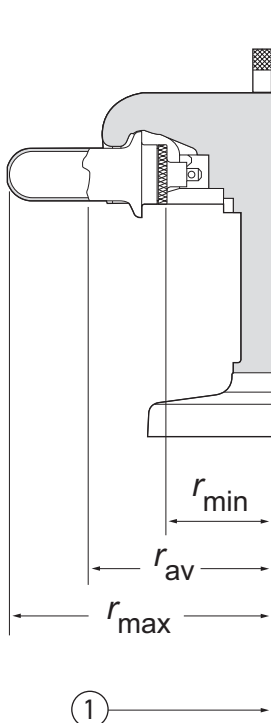
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SW 28 and SW 28.1 Swinging-Bucket Rotors

Specifications for the SW 28 Rotor

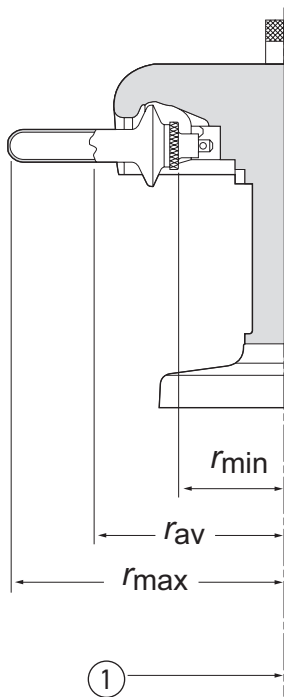


1. Axis of Rotation

Maximum speed	28,000 RPM
Density rating at maximum speed.....	1.2 g/mL
Relative Centrifugal Field ^a at maximum speed	
At r_{\max} (16.1 mm).....	$141,000 \times g$
At r_{av} (118.2 mm).....	$104,000 \times g$
At r_{\min} (75.3 mm).....	$66,100 \times g$
k factor at maximum speed.....	246
k factor at maximum speed (5 to 20% sucrose gradient; 5°C)	
When particle density = 1.3 g/mL.....	680
When particle density = 1.5 g/mL.....	622
When particle density = 1.7 g/mL.....	600
Conditions requiring speed reductions	see Run Speeds
Number of buckets	6
Available tubes	see Table 2
Nominal tube dimensions (largest tube)	25 × 89 mm
Nominal tube capacity (largest tube)	38.5 mL
Nominal rotor capacity	231 mL
Approximate acceleration time to maximum speed (rotor fully loaded).....	
4 to 5 min	
Approximate deceleration time from maximum speed (rotor fully loaded)	
4 to 5 min	
Weight of fully loaded rotor	5.9 kg (13 lb)
Rotor material	aluminum body; titanium buckets

a. Relative Centrifugal Field (RCF) is the ratio of the centrifugal acceleration at a specified radius and speed ($r\omega^2$) to the standard acceleration of gravity (g) according to the following formula: $\text{RCF} = r\omega^2/g$ —where r is the radius in millimeters, ω is the angular velocity in radians per second ($2\pi \text{ RPM}/60$), and g is the standard acceleration of gravity (9807 mm/s^2). After substitution: $\text{RCF} = 1.12r (\text{RPM}/1000)^2$

Specifications for the SW 28.1 Rotor

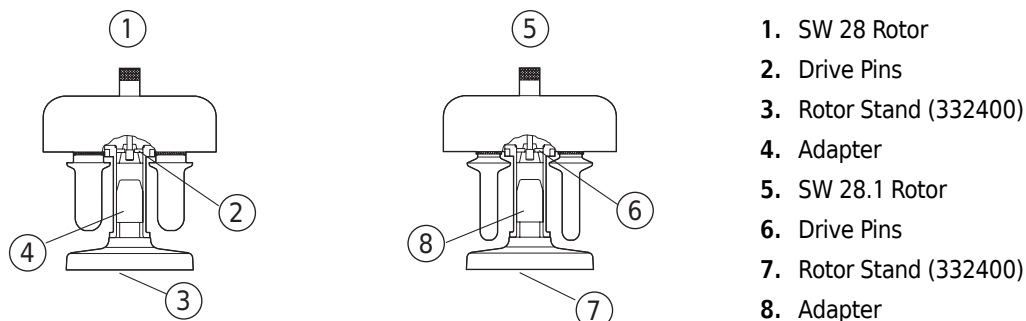


1. Axis of Rotation

Maximum speed	28,000 RPM
Density rating at maximum speed.....	1.2 g/mL
Relative Centrifugal Field ^a at maximum speed	
At r_{max} (171.3 mm).....	$150,000 \times g$
At r_{av} (122.1 mm).....	$107,000 \times g$
At r_{min} (72.9 mm).....	$64,000 \times g$
k factor at maximum speed.....	276
k factor at maximum speed (5 to 20% sucrose gradient; 5°C)	
When particle density = 1.3 g/mL.....	757
When particle density = 1.5 g/mL.....	694
When particle density = 1.7 g/mL.....	668
Conditions requiring speed reductions	see Run Speeds
Number of buckets	6
Available tubes	see Table 3
Nominal tube dimensions (largest tube)	16×102 mm
Nominal tube capacity (largest tube)	17 mL
Nominal rotor capacity	102 mL
Approximate acceleration time to maximum speed	
(rotor fully loaded).....	4 to 5 min
Approximate deceleration time from maximum speed	
(rotor fully loaded	4 to 5 min
Weight of fully loaded rotor	5.8 kg (12.8 lb)
Rotor material	aluminum body; titanium buckets

a. Relative Centrifugal Field (RCF) is the ratio of the centrifugal acceleration at a specified radius and speed ($r\omega^2$) to the standard acceleration of gravity (g) according to the following formula: $RCF = r\omega^2/g$ — where r is the radius in millimeters, ω is the angular velocity in radians per second ($2\pi \text{ RPM}/60$), and g is the standard acceleration of gravity (9807 mm/s^2). After substitution: $RCF = 1.12r (\text{RPM}/1000)^2$

Description



Beckman Coulter SW 28 and SW 28.1 rotors are manufactured in a facility that maintains certifications to both ISO 9001:2008 and ISO 13485:2003. They are for use with the specified Beckman Coulter ultracentrifuges. The rotors were developed, manufactured, and tested for safety and reliability as part of a Beckman Coulter ultracentrifuge/rotor system. Their safety or reliability cannot be assured if used in an ultracentrifuge not of Beckman Coulter's manufacture or in a Beckman Coulter ultracentrifuge that has been modified without Beckman Coulter's approval.

The SW 28 and SW 28.1 are swinging-bucket rotors designed to centrifuge up to six tubes each. Used in Beckman Coulter class H, R, and S preparative ultracentrifuges, these rotors develop centrifugal forces for the separation of subcellular particles and viruses in density gradients. The rotors have a common rotor body with buckets that can be used interchangeably (see [Rotor Preparation](#)). Bucket and rotor body positions are numbered for operator convenience.

The SW 30 and SW 30.1 rotor buckets can be used on the SW 28/SW 28.1 rotor body as well. However, the reverse is not true. The matrix in [Table 1](#) indicates interchangeability of rotor buckets between the SW 30 series, SW 28 series, and the older SW 27 series of rotors.

Table 1 Rotor Bucket Interchangeability

Buckets	May be used with rotors					
	SW 30.1	SW 30	SW 28.1	SW 28	SW 27.1	SW 27
SW 30 and SW 30.1	Yes	Yes	Yes	Yes	No	No
SW 28 and SW 28.1	No	No	Yes	Yes	No	No
SW 27 and SW 27.1	No	No	No	No	Yes	Yes

The rotor body and bucket caps are made of aluminum, anodized for corrosion resistance. The buckets are made of titanium, finished with clear polyurethane paint. Each bucket and cap assembly hooks into grooves on the rotor body. Bucket and rotor body positions are numbered for operator convenience. O-rings, made of Buna N rubber, between each bucket and bucket cap maintain atmospheric pressure inside the buckets during centrifugation. Drive pins in the rotor drive hole prevent the rotor from slipping on the centrifuge drive hub during acceleration and deceleration.

For overspeed protection, a Beckman Coulter ultracentrifuge equipped with a photoelectric detector will monitor the overspeed disk on the adapter bottom and shut down the run if a speed exceeding the maximum allowable run speed is detected.

See the Warranty at the back of this manual for warranty information.

Preparation and Use

Specific information about the SW 28 and SW 28.1 rotors is given here. Information common to these and other rotors is contained in Rotors and Tubes for Preparative Ultracentrifuges (publication LR-IM), which should be used together with this manual for complete rotor and accessory operation. Publication LR-IM (on a CD) is included in the literature package with this rotor manual.

NOTE Although rotor components and accessories made by other manufacturers may fit in the SW 28 and SW 28.1 rotors, their safety in these rotors cannot be ascertained by Beckman Coulter. Use of other manufacturers' components or accessories in these rotors may void the rotor warranty and should be prohibited by your laboratory safety officer. Only the components and accessories listed in this publication should be used in these rotors.

Prerun Safety Checks

Read the [Safety Notice](#) section at the front of this manual before using the rotor.

- 1 Make sure that the rotor, buckets, and caps are clean and show no signs of corrosion or cracking.
- 2 Make sure that the rotor is equipped with the correct overspeed disk.
If the disk is missing or damaged, replace it according to the instructions in *Rotors and Tubes*.



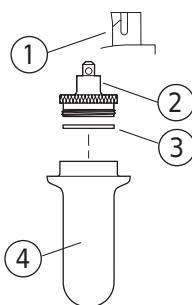
- 3 Verify that the tubes and bottles being used are listed in [Table 2](#) or [Table 3](#).
- 4 Check the chemical compatibilities of all materials used (refer to *Chemical Resistances*, publication IN-175).

Rotor Preparation

For runs at other than room temperature refrigerate or warm the rotor beforehand for fast equilibration.

NOTE Place the rotor on the rotor stand (332400) when it is not in the centrifuge. Take care to protect the overspeed disk from damage when handling the rotor.

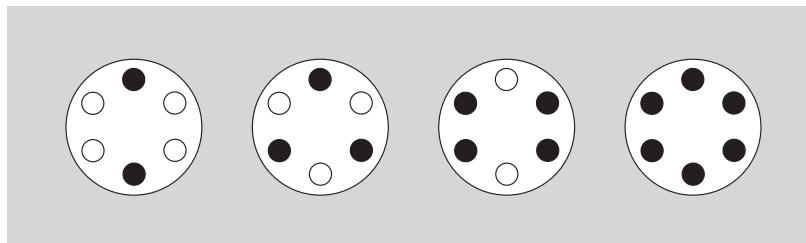
- 1 Load the filled containers into the buckets (see page 8 for tube and accessory information). Complete loading by placing the correct floating spacers (if required) over the tubes.
- 2 Ensure that bucket O-rings are lightly but evenly coated with silicone vacuum grease. Do not run a bucket without an O-ring, as the bucket will leak.



1. Hanger
2. Cap
3. O-ring 812715 (SW 28)
815472 (SW 28.1)
4. Bucket

- 3 Be sure that metal threads in the bucket caps are clean and lightly but evenly lubricated with Spinkote lubricant (306812).
 - a. Match bucket caps with numbered buckets and screw them down manually until tight.
- 4 Hook the buckets to the rotor by inserting the bucket pins into the grooves on the rotor body.
 - a. Swing each bucket back and forth slightly to ensure proper installation; the buckets should move freely.
Six buckets must be installed, whether loaded or empty.
 - b. If fewer than six tubes are being run, they must be arranged symmetrically in the rotor (see [Figure 1](#)).
Opposing tubes must be filled to the same level with liquid of the same density.

Figure 1 Arranging Tubes in the Rotor.

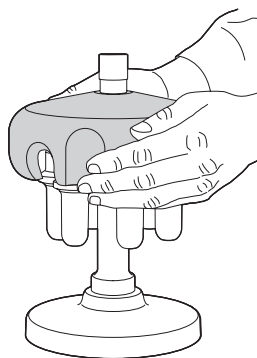


NOTE Two, three, four, or six tubes can be centrifuged per run if they are arranged in the rotor as shown. All buckets must be attached to the rotor, whether loaded or empty.

Operation

For low-temperature runs, precool the rotor in the centrifuge or in a refrigerator before use—especially before short runs—to ensure that the rotor reaches the set temperature. A suggested precooling cycle is a minimum of 30 minutes at 2000 RPM at the required temperature.

- 1** To install the rotor, carefully lift it up off the rotor stand with both hands—do not lift the rotor by the adapter—and place it on the drive hub.
 - a.** Slowly turn the rotor to the right (clockwise) to make sure that the rotor is seated properly on the hub.



CAUTION

Remove the zonal support band from the ultracentrifuges so equipped before operating these rotors.

- 2** Refer to the centrifuge instruction manual for additional operating instructions.

NOTE Some gradients may degrade when run time exceeds 8 hours.

- 3 For additional operating information, see the following:
 - [Run Times](#), page 12, for using k factors to adjust run durations.
 - [Run Speeds](#), page 13, for information about speed limitations.
 - [Selecting CsCl Gradients](#), page 19, for methods to avoid CsCl precipitation during centrifugation.

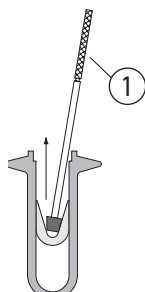
Removal and Sample Recovery

CAUTION

If disassembly reveals evidence of leakage, you should assume that some fluid escaped the rotor. Apply appropriate decontamination procedures to the centrifuge and accessories.

- 1 Remove the rotor from the centrifuge by lifting it straight up and off the drive hub.
- 2 Set the rotor on the rotor stand and carefully remove the buckets.
- 3 Remove the bucket caps and use the appropriate removal tool (listed in the [Supply List](#)) to remove the spacers and tubes.
 - a. If floating spacers were used, remove them with the threaded end of the floating spacer removal tool (338765).

NOTE If the conical-shaped adapters that support konical tubes are difficult to remove after centrifugation, an extractor tool (354468) is available to facilitate removal.



1. Extractor Tool (354468)

While pressing the rubber tip against the adapter wall, pull the tube and adapter up and out of the cavity.

Tubes and Accessories

The SW 28 rotor uses tubes and accessories listed in [Table 2](#); the SW 28.1 rotor uses tubes and accessories listed in [Table 3](#). Be sure to use only those items listed, and to observe the maximum speed limits shown. Refer to Appendix A in *Rotors and Tubes* for information on the chemical resistances of tube and accessory materials.

Table 2 Beckman Coulter Tubes and Accessories for the SW 28 Rotor^a

Tube			Required Accessory		Max Speed/ RCF/ k factor
Dimensions/ Nominal Volume/	Description	Part Number	Description	Part Number	
25 × 89 mm 38.5 mL	Ultra Clear open-top	344058 (pkg/50)	none	—	28,000 RPM 141,000 × g 246
25 × 89 mm 38.5 mL	polyallomer open-top	326823 (pkg/50)	none	—	28,000 RPM 141,000 × g 246
25 × 77 mm 32.4 mL	polyallomer OptiSeal, bell-top ^b	361625 (pkg/50)	polyetherimide (PEI) spacer	392833	28,000 RPM 141,000 × g 246
25 × 89 mm 32 mL	thickwall polyallomer open-top	355642 (pkg/25)	none	—	28,000 RPM 141,000 × g 241
25 × 89 mm 32 mL	thickwall polycarbonate open-top	355631 (pkg/25)	none	—	28,000 RPM 141,000 × g 246
25 × 83 mm 33 mL	polyallomer Quick-Seal, bell-top	344623 (pkg/50)	polyphenylene oxide (PPO) floating spacer	355536	28,000 RPM 141,000 × g 233
25 × 89 mm 30 mL	konical polyallomer open-top	358126 (pkg/50)	adapter	358156 (pkg/6)	28,000 RPM 139,000 × g 240
25 × 76 mm 25 mL	konical polyallomer open-top	358125 (pkg/50)	adapter	358156 (pkg/6)	28,000 RPM 139,000 × g 190
25 × 83 mm 28 mL	konical polyallomer Quick-Seal, bell-top	358651 (pkg/50)	adapter	358156	28,000 RPM 139,000 × g 226
			polyphenylene oxide (PPO) floating spacer	355536	

Table 2 Beckman Coulter Tubes and Accessories for the SW 28 Rotor^a (Continued)

Tube			Required Accessory		Max Speed/ RCF/ k factor
Dimensions/ Nominal Volume/	Description	Part Number	Description	Part Number	
25 × 64 mm 27 mL	polyallomer Quick-Seal, bell-top	343665 (pkg/50)	polyphenylene oxide (PPO) floating spacer	355536	28,000 RPM 134,000 × g 180
25 × 38 mm 15 mL	polyallomer Quick-Seal, bell-top	343664 (pkg/50)	polyphenylene oxide (PPO) floating spacer	355536	28,000 RPM 141,000 × g 92
25 × 38 mm 8.5 mL	konical polyallomer Quick-Seal, bell-top	358652 (pkg/50)	adapter	358156 (pkg/6)	28,000 RPM 139,000 × g 84
			polyphenylene oxide (PPO) floating spacer	355536	
25 × 76 mm 23 mL	konical polyallomer Quick-Seal, bell-top	358654 (pkg/50)	adapter	358156	28,000 RPM 139,000 × g 178
			polyphenylene oxide (PPO) floating spacer	355536	

- a. Use only the items listed here..
b. Disposable plastic plugs included.

Table 3 Beckman Coulter Tubes and Accessories for the SW 28.1 Rotor^a

Tube			Required Accessory		Max Speed/ RCF/ k factor
Dimensions/ Nominal Volume/	Description	Part Number	Description	Part Number	
16 × 102 mm 18 mL	polyallomer Quick-Seal, bell-top	356291 (pkg/50)	polyphenylene oxide (PPO) floating spacer	355579	28,000 RPM 150,000 × g 229
16 × 102 mm 17 mL	Ultra-Clear, open-top	344061 (pkg/50)	none	—	28,000 RPM 150,000 × g 275
16 × 96 mm 17 mL	polyallomer open-top	337986 (pkg/50)	none	—	28,000 RPM 150,000 × g 275

Table 3 Beckman Coulter Tubes and Accessories for the SW 28.1 Rotor^a (*Continued*)

Tube			Required Accessory		Max Speed/ RCF/ k factor
Dimensions/ Nominal Volume/	Description	Part Number	Description	Part Number	
16 × 93 mm 14.5 mL	konical polyallomer, open-top	358123 (pkg/50)	adapter	358155	28,000 RPM 148,000 × <i>g</i> 271
16 × 102 mm 12.5 mL	konical polyallomer Quick-Seal bell-top	358653 (pkg/50)	adapter	358155	28,000 RPM 148,000 × <i>g</i> 235
			polyphenylene oxide (PPO) floating spacer	355579	
16 × 67 mm 10 mL	polyallomer Quick-Seal, bell-top	344622 (pkg/50)	polyphenylene oxide (PPO) floating spacer	355579	28,000 RPM 150,000 × <i>g</i> 154
16 × 57 mm 8 mL	polyallomer Quick-Seal, bell-top	344621 (pkg/50)	polyphenylene oxide (PPO) floating spacer	355579	28,000 RPM 150,000 × <i>g</i> 117
16 × 44 mm 6.3 mL	polyallomer Quick-Seal, bell-top	345830 (pkg/50)	polyphenylene oxide (PPO) floating spacer	355579	28,000 RPM 150,000 × <i>g</i> 90
16 × 38 mm 4.2 mL	polyallomer Quick-Seal, bell-top	356562 (pkg/50)	polyphenylene oxide (PPO) floating spacer	355579	28,000 RPM 150,000 × <i>g</i> 63

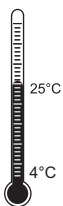
a. Use only the items listed here..

Temperature Limits

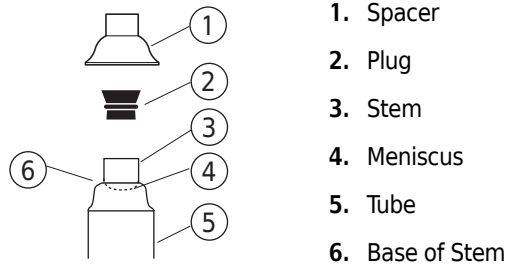
- Plastic tubes have been centrifuge tested for use at temperatures between 4 and 25°C. For centrifugation at other temperatures, pretest tubes under anticipated run conditions.
- If plastic containers are frozen before use, make sure that they are thawed to at least 4°C prior to centrifugation.

OptiSeal Tubes

OptiSeal tubes come with plastic plugs and can be quickly and easily prepared for use. With the tube spacer in place, the *g* force during centrifugation ensures a tight, reliable seal that protects your samples.



- 1 Place the tubes in the rack and fill each tube to the base of the stem, leaving no fluid in the stem. Overfilling the tube can cause spillage when the plug is inserted or can compromise seal integrity.
However, too much air can cause excessive tube deformation, disrupting gradients and sample bands.



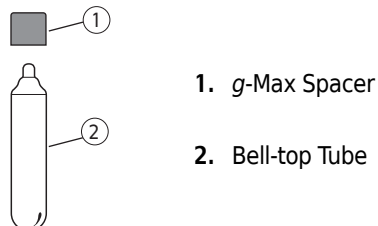
1. Spacer
2. Plug
3. Stem
4. Meniscus
5. Tube
6. Base of Stem

- 2 Refer to *Using OptiSeal Tubes* (publication IN-189), included in each box of tubes, for detailed information on the use and care of OptiSeal tubes.

Quick Seal Tubes

Quick-Seal tubes must be sealed prior to centrifugation. These tubes are heat sealed and do not need caps; however, spacers are required on top of the tubes when they are loaded into the rotor buckets.

- 1 Fill Quick-Seal tubes leaving a *small* bubble of air at the base of the neck.
Do not leave a large air space—too much air can cause excessive tube deformation.
- 2 Some of the tubes listed in [Table 2](#) and [Table 3](#) are part of the *g*-Max system, which uses a combination of small bell-top Quick-Seal tubes and floating spacers (also called *g*-Max spacers). This means that you can run the shorter tubes listed in [Table 2](#) and [Table 3](#) in the SW 28 and SW 28.1 rotors without reduction in *g* force.
For detailed information on the *g*-Max system see publication DS-709B.

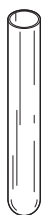
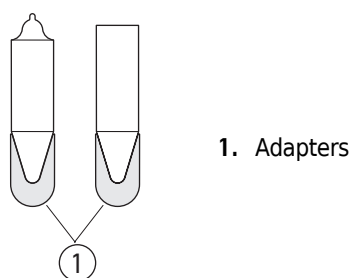


1. *g*-Max Spacer
2. Bell-top Tube

- 3** Refer to *Rotors and Tubes* for detailed information on the use and care of Quick-Seal tubes. Quick-Seal tubes are disposable and should be discarded after a single use.

konal Tubes

Polyallomer *konal* tubes, used to optimize pelleting separations, have a conical tip that concentrates the pellet in the narrow end of the tube. The narrow bottom also reduces the tube's nominal volume and minimizes gradient material requirement. The *konal* tubes come in both open-top and Quick-Seal tube designs. Conical cavity adapters hold the tubes in the rotor buckets



Polyallomer and Ultra-Clear Open-Top Tubes

Polyallomer and Ultra-Clear open-top tubes should be filled as full as possible (2 or 3 mm from the tube top) for tube support. If necessary, float mineral oil (or some other low-density, immiscible liquid) on top of the tube contents to fill the tube to its maximum volume. (Do not use an oil overlay in Ultra-Clear tubes.) All opposing tubes for a run must be filled to the same level with liquid of the same density.

Run Times

The *k* factor of the rotor is a measure of the rotor's pelleting efficiency. (Beckman Coulter has calculated the *k* factors for all of its preparative rotors at maximum rated speed and using full tubes.) The *k* factor is calculated from the formula

$$k = \frac{\ln(r_{\max}/r_{\min})}{\omega^2} \times \frac{10^{13}}{3600} \quad \text{EQ 1}$$

where ω is the angular velocity of the rotor in radians per second ($\omega = 0.105 \times \text{RPM}$), r_{\max} is the maximum radius, and r_{\min} is the minimum radius.

After substitution:

$$k = \frac{(2.533 \times 10^{11}) \ln(r_{\max}/r_{\min})}{\text{RPM}^2} \quad \text{EQ 2}$$

Use the k factor in the following equation to estimate the run time t (in hours) required to pellet particles of known sedimentation coefficient s (in Svedberg units, S).

$$t = \frac{k}{s} \quad \text{EQ 3}$$

Run times can be estimated for centrifugation at less than maximum speed by adjusting the k factor as follows:

$$k_{\text{adj}} = k \left(\frac{28,000}{\text{actual run speed}} \right)^2 \quad \text{EQ 4}$$

Run times can also be estimated from data established in prior experiments if the k factor of the previous rotor is known. For any two rotors, a and b :

$$\frac{t_a}{t_b} = \frac{k_a}{k_b} \quad \text{EQ 5}$$

where the k factors have been adjusted for the actual run speed used.

Run Speeds

The centrifugal force at a given radius in a rotor is a function of speed. Comparisons of forces between different rotors are made by comparing the rotors' relative centrifugal fields (RCF). When rotational speed is selected so that identical samples are subjected to the same RCF in two different rotors, the samples are subjected to the same force. The RCF at a number of rotor speeds is provided in [Table 4](#).

Do not select rotational speeds in excess of 28,000 RPM. In addition, speeds must be reduced under the following circumstances:

1. If nonprecipitating solutions more dense than 1.2 g/mL are centrifuged, reduce the maximum allowable run speed according to the following equation:

$$\text{reduced maximum speed} = (28,000 \text{ RPM}) \sqrt{\frac{1.2 \text{ g/mL}}{\rho}} \quad \text{EQ 6}$$

where ρ is the density of the tube contents. This speed reduction will protect the rotor from excessive stresses due to the added tube load.

2. *Further speed limits must be imposed* when CsCl or other self-forming-gradient salts are centrifuged, as equation (6) does not predict concentration limits/speeds that are required to prevent precipitation of salt crystals. Solid CsCl has a density of 4 g/mL, and if precipitated during centrifugation may cause rotor failure. [Figure 2](#) through [Figure 5](#), together with the description and examples below, show how to reduce run speeds when using CsCl gradients.

Table 4 Relative Centrifugal Fields for the SW 28 and SW 28.1 Rotors^a

SW 28 Rotor				SW 28.1 Rotor			
Rotor Speed (RPM)	Relative Centrifugal Field ($\times g$)			Rotor Speed (RPM)	Relative Centrifugal Field ($\times g$)		
	At r_{\max} (161 mm)	At r_{av} (118.2 mm)	At r_{\min} (75.3 mm)		At r_{\max} (171.3 mm)	At r_{av} (122.1 mm)	At r_{\min} (72.9 mm)
28,000	141,000	104,000	66,100	28,000	150,000	107,000	64,000
25,000	113,000	82,700	52,700	25,000	120,000	85,500	51,000
22,000	87,300	64,100	40,800	22,000	92,900	66,200	39,500
20,000	72,100	53,000	33,700	20,000	76,700	54,700	32,700
18,000	58,400	42,900	27,300	18,000	62,200	44,300	26,500
16,000	46,200	33,900	21,600	16,000	49,100	35,000	20,900
14,000	35,300	26,000	16,500	14,000	37,600	26,800	16,000
12,000	26,000	19,100	12,100	12,000	27,600	19,700	11,800
10,000	18,000	13,200	8430	10,000	19,200	13,700	8170
8000	11,500	8470	6400	8000	12,300	8750	5230
6000	6490	4770	3040	6000	6900	4920	2940
4000	2880	2120	1350	4000	3070	2190	1310
2000	721	530	337	2000	767	547	327

a. Entries in this table are calculated from the formula $\text{RCF} = 1.12r (\text{RPM}/1000)^2$ and then rounded to three significant digits.

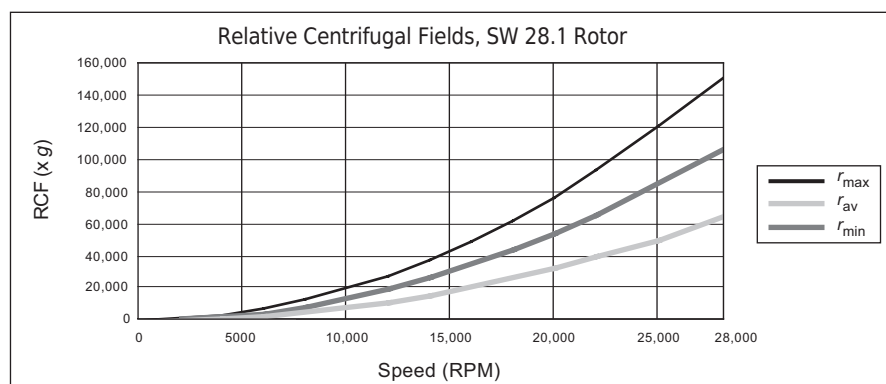
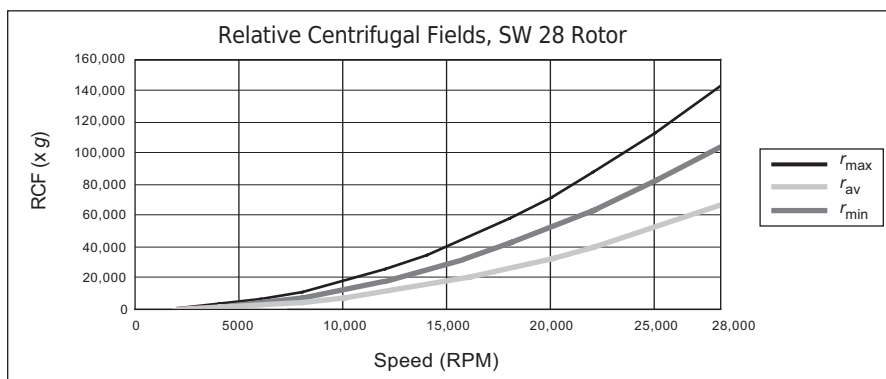
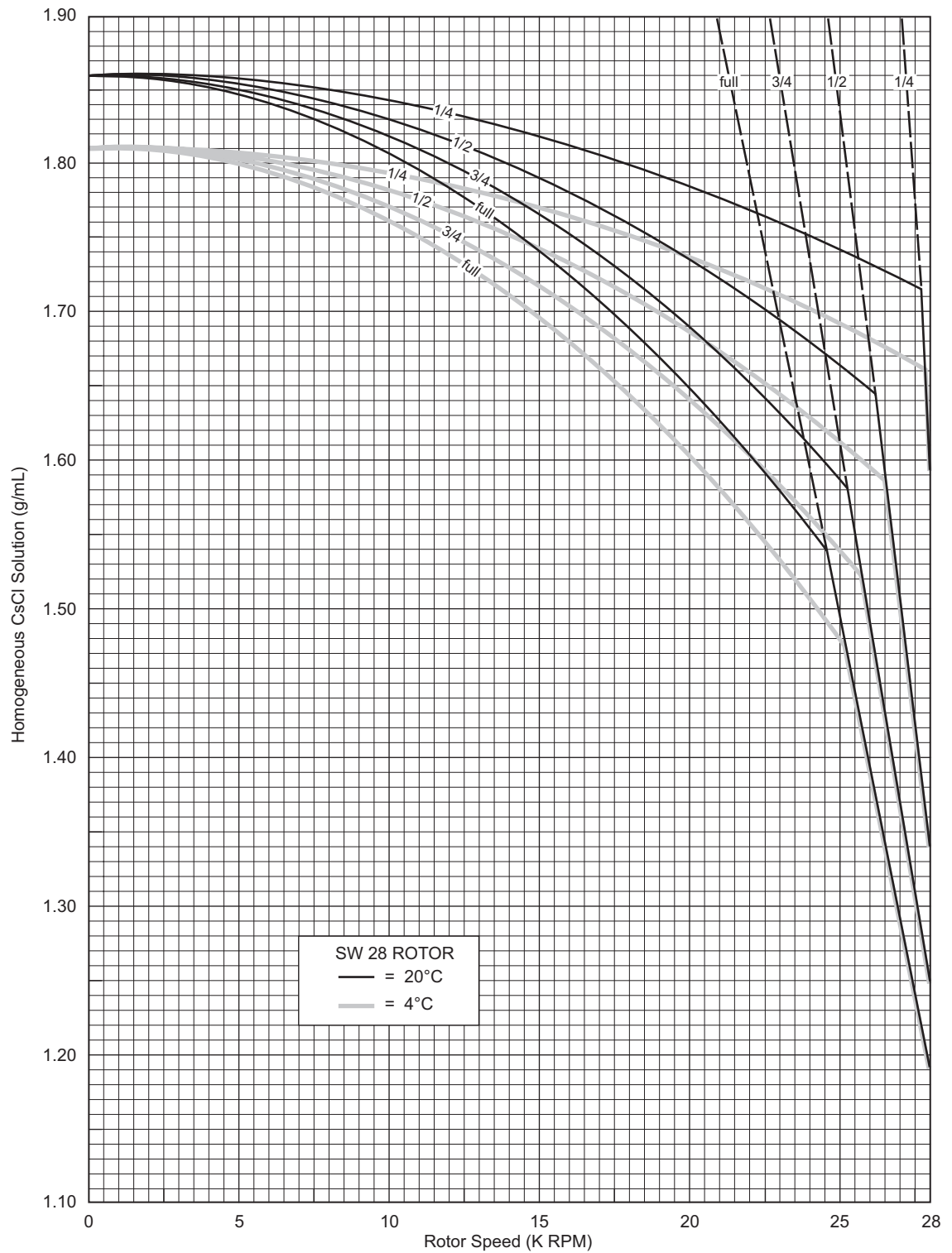
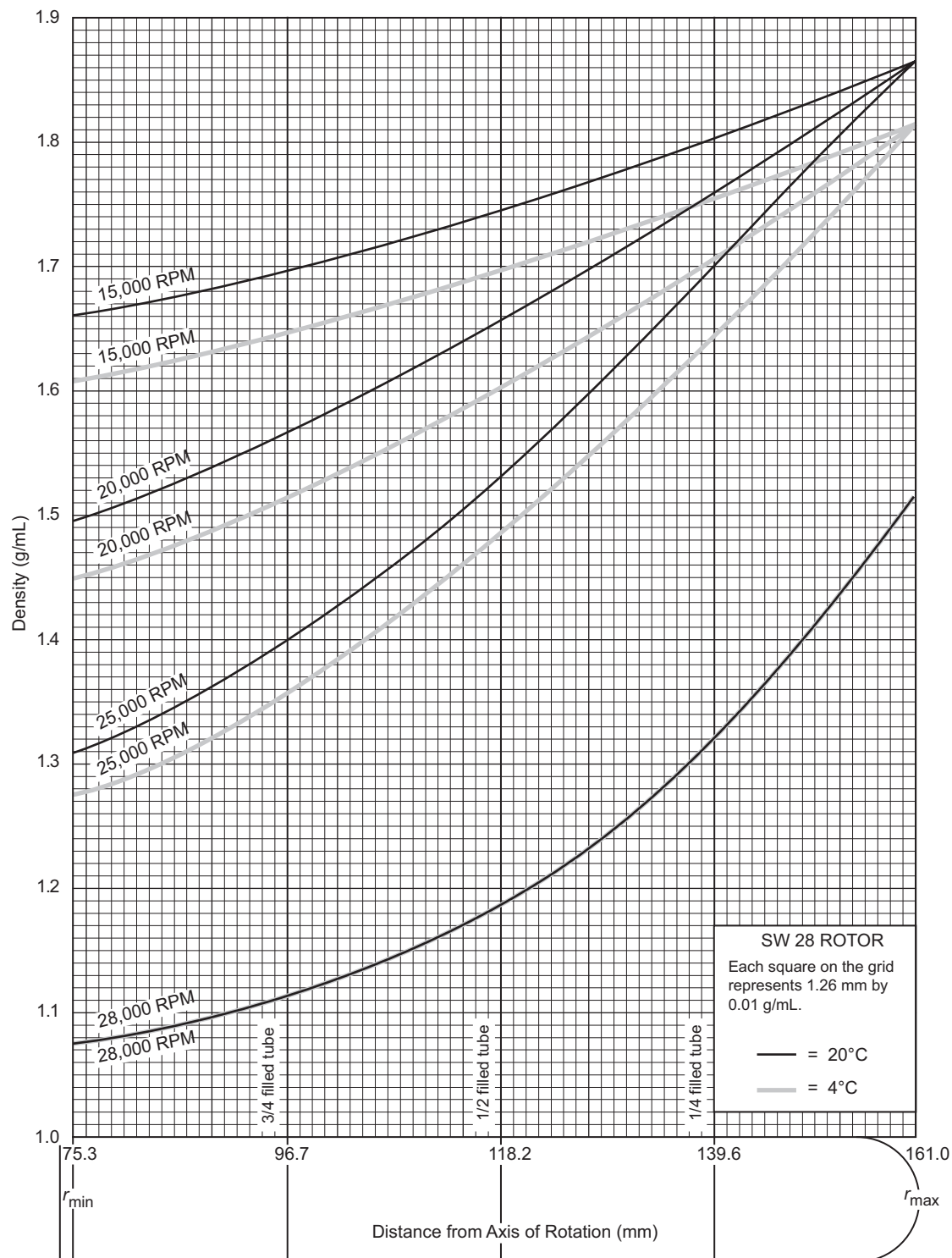


Figure 2 Precipitation Curves for the SW 28 Rotor*



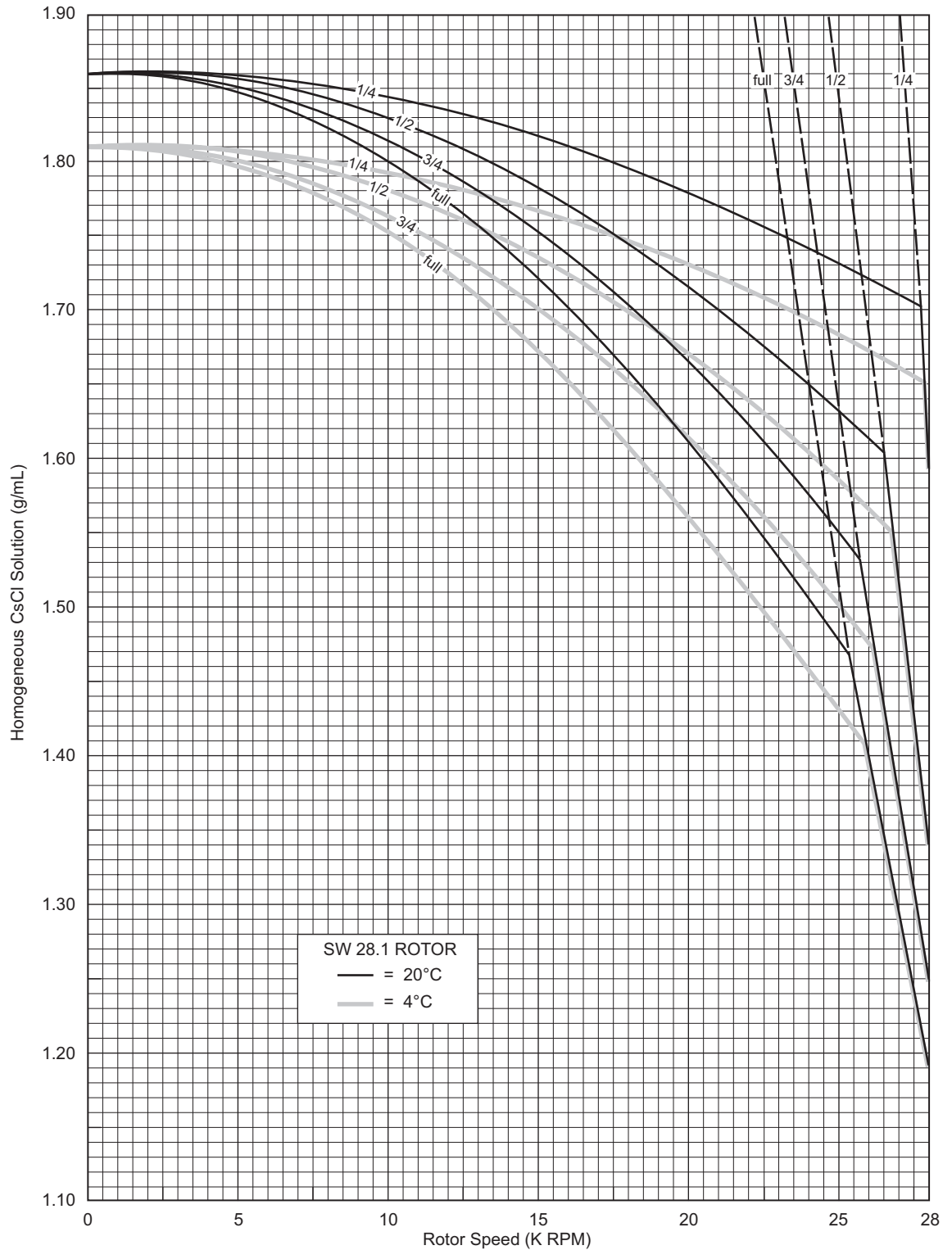
* Using speed and density combinations that intersect on or below the solid curves ensures that CsCl will not precipitate during centrifugation. Tube fill volumes are indicated on the curves. The dashed lines are a representation of [EQ 6](#) and are shown here to illustrate the inability of that equation to prevent CsCl precipitation.

Figure 3 CsCl Gradients at Equilibrium for the SW 28 Rotor*



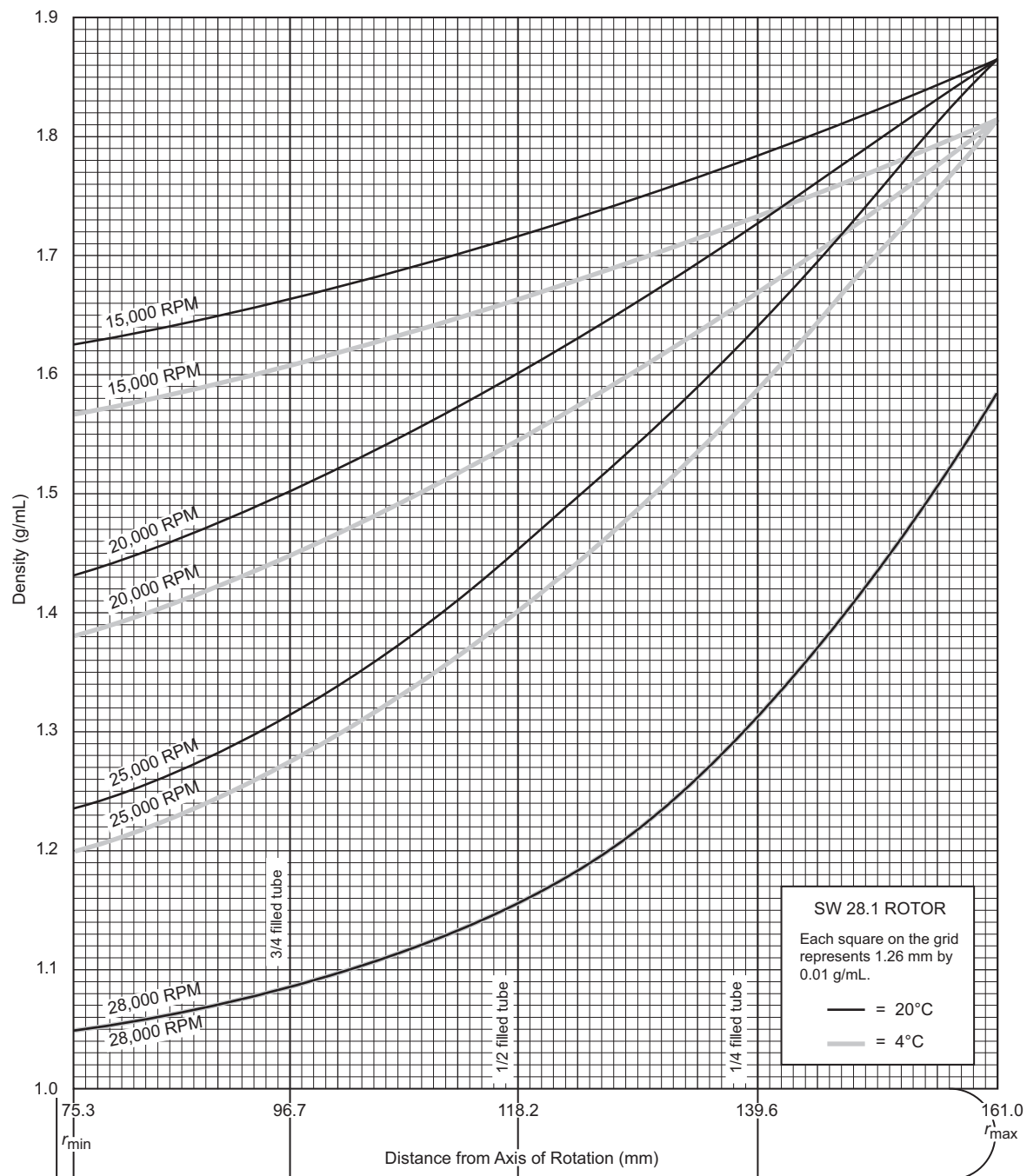
* Centrifugation of homogeneous CsCl solutions at maximum allowable speeds (from Figure 2) results in gradients presented here.

Figure 4 Precipitation Curves for the SW 28.1 Rotor*



* Using speed and density combinations that intersect on or below the solid curves ensures that CsCl will not precipitate during centrifugation. Tube fill volumes are indicated on the curves. The dashed lines are a representation of [EQ 6](#) and are shown here to illustrate the inability of that equation to prevent CsCl precipitation.

Figure 5 CsCl Gradients at Equilibrium for the SW 28.1 Rotor*



* Centrifugation of homogeneous CsCl solutions at maximum allowable speeds (from Figure 4) results in gradients presented here.

Selecting CsCl Gradients



Rotor speed is used to control the slope of a CsCl density gradient, and must be limited to prevent CsCl precipitation during centrifugation. Speed and density combinations that intersect on or below the curves in [Figure 2](#) (for the SW 28 rotor) and in [Figure 4](#) (for the SW 28.1 rotor) ensure that CsCl will not precipitate during centrifugation in these rotors. Curves are provided at two temperatures: 20°C (black curves) and 4°C (gray curves). Curves in [Figure 2](#) through [Figure 5](#) are provided up to the maximum speed of the rotor

NOTE The curves in [Figure 2](#) through [Figure 5](#) are for solutions of CsCl salt dissolved in distilled water only. If other salts are present in significant concentrations, the overall CsCl concentration may need to be reduced.

The reference curves shown in [Figure 3](#) and [Figure 5](#) show gradient distribution at equilibrium. Each curve in [Figure 3](#) is within the density limits allowed for the SW 28 rotor; each curve in [Figure 5](#) is within the density limits allowed for the SW 28.1 rotor. Each curve was generated for a single run speed using the maximum allowable homogeneous CsCl densities (one for each fill level) that avoid precipitation at that speed. (The gradients in [Figure 3](#) and [Figure 5](#) can be generated from step or linear gradients, or from homogeneous solutions. But the total amount of CsCl in solution must be equivalent to a homogeneous solution corresponding to the concentrations specified in [Figure 3](#) and [Figure 5](#).) [Figure 3](#) and [Figure 5](#) can also be used to approximate the banding positions of sample particles. Curves not shown may be interpolated.

Adjusting Fill Volumes

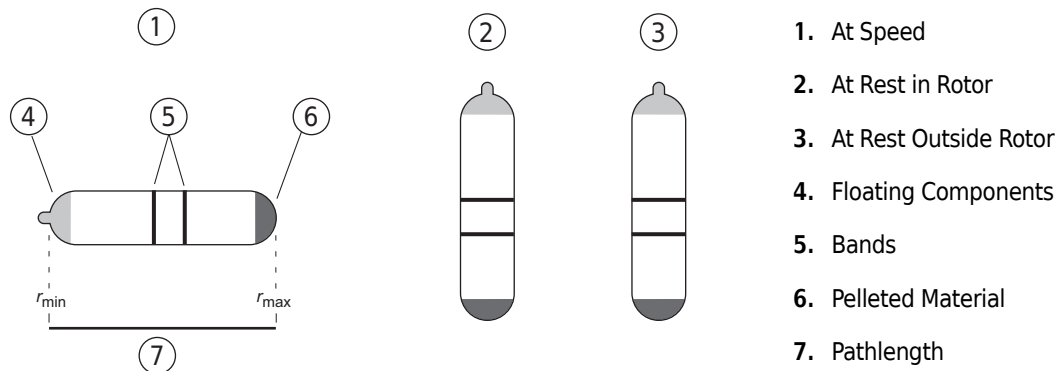
[Figure 2](#) through [Figure 5](#) show that several fill volumes are possible in a tube. If a thinwall tube is partially filled with gradient solution, float mineral oil (or some other low-density, immiscible liquid) on top of the tube contents to fill the tube to its maximum volume. (Do not use an oil overlay in Ultra-Clear tubes.) Note that for a given CsCl density, as the fill level decreases the maximum allowable speed increases. Partial filling may be desirable when there is little sample or when you wish to shorten the run time.

For example, in the SW 28 rotor, a *quarter-filled* tube of 1.67-g/mL homogeneous CsCl solution at 4°C may be centrifuged at 26,000 RPM (see [Figure 2](#)). The segment of the 26,000 RPM curve ([Figure 3](#)) from the quarter-filled line to r_{\max} (the tube bottom) represents this gradient. The same solution in a *half-filled* tube may be centrifuged no faster than 20,000 RPM, and 17,000 RPM in a *three-quarter-filled* tube. A tube *full* of the 1.67-g/mL CsCl solution may be centrifuged no faster than 15,000 RPM. Curves not shown in the figures may be interpolated.

Typical Examples for Determining CsCl Run Parameters

Example A:

Starting with a homogeneous CsCl solution density of 1.33 g/mL and approximate particle buoyant densities of 1.30 and 1.35 g/mL, at 20°C, where will particles band at equilibrium in the SW 28 rotor?



- 1 In [Figure 2](#), find the curve that corresponds to the required run temperature (20°C) and fill volume (one-half full).
The maximum allowable rotor speed is determined from the point where this curve intersects the homogeneous CsCl density (28,000 RPM).

- 2 In [Figure 3](#), sketch a horizontal line corresponding to each particle's buoyant density.

- 3 Mark the point in [Figure 3](#) where each particle density intersects the curve corresponding to the selected run speed and temperature.
Particles will band at these locations across the tube diameter at equilibrium during centrifugation.

In this example, particles will band about 145 and 151 mm from the axis of rotation, about 6 mm of centerband-to-centerband separation.

To determine interband volume in milliliters, use the following equation:

$$V = \pi r^2 h \quad \text{EQ 7}$$

where r is the tube radius in centimeters and h is the interband separation in centimeters

Example B:

Knowing particle buoyant densities (for example, 1.55 and 1.50 g/mL), how do you achieve good separation in the SW 28 rotor.

- 1 In [Figure 3](#), sketch in a horizontal line corresponding to each particle's buoyant density.
- 2 Select the curve at the desired temperature (4°C) and tube volume (full) that gives the best particle separation.

- 3 Note the run speed along the selected curve (20,000 RPM).
- 4 From Figure 2, select the maximum homogeneous CsCl density (in this case, 1.56 g/mL) that corresponds to the temperature and run speed established above.
These parameters will provide the particle-banding pattern selected in Step 2.

In this example, particles will band about 110 and 122 mm from the axis of rotation (about 12 mm apart).

Use of a CsCl Cushion

Some separations incorporate the use of cushions of CsCl. A common example is the isolation of total RNA. In this example, one-fourth of the total tube volume is filled with a cushion of 5.7 M CsCl (1.71 g/mL). A solution containing a tissue homogenate in a guanidinium thiocyanate buffer is layered over the CsCl solution.

Maximum run speeds must take into account the increased density of the solution as well as the use of the CsCl precipitation curves.

NOTE Run speeds obtained using average densities are approximate.

Example C:

Using SW 28 rotor.

- 1 Parameters
 - Cushion: 1.71 g/mL density CsCl (5.7 M)
 - Cushion volume: 9.6 mL ($1/4$ total volume)
 - Overlay: 1.2 g/mL density homogenate/buffer
 - Overlay Volume: 28.9 mL ($3/4$ total volume)
 - Average Density: 1.33 g/mL
 - Temperature: 20°C

- 2 First, use the square root derivation formula:

$$\text{RPM} = 28,000 \sqrt{\frac{1.2 \text{ g/mL}}{1.33 \text{ g/mL}}} = 28,000 (0.95) = 26,600$$

- 3 Next, use the CsCl curves for quarter-filled tubes (at 20°C) in Figure 3 to determine that the maximum run speed for the SW 28 with a quarter volume of 1.71 g/mL CsCl is 27,500 RPM.

-
- 4 Choosing the lower of the two speeds gives a maximum run speed of 26,600 RPM.
-

Example D:

-
- 1 All parameters are as listed in Example C with the exception of temperature.
Temperature: 4°C
-
- 2 As in Example C, the square root deration curve gives a maximum speed of 26,600 RPM.
-
- 3 The CsCl curves for quarter-filled tubes at 4°C in [Figure 3](#) show that the maximum run speed for the SW 28 with a quarter volume of 1.71 g/mL CsCl is 24,000 RPM.
-
- 4 Choosing the lower of the two speeds gives a maximum run speed of 24,000 RPM.
-

Care and Maintenance

Maintenance

NOTE Do not use sharp tools on the rotor that could cause scratches in the rotor surface. Corrosion begins in scratches and may open fissures in the rotor with continued use.

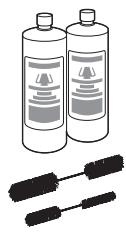
-
- 1 Frequently check the bucket O-rings for signs of wear.
- a. Replace O-rings every 6 months, or whenever worn or damaged.
 - b. Keep the O-rings lightly coated with silicone vacuum grease (335148)
Replacement instructions are in *Rotors and Tubes*.
-
- 2 Before every run, lubricate the bucket cap threads with a thin, even coat of Spinkote lubricant (306812).
-
- 3 Refer to *Chemical Resistances* (IN-175) for the chemical compatibilities of rotor and accessory materials.
-

Your Beckman Coulter representative provides contact with the Field Rotor Inspection Program and the rotor repair center.

Cleaning

Wash the rotor and rotor components immediately if salts or other corrosive materials are used or if spillage has occurred. Do not allow corrosive materials to dry on the rotor.

Under normal use, wash the rotor frequently (at least weekly) to prevent buildup of residues.



- 1 Wash the rotor buckets, O-rings, and caps in a mild detergent, such as Solution 555, that won't damage the rotor.

Dilute the detergent with water (10 parts water to 1 part detergent).

NOTE Do not immerse the rotor body in water, since the hanger mechanism is difficult to dry and can rust.

The Rotor Cleaning Kit contains two plastic-coated brushes and two quarts of Solution 555 (339555) for use with rotors and accessories.

- 2 Wash the rotor body with a sponge or cloth dampened with a mild detergent, such as Solution 555.

Dilute the detergent with water (10 parts water to 1 part detergent).

- 3 Rinse the cleaned rotor and components with distilled water.

- 4 Air-dry the rotor and lid upside down.

Do not use acetone to dry the rotor.

- 5 Clean metal threads frequently to prevent buildup of residues and ensure adequate closure.

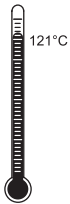
- a. Use a brush and concentrated Solution 555.
- b. Dilute the detergent with water (10 parts water to 1 part detergent).
- c. Rinse and dry thoroughly, then lubricate lightly but evenly with Spinkote to coat all threads.

Decontamination



If the rotor or other components are contaminated with toxic, radioactive, or pathogenic materials, follow appropriate decontamination procedures as outlined by your laboratory safety officer. Refer to *Chemical Resistances* (IN-175) to select solutions that will not damage the rotor and accessory materials.

Sterilization and Disinfection



- The rotor and all rotor components, except those made of polyphenylene oxide (PPO), can be autoclaved at 121°C for up to an hour. Remove the plugs from the rotor and place the rotor, plugs, and spacers in the autoclave upside down.
- Ethanol (70%) or hydrogen peroxide (6%) may be used on all rotor components, including those made of plastic. Bleach (sodium hypochlorite) may be used, but may cause discoloration of anodized surfaces. Use the minimum immersion time for each solution, per laboratory standards.



Ethanol is a flammability hazard. Do not use it in or near operating ultracentrifuges.

While Beckman Coulter has tested these methods and found that they do not damage the rotor or components, no guarantee of sterility or disinfection is expressed or implied. When sterilization or disinfection is a concern, consult your laboratory safety officer regarding proper methods to use.

Refer to publication IN-192 (included with each box of tubes) for tube sterilization and disinfection procedures. *Quick-Seal, Ultra Clear, and thinwall open-top tubes are disposable and should be discarded after a single use.*

Storage

When it is not in use, store the rotor and buckets in a dry environment (not in the instrument). Remove the bucket caps to allow air circulation so that moisture will not collect in the buckets.

Returning a Rotor

Before returning a rotor or accessory for any reason, prior permission must be obtained from Beckman Coulter, Inc. A return authorization form is necessary and may be obtained from your local Beckman Coulter office. The return form should contain the following information:

- rotor type and serial number,
- history of use (approximate frequency of use),
- reason for the return,
- original purchase order number, billing number, and shipping number, if possible,
- name and email address of the person to be notified upon receipt of the rotor or accessory at the factory,
- name and email address of the person to be notified about repair costs, etc.

To protect our personnel, it is the customer's responsibility to ensure that all parts are free from pathogens and/or radioactivity. Sterilization and decontamination must be done before returning the parts. Smaller items (such as tubes, bottles, etc.) should be enclosed in a sealed plastic bag.

*All parts must be accompanied by a note, plainly visible on the outside of the box or bag, stating that they are safe to handle and that they are not contaminated with pathogens or radioactivity. **Failure to attach this notification will result in return or disposal of the items without review of the reported problem.***

Use the address label printed on the return form when mailing the rotor and/or accessories.

Customers located outside the United States should contact their local Beckman Coulter office.

Supply List

See the Beckman Coulter *Ultracentrifuge Rotors, Tubes & Accessories* catalog (BR-8101, available at www.beckmancoulter.com), call Beckman Coulter Customer Service at 1-800-742-2345 (U.S.A. or Canada), or contact your local Beckman Coulter office for detailed information on ordering parts and supplies. For your convenience, a partial list is given below.

Replacement Rotor Parts

Description	Part Number
SW 28 rotor assembly	342207
SW 28 buckets (set of 6, with caps and O-rings)	342217
SW 28 bucket O-ring	812715
SW 28.1 rotor assembly	342216
SW 28.1 buckets (set of 6, with caps and O-rings)	342212
SW 28.1 bucket O-ring	815472

Description	Part Number
Rotor stand	332400
Overspeed disk (28,000 RPM)	342211

Other

NOTE For MSDS information, go to the Beckman Coulter website at www.beckmancoulter.com.

Description	Part Number
Tubes and accessories	see Table 2 and Table 3
Bucket holder rack	331186
Quick-Seal Cordless Tube Topper kit, 60 Hz	358312
Quick-Seal Cordless Tube Topper kit, 50 Hz (Europe)	358313
Quick-Seal Cordless Tube Topper kit, 50 Hz (Great Britain)	358314
Quick-Seal Cordless Tube Topper kit, 50 Hz (Australia)	358315
Quick-Seal Cordless Tube Topper kit, 50 Hz (Canada)	367803
Tube racks for the Tube Topper for 16-mm diameter tubes for 38-mm diameter tubes	348123 348124
Floating spacer removal tool	338765
Tube removal tool (Quick-Seal tubes)	361668
Extractor tool (konical tube adapters)	354468
Spinkote lubricant (2 oz)	306812
Silicone vacuum grease (1 oz)	335148
Rotor Cleaning Kit	339558
Solution 555 (1 qt)	339555
Rotor cleaning brush	339379
Centering tool (for overspeed disk replacement)	331325

Beckman Coulter, Inc.

Ultracentrifuge Rotor Warranty

All Beckman Coulter ultracentrifuge Fixed Angle, Vertical Tube, Near Vertical Tube, Swinging Bucket, and Airfuge rotors are warranted against defects in materials or workmanship for the time periods indicated below, subject to the Warranty Conditions stated below.

Preparative Ultracentrifuge Rotors	5 years — No Proration
Analytical Ultracentrifuge Rotors	5 years — No Proration
ML and TL Series Ultracentrifuge Rotors	5 years — No Proration
Airfuge Ultracentrifuge Rotors	1 year — No Proration
For Zonal, Continuous Flow, Component Test, and Rock Core Ultracentrifuge Rotors, see separate warranty.	

1. This warranty is valid for the time periods indicated above from the date of shipment to the original Buyer by Beckman Coulter or an authorized Beckman Coulter representative.
2. This warranty extends only to the original Buyer and may not be assigned or extended to a third person without written consent of Beckman Coulter.
3. This warranty covers the Beckman Coulter Centrifuge Systems only (including but not limited to the centrifuge, rotor, and accessories) and Beckman Coulter shall not be liable for damage to or loss of the user's sample, non-Beckman Coulter tubes, adapters, or other rotor contents.
4. This warranty is void if the Beckman Coulter Centrifuge System is determined by Beckman Coulter to have been operated or maintained in a manner contrary to the instructions in the operator's manual(s) for the Beckman Coulter Centrifuge System components in use. This includes but is not limited to operator misuse, abuse, or negligence regarding indicated maintenance procedures, centrifuge and rotor classification requirements, proper speed reduction for the high density of certain fluids, tubes, and tube caps, speed reduction for precipitating gradient materials, and speed reduction for high-temperature operation.
5. Rotor bucket sets purchased concurrently with or subsequent to the purchase of a Swinging Bucket Rotor are warranted only for a term co-extensive with that of the rotor for which the bucket sets are purchased.
6. This warranty does not cover the failure of a Beckman Coulter rotor in a centrifuge not of Beckman Coulter manufacture, or if the rotor is used in a Beckman Coulter centrifuge that has been modified without the written permission of Beckman Coulter, or is used with carriers, buckets, belts, or other devices not of Beckman Coulter manufacture.
7. Rotor parts subject to wear, including but not limited to rotor O-rings, VTi, NVT, TLV, MLN, and TLN rotor tube cavity plugs and gaskets, tubing, tools, optical overspeed disks, bearings, seals, and lubrication are excluded from this warranty and should be frequently inspected and replaced if they become worn or damaged.
8. Keeping a rotor log is not mandatory, but may be desirable for maintenance of good laboratory practices.

Repair and Replacement Policies

1. If a Beckman Coulter rotor is determined by Beckman Coulter to be defective, Beckman Coulter will repair or replace it, subject to the Warranty Conditions. A replacement rotor will be warranted for the time remaining on the original rotor's warranty.
2. If a Beckman Coulter centrifuge is damaged due to a failure of a rotor covered by this warranty, Beckman Coulter will supply free of charge (i) all centrifuge parts required for repair (except the drive unit, which will be replaced at the then current price less a credit determined by the total number of revolutions or years completed, provided that such a unit was manufactured or rebuilt by Beckman Coulter), and (ii) if the centrifuge is currently covered by a Beckman Coulter warranty or Full Service Agreement, all labor necessary for repair of the centrifuge.
3. If a Beckman Coulter rotor covered by this warranty is damaged due to a malfunction of a Beckman Coulter ultracentrifuge covered by an Ultracentrifuge System Service Agreement, Beckman Coulter will repair or replace the rotor free of charge.
4. If a Beckman Coulter rotor covered by this warranty is damaged due to a failure of a Beckman Coulter tube, bottle, tube cap, spacer, or adapter, covered under the Conditions of this Warranty, Beckman Coulter will repair or replace the rotor and repair the instrument as per the conditions in policy point (2) above, and the replacement policy.
5. Damage to a Beckman Coulter rotor or instrument due to the failure or malfunction of a non-Beckman Coulter tube, bottle, tube cap, spacer, or adapter is not covered under this warranty, although Beckman Coulter will assist in seeking compensation under the manufacturer's warranty.

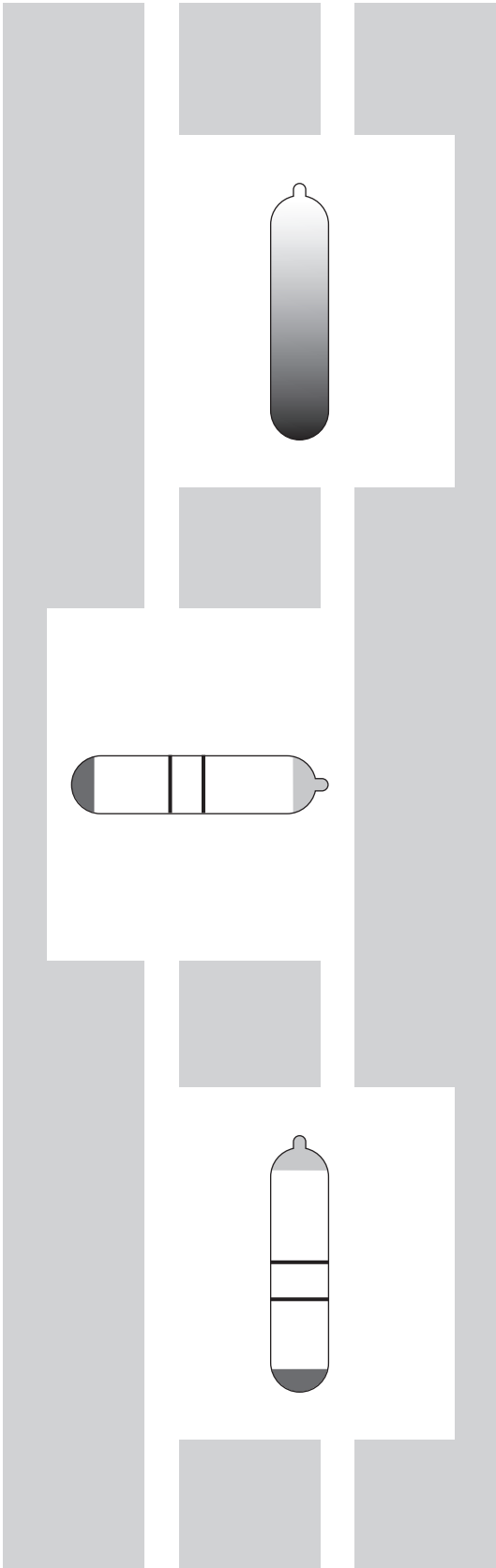
Disclaimer

IT IS EXPRESSLY AGREED THAT THE ABOVE WARRANTY SHALL BE IN LIEU OF ALL WARRANTIES OF FITNESS AND OF THE WARRANTY OF MERCHANTABILITY AND BECKMAN COULTER, INC. SHALL HAVE NO LIABILITY FOR SPECIAL OR CONSEQUENTIAL DAMAGES OF ANY KIND WHATSOEVER ARISING OUT OF THE MANUFACTURE, USE, SALE, HANDLING, REPAIR, MAINTENANCE, OR REPLACEMENT OF THE PRODUCT.

Factory Rotor Inspection Service

Beckman Coulter, Inc., will provide free mechanical and metallurgical inspection in Indianapolis, Indiana, USA, of any Beckman Coulter rotor at the request of the user. (Shipping charges to Beckman Coulter are the responsibility of the user.) Rotors will be inspected in the user's laboratory if the centrifuge in which they are used is covered by an appropriate Beckman Coulter Service Agreement. Contact your local Beckman Coulter office for details of service coverage or cost.

Before shipping, contact the nearest Beckman Coulter Sales and Service office and request a Returned Goods Authorization (RGA) form and packaging instructions. Please include the complete rotor assembly, with buckets, lid, handle, tube cavity caps, etc. A SIGNED STATEMENT THAT THE ROTOR AND ACCESSORIES ARE NON-RADIOACTIVE, NON-PATHOGENIC, NON-TOXIC, AND OTHERWISE SAFE TO SHIP AND HANDLE IS REQUIRED.



Related Documents

Rotors and Tubes for Preparative Ultracentrifuges (LR-IM-24)

- Rotors
- Tubes, Bottles, and Accessories
- Using Tubes, Bottles, and Accessories
- Using Fixed-Angle Rotors
- Using Swinging-Bucket Rotors
- Using Vertical-Tube and Near-Vertical Tube Rotors
- Care and Maintenance
- Chemical Resistances for Beckman Coulter Centrifugation Products
- Use of the w2t Integrator
- The Use of Cesium Chloride Curves
- Gradient Materials
- References
- Glossary

Available in electronic pdf by request.

Rotors and Tubes CD (369668)

- Rotors and Tubes for Tabletop Preparative Ultracentrifuges
- Rotors and Tubes for J2, J6, Avanti J Series Centrifuges
- Rotors and Tubes for Preparative Ultracentrifuges
- Rotor Safety Bulletin
- Chemical Resistances for Beckman Coulter Centrifugation Products

Included with shipment of instrument.

Additional References

- Chemical Resistances for Beckman Coulter Centrifugation Products (IN-175)
- Beckman Coulter Ultracentrifuge Rotors, Tubes & Accessories catalog (BR-8101)
- Using OptiSeal Tubes (IN-189)
- Use and Care of Centrifuge Tubes and Bottles (IN-192)

Available in hard copy or electronic pdf by request, also available at www.beckmancoulter.com.

Data Sheets

- *g*-Max System: Short Pathlengths in High Force Fields (DS-709B)

Available at www.beckmancoulter.com

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