Thermo Fisher Scientific

AH-629

Instruction Manual

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Table of contents

This manual is a guide for the use of

Thermo Scientific AH-629 Aluminum Swinging Bucket Ultracentrifuge Rotor

Data herein has been verified and is believed adequate for the intended use of the centrifuge. 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.

NOTES, CAUTIONS, and WARNINGS within the text of this manual are used to emphasize important and critical instructions.

WARNING informs the operator of a hazard or 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 materials 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.
- the compartment load exceeds the maximum allowable compartment load specified. See Chapter 3, Operation. Failure to reduce rotor speed under these conditions can cause rotor failure.

Centrifuges routinely deal with high energy levels and could move suddenly in the unlikely event of rotor failure. During centrifuge operation, never lean on or move the centrifuge, keep the surrounding area clear of objects (including all hazardous materials), and do not work on top of or next to the centrifuge.

Do not attempt to open the chamber door when the rotor is spinning; never override or otherwise disable any of the safety systems of the centrifuge.

CAUTION

Do not expose aluminum rotor components to: strong acids, bases, alkaline laboratory detergents, liquid chlorine bleach or salts (chlorides) of heavy metals such as cesium, lead, silver, or mercury. Use of these materials with aluminum can cause a chemical reaction that initiates corrosion.

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

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 rotor chamber. See Chapter 3, Operation.

Always maintain the centrifuge in the recommended manner. All accessories must be clean and inspected prior to each run: do not use rotor showing signs of corrosion or cracking. See Chapter 4, Maintenance.

Do not autoclave the aluminum rotor body or the aluminum cap assemblies to temperatures in excess of 100°C.

DESCRIPTION

This manual provides you with the information you will need to operate and maintain your Thermo Scientific A-629 Swinging Bucket Ultracentrifuge Rotor. If you encounter any problem concerning either operation or maintenance that is not covered in the manual, please contact our Marketing Technical Group for assistance. In the United States, call toll free 1-866-9THERMO. Outside the United States, contact the distributor or agent for Thermo Fisher Scientific products. Thermo Fisher Scientific product information is available on our internet web site at http://www.thermo.com/centrifuge .

Contents

Rotor Description

The AH-629 is an aluminum swinging bucket ultracentrifuge rotor that can produce up to six sets of data during a single run at speeds up to 29,000 rpm.[1] Each titanium rotor bucket will hold a centrifuge tube having a nominal fluid capacity of either 36 ml, 20 ml, or 17 ml depending on the buckets purchased. The buckets are sealed during operation by an O-ring and an aluminum bucket cap. The buckets attach to the rotor body, each at its own numbered position. During a centrifuge run, they swing out horizontally and return to a vertical position during deceleration. A disc with alternating black and reflective segments attached to the bottom of the rotor provides overspeed protection.

Rotor Specifications

General

The following specifications apply to the rotor when used with 36 ml, 20 ml, or 17 ml buckets.

Table 1-1. Rotor Specifications

Rotor Type	Swinging Bucket
Maximum Speed	29,000 rpm*
Number of Buckets	6
Rotor Diameter	21 cm (8.26 in)
Critical Speed	1100 rpm

*With tubes filled with a homogeneous solution having an average density of 1.2 g/ml or less

Rotor with 36 ml Buckets:

Table 1-2. Rotor Specifications with 36 ml Bucket

Relative Centrifugal Force (RCF) at maximum speed:	
at $r_{minimum}$ (7.21 cm) at $r_{average}$ (11.655 cm) at $r_{maximum}$ (16.10 cm)	67,731 109,487 151,243
K Factor at maximum speed	242
Total volume capacity (nominal)	216 ml
Tube compartment diameter	2.5 cm (1.0 in)
Tube length (nominal)	8.9 cm (3.5 in)
Maximum compartment mass (includes bucket weight)	156.6 g
Rotor weight including buckets	6.4 kg (14.1 lb)

[1] Speed in revolutions per minute (rpm) is related to angular velocity, w, according to the following:

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

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

Rotor with 20 ml Buckets:

Table 1-3. Rotor Specifications with 20 ml Bucket

Relative Centrifugal Force (RCF) at maximum speed:	
at $r_{minimum}$ (7.21 cm)	67,731
at $r_{average}$ (10.07 cm)	94,597
at $r_{maximum}$ (12.93 cm)	121,464
K Factor at maximum speed	176
Total volume capacity (nominal)	120 ml
Tube compartment diameter	2.5 cm (1.0 in)
Tube length (nominal)	5.1 cm (2.0 in)
Maximum compartment mass (includes bucket weight)	115.0 g
Rotor weight including buckets	6.1 kg (13.5 lb)

Rotor with 17 ml Buckets:

Table 1-4. Rotor Specifications with 17ml Bucket

Relative Centrifugal Force (RCF) at maximum speed:	
at $r_{minimum}$ (6.45 cm)	60,591
at $r_{average}$ (11.52 cm)	108,219
at $r_{maximum}$ (16.59 cm)	155,846
K Factor at maximum speed	284
Total volume capacity (nominal)	102 ml
Tube compartment diameter	1.6 cm (0.63 in)
Tube length (nominal)	10.2 cm (4.0 in)
Maximum compartment mass (includes bucket weight)	130.1 g
Rotor weight including buckets	6.2 kg (13.7 lb)

Accessories

The accessories supplied with the AH-629 Rotor ordered with complete accessories are listed in Table 1-5. Catalog numbers are: 54283 (with 17 ml buckets), 54311 (with 20 ml buckets), or 54282 (with 36 ml buckets). The AH-629 Rotor can also be purchased with basic accessories only, which includes all items listed in Table 1-5 except the tubes. The catalog numbers for the rotor with basic accessories only are: 54285 (17 ml buckets), 54308 (20 ml buckets), and 54284 (36 ml buckets).

Table 1-5. Accessories Supplied

Quantity	Catalog Number	Description
1 set	52030	Buckets, 17 ml; or
	54293	Buckets, 20 ml; or
	52035	Buckets, 36 ml
4 boxes of 50	03126*	Tubes, Polyallomer (17 ml buckets); or

Table 1-5. Accessories Supplied

Quantity	Catalog Number	Description
8 boxes of 25	03288*	Tubes, Polyallomer (20 ml buckets); or
8 boxes of 25	03141*	Tubes, Polyallomer (36 ml buckets)
6	63712*	O-rings (17 ml buckets) or
	64667*	O-rings (20 ml and 36 ml buckets)
1	51362	Overspeed Decal, 29 000 rpm (extra)
1	52240	Bucket Rack
1	51942	Rotor Storage Stand
1	65937	Vacuum Grease
1	61556	Lubricant
1	52384	Ultraspeed Centrifuge/Rotor Log Book
1	54276	AH-629 Rotor Instruction Manual

*The catalog number supplied depends on the size of the buckets ordered with the rotor. No tubes are supplied with catalog numbers 54285, 54308, and 54284.

SPECIAL OPERATING CONSIDERATIONS

This chapter provides special operating considerations for Basic Operation.

Contents

Derating Rotor Speed

Because of the stresses that the rotor body and buckets must withstand during centrifugation, it is necessary to eventually derate the maximum operating speed of the rotor. Specifically, the maximum speed of 29,000 rpm must be derated to 26,000 rpm after the rotor has been used for 1000 runs. To know when the maximum rotor speed must be lowered, all runs should be recorded in the Ultraspeed Centrifuge/Rotor Log Book (supplied with the rotor)..

Note After the maximum speed has been derated, the new, lowered maximum speed should be used in all calculations and during all operations for the ensuing 1000 runs. (These runs should also be recorded in the Ultraspeed Centrifuge/Rotor Log Book.) In addition, the overspeed decal on the bottom of the rotor must be replaced with a new decal (Catalog No. 51365) for the lowered speed.

WARNING After the rotor has been used for 1000 runs at the derated speed, the rotor body and any set of buckets used with the rotor body should no longer be used.

Compartment Loads in Excess of Design Mass

The maximum run speed (29,000 rpm) is based on the recommended design mass that has been established for the rotor, representing the maximum mass that can be carried in each rotor bucket at topspeed operation. Total contents of each bucket, including the bucket, specimen and tube, should not exceed the recommended figure unless the rotor speed is reduced proportionately.

The design mass (that is, the weight of the bucket, tube and contents) for the AH-629 rotor at 29,000 rpm is: 156.6 g (36 ml buckets), 115.0 g (20 ml buckets), or 130.1 g (17 ml buckets). These figures are based on the use of a Thermo Fisher Scientific thinwall polyallomer tube filled with a liquid at 1.2 specific gravit.y If the specific gravity of the solution is greater than 1.2 g, use the following formula to determine the reduced speed:

$$\text{Reduced Speed} = 29000\sqrt{\frac{1.2\ \text{g/ml}}{\text{Average Fluid Density}}}$$

* 26 000 rpm if rotor has been derated.

This formula does not apply when using gradients that can precipitate.

Precautions to Prevent Precipitation of Cesium Chloride

Reducing Speed to Prevent Precipitation

Maximum speed must be reduced for an average fluid density greater than 1.2 g/ml (square-root reduction) to prevent excessive hydraulic pressure in the bucket. Although the standard formula (see previous paragraph) pertains to sucrose and similar gradient materials, it will not prevent precipitation of crystals when materials such as cesium chloride (CsCl) are used in an ultracentrifuge.

WARNING Rotor speed must be reduced according to the following instructions for applications where precipitation is possible. Failure to do so can cause rotor failure with subsequent sample loss and damage to your centrifuge.

When solid crystalline CsCl forms, it places a density of 4 g/ml at the bottom of each bucket. This density is dangerously high and can cause the rotor to fail, with subsequent sample loss. Therefore, CsCl 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. Saturation limits of CsCl in aqueous solutions are temperature dependent. The solubility limit of 1.86 g/ml at 25°C becomes 1.81 g/ml at 5°C. CsCl precipitation curves are given for each size bucket for specific average densities at 5°C and 25°C that will prevent both precipitation and hydraulic pressure. These curves should be used to determine the maximum operating speed of the rotor. Curves are also given that show the standard speed (square root) reductions to avoid only excessive hydraulic pressure at 5°C and at 25°C. For example, standard speed reduction would allow you to run a full tube of solution having a homogenous density of 1.65 g/ml at 24,700 rpm in any bucket at both the 5°C and 25°C temperatures. However, you can see that a CsCl solution will precipitate at this speed in the 17 ml and 36 ml bucket at both 5°C and 25°C and in the 20 ml buckets at 5°C.

The graphs show that the highest speed you can run a full tube of a CsCl solution having a density of 1.65 g/ml is:

14,400 rpm at 5°C using 17 ml buckets (Figure 2-1)

22,300 rpm at 5°C using 20 ml buckets (Figure 2-3)

15,600 rpm at 5°C using 36 ml buckets (Figure 2-5)

18,700 rpm at 25°C using 17 ml buckets (Figure 2-7)

24,700 rpm at 25°C using 20 ml buckets (Figure 2-9)

20,300 rpm at 25°C using 36 ml buckets (Figure 2-11)

Similarly, if you are to run the same CsCl solution (1.65 g/ml) in a 3/4-filled tube, the highest speed you can run this solution at is:

16,000 rpm at 5°C using 17 ml buckets (Figure 2-1)

25,400 rpm at 5°C using 20 ml buckets (Figure 2-3)

17,500 rpm at 5°C using 36 ml buckets (Figure 2-5)

21,000 rpm at 25°C using 17 ml buckets (Figure 2-7)

26,000 rpm at 25°C using 20 ml buckets (Figure 2-9)

22,600 rpm at 25°C using 36 ml buckets (Figure 2-11)

The Gradient Shape

The curves in Figures 2-2, 2-6, 2-8, 2-10 and 2-12 show the gradient shape at equilibrium for tubes filled with a CsCl solution using the homogenous density and speeds selected from the CsCl precipitation curves. The shape of a gradient produced in a partially filled tube can be determined by using lines for 3/4, 1/2 and 1/4 fills. For example, Figure 2-1 indicates that a tube 3/4-filled with a 1.65 g/ml homogenous CsCl solution using 17 ml buckets cannot be run any faster than 16,000 rpm at 5°C. Figure 2-2 shows the shape of the gradient curve which can be interpolated between the 15,000 rpm curve and 17,500 rpm curve. The gradient profile of this tube, 1.53 g/ ml at the meniscus to 1.81 g/ml at the bottom of the tube. To locate a band of particles having a specific density of 1.58 g/ml in a 3/4-filled tube using 17 ml buckets run at 16,000 rpm at 5°C, the particles will band approximately 3 ml below the 3/4 fill line of the tube (Figure 2-2). Similarly, Figure 2-7 shows that the same solution at 25°C using the 17 ml buckets cannot be run any faster than 21,000 rpm. Figure 2-8 shows the shape of the gradient curve which can be interpolated between the 20,000 rpm curve and 22,500 rpm curve.

The gradient profile of this tube, 1.48 g/ml at the meniscus to 1.86 g/ml at the bottom of the tube. To locate a band of particles having a specific density of 1.58 g/ml in a 3/4-filled tube using 17 ml buckets run at 21,000 rpm at 25°C, the particles will band approximately 4 ml below the 3/4 fill line of the tube (Figure 2-8). Similarly, the example illustrated in Figures 2-4, 2-6, 2-10 and 2-12 shows the gradient profile using the same homogenous CsCl solution (1.65 g/ml) in a 3/4-filled tube run at the 5°C and 25°C temperatures for 20 ml buckets and 36 ml buckets.

Note The gradient shape curves can be used for any fill volume up to the maximum volume of the tube, unless noted otherwise, in which case, examples are given for partial fills. In these cases, gradient shapes for other fill volumes at those speeds must be derived by interpolation..

Critical Speed

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, 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 range which is 1100 rpm for the AH-629 rotor.

CAUTION Continued operation at the critical speed will have a detrimental effect on centrifuge component life.

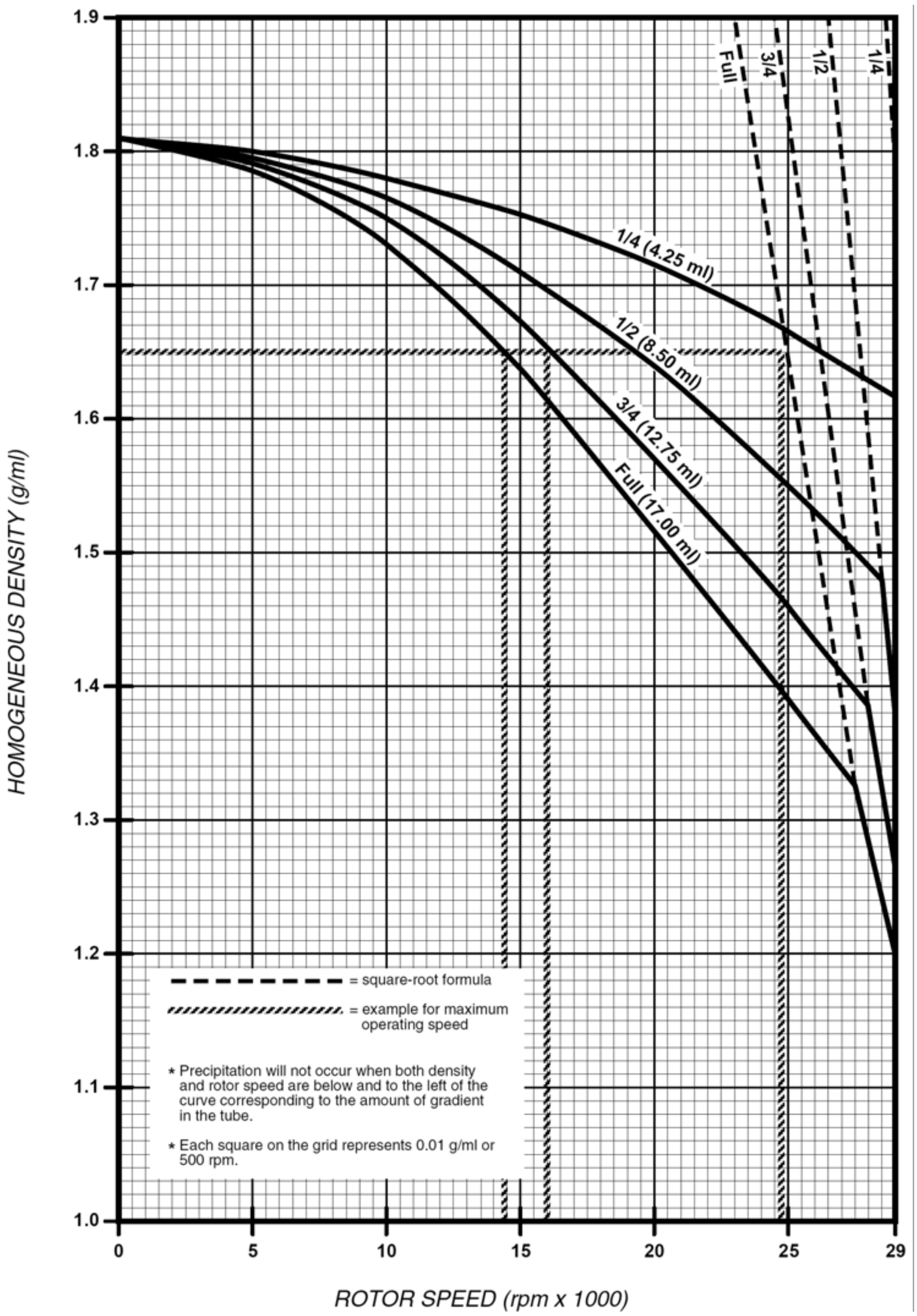

Figure 2-1. CsCl Precipitation Curve, 17 ml Buckets, 5°C

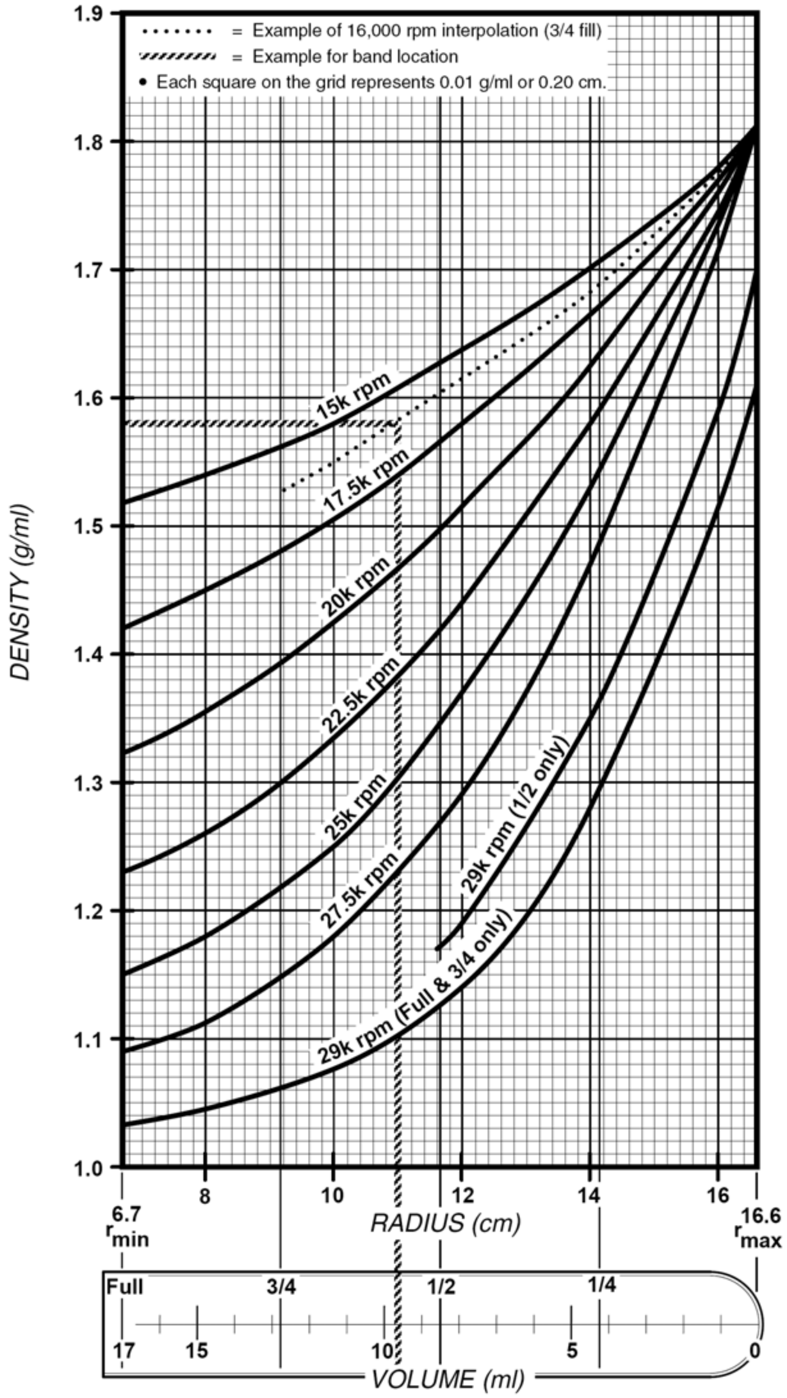

Figure 2-2. CsCl Gradients at Equilibrium, 17 ml Buckets, 5°C

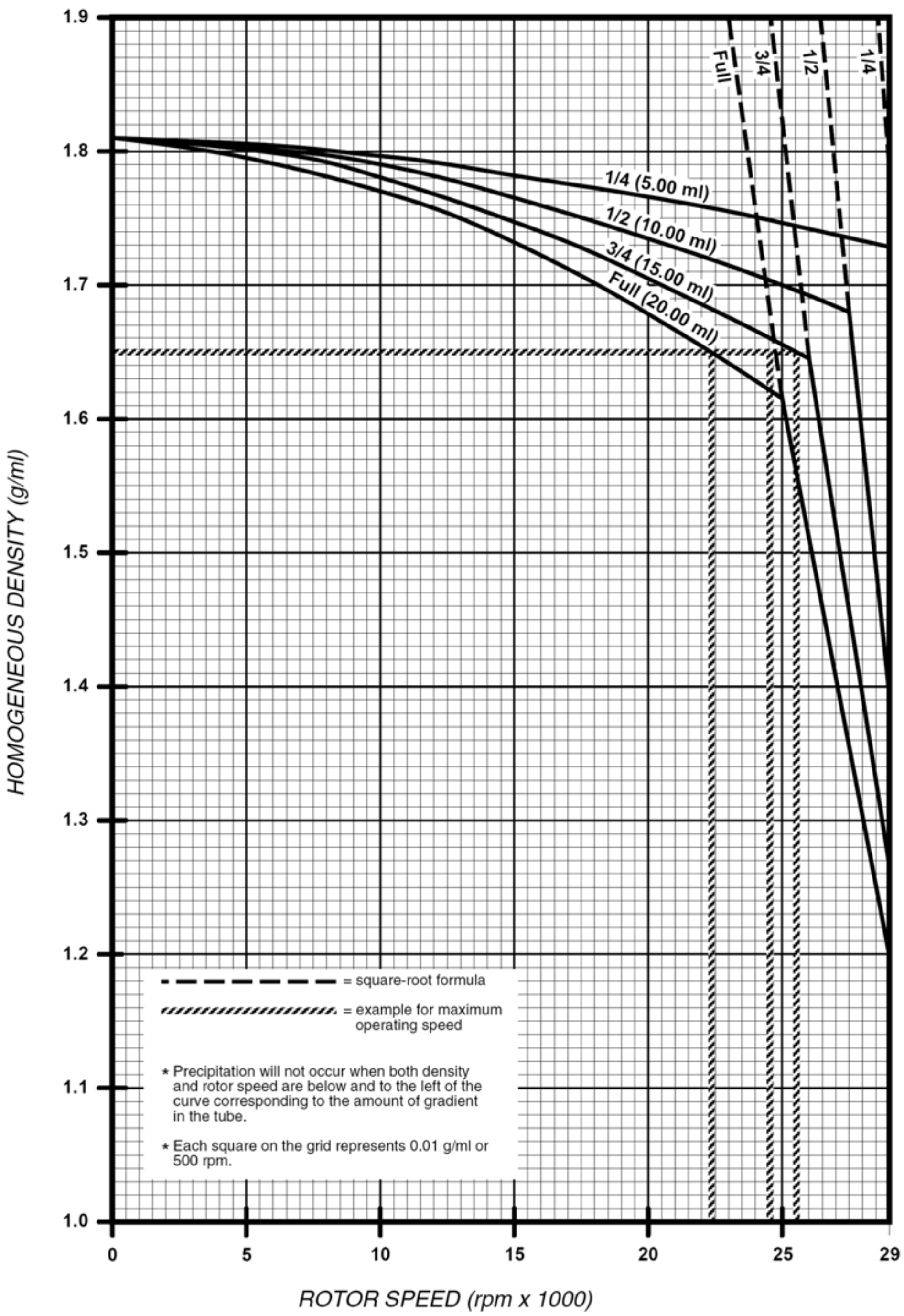

Figure 2-3. CsCl Precipitation Curve, 20 ml Buckets, 5°C

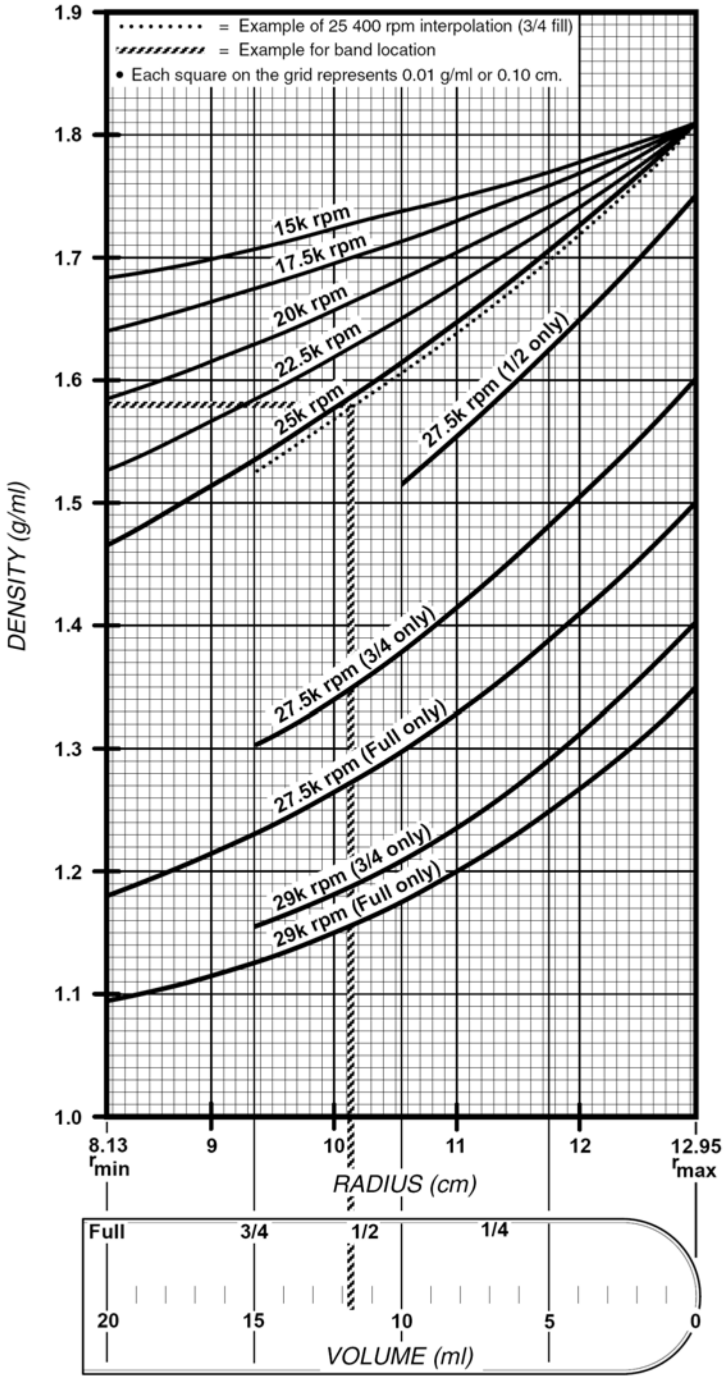

Figure 2-4. CsCl Gradients at Equilibrium, 20 ml Buckets, 5°C

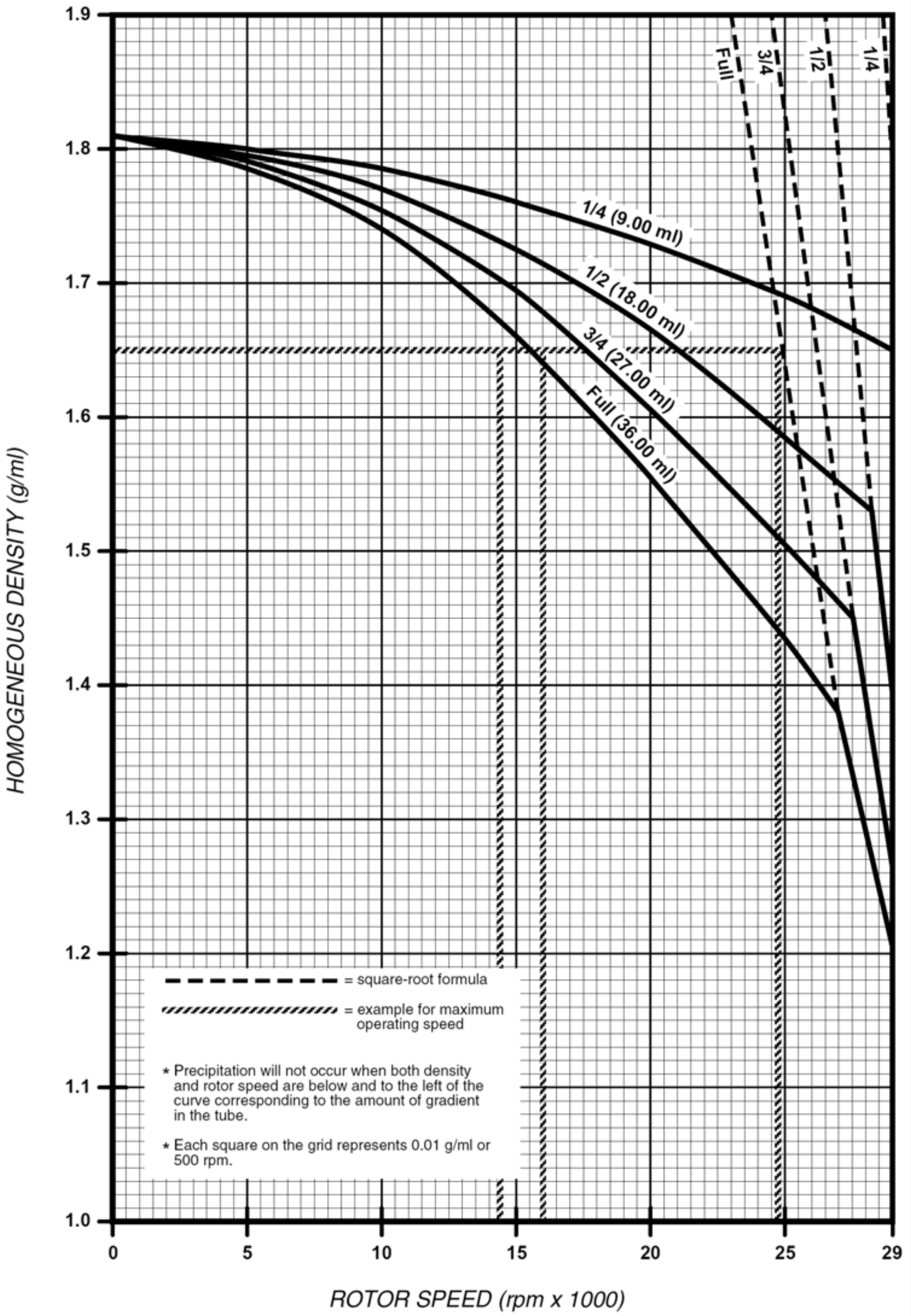

Figure 2-5. CsCl Precipitation Curve, 36 ml Buckets, 5°C

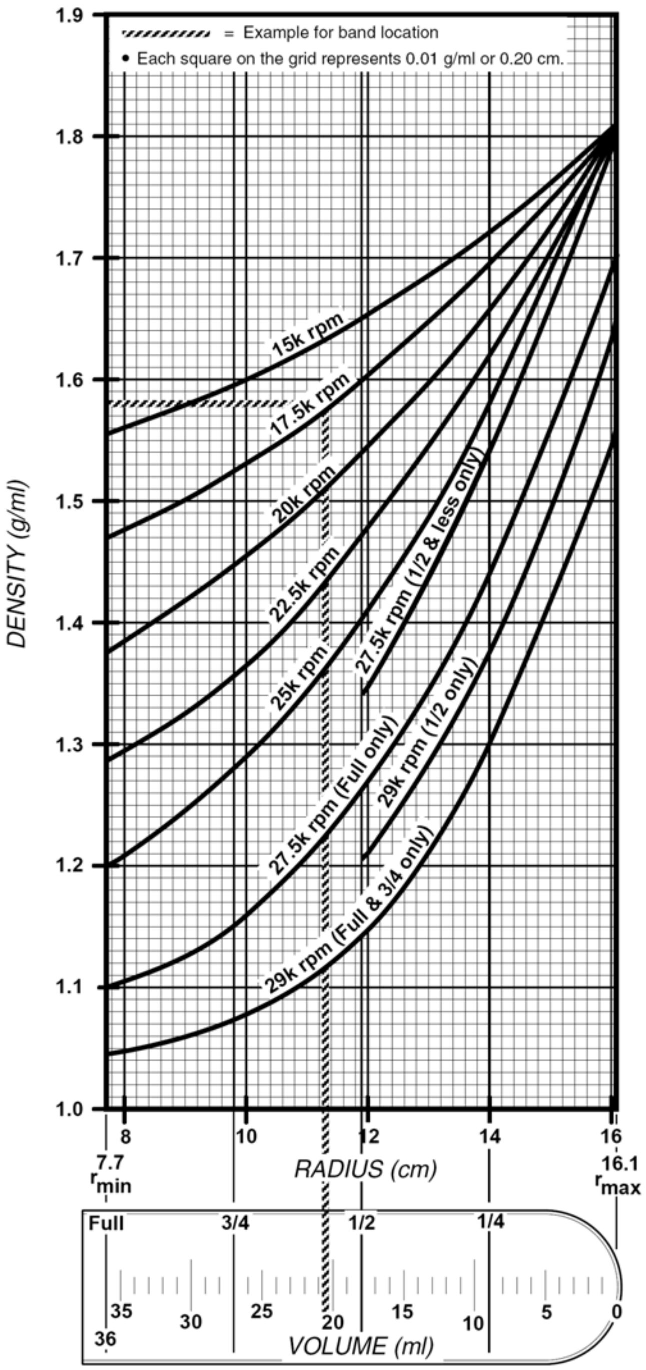

Figure 2-6. CsCl Gradients at Equilibrium, 36 ml Buckets, 5°C

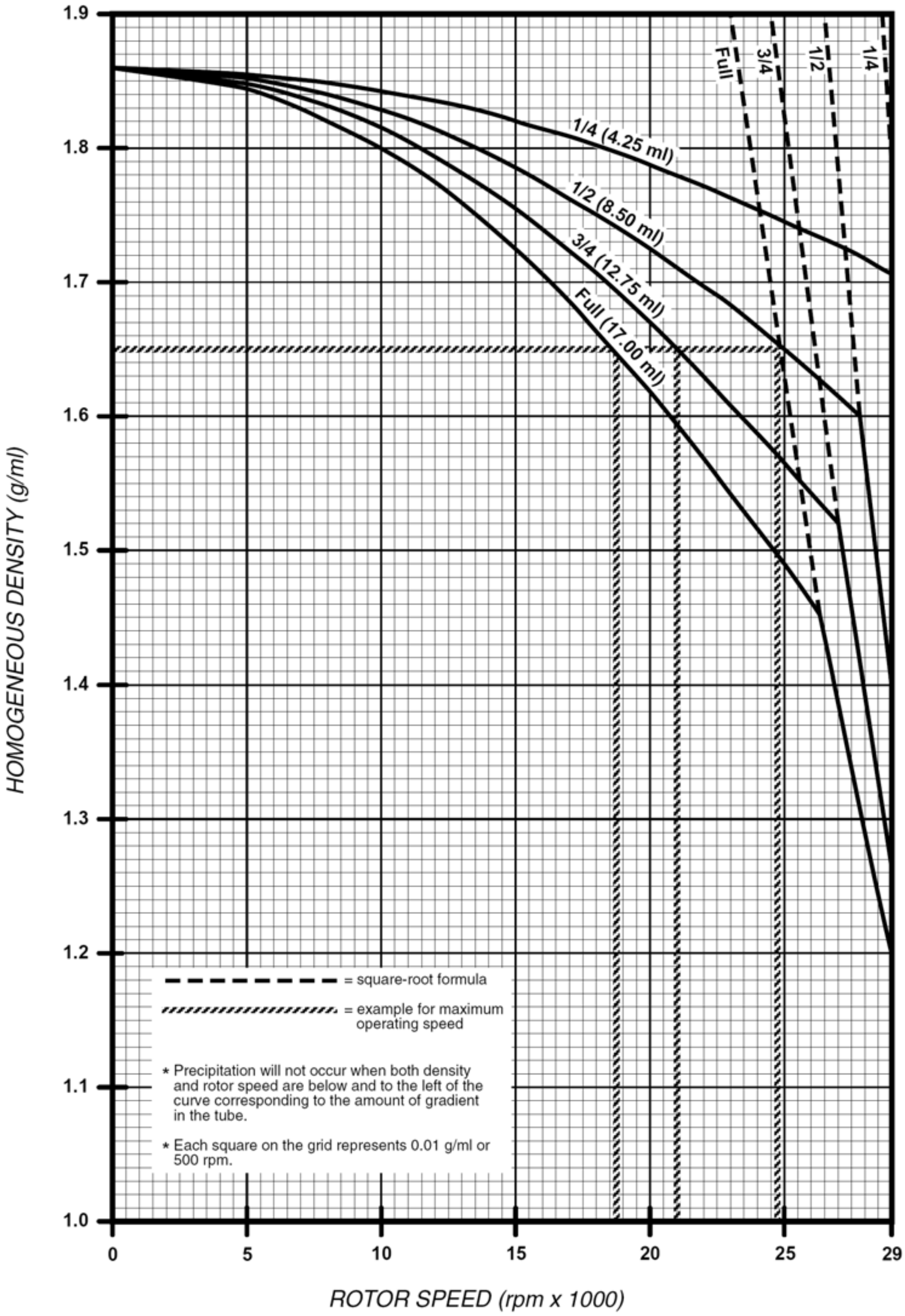

Figure 2-7. CsCl Precipitation Curve, 17 ml Buckets, 25°C

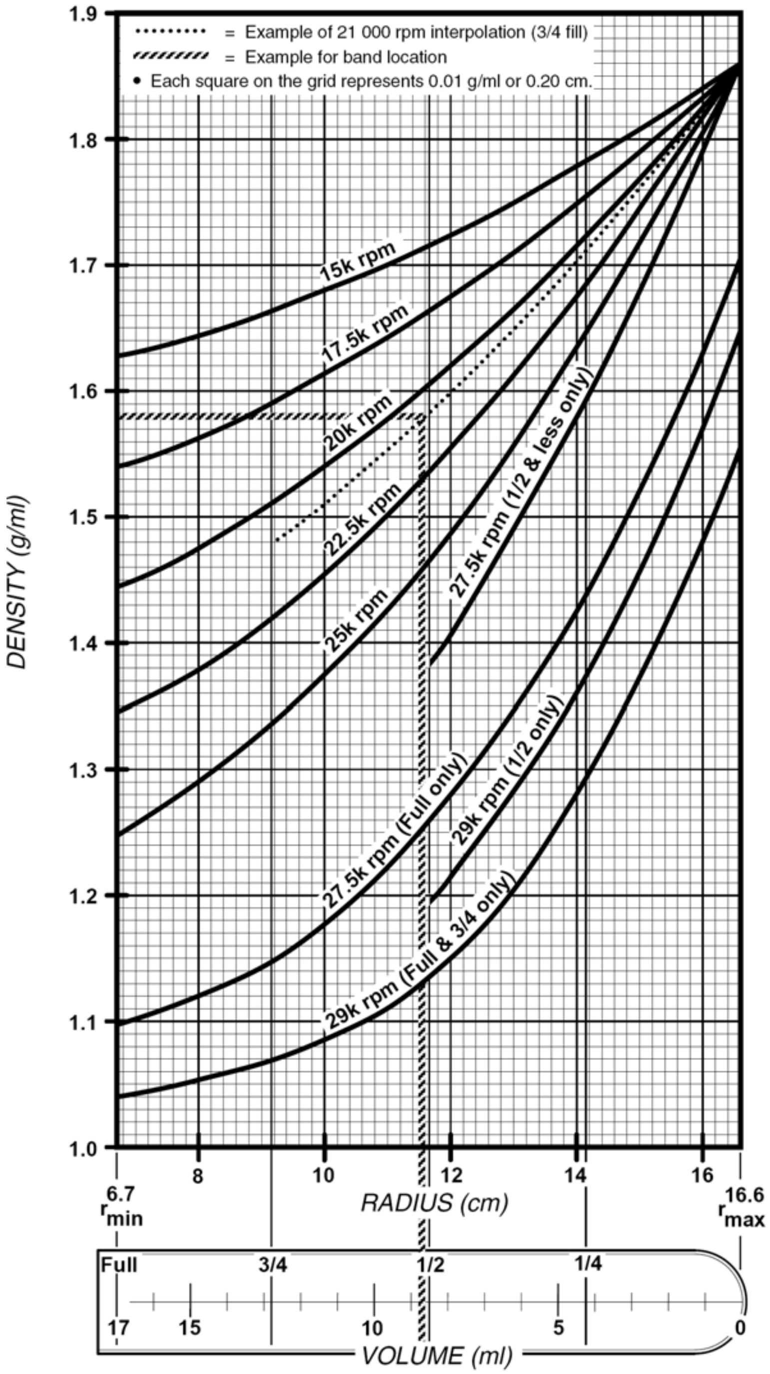

Figure 2-8. CsCl Gradients at Equilibrium, 17 ml Buckets, 25°C

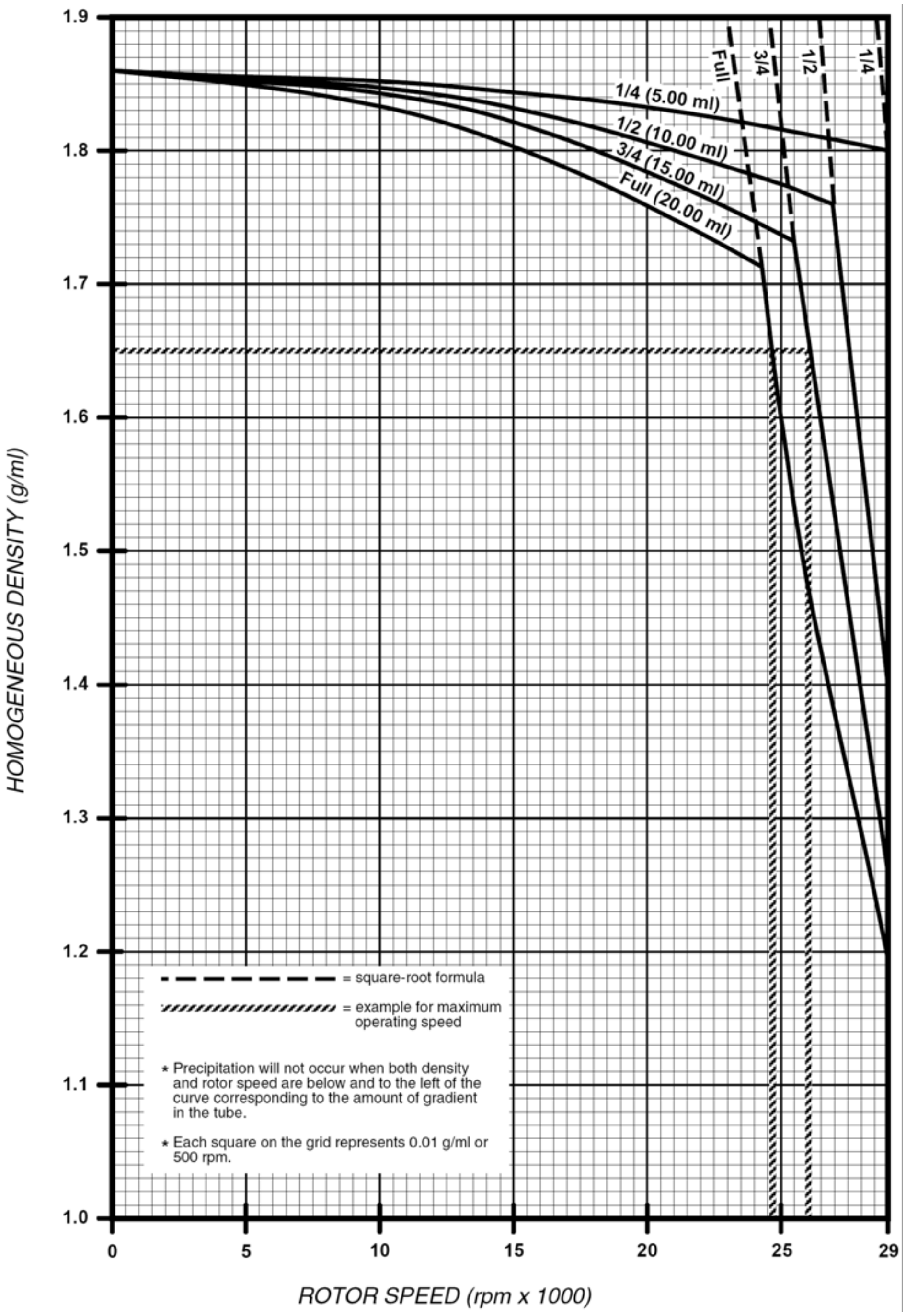

Figure 2-9. CsCl Precipitation Curve, 20 ml Buckets, 25°C

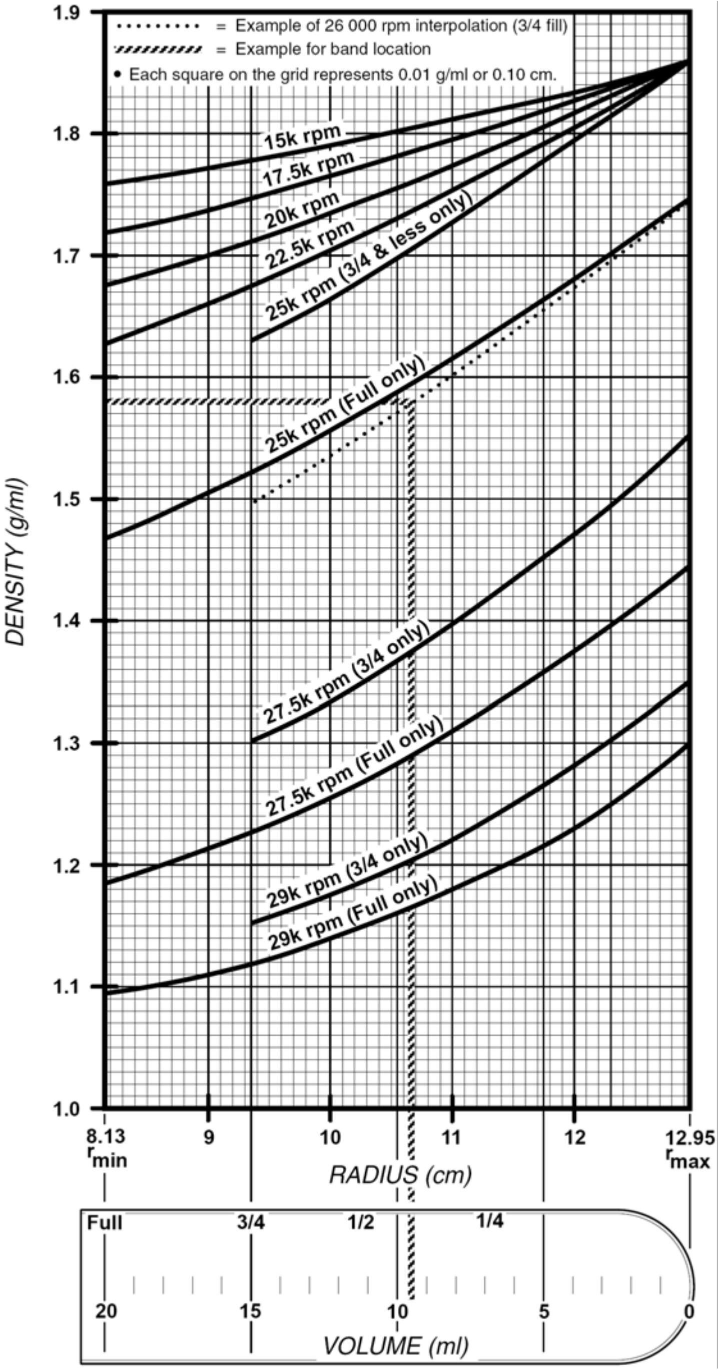

Figure 2-10. CsCl Gradients at Equilibrium, 20 ml Buckets, 25°C

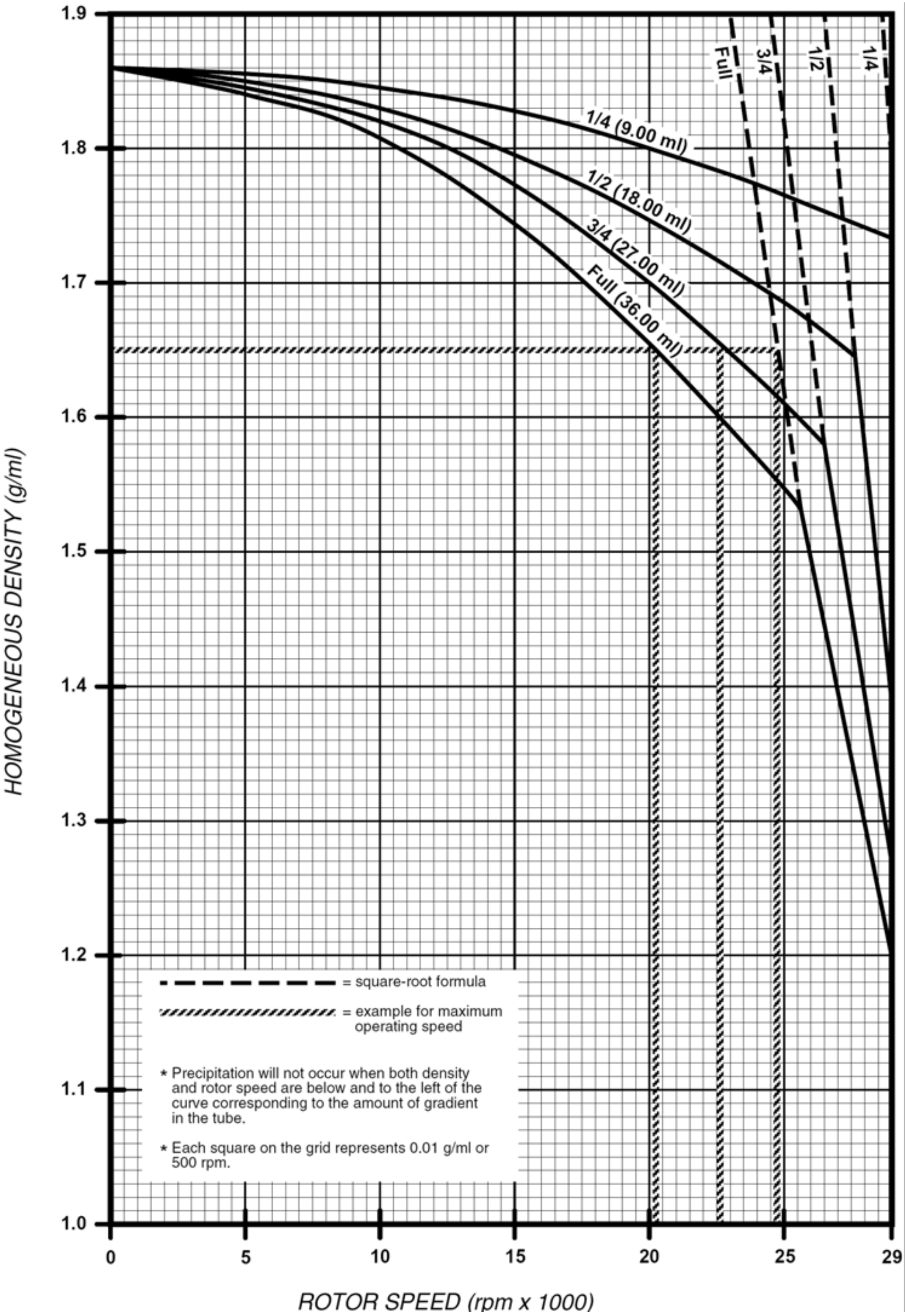

Figure 2-11. CsCl Precipitation Curve, 36 ml Buckets, 25°C

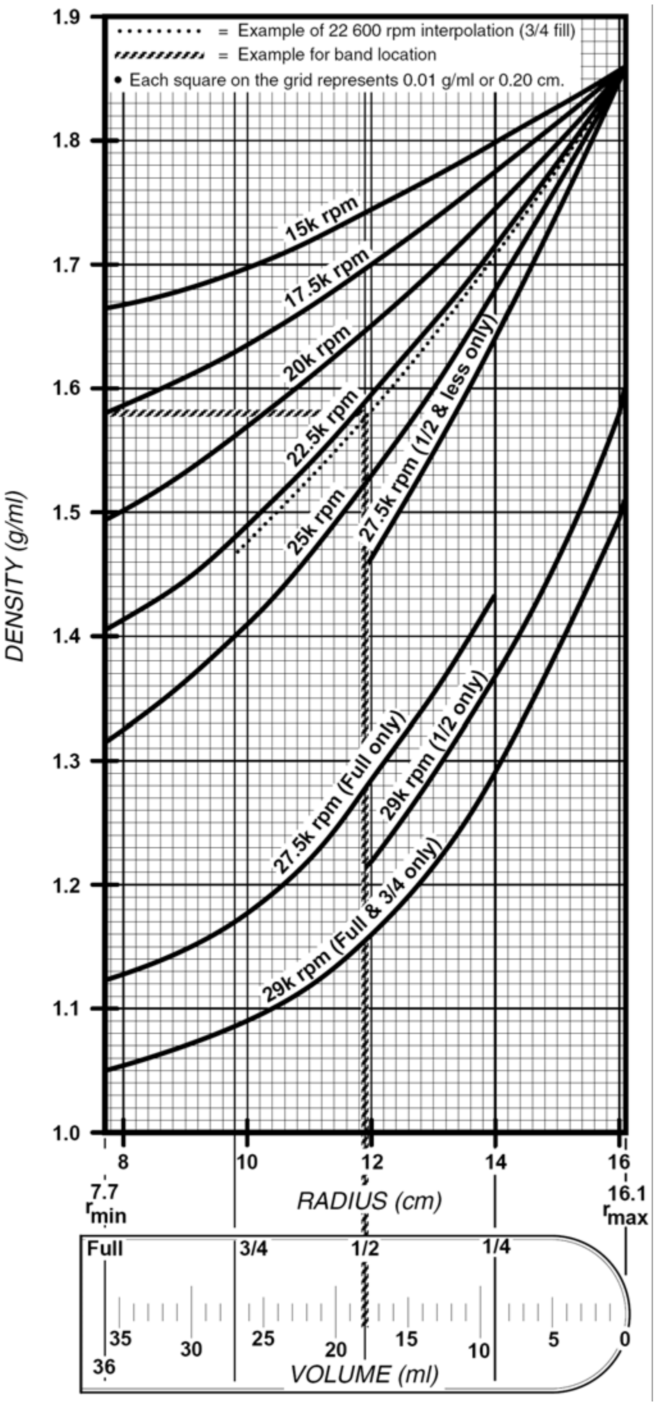

Figure 2-12. CsCl Gradients at Equilibrium, 36 ml Buckets, 25°C

OPERATION

This chapter contains the information necessary to prepare the AH-629 Rotor for operation and includes important safety information.

Contents

Prerun Safety Checks

WARNING Failure to properly maintain your rotor can cause rotor failure with subsequent damage to your centrifuge. Also, depending on the sample being processed, rotor failure can result in biological or radioactive contamination. Therefore, every part of the rotor must be clean and should be carefully inspected before every run. If there is any sign of corrosion or cracking, the rotor should not be used.

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

a. read the Important Safety Information on page iii.

b. make sure that there are no burrs or scratches on the bucket, bucket seats, or drive spindle.

c. check the centrifuge drive chamber, drive spindle, and mount ing surface of the rotor to be sure that they are clean and free of scratches or burrs.

d. make sure that the proper overspeed decal is firmly attached to the bottom of the rotor; it must have 31 black segments or, if the rotor has been derated to 26,000 rpm, 34 black segments (refer to page 4-2 for overspeed decal replacement procedure).

e. inspect the bucket cap O-rings for cracks, tears, or abrasions; replace if necessary.

f. check that each bucket cap is on tight and numbers on buckets and caps are aligned.

g. make sure that the buckets are properly seated on the support pins.

h. check the chemical compatibility of all materials used (see Table in Appendix).

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

j. check the top speed capability of the tube being used.

CAUTION When using tubes other than those supplied with this rotor, be sure to do a test run for the desired application to check the top speed capability of the tubes being used.

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 Ultracentrifuge Instruction Manual for pre-cooling directions.

Chemical Compatibility

The critical components of the AH-629 Rotor apt to come in contact with solution are: rotor body (aluminum), rotor buckets (titanium), bucket cap (aluminum), O-rings (Viton®), and tubes (polyallomer).

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. When in doubt, we recommend pretesting of sample lots.

Relative Centrifugal Force (RCF) Determination

RCF refers to the force during centrifugation that moves the par-ticulate outward from the center of rotation. This force is proportional to the radial distance and the square of the rotor speed. The RCF value 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 3-1 shows the minimum, average, and maximum radii of the AH-629. Table 3-1 gives the RCF value at each radius at speeds from 5000 rpm to 29,000 rpm (in increments of 500 rpm). The RCF value at any other given speed can be calculated by using the above formula.

Note The radii values given are the actual rotor specifications; these values do not take the thickness of the tube into consideration.

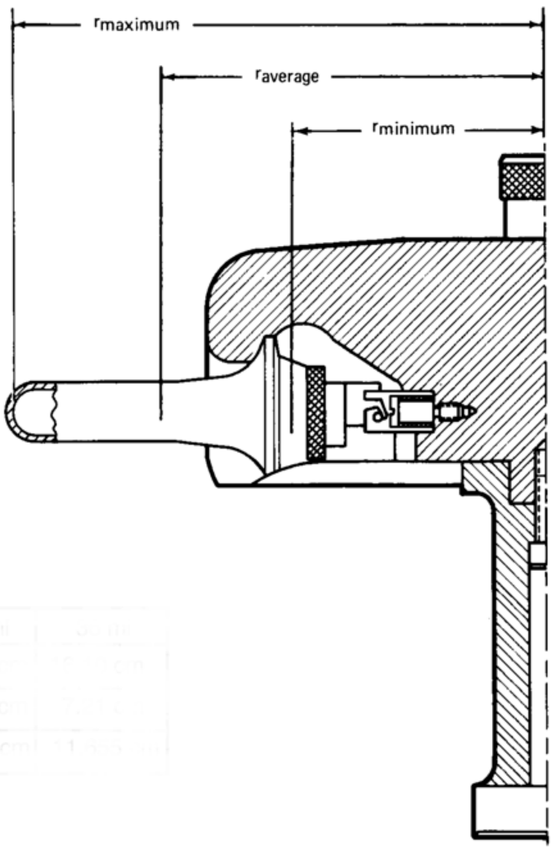

Figure 3-1. AH-629 Rotor Cross Section Showing Radial Distances

	17 ml	20 ml	36 ml
$r_{maximum}$	16.59 cm	12.93 cm	16.10 cm
$r_{average}$	11.52 cm	7.21 cm	7.21 cm
$r_{minimum}$	6.45 ml	10.07 cm	11.655 cm

Calculation of Sedimentation Times 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 $r_{minimum}$ and $r_{maximum}$) can be estimated 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]

AH-629 RCF Values and K Factors

Table 3-6. 17 ml Buckets

	RCF			
Speed (rpm)	$r_{maximum}$ 16.59 cm	$r_{average}$ 11.52 cm	$r_{minimum}$ 6.45 cm	K Factor
5,000	4,633	3,217	1,801	9,561
5,500	5,606	3,893	2,179	7,901
6,000	6,671	4,632	2,594	6,639
6,500	7,829	5,437	3,044	5,657
7,000	9,080	6,305	3,530	4,878
7,500	10,424	7,238	4,053	4,249
8,000	11,860	8,235	4,611	3,735
8,500	13,389	9,297	5,205	3,308
9,000	15,010	10,423	5,836	2,951

[1] The sedimentation coefficient (S) in seconds, for a particle in a centrifugal field is defined by the equation S = (dx/dt) [$1/(\omega^2 x)$]; where dx/dt = sedimentation velocity of the particle in cm/s; ω = rotor speed in rad/s; and x = the distance of 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 for 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.

Table 3-6. 17 ml Buckets

	RCF			
Speed (rpm)	$r_{maximum}$ 16.59 cm	$r_{average}$ 11.52 cm	$r_{minimum}$ 6.45 cm	K Factor
9,500	16,724	11,613	6,502	2,648
10,000	18,531	12,868	7,205	2,390
10,500	20,430	14,187	7,943	2,168
11,000	22,423	15,570	8,718	1,975
11,500	24,507	17,018	9,528	1,807
12,000	26,685	18,530	10,375	1,660
12,500	28,955	20,106	11,257	1,530
13,000	31,317	21,747	12,176	1,414
13,500	33,776	23,452	13,130	1,311
14,000	36,321	25,221	14,121	1,219
14,500	38,961	27,055	15,148	1,137
15,000	41,695	28,953	16,210	1,062
15,500	44,521	30,915	17,309	995
16,000	47,439	32,942	18,444	934
16,500	50,451	35,033	19,615	878
17,000	53,555	37,188	20,821	827
17,500	56,751	39,408	22,064	780
18,000	60,041	41,692	23,343	738
18,500	63,422	44,040	24,658	698
19,000	66,897	46,453	26,009	662
19,500	70,464	48,930	27,396	629
20,000	74,124	51,471	28,819	598
20,500	77,877	54,077	30,278	569
21,000	81,722	56,747	31,773	542
21,500	85,660	59,482	33,303	517
22,000	89,690	62,280	34,871	494
22,500	93,813	66,143	36,474	472
23,000	98,029	68,071	38,113	452
23,500	102,338	71,063	39,788	433
24,000	106,739	74,119	41,499	415
24,500	111,233	77,239	43,246	398
25,000	115,819	80,424	45,029	382
25,500	120,498	83,673	46,848	368
26,000	125,270	86,987	48,703	354
26,500	130,134	90,364	50,595	340

Table 3-6. 17 ml Buckets

	RCF			
Speed (rpm)	$r_{maximum}$ 16.59 cm	$r_{average}$ 11.52 cm	$r_{minimum}$ 6.45 cm	K Factor
27,000	135,091	93,807	52,522	328
27,500	140,141	97,313	54,485	316
28,000	145,283	100,884	56,484	305
28,500	150,518	104,519	58,520	294
29,000	155,846	108,219	60,591	284

Table 3-7. 20 ml Buckets

	RCF			
Speed (rpm)	$r_{maximum}$ 12.93 cm	$r_{average}$ 10.07 cm	$r_{minimum}$ 7.21 cm	K Factor
5,000	3,611	2,812	2,013	5,911
5,500	4,369	3,403	2,436	4,885
6,000	5,199	4,049	2,899	4,105
6,500	6,102	4,752	3,403	3,498
7,000	7,077	5,512	3,946	3,016
7,500	8,124	6,327	4,530	2,627
8,000	9,243	7,199	5,154	2,309
8,500	10,435	8,127	5,819	2,045
9,000	11,699	9,111	6,523	1,824
9,500	13,035	10,151	7,268	1,637
10,000	14,443	11,248	8,054	1,478
10,500	15,923	12,401	8,879	1,340
11,000	17,476	13,610	9,745	1,221
11,500	19,101	14,876	10,651	1,117
12,000	20,798	16,197	11,597	1,026
12,500	22,567	17,575	12,584	946
13,000	24,408	19,009	13,611	874
13,500	26,322	20,500	14,678	811
14,000	28,308	22,046	15,785	754
14,500	30,366	23,649	16,933	703
15,000	32,496	25,308	18,121	657
15,500	34,699	27,024	19,349	615
16,000	36,974	28,795	20,617	577
16,500	39,321	30,623	21,926	543
17,000	41,740	32,507	23,275	511

Table 3-7. 20 ml Buckets

	RCF			
Speed (rpm)	$r_{maximum}$ 12.93 cm	$r_{average}$ 10.07 cm	$r_{minimum}$ 7.21 cm	K Factor
17,500	44,231	34,448	24,664	483
18,000	46,795	36,444	26,094	456
18,500	49,431	38,497	27,563	432
19,000	52,139	40,606	29,073	409
19,500	54,919	42,771	30,624	389
20,000	57,771	44,993	32,214	369
20,500	60,696	47,271	33,845	352
21,000	63,693	49,605	35,516	335
21,500	66,762	51,995	37,228	320
22,000	69,903	54,441	38,979	305
22,500	73,117	56,944	40,771	292
23,000	76,402	59,503	42,603	279
23,500	79,760	62,118	44,476	268
24,000	83,191	64,790	46,389	257
24,500	86,693	67,517	48,342	246
25,000	90,268	70,301	50,335	236
25,500	93,914	73,141	52,368	227
26,000	97,633	76,038	54,442	219
26,500	101,425	78,990	56,556	210
27,000	105,288	81,999	58,711	203
27,500	109,224	85,064	60,905	195
28,000	113,232	88,186	63,140	188
28,500	117,312	91,363	65,415	182
29,000	121,464	94,597	67,731	176

Table 3-8. 36 ml Buckets

	RCF			
Speed (rpm)	$r_{maximum}$ 16.10 cm	$r_{average}$ 11.655 cm	$r_{minimum}$ 7.21 cm	K Factor
5,000	4,496	3,255	2,013	8,130
5,500	5,440	3,938	2,436	6,719
6,000	6,474	4,687	2,899	5,646
6,500	7,598	5,615	3,633	4,811
7,000	8,812	6,379	3,946	4,148
7,500	10,116	7,323	4,530	3,613
8,000	11,510	8,332	5,154	3,176

Table 3-8. 36 ml Buckets

	RCF			
Speed (rpm)	**$r_{maximum}$ 16.10 cm**	**$r_{average}$ 11.655 cm**	**$r_{minimum}$ 7.21 cm**	**K Factor**
8,500	12,993	9,406	5,819	2,813
9,000	14,567	10,545	6,523	2,509
9,500	16,230	11,749	7,268	2,252
10,000	17,984	13,019	8,054	2,032
10,500	19,827	14,353	8,879	1,844
11,000	21,760	15,753	9,745	1,680
11,500	23,783	17,217	10,651	1,537
12,000	25,897	18,747	11,597	1,411
12,500	28,100	20,342	12,584	1,301
13,000	30,392	22,001	13,611	1,203
13,500	32,775	23,726	14,678	1,115
14,000	35,248	25,517	15,785	1,037
14,500	37,811	27,372	16,933	967
15,000	40,463	29,292	18,121	903
15,500	43,206	31,277	19,349	846
16,000	46,038	33,328	20,617	794
16,500	48,961	35,443	21,926	747
17,000	51,973	37,624	23,275	703
17,500	55,075	39,870	24,664	664
18,000	58,267	42,180	26,094	627
18,500	61,549	44,556	27,563	594
19,000	64,921	46,997	29,073	563
19,500	68,383	49,503	30,624	535
20,000	71,935	52,075	32,214	508
20,500	75,576	54,711	33,845	484
21,000	79,308	57,412	35,516	461
21,500	83,130	60,179	37,228	440
22,000	87,041	63,010	38,979	420
22,500	91,042	65,907	40,771	401
23,000	95,134	68,869	42,603	384
23,500	99,315	71,895	44,476	368
24,000	103,586	74,987	46,389	353
24,500	107,947	78,144	48,342	339
25,000	112,398	81,366	50,335	325
25,500	116,939	84,654	52,368	313

Table 3-8. 36 ml Buckets

	RCF			
Speed (rpm)	$r_{maximum}$ **16.10 cm**	$r_{average}$ **11.655 cm**	$r_{minimum}$ **7.21 cm**	**K Factor**
26,000	121,570	88,006	54,442	301
26,500	126,291	91,423	56,556	289
27,000	131,101	94,906	58,711	279
27,500	136,002	98,453	60,905	269
28,000	140,992	102,066	63,140	259
28,500	146,073	105,744	65,415	250
29,000	151,243	109,487	67,731	242

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

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

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

K factors for the AH-629 rotor at speeds from 5000 rpm to 29,000 rpm have been listed in Table 4-1.

Example: The AH-629 Rotor has a K factor of 284 at the maximum speed (29,000 rpm) when 17 ml buckets are used. If the particles to be sedimented have a sedimentation coefficient of 40 S, the estimated run time required at maximum speed will be:

$$t = \frac{284}{40S} \; 7.10 \text{ hours} = 7 \text{ hours, } 6 \text{ minutes}$$

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 formula:

$$t = \frac{K^1}{S_{20},w}$$

where:

t = sedimentation time in hours
K = the clearing factor for the rotor (the value of K^1 is dependent on the gradient being used, the temperature of the gradient, and the density of the particle being sedimented).
S_{20} , w = the sedimentation coefficient for the particle of interest in water at 20°C as expressed in Svedbergs.

Table 3-4 gives K[1] factors for the AH-629 Rotor when operated at maximum speed (that is, 29,000 rpm) with particles ranging in density from 1.1g/cm3 to 1.9g/cm3. In this case, the K[1] factors are based on the use of a 5% - 20% (w/w) linear sucrose density gradient at 5°C.

Table 3-9. K' Factors for the AH-629 Rotor (at maximum speed)

Particle Density (g/cm3)	K[1] Factor		
	17 ml Bucket	20 ml Bucket	36 ml Bucket
1.1	1481	836	1293
1.2	819	446	707
1.3	726	393	625
1.4	687	370	592
1.5	666	360	573
1.6	651	351	560
1.7	641	346	551
1.8	634	340	545
1.9	628	337	539

Tube Filling and Bucket Loading Procedure

The tubes that are supplied with the AH-629 are thinwall polyal-lomer. They are translucent, easily cut or pierced (for sample removal), and resistant to most chemicals (see Appendix A). The tubes cannot be autoclaved.

CAUTION When using tubes other than those supplied with this rotor, be sure to do a test run for the desired application to check the top speed capability of the tubes being used.

Assemble the tube and bucket as follows (see Figure 3-2):

1. Before each run, apply a thin film of vacuum grease (Catalog No. 65937) to the bucket cap O-ring. Then, apply a thin film of lubricating grease (Catalog No. 61556) on the threads of the bucket cap.

2. Be sure that the outside of the tube and the inside of the bucket are completely dry.

CAUTION Correct balance is essential for ultracentrifuge rotors, particularly for a swinging bucket rotor. The loaded buckets (including tube, bucket cap and sample) must match within 0.1 gram. If not, rotor imbalance with subsequent damage to the rotor chamber may result.

Note Moisture between the tube and the bucket can cause a difficult-to-break vacuum seal to form during centrifuga-tion and can cause the tube to collapse.

3. Fill each tube to within 3 mm (1/8 inch) from the top to prevent the tube from collapsing during centrifugation. If the sample does not fill the tube to this level, add a light mineral oil above the sample or a dense, inert liquid below it.

CAUTION For maximum rotor and bucket life, you should always use the same set of buckets and bucket caps with the same rotor body. Failure to do so invalidates the rotor warranty.

4. Screw the cap into the bucket. Each cap is numbered and must be used with corresponding numbered bucket for proper balance.
5. To seal the bucket, screw the bucket cap down until metal-to-metal contact is made. Bucket and cap numbers will align when the cap is tight.

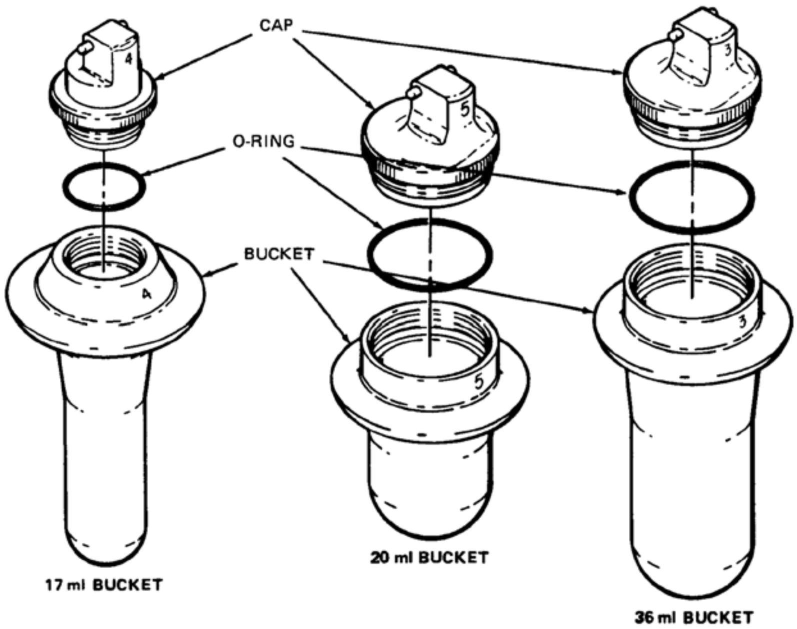

Figure 3-2. Cap and Bucket Assembly

Rotor Balancing

CAUTION Do not operate this rotor unless it is symmetrically balanced. Operating the centrifuge with the rotor out of balance can cause damage to the centrifuge drive assembly.

Always balance the rotor according to the following criteria:

- Tubes containing fluid of identical specific gravity must be placed in opposite rotor compartments.
- When using less than a full complement of six buckets, the rotor can be operated at its maximum allowable speed with two, three of four samples, provided opposing pairs of buckets are positioned as shown in Figure 3-3. Empty buckets must be placed in the remaining positions.

CAUTION For proper rotor balance, always install empty buckets into all unused bucket positions.

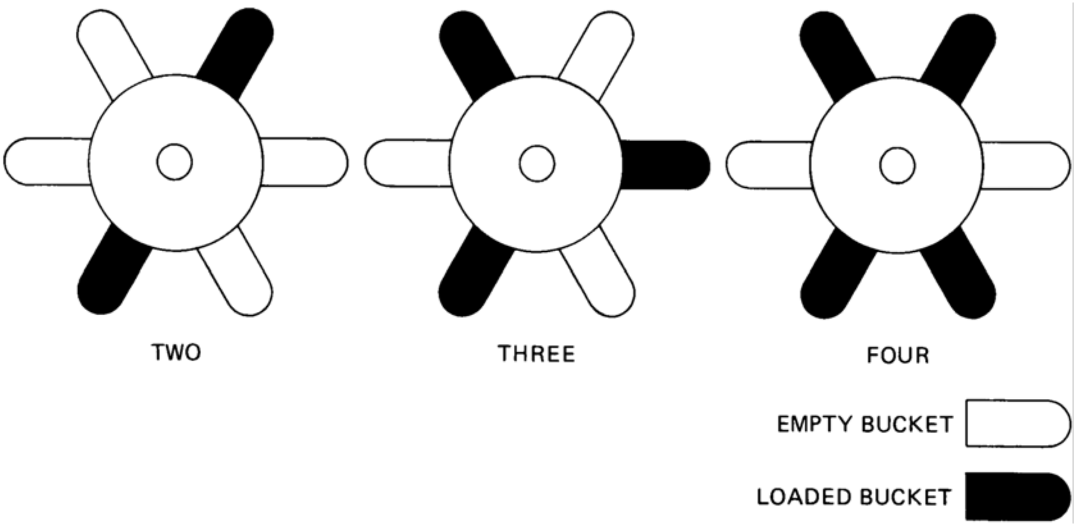

Figure 3-3. Rotor Balancing

Bucket Attachment

To attach the buckets to the rotor:

1. Hold each loaded bucket vertically with the single-digit number facing you. Gently insert it in the proper bucket position (matching number) on the rotor body.

CAUTION For maximum rotor and bucket life, you should always use the same set of buckets and bucket caps with the same rotor body. Failure to do so invalidates the rotor warranty.

Note Buckets must be attached to the rotor body at the bucket positions with the number that matches that on the bucket.

2. Gently bring the bucket down until the pin engages on the two hooks on the rotor body.
3. Check the bucket attachment by gently twisting the bucket in both directions about its vertical axis. A properly seated bucket can be moved a few degrees in each direction. Be careful not to unscrew the bucket cap.

Note Buckets should hang freely and vertically with bottoms even.

Rotor Installation

To install the rotor in the centrifuge:

1. Carry the rotor carefully with both hands placed around the rotor body.

Note Be careful not to bump the buckets against any object. If buckets are jarred, check them to be sure no fluid has spilled between the tube and the buckets. Then, recheck the bucket seating.

2. Lower the rotor in the chamber smoothly and vertically.

3. Be sure the rotor snaps in place on the drive adapter. Check that the rotor is properly seated by pulling it gently in an upward direction and noting a small amount of resistance.
4. When the rotor is seated, recheck the buckets to be sure they swing freely.

Perform the run as explained in the centrifuge instruction manual.

CAUTION Never operate the centrifuge at a rotor speed/temperature combination that will exceed the solubility limit of the gradient material. To do so may cause the material to precipitate, which can result in rotor failure, damaging the centrifuge and possibly causing personal injury.

Centrifuge/Rotor Log

An Ultraspeed Centrifuge/Rotor Log Book is supplied with the AH-629 Rotor so that you can easily record all data necessary to meet the warranty stipulation that any defective Ultraspeed Centrifuge Rotor (or Ultracentrifuge) being returned to Thermo Fisher Scientific must be accompanied by an up-to-date history of the rotor (see Warranty Statement, Appendix).

Each time the AH-629 Rotor is used, record the run in the log book as shown in Figure 3-4, Sample Centrifuge/Rotor Log Sheet

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.

Figure 3-4. Sample Centrifuge/Rotor Log Sheet

MAINTENANCE

Contents

Corrosion

The AH-629 rotor body and bucket caps are made from aluminum alloy for high strength-to-weight ratio, and the buckets are made of titanium. Although aluminum corrosion resistance is good, it is not as good as stainless steel or titanium, and should be maintained and kept clean. 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 and pitting) recognized by growing areas of visible deterioration. On the other hand, stress corrosion attacks the inside of the metal; 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 reactions. The most common chemical causing harmful effects is chloride, whether in a solution such as ammonium salts or as subtle a form as hand perspiration. If the rotor is not kept clean and chemicals remain on the rotor, corrosion will result. Also, any moisture left on the rotor for an extended period of time can initiate corrosion. Therefore, it is important that the rotor is thoroughly dried after use.

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

Cleaning and Decontamination

1. Washing

   Wash the rotor body, buckets, and cap assemblies with warm water and mild soap or detergent at least once a week, or ideally, after each use. It is particularly important to wash the rotor 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 well, inside and out. After rinsing, dry thoroughly with a soft absorbent cloth or an air blast

   WARNING These procedures are to be used for general cleaning purposes only. If the rotor or any of its parts are exposed to a contaminant, it must be decontaminated first, then washed.

   After washing, be sure to lubricate the O-rings with vacuum grease (Catalog No. 65937). Also, apply a thin film of lubricating grease (Catalog No. 61556) to the bucket and bucket cap threads.

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

2. Decontamination

   Ethylene oxide, a 2% glutaraldehyde solution, or ultraviolet radiation are the recommended methods of sterilization; however, the titanium buckets of the AH-629 can be autoclaved at temperatures up to 121°C.

CAUTION DO NOT autoclave the AH-629 rotor body or the aluminum cap assemblies. If required, use gas or chemical sterilization. If subjected to temperatures above 100°C, they should not be used.

For general radioactive decontamination, use a solution of equal parts of 70% ethanol, 10% SDS, and water. Follow this with ethanol rinses, then deionized water rinses, and dry with a soft absorbent cloth. Dispose of all wash solutions in proper radioactive waste containers.

CAUTION Most commercially available radioactive decontamination solutions are not compatible with titanium or aluminum.

Inspection

Periodically, inspect the rotor body, buckets and cap assemblies for signs of stress, corrosion, cracking, abrasions, wear or deformation. If such problems are found, contact Thermo Fisher Scientific for information on factory inspection or replacement.

Inspect bucket O-ring regularly for cracks, tears or abrasions; replace if necessary. Occasionally apply a thin film of lubricating grease (Catalog No. 61556) to the bucket and cap threads. This will prevent galling and permit easier cap removal.

Overspeed Decal Replacement

Before replacing the decal, be sure that the rotor is dry and at room temperature; if it is not, the new decal will not adhere properly.

To replace the decal:

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

Note Check that the decal has the correct number of black segments. The AH-629 Rotor decal has 31 black segments; if the rotor has been derated to 26,000 rpm, the decal has 34 black segments.

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

Storage

Rinse and dry each bucket, then store them (with caps off) upside down and slightly tilted so air can circulate through the bucket. This will help prevent moisture from settling in the bottom of the bucket.

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 procedure to ensure the safety of all personnel:

1. Clean the centrifuge or rotor to be serviced of all encrusted material and decontaminate (see Maintenance Section of centrifuge or rotor instruction manual) it prior to servicing by the Thermo Fisher Scientific representative or returning it 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 Care and Maintenance Section of 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 ultraspeed centrifuges:

a. Remove rotor from the rotor chamber.
b. Decontaminate door and rotor chamber using an appropriate method.

For rotors:

Remove tubes, bottles, and adapters from the rotor and decontaminate rotor using an appropriate method. If tubes or rotor caps are stuck in the rotor, or the rotor lid is stuck, 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.

Do not leave a loaded rotor locked inside a centrifuge that requires servicing. If, with a loaded rotor installed in the chamber, a centrifuge malfunction makes it so the chamber door will not open by normal means, follow the Emergency Sample Recovery procedure found in your centrifuge operating instructions manual to gain access to the rotor.

2. Complete and attach Decontamination Information Certificate (in the back of your rotor or instrument or manual) to the centrifuge or rotor before servicing.

Decontamination Information Certificates are included with this book. Additional certificates are available from the local Thermo Fisher Scientific Representative or Field Service Engineer. In the event these certificates are not available, a signed, written statement certifying that the unit has been properly decontaminated, identifying what the contaminants were and outlining the decontamination procedures used will be acceptable.

Note The Field Service Engineer will note on the 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.

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

1. Contact your Thermo Fisher Scientific representative to obtain an Equipment Return Form; be prepared with the name and serial number of the centrifuge or rotor and the repairs required.
2. Contact your Thermo Fisher Scientific representative to obtain an Equipment Return Form and return it to Thermo Fisher Scientific. Upon receipt of a completed form, a Returned Material Authorization Number (RMA Number) will be issued to you.
3. With the RMA Number clearly marked on the outside of packaging, send the items 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 equipment is received at Thermo Fisher Scientific facilities without a valid RMA Number on the outside of the shipping container and a completed Equipment Return Decontamination Form on file, the equipment will be treated as a potential contamination hazard, and will not be serviced until decontamination certification has been completed. The sender will be contacted for instructions regarding disposition of the equipment in question; all disposition costs will be borne by the sender. If contaminated equipment is received at Thermo Fisher Scientific facilities, both the carrier and appropriate authorities shall be notified.

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

CHEMICAL	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®
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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