
**Thermo Fisher Scientific**

# TV-860

## Instruction Manual

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

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This manual is a guide for the use of

# Thermo Scientific TV-860 Titanium Vertical Ultraspeed Centrifuge 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.

# 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, beware of all characteristics of the materials and the hazards associated with them in the event leakage occurs during centrifugation. If leakage does occur, 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.

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 used 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, paragraph 3-1.

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

**CAUTION**

Do not expose aluminum rotor components to: strong acids, bases, or 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 the rotor at the critical speed, as this will have a detrimental effect on centrifuge component life. See Chapter , paragraph 3-3.

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

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

Do not autoclave or expose any aluminum rotor parts to temperatures in excess of 100°C.

# DESCRIPTION

This manual contains information required to operate and maintain the Thermo Scientific TV-860 Vertical Ultraspeed Centrifuge Rotor. If you require additional information regarding operation or maintenance, please contact Thermo Fisher Scientific for assistance. In the United States, call Thermo Fisher Scientific toll-free 1-800-522-7746; outside the United States, contact the nearest Thermo Fisher Scientific office (see back cover) or your local representative for Thermo Scientific products. Thermo Scientific product information is available on our internet web site at http://www.thermo.com/centrifuge .

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# Rotor Description

The TV-860 Rotor assembly consists of eight sealing assemblies and an eightcompartment rotor body that is machined from a titanium forging for strength and corrosion resistance. The rotor has a black coating which provides surface protection and aids temperature regulation. The tube compartments are bored parallel to the rotor axis and, occasionally, are counterbored to achieve precision balance. A disc with alternative black and reflective segments is attached to the bottom of the rotor; this disc will prevent the rotor from being operated at a speed above the recommended maximum speed of the rotor.

# Rotor Application

The TV–860 Rotor is used in an ultracentrifuge, primarily for density gradient separations; the design of the vertical rotor allows these separations to be done in shorter times than the conventional fixed-angle or swinging-bucket rotor. Specifically, the TV–860 can be used for many isopycnic and rate zonal applications. Proper operation of the TV–860 Rotor requires use of the automatic slow acceleration and deceleration controls that are standard on all Thermo Fisher Scientific Ultracentrifuges. Without the use of this feature, the gradient will orient and reorient too fast—the slow acceleration and slow deceleration pr events disturbance of the gradient.

# Rotor Specifications

**Table 1-1.** Rotor Specifications

| Rotor Type | Vertical |
|---|---|
| Maximum Speed * | 60 000 rpm ** |
| Relative Centrifugal Force (RCF) at Maximum Speed: | |
| at $r_{maximum}$, 8.47 cm | 340 596 |
| at $r_{average}$, 7.195 cm | 289 325 |
| at $r_{minimum}$, 5.92 cm | 238 055 |
| Number of Tube Compartments | 8 |
| ULTRACRIMP® Tube Size | 25 mm x 97 mm |
| Tube Compartment Diameter | 2.54 cm (1 in) |
| Tube Compartment Length (Nominal) | 8.89 cm (3.5 in) |
| Tube Volume (Nominal) | 35 ml |
| Total Rotor Capacity (Nominal) | 280 ml |
| Critical Speed | 700 rpm |
| Maximum Compartment Mass (includes tube, contents, sealing assembly and rotor cap) | 82.5 g |
| Rotor Mass (Weight) | 11.4 kg (24.5 lb) |
| K Factor at Maximum Speed | 25.2 |

*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.

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

# Accessories

## a. Accessories Supplied

The accessories that are supplied with the TV-860 Rotor, Catalog Number 53290 (rotor with complete accessories), are listed in Table 1-2. Those items indicated by an asterisk (*) are not supplied with the TV-860 Rotor, Catalog Number 53289, which is the rotor with basic accessories only.

**Note** In order to seal the ULTRACRIMP® Tubes supplied with the rotor (Catalog No. 53290), you must have an ULTRACRIMP® Sealing Tool (Catalog No. 03920) and a Tool Kit (Catalog No. 12771)

To order or for information, in the United States, call Thermo Fisher Scientific toll-free 1-800-522-7746; outside the United States, contact the nearest Thermo Fisher Scientific office (see back cover) or your local representative for Thermo Fisher Scientific products. Be sure to provide a description of the part, the catalog number, plus the rotor model and serial number. Thermo Fisher Scientific product information is available on our internet web site at http://www.thermo.com/centrifuge .

**Table 1-2.** Accessories Supplied

| Quantity | Catalog Number | Description |
|---|---|---|
| 8 | 03989* | ULTRACRIMP® Tubes, Polyallomer, 35 ml (25/pkg)** |
| 8 | 03994* | Rotor Cap |
| 1 | 03935* | Tube Rack, 4-place (1 pair) |
| 1 | 12826* | ULTRACRIMP® Tube Removal Tool |
| 1 | 51346 | Overspeed Decal, 60 000 rpm (extra) |
| 1 | 51942 | Rotor Stand |
| 1 | 61556 | Lubricant |
| 1 | 52384 | Ultraspeed Centrifuge Rotor Log Book |
| 1 | 53292 | Instruction Manual |

*Not supplied with Cat. No. 54289 (rotor with basic accessories only).

**Each package of tubes is supplied with an equal number of tube caps and tube plugs.

## b. Tool Kit, Catalog No. 12771

This kit is required for use with the TV-860 Rotor when used with the ULTRACRIMP® Tube Sealing System. Table 1-3 lists the items supplied in the Tool Kit. If you already have these tools, it is not necessary to order the kit. Any of the tools listed can also be ordered individually; to do so, specify the catalog number given in the table.

**Table 1-3.** Tool Kit (Cat. No. 12771) for use with ULTRACRIMP® Tube Sealing System

| Catalog Number | Description |
|---|---|
| 52580 | Torque Wrench, 3/8-inch drive |
| 54519 | Rotor Body Cap Tool |
| 52540 | Rotor Holding Fixture (with mounting screws) |

### c. Optional Sealing Assembly

If you prefer, you can use the TV-860 with the optional sealing assembly which consists of a rotor body cap and a tube plug. When the body cap is tightened, the tube plug is pushed into the tube to form the seal. To use this style sealing assembly, you must purchase the TV-860 Rotor with basic accessories only, Catalog No. 52389; a Tool Kit, Catalog No. 52599; the tubes; and the sealing assembly components listed in Table 1-4. Table 1-5 lists the items supplied in the Tool Kit; any of these tools can also be purchased individually.

**Table 1-4.** Optional Sealing Assembly Components

| Catalog Number | Description |
|---|---|
| 03141 | Tube, Polyallomer, 36 ml (package of 25) |
| 52556 | Rotor Body Cap, Red (each); 8 required |
| 52557 | Tube Plug (package of 8) |
| 52555 | Tube Plug O-ring (package of 16) |
| 52596 | Titanium Seal Ring, Blue (package of 8) |
| 09073 | Tube Trimmer (optional) |

**Table 1-5.** Tool Kit (Cat. No. 52599) for use with Optional Sealing Assembly

| Quantity | Catalog Number | Description |
|---|---|---|
| 1 | 52448 | Tube Plug Removal Tool |
| 1 | 52577 | Torque Wrench Adapter |
| 1 | 52580 | Torque Wrench |
| 1 | 52540 | Rotor Holding Fixture (with mounting screws) |

# RUN PREPARATION

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- "Rotor Holding Fixture" on page 2-2
- "Rotor Precool" on page 2-3
- "Chemical Compatibility" on page 2-3
- "Sample Preparation" on page 2-3

# Prerun Safety Checks

To ensure safe performance of the rotor, the following items should be checked before every run:

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

b. make sure each tube compartment and rotor cap is clean and that there is no sign of corrosion, and that the centrifuge chamber and the drive spindle are clean.

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

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

e. verify that the proper overspeed decal is firmly attached to the bottom of the rotor; the decal should have 15 black segments (refer to paragraph 6-5 for Overspeed Decal Replacement procedure).

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

g. be sure the rotor caps are torqued to the recommended value (paragraph 4-1).

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

i. check the top speed capability of the tube being used; observe the CAUTION below.

**WARNING** If using a Thermo Fisher Scientific tube (or bottle) assembly other than the one specified, refer to the Rotors, Tubes, Bottles and Adapters Catalog for the maximum speed. When using a tube or bottle assembly other than those supplied by Thermo Fisher Scientific, be sure to check its top speed capability. When in doubt, do a test run for the desired application. Exceeding the top speed capability of the tube or bottle assembly can result in tube breakage.

# Rotor Holding Fixture

The rotor holding fixture (Cat. No. 52540) is used to hold the rotor during the rotor loading and unloading procedure to prevent disturbance of the gradient.

Fasten the fixture to a workbench with the two mounting screws supplied as shown in figure 2-1.

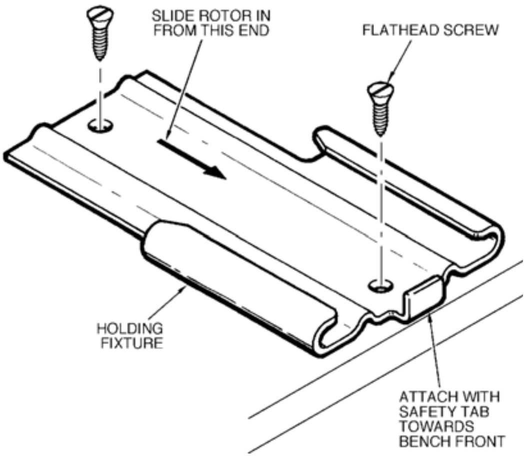


**Figure 2-1.** Rotor Holding Fixture Installation

# Rotor Precool

If samples are routinely processed around 4°C or below, the rotor should 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 Ultraspeed Centrifuge. Refer to the Ultraspeed Centrifuge Instruction Manual for precooling directions. Be careful not to precool the rotor at its critical speed (read paragraph 3-3).

# Chemical Compatibility

The critical components of the TV-860 Rotor that are apt to come in contact withsolution ar e: the rotor body (titanium), the tubes (polyallomer), and all sealing assembly components. ULTRACRIMP® sealing assembly components include: rotor caps and tube caps (aluminum) and the tube plugs (Buna N). Optional sealing assembly components include: tube plugs (Delrin ®) and rotor body caps (aluminum). The chemical compatiblity of rotor elements and accessory materials is given in the Appendix A.

Because no organized chemical resistance data exists for materials under the stress of centrifugation, this data is intended to be used only as a guide to the selectionof tube materials. When in doubt, we r ecommend pretesting of sample lots.

# Sample Preparation

### a. ULTRACRIMP® Tubes, Catalog No. 03989

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

### b. Optional Tubes, Catalog No. 03141

When using optional tubes, Catalog Number 03141, each tube must contain a total of 34 ml of solution; the recommended capacity for each tube is: 32.0 ml of gradient, 1.0ml of sample and 1.0 ml of overlay (e.g. mineral oil).

> **CAUTION** To prevent the tube from collapsing or leaking during centrifugation, each tube must always contain 34 ml of solution. Also, use a new tube for each operation — do not reuse these tubes.

# SPECIAL OPERATING CONSIDERATIONS

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- "Critical Speed" on page 3-7

# Compartment Loads in Excess of Design Mass

A recommended design mass has been established for each ultraspeed centrifuge rotor, representing the maximum mass that each tube compartment can contain at top speed operation. To prevent rotor failure, the total contents of each compartment, including the specimen, rotor cap, tube cap, tube plug, and the tube, should not exceed the recommendedfigur e unless the rotor speed is reduced proportionately. (If using the optionalsealing assembly, include the weight of all components.)

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

The design mass for each tube compartment of the TV-860 Rotor is 82.5 g at 60 000 rpm. This figure is based on the use of an ULTRACRIMP® tube filled with a liquid at 1.7 specific gravity. If the density is greater than 1.7 g/ml, use the following formula to determinethe r educed speed:

$$\text{Reduced Speed} = 60000\sqrt{\frac{1.7}{\text{Average Fluid Density (g/ml)}}}$$

Refer to figures 3-1, 3-2, and 3-3 for derating factors when using cesium chloride solutions.

# 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 front of this manual.

Maximum speed must be reduced for an average fluid density greater than 1.7 g/ml (square-root reduction) to prevent excessive hydraulic pressure in a rotor. Although the standard formula (see paragraph 3-1) pertains to sucrose and similar gradientmaterials, it will not pr event precipitation of heavy crystals when material suchas cesium chloride (CsCl) is used in an ultraspeed centrifuge.

When solid, crystalline CsCl forms, it places a density of 4 g/ml along the outside edge of each tube compartment. This density is dangerously high and can cause the rotor to fail, with subsequent sample loss. Therefore, cesium chloride solutions must be run at 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 3-1 should be used to determine the maximum operating speed. Curves are given for specific average densities at 5°C and 25°C that will prevent precipitation. Also, figure 3-1 includes a curve that shows the standard speed (square-root) reduction to avoid excessive hydraulic pressure only. The standard, square-root reductionfor mula cannot be used when precipitation of CsCl must be considered. For example, standard speed reduction would allow you to run a solution with a density of 1.6g/ml at 60 000 rpm; however , you can see that a cesium chloride solution will precipitateat this speed. The graph shows that the highest speed you can run a cesium chloride solution having a density of 1.6 g/ ml is 55 000 rpm at 25°C or 45 000 rpm at 5°C.

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

### b. The Gradient Shape

The curves in figures 3-2 and 3-3 show the gradient shape at equilibrium, 5°C and 25°C respectively, for tubes filled with a CsCl solution. Figure 3-2 illustrates the shape of the gradient curve at various speeds. For example, to find the gradient profile of a tube filled with a 1.6 g/ml solution at 45000 rpm at 5 °C, locate the 45 000 rpm curve. The gradient profile is 1.43 g/ml at the meniscus to 1.81 g/ml at the bottom of the tube. Use figure 3-3 to find the shape of the gradient (1.6 g/ml) that corresponds to 55 000 rpm at 25°C. Interpolate to find gradient shapes at speeds other than those illustrated.

Next, use figures 3-2 and 3-3 to determine the position of a band of particles in the tube when run at 5°C and 25°C respectively. Using the example given above (i.e., 45 000 rpm at 5°C), use figure 3-2 to locate the position of a band of particles having a density of 1.52g/ml. Find 1.52 on the side scale (DENSITY , g/ml) and follow the line across until it intersects the curve at 45000 rpm. At this point, follow the line down the graph until it intersects the bottom scale (RADIUS, cm) in this example the line corresponds to a radius of 6.53cm. T o find this band of particles after reorientation, continue to follow the line to the VOLUME (ml) of Fluid Above Band scale; you can see that the band of particles after reorientation is at 7.5. This means that there will be 7.5 ml of gradient above the band and 26.5ml below the band; ther efore, measuring from the top of the meniscus, the particles will be located at 78% of the fluid column.

Use figure 3-3 to locate a band of particles having the same density (i.e., 1.52 g/ml) run at 25°C. In this example, the band of particles can be located at a radius of 6.55 cm. Continue to follow the line to the VOLUME (ml) of Fluid Above the Band scale to locate the band of particles after reorientation Ð which is at 9.2. This means there is 9.2ml above the band and 24.8 ml below the band. Again, measuring from the top of the meniscus, the particles will be located at 73% of the fluid column.

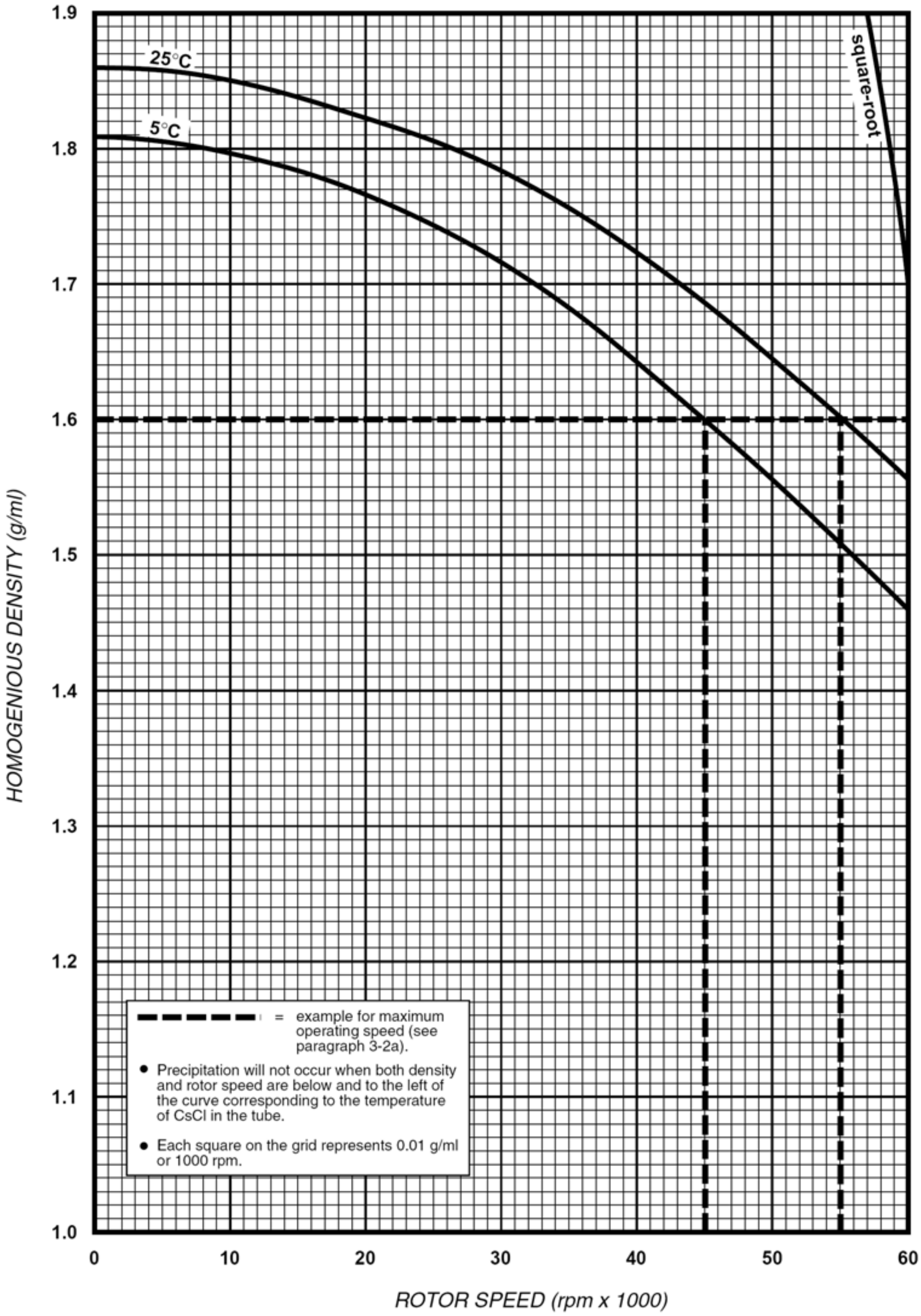


**Figure 3-1.** CsCl Precipitation Curves for the TV-860 Rotor

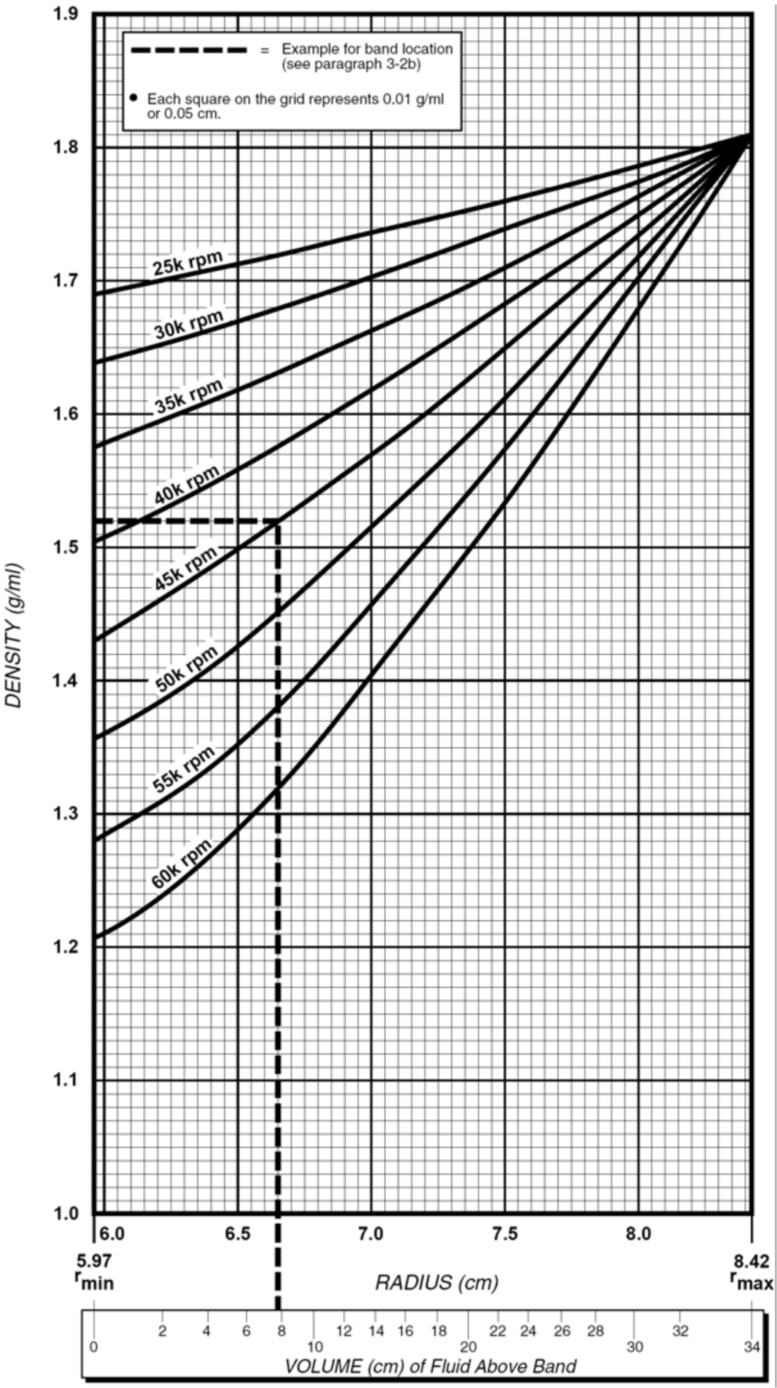


**Figure 3-2.** CsCl Density Gradient Shapes at Equilibrium (5°C)

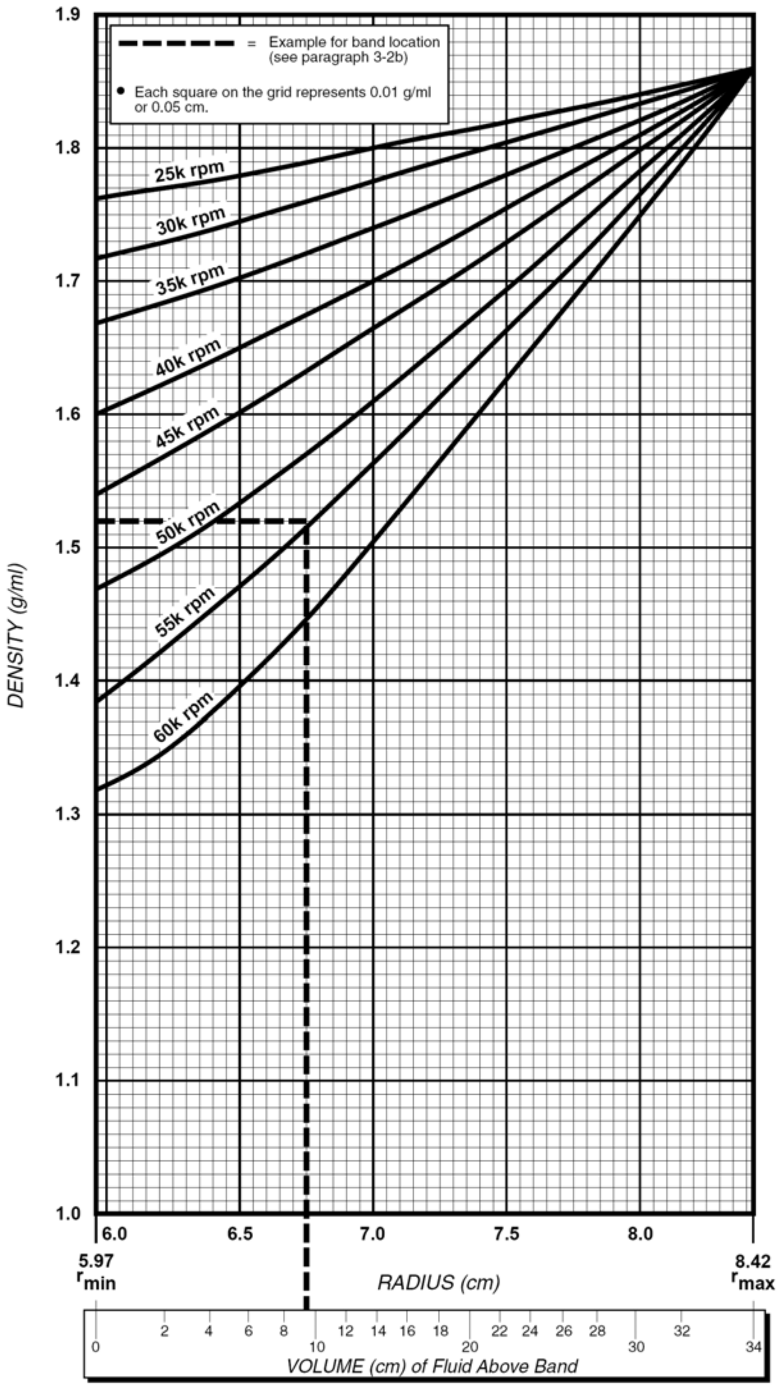


**Figure 3-3.** CsCl Density Gradient Shapes at Equilibrium (25°C)

# 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 (for example, the rotor and the centrifuge drive). At this speed, the rotor may produce large amplitude vibrations which can be felt in the centrifuge frame. Mass imbalance will contribute to increased vibrationintensity at the critical speed. A void operating the rotor at the critical speed, which is 700 rpm for the TV-860 Rotor. Operation at the critical speed will have a detrimentalef fect on centrifuge component life. Observe the CAUTION on the Safety Information Page in the front of this manual.

# OPERATION

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- "Rotor Log Book" on page 4-7

**WARNING** The stresses that this rotor withstands during centrifugation eventually cause the rotor body to weaken, increasing the possibility of rotor failure. For your safety, we recommend that this rotor be withdrawn from service after it has been used for 5 000 runs or 10 000 hours, whichever comes first. Failure to do so can cause rotor failure with subsequent sample loss and damage to the rotor and/or centrifuge. If the material being processedis hazar dous, take all necessary precautions to prevent exposureshould r otor failure occur.

# Rotor Loading and Sealing

To be sure that each tube and rotor compartment is properly sealed for operation, these instructions must be carefully followed. If necessary, precool the rotor, tube plugs and rotor body caps to the same temperature. (See the Ultraspeed Centrifuge Instruction Manual for precooling instructions.)

Prepare samples according to the instructions in Chapter 2, paragraph 2-5 then load and seal the rotor as follows:

## a. Using ULTRACRIMP®Tubes and Sealing System

1. Place the rotor in the rotor holding fixture (Cat. No. 52540). Gently put filled tubes into the tube compartments, balancing the rotor as explained inparagraph4-2.
2. Apply a light coat of lubricant (Cat. No. 61556) to each rotor cap (Cat. No. 03994).
3. Place a rotor cap in each compartment that contains a filled tube.

**CAUTION** Do not put a rotor cap in an empty tube compartment. Rotor caps should only be installed in compartments that contain a filled tube.

4. Hand tighten each rotor cap.
5. Using the torque wrench (Cat. No. 52580) with the rotor body cap tool (Cat. No.54519), tighten each rotor cap to 180 in lbs (20.3 Nm).

**CAUTION** Do not undertighten or overtighten the rotor caps. Always use a torque value not less than 180 in lbs (20.3 Nm) or greater than 200 in lbs (22.6 Nm).

## b. Using Optional Tubes and Sealing Assembly (refer to figure 4-1)

Precool the rotor, seal rings, tube plugs and body caps to the same temperature if necessary.

Prepare sample as explained in paragraph 2-5 then load and seal the rotor as follows:

**CAUTION** Before every run inspect the counterbore area where the seal ring fits into the tube compartment be sure there are no nicks or scratches in the area and that the area is clean.

1. Place the rotor in the rotor holding fixture with either compartment #1 or #5 facing you.

2. Install a seal ring (Cat. No. 52596), chamfer side up, into the counterbore of each rotor compartment that will contain a tube (see figure 4-1).

**CAUTION** The chamfer side of each seal ring must be facing upward, if not the tube may stick in the rotor compartment.

3. Gently put the filled tubes into the rotor tube compartments (balancing the rotor as described in paragraph 4-2).
4. Lubricate each tube plug O-ring (Cat. No. 52555) with a light film of vacuum grease (Cat. No. 65937).
5. Insert a lubricated O-ring in the groove of each tube plug (Cat. No. 52557). Place a tube plug (with O-ring) into the top of each tube in the rotor.
6. Apply a light coat of lubricant (Cat. No. 61556) to the threads of the rotor body caps, then place a body cap into each tube compartment that contains a filled tube. Finger tighten each body cap.

**CAUTION** Do not put a body cap in an empty tube compartment. Body caps should onlybe installed in compartments that contain a filled tube.

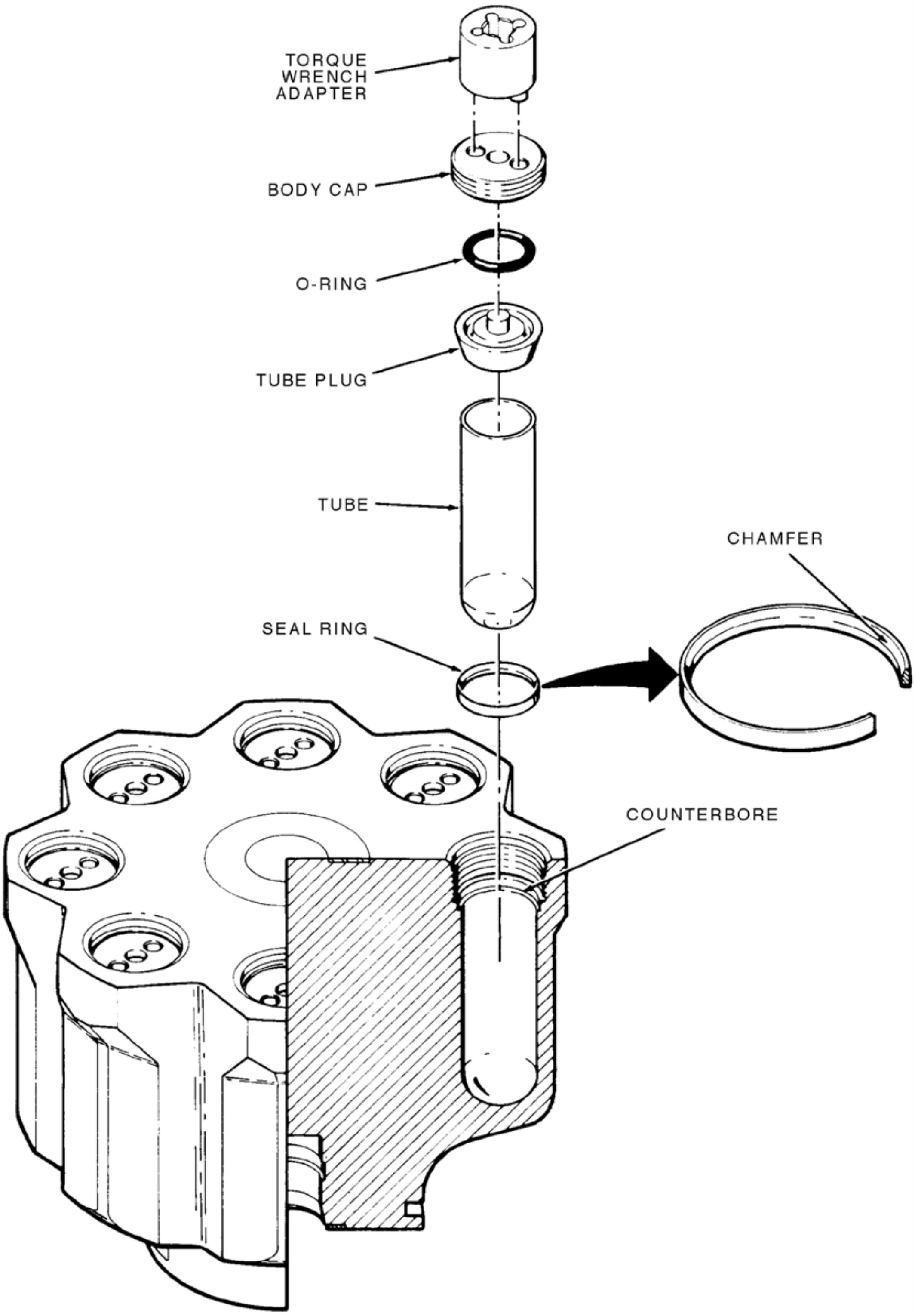


**Figure 4-1.** Optional Rotor Sealing Assembly

7. Preset torque wrench (Cat. No. 52580) to 220 in lb. (24.9 Nm) according to the instructions supplied. Attach the torque wrench to the torque wrench adapter (Cat. No. 52577) and tighten each body cap to 220 in lb. When the torque being applied equals the preset torque value, the wrench will automatically release (approximately 10° arc). This release, or break away, can be distinctly felt and heard by the operator and signals that the operation is complete. When pressure is released, the wrench resets itself and is ready for use.

**CAUTION** Do not undertighten or overtighten the body caps. Always use a torque value between 180 in lb. (20.3 Nm) and 240 in lb. (27.1 Nm).

# Rotor Balancing

Always balance the rotor according to the following criteria:

a. observe CAUTION on the Safety Information Page in the front of this manual.

b. pairs of tubes containing a sample of identical specific gravity must be balanced to within 0.5 gram and placed in opposing compartments.

c. the rotor can be operated at any speed up to its maximum speed with groups of two, four, six or eight samples, as long as each sample is paired to another of identical specific gravity and the tubes are placed in opposite rotor compartments as shown in figure 4-2.

**CAUTION** When the rotor is operated with two, four or six samples placed in opposingtube compartments, the r emaining tube compartments must be empty. Do no put rotor body caps in empty compartments.

d. if an uneven number of samples is to be run, the odd sample must be counterbalanced with a tube that contains a solution of the same specific gravity.

# Rotor Installation

**Note** Whenever you carry the rotor after it has been loaded, hold it vertically with both hands underneath it; the rotor must always be moved slowly and carefully so the gradient will not be disturbed.

To install the rotor in the centrifuge, remove it from the rotor holding fixture and carefullylower it onto the drive adapter in the centrifuge r otor chamber. The rotor will snap in place on the drive adapter. To make sure the rotor is fully seated, pull up on it gently if ther e is a small amount of resistance, it is properly seated.

The rotor is ready for operation per form the centrifuge run according to the instructionsfor the ultracentrifuge.

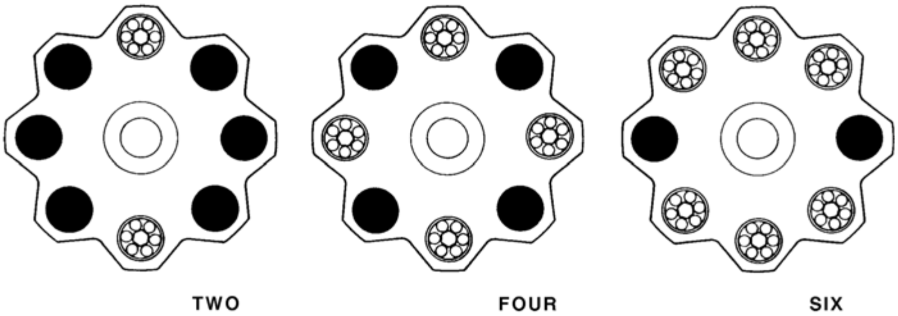


**Figure 4-2.** Rotor Balancing

# Acceleration and Deceleration

When using the TV-860 Rotor for density gradient separations, the automatic rate controlleror the REOGRAD mode must be used for slow acceleration and slow deceleration. For instructions on the use of these contr ols, refer to the ultracentrifuge instruction manual.

# Tube Removal

To remove the tubes from the rotor:

### a. ULTRACRIMP® Tubes

1. Place the rotor in the rotor holding fixture.
2. Remove the rotor caps from the rotor using the torque wrench with the body cap tool.
3. Remove tubes from the rotor. Because the tubes expand slightly during centrifugation, use the UL TRACRIMP® Tube Removal Tool (Cat. No. 12826), needlenose pliers, or a hemostat to grasp the tube and gently pull it from the rotor.

**Note** You may notice that the inner side wall of a tube may appear slightly flattened after centrifugation. This is a nor mal effect of centrifugation and should not be cause for any concern.

### b. Optional Tubes, Catalog No. 03141

1. Place the rotor in the rotor holding fixture.
2. Remove the rotor body caps using the torque wrench and torque wrench adapter.
3. Push the tube plug tool onto the stem of the tube plug and gently rock the plug until it pops loose, then remove the plug.

**WARNING** Be extremely careful when removing the tube plugs, particularly if the samples are radioactive or pathogenic. If liquid is trapped between the plug and the tube wall, it may be forced out by an air bubble when the plug is loosened. This is one reason we recommend the use of an overlay, such as mineral oil, on the sample.

4. Grasp the edge of each tube with a hemostat or forceps and slowly pull the tube out of the rotor. If you have difficulty getting hold of the edge of the tube, insert a small tool such as an 18 gauge needle or a spatula between the wall of the rotor tube compartment and the tube and pry the tube until it can be gripped with the hemostat or forceps.
5. Remove seal rings.

Clean all sealing assembly components according to the procedure given in paragraph 6-2.

# Tube Trimmer Accessory (for use with Optional Tubes)

The rim of the optional tubes (Cat. No. 03141) will be deformed by the sealing assembly during operation. This may cause the tubes to leak when used with certain density gradient fractionators. To correct this problem, a tube trimmer is supplied with the rotor. After the tube has been removed from the rotor, insert it into the trimmer. The deformed portion of the tube will extend above the top of the trimmer. Use a razor blade and very carefully cut it away from the rest of the tube.

**Note** The tube trimmer is not required when using the TV-860 Rotor with ULTRACRIMP® tubes (Cat. No. 03989).

# Rotor Log Book

An Ultraspeed Centrifuge Rotor Log Book is supplied with the TV-860 so you can easily record all data necessary to meet the warranty stipulation that if a defective rotor is returned to Thermo Fisher Scientific it is accompanied by an up-to-date history of the rotor.

Each time the TV-860 Rotor is used, record the run in the log book as shown in Figure 4-3, Sample 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 4-3.** Sample Centrifuge/Rotor Log Sheet

5

# OPERATION

This chapter contains the information necessary to prepare the TFT-45.6 Rotor for operation and includes important safety information.

**Contents**


- "Relative Centrifugal Force (RCF) Determination" on page 5-2
- "Calculation of Sedimentation Time in Aqueous (Non-gradient) Solutions" on page 5-5
- "Calculation of Sedimentation Time in Gradient Solutions" on page 5-6

# 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:

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

when r = the radius in centimeters from the centerline of the rotor to the point in the tube where RCF value is required
and rpm = the rotor speed in revolutions per minute

Figure 5-1 shows the minimum, average, and maximum radii of the TV-860. Table 5-1 gives the RCF value at each radius at speeds from 20 000 rpm to 60 000 rpm (in increments of 500 rpm). The RCF value at any other speed can be calculated by using the given formula.

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

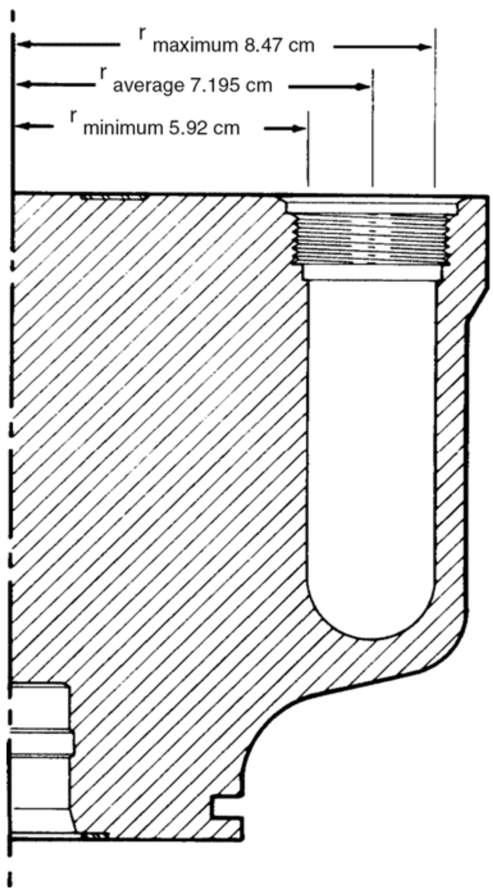


**Figure 5-4.** TV-860 Rotor Radii

**Table 5-1.** TV-860 Rotor: RCF Values and K Factors*

| Speed (rpm) | RCF $r_{max.}$ 8.47 cm | $r_{avg.}$ 7.195cm | $r_{min.}$ 5.92cm | K Factors |
|---|---|---|---|---|
| 20 000 | 37 844 | 32 147 | 26 451 | 227 |
| 20 500 | 39 760 | 33 775 | 27 790 | 216 |
| 21 000 | 41 723 | 35 442 | 29 162 | 205 |
| 21 500 | 43 733 | 37 150 | 30 567 | 196 |
| 22 000 | 45 791 | 38 898 | 32 005 | 187 |
| 22 500 | 47 896 | 40 686 | 33 476 | 179 |
| 23 000 | 50 049 | 42 515 | 34 981 | 171 |
| 23 500 | 52 248 | 44 383 | 36 518 | 164 |
| 24 000 | 54 495 | 46 292 | 38 089 | 157 |
| 24 500 | 56 790 | 48 241 | 39 692 | 151 |
| 25 000 | 59 131 | 50 230 | 41 329 | 145 |
| 25 500 | 61 520 | 52 259 | 42 999 | 139 |
| 26 000 | 63 956 | 54 329 | 44 701 | 134 |
| 26 500 | 66 440 | 56 439 | 46 437 | 129 |
| 27 000 | 68 971 | 58 588 | 48 206 | 124 |
| 27 500 | 71 549 | 60 778 | 50 008 | 120 |
| 28 000 | 74 174 | 63 009 | 51 843 | 116 |
| 28 500 | 76 847 | 65 279 | 53 711 | 112 |
| 29 000 | 79 567 | 67 590 | 55 612 | 108 |
| 29 500 | 82 334 | 69 940 | 57 546 | 104 |
| 30 000 | 85 149 | 72 331 | 59 514 | 101 |
| 30 500 | 88 011 | 74 762 | 61 514 | 97.4 |
| 31 000 | 90 920 | 77 234 | 63 547 | 94.3 |
| 31 500 | 93 877 | 79 745 | 65 614 | 91.3 |
| 32 000 | 96 881 | 82 297 | 67 713 | 88.5 |
| 32 500 | 99 932 | 84 889 | 69 846 | 85.8 |
| 33 000 | 103 030 | 87 521 | 72 012 | 83.2 |
| 33 500 | 106 176 | 90 193 | 74 210 | 80.8 |
| 34 000 | 109 369 | 92 906 | 76 442 | 78.4 |
| 34 500 | 112 609 | 95 658 | 78 707 | 76.1 |
| 35 000 | 115 897 | 98 451 | 81 005 | 74.0 |
| 35 500 | 119 232 | 101 284 | 83 336 | 71.9 |
| 36 000 | 122 614 | 104 157 | 85 700 | 69.9 |

**Table 5-1.** TV-860 Rotor: RCF Values and K Factors*

| Speed (rpm) | RCF $r_{max.}$ 8.47 cm | $r_{avg.}$ 7.195cm | $r_{min.}$ 5.92cm | K Factors |
|---|---|---|---|---|
| 36 500 | 126 044 | 107 070 | 88 097 | 68.0 |
| 37 000 | 129 521 | 110 024 | 90 527 | 66.2 |
| 37 500 | 133 045 | 113 018 | 92 990 | 64.4 |
| 38 000 | 136 617 | 115 052 | 95 487 | 62.8 |
| 38 500 | 140 236 | 119 126 | 98 016 | 61.1 |
| 39 000 | 143 902 | 122 240 | 100 578 | 59.6 |
| 39 500 | 147 615 | 125 394 | 103 174 | 58.1 |
| 40 000 | 151 376 | 128 589 | 105 802 | 56.6 |
| 40 500 | 155 184 | 131 824 | 108 464 | 55.2 |
| 41 000 | 159 039 | 135 099 | 111 158 | 53.9 |
| 41 500 | 162 942 | 138 414 | 113 886 | 52.6 |
| 42 000 | 166 892 | 141 769 | 116 647 | 51.4 |
| 42 500 | 170 889 | 145 165 | 119 441 | 50.2 |
| 43 000 | 174 934 | 148 601 | 122 268 | 49.0 |
| 43 500 | 179 026 | 152 077 | 125 128 | 47.9 |
| 44 000 | 183 185 | 155 593 | 128 021 | 46.8 |
| 44 500 | 187 351 | 159 149 | 130 947 | 45.8 |
| 45 000 | 191 585 | 162 746 | 133 906 | 44.8 |
| 45 500 | 195 866 | 166 382 | 136 898 | 43.8 |
| 46 000 | 200 195 | 170 059 | 139 923 | 42.8 |
| 46 500 | 204 570 | 173 776 | 142 982 | 41.9 |
| 47 000 | 208 993 | 177 533 | 146 073 | 41.0 |
| 47 500 | 213 464 | 181 331 | 149 198 | 40.2 |
| 48 000 | 217 981 | 185 168 | 152 355 | 39.3 |
| 48 500 | 222 546 | 189 046 | 155 546 | 38.5 |
| 49 000 | 227 158 | 192 964 | 158 769 | 37.7 |
| 49 500 | 231 818 | 196 922 | 162 026 | 37.0 |
| 50 000 | 236 525 | 200 920 | 165 316 | 36.2 |
| 50 500 | 241 279 | 204 959 | 168 639 | 35.5 |
| 51 000 | 246 080 | 209 038 | 171 995 | 34.8 |
| 51 500 | 250 929 | 213 156 | 175 384 | 34.2 |
| 52 000 | 255 825 | 217 315 | 178 806 | 33.5 |
| 52 500 | 260 769 | 221 515 | 182 261 | 32.9 |
| 53 000 | 265 759 | 225 754 | 185 749 | 32.3 |

**Table 5-1.** TV-860 Rotor: RCF Values and K Factors*

| Speed (rpm) | RCF $r_{max.}$ 8.47 cm | $r_{avg.}$ 7.195cm | $r_{min.}$ 5.92cm | K Factors |
|---|---|---|---|---|
| 53 500 | 270 979 | 230 034 | 189 270 | 31.7 |
| 54 000 | 275 882 | 234 354 | 192 825 | 31.1 |
| 54 500 | 281 015 | 238 713 | 196 412 | 30.5 |
| 55 000 | 286 195 | 243 114 | 200 032 | 30.0 |
| 55 500 | 291 422 | 247 554 | 203 686 | 29.4 |
| 56 000 | 296 697 | 252 035 | 207 372 | 28.9 |
| 56 500 | 302 018 | 256 555 | 211 092 | 28.4 |
| 57 000 | 307 388 | 261 116 | 214 845 | 27.9 |
| 57 500 | 312 804 | 265 717 | 218 630 | 27.4 |
| 58 000 | 318 268 | 270 358 | 222 449 | 26.9 |
| 58 500 | 323 779 | 275 040 | 226 301 | 26.5 |
| 59 000 | 329 337 | 279 762 | 230 186 | 26.0 |
| 59 500 | 334 943 | 284 523 | 234 104 | 25.6 |
| 60 000 | 340 596 | 289 325 | 238 055 | 25.2 |

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

# 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 Svedbergs[1]

[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.

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 TV-860 Rotor at speeds from 20 000 rpm to 60 000 rpm (in increments of 500 rpm) are listed in Table 5-1.

For example: the TV-860 Rotor has a K factor of 25.2 at the maximum permitted speed (60 000 rpm). If the particles to be sedimented have a sedimentation coefficient of 10 S, the estimated run time required at maximum speed for the outer row will be:

$$t = \frac{25.2}{10S}\ 2.52 \text{ hours} = 2 \text{ hours, } 31 \text{ minutes}$$

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
$K^1$ = 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 Svedbergs[1]

Table 5-2 gives $K^1$ factors for the TV-860 Rotor when operated at maximum speed (i.e., 60000 rpm) with particles ranging in density from 1.1 g/cm3 to 1.5 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 4°C.

**Table 5-2.** $K^1$ Factors for TV-860 (at maximum speed)

| Particle Density (g/cm$^3$) | $K^1$ Factor (at 60000 rpm) |
|---|---|
| 1.1 | 151 |
| 1.2 | 80 |
| 1.3 | 70 |
| 1.4 | 66 |
| 1.5 | 64 |

# DESCRIPTION

Observe all WARNINGS and CAUTIONS found on the Safety Information Page in the front of this manual.

**Contents**


- "Corrosion" on page 6-2
- "Cleaning" on page 6-2
- "Storage" on page 6-3
- "Inspection" on page 6-3
- "Overspeed Decal Replacement" on page 6-3
- "Service Decontamination Policy" on page 6-4

# Corrosion

The TV-860 rotor body is made from titanium, making it more resistant to corrosion than an aluminum rotor; however, it should be maintained and kept clean the same as an aluminum rotor. Proper care will lessen the chances of rotor failure and significantly prolong the useful life of the rotor.

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

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

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

# Cleaning

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

### a. Washing

Wash the rotor body, and sealing assembly components with warm water and mild soap or detergent at least once a week or, ideally, after each use. It is particularly important that the rotor is washed immediately after any spills have occurred. Most laboratory chemicals can be removed with a lukewarm, 1% solution of a mild, non-alkaline detergentsuch as a mild dishwashing liquid. Rinse and dry thor oughly before storing.

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

### b. Decontamination

Ethylene oxide, a 2% glutaraldehyde solution, or ultraviolet radiation are the recommended methods of sterilizing; however, the titanium rotor body of the TV-860 can be autoclaved at temperatures up to 121°C. Do not autoclave the ULTRACRIMP® rotor caps or the optional sealing assembly components. If these parts are subjected to temperatures above 100°C, they should not be used.

**CAUTION** Do not autoclave any sealing assembly components. If any of these parts are subjected to a temperature 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.

# Storage

After the rotor has been cleaned and dried, it should be stored upside-down without rotor body sealing caps; this will keep the tube compartments dry.

# Inspection

Periodically, inspect the rotor body and sealing assembly components for signs of: stress, including cracks, tears, or abrasions; wear (particularly the threads of the rotor body caps); corrosion or deformation. If such problems are found, contact Thermo Fisher Scientific for information on factory inspection or replacement.

# 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 (Cat. No. 51346):

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 AdhesiveRemover #8984.
3. Wipe the surface dry with a clean, soft cloth.

**Note** Check that the new decal has the correct number of black segments the TV-860 Rotor decal should have 15 black segments.

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

# 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.

Observe the WARNING on hazardous materials found on the Safety Information Page in the front of this manual.

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

1. Clean the equipment to be serviced of all encrusted material and decontaminate it (see Care and Maintenance section of centrifuge or rotor instruction manual) 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 ultracentrifuges:

   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 that 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 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 Decontamination Form; be prepared with the name and serial number of the centrifuge or rotor and the repairs required.
2. Complete the Equipment Return Decontamination Form and returned 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 Kendro representative.

**CAUTION** Do not ship or transport a centrifuge with a rotor installed on the drive spindle. If a centrifuge chamber door cannot be opened using conventional methods, refer to the Emergency Sample Recovery (mechanical override) instructions that are provided in your centrifuge operating manual.

**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 |
| 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 |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 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 |
| 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 |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 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 |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 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 |
| 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 |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 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 |
| 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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