



Thermo Fisher Scientific

TH-660

Instruction Manual

10506-4

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This manual is a guide for the use of

Thermo Scientific TH-660 Titanium Swinging Bucket Ultracentrifuge Rotor

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

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

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.

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Important Safety Information

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

WARNING

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

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

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

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

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

- the rotor speed/temperature combination exceeds the solubility of the gradient material and causes it to precipitate.
- 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



CAUTION

Do not expose aluminum rotor components to: strong acids, bases, or 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 centrifuge drive assembly.

Do not operate the rotor without the cover in position and locked in place and the rotor locked to the centrifuge drive. See Chapter 3, Operation.

Always maintain the rotor in the recommended manner. The rotor and all accessories should be clean and inspected prior to each run; do not use rotors showing signs of corrosion or cracking. See Chapter 5, Care and Maintenance.

Do not autoclave or expose any aluminum rotor body and cover or expose any aluminum rotor parts 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 TH-660 Swinging Bucket Ultraspeed Centrifuge Rotor. If you encounter any problem concerning either operation or maintenance that is not covered in the manual, contact Thermo Fisher Scientific for assistance. In the United States, telephone toll free 1-866-9THERMO. Outside the United States, contact your 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/rotor](http://www.thermo.com/rotor) .

Contents

- “Rotor Description” on page 1-2
- “Rotor Specifications” on page 1-2
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Rotor Description

The TH-660 is a titanium swinging bucket ultraspeed centrifuge rotor that can produce up to six sets of data during a single run at speeds up to 60 000 rpm.¹ Each titanium rotor bucket will hold a centrifuge tube having a nominal fluid capacity of 4.4 ml; the buckets are sealed during operation by an O-ring and an aluminum bucket cap, tightened with a special tool supplied with the rotor. The buckets attach to the rotor body, each at its own numbered position. During a centrifuge run, the buckets swing out horizontally and return to a vertical position during deceleration. A disc with alternative black and reflective segments attached to the bottom of the rotor provides overspeed protection.

Rotor Specifications

Table 1-1. Rotor Specifications

Rotor Type	Swinging Bucket
Maximum Speed (rpm)	60,000*
Relative Centrifugal Force (RCF) at Max. Speed	
- at r_{maximum} 12.15 cm	488,576
- at r_{average} 9.305 cm	374,173
- at r_{minimum} 6.46 cm	259,770
K Factor at Maximum Speed	44.4
Critical Speed	1100 rpm
Number of Buckets	6
Total Capacity (Nominal)	26.4 ml**
Tube Compartment Diameter	11.1 mm (7/16 inch)
Tube Compartment Length (Nominal)	60.3 mm (2-3/8 inch)
Maximum Compartment Mass (including tube and contents)	5.78 g
Rotor Diameter	24.6 cm (9.7 in)
Rotor Weight (empty)	5.83 kg (12.9 lbs)

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

**Actual tube capacity is 4.0 ml (24 ml total rotor capacity) with standard tubes, Catalog No. 03955, filled to within 2 to 3 mm of the top.

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

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

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

Accessories

Accessories Supplied

The accessories supplied with the TH-660 Rotor, PN 10500 (rotor with complete accessories), are listed in Table 1-2. The TH-660 Rotor can also be purchased with basic accessories only, PN 10502, which includes all items listed in Table 1-2 except the tubes.

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

Table 1-2. Accessories Supplied

Qty.	Catalog No.	Description
4 pkgs	03955*	Tubes, Polyallomer, 4.4 ml (50/pkg)
1	10509	Buckets, 4.4 ml, set of 6
6	63713	O-rings (for rotor buckets)
1	52243	Bucket Rack
1	51942	Rotor Stand
1	73031	Bucket Cap Tool
1	65937	Vacuum Grease
1	61556	Lubricant
1	51346	Overspeed Decal, 60 000 rpm (extra)
1	52384	Ultraspeed Centrifuge/ Rotor Log Book
1	10506	Instruction Manual

*Tubes are not supplied with Catalog No. 10502.

SPECIAL OPERATING CONSIDERATIONS

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- “Compartment Loads in Excess of Design Mass” on page 2-2
- “Precautions to Prevent Precipitation of Cesium Chloride” on page 2-3
- “Critical Speed” on page 2-4
- “Chemical Compatibility” on page 2-4

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 60 000 rpm should be derated 10% after 1000 runs. To know when the 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. 51348 for the lowered speed (see Chapter 5, Overspeed Decal Replacement)



WARNING After the rotor has been used for 1000 runs at the derated speed, the rotor body and the set of buckets used with it should no longer be used. Failure to do so can cause rotor failure with subsequent loss of sample and damage to the rotor and/ or centrifuge. Also, if the material being processed is hazardous, the loss of sample may result in personal injury.

Compartment Loads in Excess of Design Mass

The maximum run speed of the TH-660 Rotor is based on the recommended design mass has been established for the rotor representing the maximum mass that can be carried in each rotor bucket at top-speed operation. To prevent rotor failure, the total contents of each bucket, including specimen and tube, should not exceed the recommended figure unless the rotor speed is reduced proportionately.

Strict adherence to the maximum allowable compartment mass or reduced rotor speed is required to prevent rotor failure. Observe the WARNING on the Safety Information Page in the front of this manual.

If the density is greater than 1.2 g/ml, use the following formula to determine the reduced speed:

$$\text{Reduced Speed} = 60000 \sqrt{\frac{1.2 \text{ g/ml}}{\text{average fluid density}}}^1$$

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

¹53 000 rpm if the rotor has been derated.

Precautions to Prevent Precipitation of Cesium Chloride

a. Reducing Speed to Prevent Precipitation

Observe the WARNING on reducing rotor speed found on the Safety Information Page in the front of this manual.



WARNING Always reduce (derate) rotor speed as instructed in this manual whenever the compartment load exceeds the maximum allowable compartment load specified. Failure to reduce rotor speed under these conditions can cause rotor failure.

The 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 Compartment Loads in Excess of Design Mass, page 2-2) pertains to sucrose and similar gradient materials, it will not prevent precipitation of heavy crystals when material such as cesium chloride (CsCl) is used in an ultracentrifuge.

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, cesium chloride solutions must be run at a reduced speed to avoid this precipitation. The allowable speed is determined by the average density of the CsCl solution and the run temperature. Figure 2-1 should be used to determine the maximum operating speed at 4°C and 20°C that will prevent precipitation. Also, figure 2-1 includes a curve that shows the standard speed (square root) reduction to avoid excessive hydraulic pressure only. The standard, square root reduction formula cannot be used when precipitation of CsCl must be considered. For example, standard speed reduction would allow you to run a full tube of solution with a homogeneous density of 1.725 g/ml at 50 000 rpm; but the dashed line shows that precipitation will occur at this speed when the average density is higher than 1.295 g/ml. This shows that 1.295 g/ml is the highest average density limit permissible at 50 000 rpm and 25°C.

b. The Gradient Shape

The curves in figure 2-2 shows the gradient shape at equilibrium for tubes filled with CsCl solution using the homogeneous density and speeds selected from figure 2-1. Shape of the 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 2-2 indicates that a 3/4-filled tube having a 1.52 g/ml homogeneous CsCl solution cannot be run any faster than 30 000 rpm at 5°C. Figure 2-2 shows the gradient profile of this tube, 1.31 g/ml at the meniscus to 1.81 g/ml at the bottom of the tube. The same solution, 1.52 g/ml, can be run at 34 000 rpm in a 3/4-filled tube. The shape of the gradient curve in figure 2-2 can be interpolated between the 30 000 rpm curve and the 40 000 rpm curve. This interpolation gives a gradient profile from approximately 1.30 g/ml at the top of the gradient to 1.81 g/ml at the bottom of the tube. In a half-filled tube, this solution can be run at 40 000 rpm and in a 1/4-filled tube at 57 000 rpm.

Note The top portion of the fluid column in a partially-filled tube is assumed to have an overlay of 10 g/ml density or less. (Polyallomer and thin-walled open-topped tubes must be filled to within 3 mm of the top to prevent the tube from collapsing during centrifugation.)

c. Effect of 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.

2 SPECIAL OPERATING CONSIDERATIONS

Critical Speed

The curves in figure 2-1 for a 5-degree run show the maximum allowable density for a full tube at 50 000 rpm is 1.24 g/ml, or 0.05 g/ml less than the 1.29 g/ml allowed at 25°C. Determine the maximum run densities at temperatures between 5°C and 25°C by interpolation.

Similarly, figure 2-2 shows the gradient shapes curves at 5°C superimposed on the 25°C curves. Again, interpolate to plot the intermediate temperature gradients.

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 (the rotor and the centrifuge drive). At this speed, the rotor may produce large amplitude vibrations which can be felt in the instrument frame. Mass imbalance will contribute to increased vibration intensity at the critical speed. Avoid operating the rotor at the critical speed range which is 1100 rpm for the TH-660 Rotor. Operation at the critical speed will have a detrimental effect on centrifuge component life. Observe the WARNING.



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

Chemical Compatibility

The chemical compatibility chart 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.

The critical components of the TH-660 Rotor apt to come in contact with solution are: rotor body and buckets (titanium), bucket caps (aluminum), O-rings (Viton[®]), and the material of the tubes used.

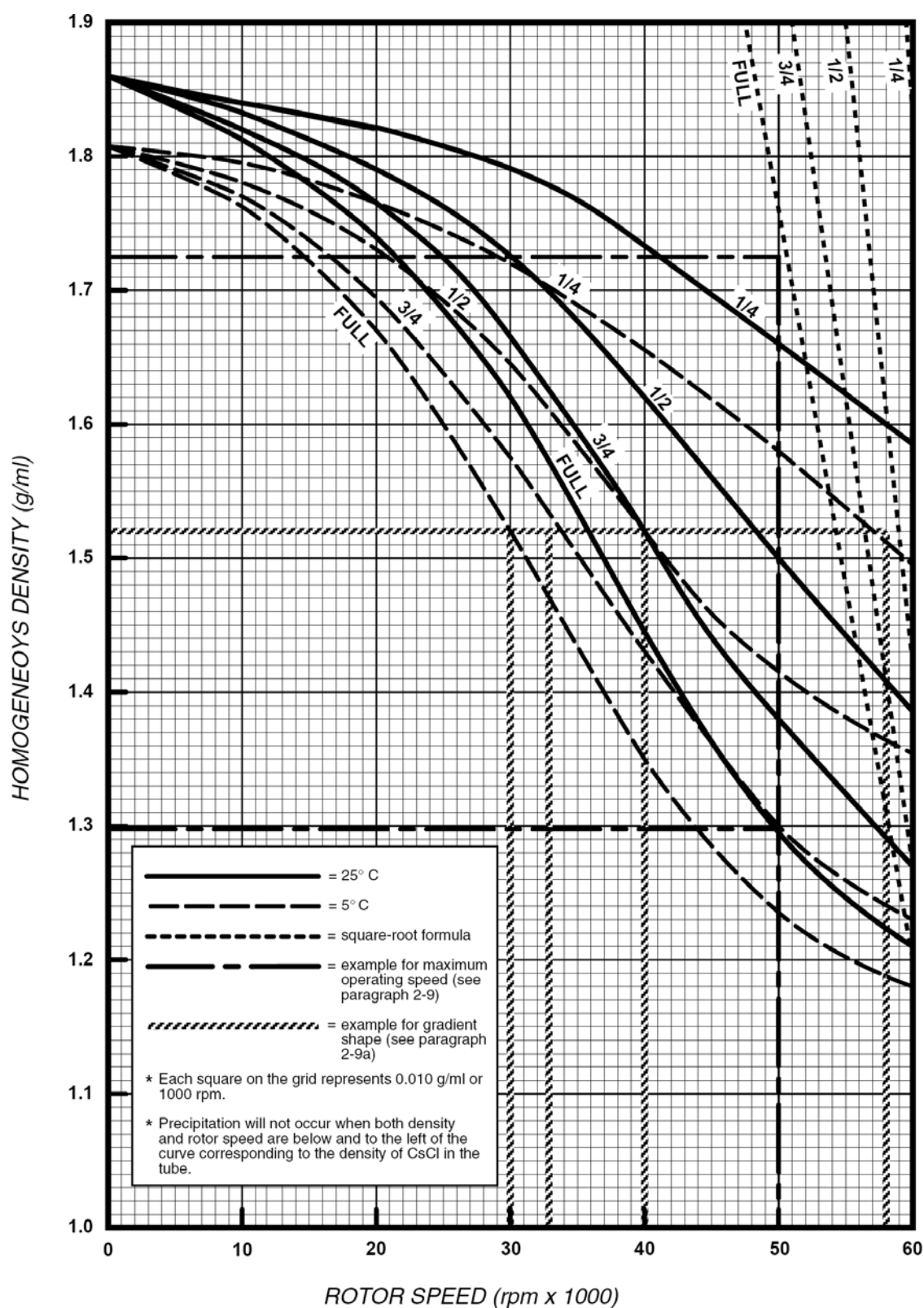


Figure 2-1. CsCl Precipitation Curves for the TH-660 Rotor

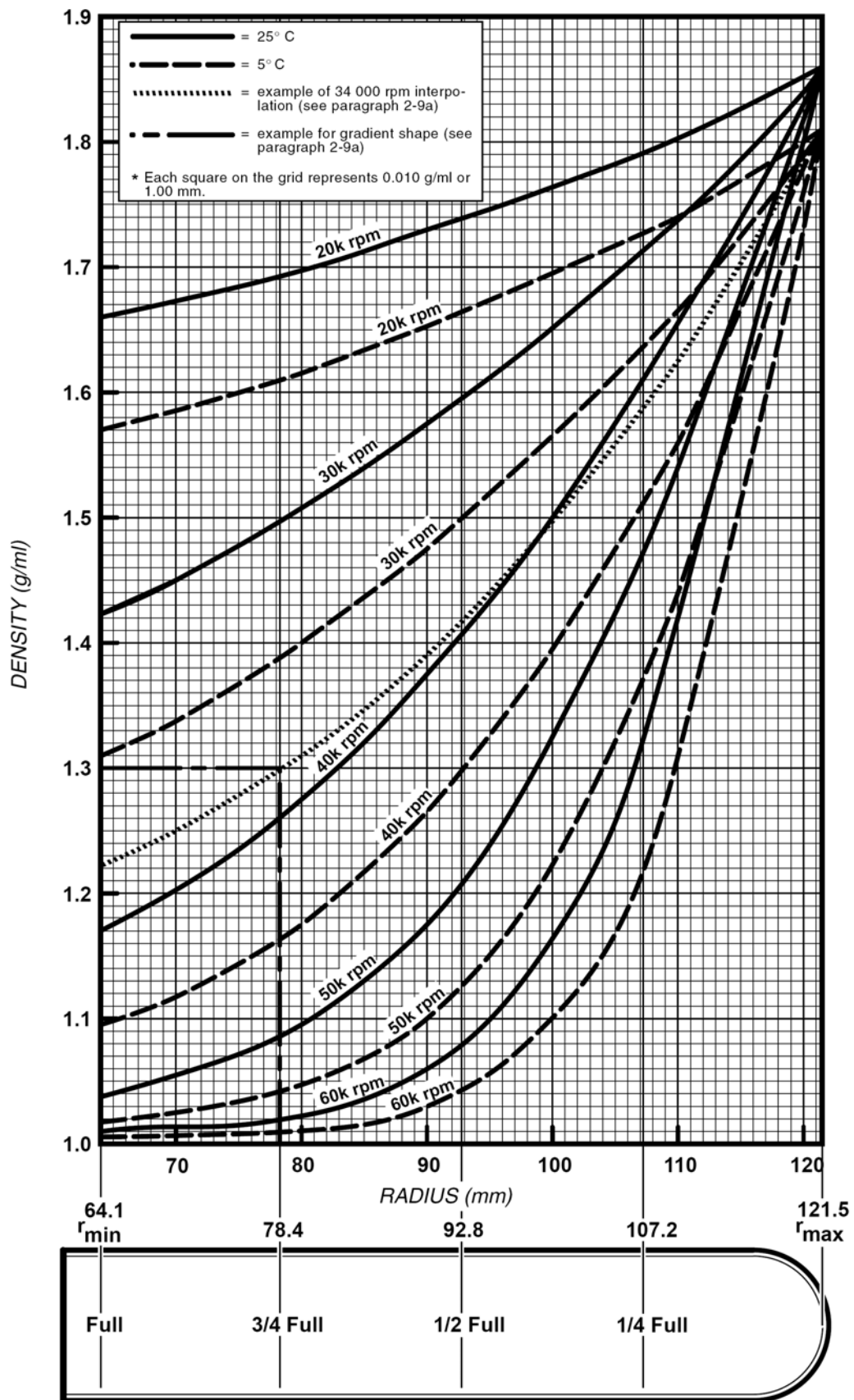


Figure 2-2. CsCl Gradients at Equilibrium

OPERATION

This chapter contains the information necessary to prepare the TH-660 Rotor for operation and includes important safety information.

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- “Rotor Precool” on page 3-2
- “Tube Filling and Bucket Loading” on page 3-2
- “Rotor Balancing” on page 3-3
- “Rotor Installation” on page 3-4
- “Centrifuge / Rotor Log Book” on page 3-5

Prerun Safety Checks

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

- read the Safety Information Page in the front of this manual.
- make sure each tube compartment is clean and that there is no sign of corrosion.
- be sure the rotor itself is clean and shows no sign of corrosion or cracking. Also, make sure there are no scratches or burrs around the rim of the rotor.
- check the centrifuge chamber and drive spindle to be sure they are clean and free of scratches and burrs.
- verify that proper overspeed decal is firmly attached to bottom of rotor; decal should have 19 black segments (see page 3-4 for Overspeed Decal Replacement).
- check the chemical compatibility of all materials used (see Appendix).
- inspect the rotor cover O-rings for cracks, tears, or abrasions; replace if necessary. Be sure the O-rings are properly lubricated.
- make sure the rotor cover is on and properly tightened and that the rotor cover tool has been removed from the locking nut.
- be sure the proper environment has been selected for operation; for example, controlled ventilation or isolation, if required.
- check the top speed capability of the tube (or bottle) being used; observe the CAUTION.



CAUTION When using a tube assembly other than those supplied by Thermo Fisher Scientific, be sure to check the top speed capability; when in doubt, do a test run for the desired application. If using a Thermo Fisher Scientific tube assembly other than those supplied with the rotor, refer to the Product Guide for the maximum speed of the tube. Exceeding the top speed capability of the tube assembly can result in its breakage.

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 be precooled easily in a Thermo Fisher Scientific Ultracentrifuge. Refer to the Ultracentrifuge Instruction Manual for precooling directions. Be careful not to precool the rotor at its critical speed (see Chapter 2, page 2-4).

Tube Filling and Bucket Loading

The 4.4 ml tubes that are supplied with the TH-660, PN 03955 are made of thinwall polyallomer. They are translucent, easily cut or pierced (for sample removal), and resistant to most chemicals (see Appendix A).



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

The dimensions of the tubes supplied are 11 mm x 60.3 mm, with a fluid fill capacity of 4 ml each.

Assemble the tube and bucket as follows (see figure 3-1):

1. Before each run apply a thin film of vacuum grease, PN 65937 to the bucket cap O-ring. Then, apply a thin film of lubricant, PN 61556 on the threads of the bucket cap. Reinstall the greased O-ring in the bucket making sure it is seated in the groove below the threads.



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

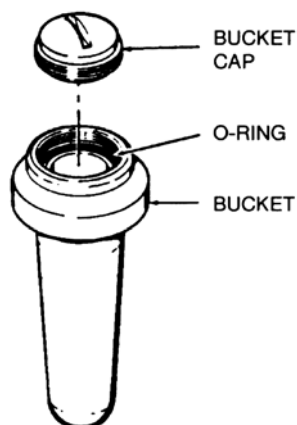


Figure 3-1. Cap and Bucket Assembly

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

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

3. Fill each tube 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.
4. Hold the bucket upright and insert the tube into the bucket.
5. To seal the bucket, screw the bucket cap on tightly. Use the bucket cap tool, PN 73031 supplied with the rotor and tighten the cap.



WARNING Correct balance is essential for swinging bucket rotors. 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.

Rotor Balancing

Always balance the rotor according to the following criteria:

- a. observe the CAUTION on the Safety Information Page in the front of this manual.
- b. balance pairs of tubes containing fluid of identical specific gravity to within 0.1 gram and place them in opposite rotor compartments.



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

- c. when using less than a full complement of six buckets, the rotor can be operated with two, three or four samples, provided opposing pairs of buckets are positioned as shown in figure 3-2. Empty buckets must be placed in the remaining positions.

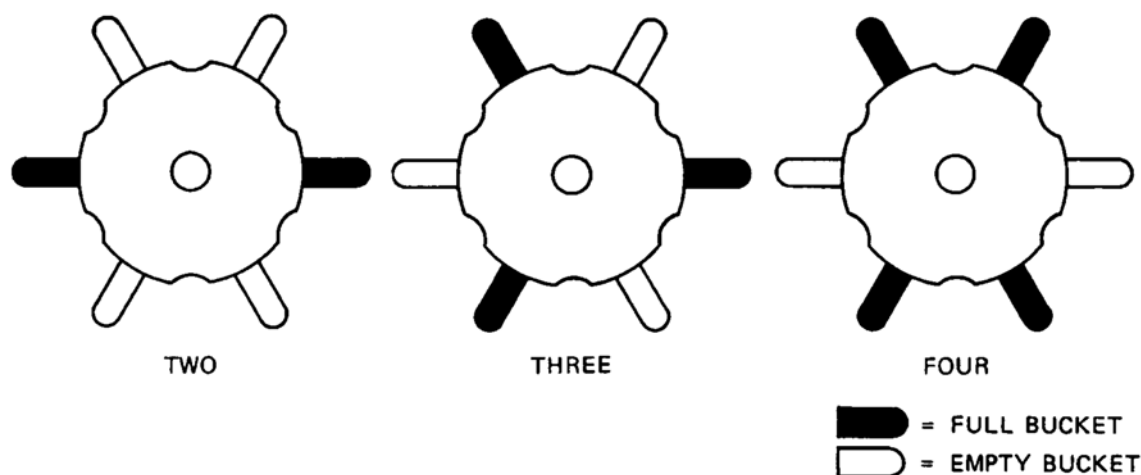


Figure 3-2. Rotor Balancing

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.
2. Gently slide the bucket as far back as it will go, then push it straight up and pull it forward until it seats.

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 objects. 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 into 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.

Centrifuge / Rotor Log Book

An Ultracentrifuge/Rotor Log Book is supplied with the TH-660 so that you can easily record all data necessary to meet the warranty stipulation that any defective ultracentrifuge rotor (or ultracentrifuge) returned to Thermo Fisher Scientific must be accompanied by a current history of the rotor (see Warranty Statement in the Appendix).

Each time the TH-660 Rotor is used, record the run in the appropriate log book. If desired, the information may be recorded elsewhere, however, it must include all data as shown in figure 3-3, 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: <i>ULTRA 80</i>
Date	Operator	Rev. Count @ Run Start	TEMP	SPEED	HRS	MIN	HRS	MIN	HRS	MIN	HRS	MIN	Ser. No.: 9102448
													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 3-3. Sample Centrifuge/Rotor Log Sheet

OPERATION

This chapter contains the information necessary to prepare the TH-660 Rotor for operation and includes important safety information.

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- “Relative Centrifugal Force (RCF) Determination” on page 4-2
- “Calculation of Sedimentation Time in Aqueous (Non-gradient) Solutions” on page 4-2

Relative Centrifugal Force (RCF) Determination

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

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

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

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

Figure 4-1 shows the minimum, average, and maximum radii of the TH-660 Rotor. Table 4-1 gives the RCF value at each radius at speeds from 20 000rpm to 60 000 rpm in increments of 500 rpm. The RCF value at any other speed can be calculated by using the RCF formula on page 4-1.

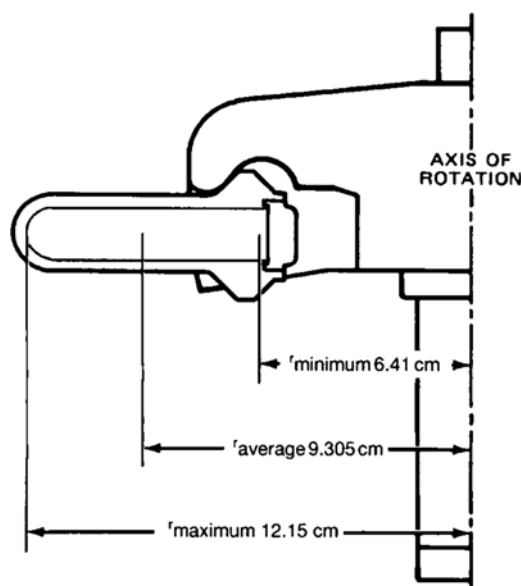


Figure 4-1. TH-660 Rotor Radii

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

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

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

where:

t = sedimentation time in hours

K = the clearing factor for the rotor (defined on the next page)

$S_{20,w}$ = the sedimentation coefficient for the particle of interest in water at 20°C as expressed in Svedbergs¹

The clearing (or K) factor is defined by the equation:

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

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 TH-660 Rotor, at speeds from 20 000 rpm to 60 000 rpm (in increments of 500 rpm), are listed in Table 4-1.

Example: The TH-660 Rotor has a K factor of 44.4 at the maximum permitted speed (60 000 rpm). If the particles to be sedimented have a sedimentation coefficient of 40S, the estimated run time required at maximum speed will be:

$$t = \frac{44.4}{40S} \text{ 3.63 hours} = 3 \text{ hours, 38 minutes}$$

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.

Table 4-1. T-647.5 Rotor: RCF Values and K Factors*

Speed (rpm)	$r_{\text{max.}}$ 12.15 cm	RCF $r_{\text{avg.}}$ 9.305 cm	$r_{\text{min.}}$ 6.46 cm	K Factors
20 000	54 286	41 575	28 863	400
20 500	57 034	43 679	30 324	380
21 000	59 851	45 836	31 822	362
21 500	62 734	48 045	33 355	346
22 000	65 686	50 305	34 925	330
22 500	68 706	52 618	36 530	316
23 000	71 793	54 983	38 172	302
23 500	74 949	57 399	39 849	289
24 000	78 172	59 868	41 563	277
24 500	81 463	62 388	43 313	266
25 000	84 822	64 961	45 099	256
25 500	88 249	67 585	46 921	246
26 000	91 744	70 261	48 779	236
26 500	95 306	72 990	50 673	228
27 000	98 937	75 770	52 603	219

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 $S_{20, w}$.

4 OPERATION

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

Table 4-1. T-647.5 Rotor: RCF Values and K Factors *

Speed (rpm)	$r_{\text{max.}}$ 12.15 cm	RCF $r_{\text{avg.}}$ 9.305 cm	$r_{\text{min.}}$ 6.46 cm	K Factors
27 500	102 635	78 602	54 570	211
28 000	106 401	81 486	56 572	204
28 500	110 235	84 423	58 610	197
29 000	114 137	87 411	60 685	190
29 500	118 106	90 451	62 796	184
30 000	122 144	93 543	64 942	178
30 500	126 249	96 687	67 125	172
31 000	130 423	99 883	69 344	166
31 500	134 664	103 131	71 599	161
32 000	138 973	106 431	73 890	156
32 500	143 349	109 783	76 217	151
33 000	147 794	113 187	78 580	147
33 500	152 307	116 643	80 980	142
34 000	156 887	120 151	83 415	138
34 500	161 535	123 711	85 886	134
35 000	166 251	127 323	88 394	130
35 500	171 035	130 986	90 937	127
36 000	174 887	134 702	93 517	123
36 500	180 807	138 470	96 133	120
37 000	185 795	142 290	98 785	117
37 500	190 850	146 161	101 472	114
38 000	195 973	150 085	104 196	111
38 500	201 164	154 060	106 956	108
39 000	206 423	158 088	109 753	105
39 500	211 750	162 167	112 585	102
40 000	217 145	166 299	115 453	100
40 500	222 607	170 482	118 357	97.4
41 000	228 138	174 718	121 298	95.1
41 500	233 736	179 005	124 274	92.8
42 000	239 402	183 345	127 287	90.5
42 500	245 136	187 736	130 336	88.5
43 000	250 938	192 179	133 421	86.4
43 500	256 808	196 675	136 541	84.5
44 000	262 745	201 222	139 698	82.6
44 500	268 751	205 821	142 891	80.7

Table 4-1. T-647.5 Rotor: RCF Values and K Factors*

Speed (rpm)	r _{max.} 12.15 cm	RCF r _{avg.} 9.305 cm	r _{min.} 6.46 cm	K Factors
45 000	274 824	210 472	146 120	78.9
45 500	280 965	215 175	149 386	77.2
46 000	287 174	219 930	152 687	75.5
46 500	293 451	224 737	156 024	73.9
47 000	299 796	229 597	159 397	72.3
47 500	306 208	234 508	162 807	70.8
48 000	312 689	239 471	166 252	69.4
48 500	319 237	244 485	169 734	67.9
49 000	325 853	249 552	173 252	66.6
49 500	332 537	254 671	176 806	65.2
50 000	339 289	259 842	180 396	63.9
50 500	346 108	265 065	184 021	62.7
51 000	352 996	270 340	187 683	61.4
51 500	359 951	275 667	191 382	60.3
52 000	366 975	281 045	195 116	59.1
52 500	374 066	286 476	198 996	58.0
53 000	381 225	291 959	202 692	56.9
53 500	388 452	297 493	206 535	55.8
54 000	395 746	303 080	210 413	54.8
54 500	403 109	308 718	214 328	53.8
55 000	410 539	314 409	218 279	52.8
55 500	418 038	320 151	222 265	51.9
56 000	425 604	325 946	226 288	51.0
56 500	433 238	331 792	230 347	50.1
57 000	440 940	337 691	234 442	49.2
57 500	448 709	343 641	238 573	48.3
58 000	456 547	349 644	242 740	47.5
58 500	464 452	355 698	246 943	46.7
59 000	472 426	361 804	251 183	45.9
59 500	480 467	367 962	255 458	45.1
60 000	488 576	374 173	259 770	44.4

*These values do not take the thickness of the tube into consideration.

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^1 = 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 Svedbergs¹

Table 4-2 gives K^1 factors for the TH-660 Rotor when operated at maximum speed (that is, 60 000 rpm) with particles ranging in density from 1.1 g/cm³ to 1.9 g/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 4-2. K^1 Factors for the TH-660 Rotor (at maximum speed)

Particle Density (g/cm ³)	K^1 Factor
1.1	558
1.2	302
1.3	267
1.4	252
1.5	244
1.6	239
1.7	235
1.8	232
1.9	230

CARE and MAINTENANCE

This chapter provides instructions on how to clean, decontaminate, and maintain your rotor. Always maintain the rotor in the recommended manner. Do not use rotors that show signs of corrosion or cracking.

Contents

- “Corrosion” on page 5-2
- “Cleaning and Decontamination” on page 5-2
- “Inspection” on page 5-3
- “Overspeed Decal Replacement” on page 5-3
- “Storage” on page 5-4
- “Service Decontamination Policy” on page 5-4

Corrosion

The titanium rotor body and buckets of the TH-660 are more resistant to corrosion than an aluminum rotor body, but it should be maintained and kept clean in the same manner. With proper care, corrosion can be minimized to significantly prolong the life of the rotor and lessen the chances of rotor failure and potential damage to the centrifuge.

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

Stress corrosion is thought to be initiated by certain combinations of stress and chemical reaction. The most common chemical causing harmful effects is chloride, whether in a solution 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 the rotor is thoroughly dried after each use.

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

Cleaning and Decontamination



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

These procedures are to be used for general cleaning purposes only.

If the rotor or any of its parts are exposed to a contaminant, they must be decontaminated first, then washed.

1. Washing

Wash the rotor body and buckets 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 the rotor thoroughly with a soft absorbent cloth or an air blast.

Do not use strong laboratory detergents to clean rotor surface. Use a soft bristle brush to loosen encrusted materials only if necessary; be careful not to scratch the rotor surface. Wash cap assemblies with a mild detergent solution, rinse and dry carefully before storing.

Occasionally apply a thin film of lubricant, PN 61556 to the bucket and cap threads. This will prevent galling and permit easier cap removal.



Note Do not expose aluminum rotor components to: strong acids, bases, or 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.

Always maintain the centrifuge in the recommended manner. The rotor and all accessories must be clean and inspected prior to each run: do not use a rotor showing signs of corrosion or cracking.

2. Decontamination

Ethylene oxide, a 2% glutaraldehyde solution, or ultraviolet radiation are the recommended methods of sterilization; however, the rotor body of the titanium rotor body and the individual parts of the bucket assemblies can be separated and autoclaved at temperatures up to 121°C.

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 bucket caps for signs of stress corrosion, including cracking, abrasions, wear or deformation.

Inspect bucket O-ring regularly for cracks, hardening, swelling or chipping; replace if necessary.

Overspeed Decal Replacement

Before replacing the decal, be sure 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 acetone or 3M General Adhesive Remover #8984.
3. Wipe the surface dry with a clean, soft cloth.

Note Check that the new decal has the correct number of black segments for the rotor being used. The decal for the TH-660 Rotor should have 15 black segments, or if the rotor has been derated, 17 black segments.

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

Storage

Clean, rinse and dry the rotor body and each bucket assembly before storing in a cool, dry place. Store the rotor body upright on the rotor stand supplied, and store buckets (with caps off) upside down and slightly tilted so air can circulate. This will help prevent moisture from gathering and settling in the bottom of cavities to initiate corrosion.

Service Decontamination Policy



WARNING Because of the characteristics of the samples likely to be processed in this centrifuge, biological or radioactive contamination may occur. Always be aware of this possibility and take normal precautions. Use appropriate decontamination procedures should exposure occur.

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

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

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

Clean and decontaminate your centrifuge or rotor as follows:

For ultracentrifuges:

- i. Remove rotor from the rotor chamber.
- ii. 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 that the Thermo Fisher Scientific Chemical Hazards Officer can decide whether to authorize the rotor's return to a Thermo Fisher Scientific facility.

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

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

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

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

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

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

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

Chemical Compatibility Chart

CHEMICAL	MATERIAL	ALUMINUM	ANODIC COATING for ALUMINUM	BUNA N	CELLULOSE ACETATE BUTYRATE	POLYURETHANE ROTOR PAINT	COMPOSITE Carbon Fiber/Epoxy	DELRI [®]	ETHYLENE PROPYLENE	GLASS	NEOPRENE	NORYL [®]	NYLON	PET [®] , POLYCLEAR [®] , CLEARCRIMP [®] , CCLEARCRIMP [®]	POLYALLOMER	POLYCARBONATE	POLYESTER, GLASS THERMOSET	POLYETHERIMIDE	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	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	M	S	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
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

A Chemical Compatibility Chart

CHEMICAL	MATERIAL	ALUMINUM	ANODIC COATING for ALUMINUM	BUNA N	CELLULOSE ACETATE BUTYRATE	POLYURETHANE ROTOR PAINT	COMPOSITE Carbon Fiber/Epoxy	DELRI [®]	ETHYLENE PROPYLENE	GLASS	NEOPRENE	NORYL [®]	NYLON	PET ⁺ , POLYCLEAR [®] , CLEARCRIMP [®] , CCCCLEARCRIMP [®]	POLYALLUMER	POLYCARBONATE	POLYESTER, GLASS THERMOSET	POLYETHERIMIDE	POLYRTHYLENE	POLYPROPYLENE	POLYSULFONE	POLYVINYL CHLORIDE	RULON A [®] , TEFLON [®]	SILICONE RUBBER	STAINLESS STEEL	TITANIUM	TYGON [®]	VITON [®]
Cesium Acetate	M	-	S	-	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	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	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	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	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	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	U	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	
Ethylene Oxide Vapor	S	-	U	-	-	U	-	-	S	U	-	S	-	S	M	-	-	S	S	S	S	U	S	U	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	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®, CQCLEARCRIMP®	POLYALLUMER	POLYCARBONATE	POLYESTER, GLASS THERMOSET	POLYETHERIDE	POLYETHYLENE	POLYPROPYLENE	POLYSULFONE	POLYVINYL CHLORIDE	RULON A®, TEFLON®	SILICONE RUBBER	STAINLESS STEEL	TITANIUM	TYGON®	VITON®
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
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

A 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®	POLYALLUMER	POLYCARBONATE	POLYESTER, GLASS THERMOSET	POLYETHERIMIDE	POLYETHYLENE	POLYPROPYLENE	POLYSULFONE	POLYVINYL CHLORIDE	RULON A®, TEFLON®	SILICONE RUBBER	STAINLESS STEEL	TITANIUM	TYGON®	VITON®
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	U	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	M	S	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	M	S	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	U	M	S	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
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

CHEMICAL	MATERIAL		ALUMINUM	ANODIC COATING for ALUMINUM	BUNA N	CELLULOSE ACETATE BUTYRATE	POLYURETHANE ROTOR PAINT	COMPOSITE Carbon Fiber/Epoxy	DELIN®	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®
Pyridine (50%)	U	S	U	U	S	U	U	-	U	S	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	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	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	S	
Sucrose, Alkaline	M	S	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	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	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	S	U	S	S	M	S	
Nitric Acid (95%)	U	-	U	U	-	U	U	-	-	U	U	U	U	M	U	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	S	U	M	S	S	
Hydrochloric Acid (50%)	U	U	U	U	S	U	U	-	S	M	S	U	U	M	U	U	S	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	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	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	S	M	M	S	S	S	
Tetrahydrofuran	S	S	U	U	S	U	U	M	S	U	U	S	U	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	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	U	S	U	-	S	-	S	
Trichloroethylene	-	-	U	U	-	-	-	U	-	U	-	S	U	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	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	S	
Urea	S	-	U	S	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	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	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	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	S	U	S	S	S	
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	S	
Citric Acid (10%)	M	S	S	M	S	S	M	S	S	S	S	S	S	S	S	S	S	S	M	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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