INTRODUCTION
The centrifuge is a commonly used tool in laboratory research. It uses centrifugal force to separate substances in liquid or solid media according to particle size and density differences. Centrifuges, which operate at high speed, have great potential for injuring users if not operated properly. Unbalanced centrifuge rotors can result in injury or death. Sample container breakage can release aerosols that are harmful if inhaled. Hazards presented by all centrifuges, including microcentrifuges, if used and/or maintained improperly include:

- Physical hazards: Mechanical stress, metal fatigue, and corrosion of the rotor over time
- Exposure hazards: Aerosolization of biological, chemical, or radioactive materials

Three factors that govern a safe life for any rotor (the rotating unit of the centrifuge) are:

- Design and manufacture
- Proper care and handling during use
- Retirement, when damage or fatigue make continued use unsafe

PROPER CARE AND HANDLING

- Record the purchase date of each rotor, along with manufacturing date and serial number.
- Read the manuals for the rotors and tubes before using the equipment. Follow all operational specifications published in each rotor manual.
- Rotors must be used with the correct centrifuge (Beckman rotors in Beckman centrifuges). Proper rotor and centrifuge combinations will meet laboratory equipment standards and regulations of UL.
- Maximum speed and sample density ratings designated by the manufacturer for each rotor are intended to prevent stress failures and should always be observed.
- Each rotor has a maximum allowable compartment mass. The total contents of any compartment, including specimen, tubes, sealing assembly and adapters must not exceed the specified maximum compartment mass unless rotor speed is reduced proportionately.

\[
\text{Reduced Speed} = \frac{\text{Maximum Rotor Speed}}{\sqrt{\frac{\text{Maximum Compartment Load}}{\text{Actual Compartment Mass}}}}
\]

- Speed reductions required for running high-density solutions, plastic adapters, or stainless steel tubes should always be observed. Inspect centrifuge:
  - Ensure tubes are rated for intended use (speed, temperature, and chemical resistance)
  - Rotor compatible with centrifuge and seated on drive correctly
  - Rotor and safety cups/buckets free of cracks and deformities
  - Rotor O-ring not cracked, missing, or worn
  - Safety cups/buckets attached correctly and able to move freely
- Before running an ultracentrifuge, check the classification decal on the ultracentrifuge and make sure it matches the classification decal on the rotor.
• The correct over speed disk must be used with ultracentrifuges. The disk must be on the bottom of the rotor and the disk must be in good condition.
• A speed-derating disk must be installed if and when the warranty conditions require it.
• A well-kept rotor log is essential for continued safe operation of an ultracentrifuge. Include date, user, rotor used, and any problems encountered.
• Set the proper run speed on each time to prevent over speeding.
• Prepare centrifuge tubes for loading:
  • Inspect centrifuge tubes before use.
  • Follow manufacturer’s filling limits for tubes. Do not overfill or under fill tubes.
  • For biohazardous materials, disinfect outside of tubes prior to removal from biosafety cabinet and loading into rotor.
• Use a titanium rotor if corrosive salt solutions will be used frequently.
• Sample loads must be balanced and swinging bucket rotors must not be run with missing buckets.
• Tips on Centrifugation without a Balance Tube
  • Safe centrifugation requires balanced loading of the centrifuge rotor. Imbalanced rotors can lead to damage to centrifuge rotors. When an odd number of tubes are loaded, a balance tube is loaded opposite the last sample tube. The balance tube must be identical to the sample tubes, and must contain liquid of equal density to the sample. Balancing by mass alone is not correct, since the centrifugal force that the sample applies to the rotor is dependent on both mass and radius. See Figure 1 for balance loading patterns based on a 12-position microcentrifuge rotor. See table 1.
• If using centrifuges with Biosafety Level 2 or higher material, rotors must have aerosol containment ("O-rings") or be used in a biosafety cabinet. Rotors must be loaded and unloaded in a biosafety cabinet.
• If using centrifuges with radioactive material, keep centrifuge behind an appropriate shield.

OPERATING THE CENTRIFUGE
• Do not leave centrifuge until full operating speed is reached and appears to be running safely without incident.
• Stop centrifuge immediately if you notice any unusual noises or shaking. Confirm rotor is balanced.
• Make sure that the rotor has come to a complete stop before opening the lid.
• When centrifuging hazardous materials, wait at least 10-30 minutes after run to allow aerosols to settle before opening centrifuge.
• When centrifuging infectious materials, wait 10-30 minutes after the rotor comes to a complete stop before opening the lid.
• If you know or suspect a spill has occurred Keep centrifuge cover closed for at least 30 minutes to reduce aerosolization of hazardous material.
• Check for leaks/spills: In samples, rotor, safety cups/buckets, and centrifuge well.
• If a spill occurs, use appropriate decontamination and cleanup procedures for the spilled materials.
• Open sealable tubes/safety cups/rotors: Wear appropriate PPE and open inside fume hood or biosafety cabinet, depending on hazard.
MECHANICAL FAILURE
- Turn off centrifuge immediately and unplug power cord.
- Do not use centrifuge again until inspected by qualified service technician.

MAINTENANCE
- Rotors and accessories must be made non-radioactive, non-pathogenic, non-toxic and otherwise safe prior to maintenance or repair. A signed statement must be included with the equipment.
- Do not scratch or otherwise damage the aluminum oxide layer that protects the underlying metal.
- Rotor cavities and buckets must never be cleaned with an ordinary bottle brush with sharp wire ends. Use special plastic coated brushes.
- Do not use alkaline detergents or cleaning solutions that may remove the anodized coating. Most commercially available solutions for radioactive decontamination are highly alkaline.
- If corrosive materials have been run or spilled on the rotor, wash it immediately.
- Clean all spills or breakage involving radiological, toxic, pathogenic or biological material immediately. Refer to appropriate safety guides for information.
- Only wash the buckets of a swinging bucket rotor. The body of the rotor should never be immersed: the hanger mechanisms are hard to dry and can rust.
- Air dry the rotor after it has been cleaned and thoroughly rinsed with water.
- Store all fixed angle vertical tube and near-vertical tube rotors upside down, with the lids or plugs removed.
- Swinging bucket rotors should be stored with the bucket caps removed.
- Store all rotors in a dry environment, not in the centrifuge.
- Use plastic or wooden tools to carefully remove O-rings or gaskets for cleaning.
- Lubricate O-rings and threads as recommended by the manufacturer.
- Observe warranty period and retirement recommendations for each class of rotor.
- Consideration should be given to retiring the rotor when the warranty period has expired.
- Do not use a rotor after the expiration date permanently marked (on some models) on the rotor or rotor accessories. The components must be taken out of service.

ROTOR PRECAUTIONS
- Ensure that the rotor and lid are clean and show no signs of corrosion or cracking.
- Ensure that the metal threads in the rotor are clean and lightly, but evenly, lubricated with silicone vacuum grease.
- Ensure that O-rings are present and clean, in place and lightly, but evenly, coated with silicone vacuum grease.
- Ensure that the rotor pins are not sitting ON the spindle pins. Attach rotor and check for movement.
- HANDLE rotors carefully; place rotors on clean soft surfaces only. NEVER sit or slide rotors on benches or any other surface. Take care to not hit the rotor against hard surfaces, especially the centrifuge spindle.
- NEVER run a rotor with a missing O-ring, the sample contents may be lost, leading to rotor imbalance, failure, and serious damage to the ultracentrifuge.
• Do not glob vacuum grease, apply a very fine/light coating to the threads and O-rings, if necessary.

SELECTION OF CENTRIFUGE BOTTLES OR TUBES
Consider the following, when choosing or using sample bottles or tubes:
• Rotor specifications for tube style, i.e., conical, round or flat bottom.
• Sample compatibility with tube materials.
• Volume of sample.
• Maximum allowable compartment mass.
• Relative speed required (g-force).
• Protocols to be used for loading and sample recovery.
• ALWAYS, examine tubes for signs of stress and discard tubes that look suspicious (i.e., discoloration, crazing, spots that do not come off, scratches, cracks, etc.).

PROLONG TUBE LIFE AND AVOID BREAKAGE OR COLLAPSE
• Autoclave tubes only if absolutely necessary and only at 100°C or less for 15 min.
• Avoid cleaning plastic tubes in automated dishwashers or glassware washers, which may produce excessively hot temperatures.
• Clean tubes with a mild laboratory detergent in warm water, rinse, and air dry.
• Tubes must be carefully matched with rotor type to prevent sample loss and/or failure.

Reference Source

Beckman and Sorvall Technical Guides
Stoney brook University
Stanford University
University of Georgia
Table 1

Algorithms for Balanced Microcentrifuge Rotor Loading

Requirements

- The rotor has \( n \) positions, such that \( n \) is divisible by 6, or
- If less than 6 an even number of positions.
- The number of samples is between 2 and \( n \), but not equal to \( n-1 \).
- Tubes and sample volumes are identical.

Algorithm A. Sample number is even:

- Load pairs of tubes in opposite positions

Algorithm B. Sample number is odd:

- Load three tubes at equal intervals in the rotor, forming an equilateral triangle.
- Load the remaining tube in pairs in opposite positions.

Credits on this page
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Also http://web.stanford.edu/dept/EHS/prod/researchlab/lab/centrifuge.html
Vertical Rotors
In a vertical rotor the tubes are vertical during rotation.

Near Vertical Rotors
The near-vertical tube rotor angles the sample tube slightly off vertical—somewhere around 7.5 to 9 degrees.

For a discussion on centrifuge rotor selection and maintenance see: Centrifuge Rotor Selection and Maintenance, by Tammy Goodman. Link below


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