LAB SAFETY

Working with Centrifuges

OVERVIEW

Earth's gravitational force is capable of separating heterogeneous mixtures. However, many systems avert this type of separation owing to the length of time usually required in such cases. Centrifugation is one of the most powerful tools for the separation of heterogeneous mixtures[1]. It involves the application of centripetal force for sedimentation of the heavier phase, leading to separation of the two phases, and is a commonly used technique in industrial and laboratory settings.

In a typical centrifugation process, particles suspended in a fluid are spun about the centrifuge axis of rotation, causing a force away from the axis. This force drives the particles to the bottom of the centrifuge sample holder at a rate which is dependent on the size and density of the particles. Centrifugation is therefore a technique to speed up the process of sedimentation.

To ensure safety in the usage of a centrifuge, the user should be properly trained and made aware of the hazards that might result from its usage. The following sections present a discussion of handling and safety while working with centrifuges.

PRINCIPLES

A centrifuge consists of three basic parts-a rotor, a drive shaft, and a motor[2]. The rotor holds the tubes, bottles, or bags containing the liquids to be centrifuged. It is usually made of a high strength material, such as an aluminum alloy or stainless steel. Different rotor types and sizes, interchangeable with one another, can be mounted on the drive shaft, which connects to the motor. The motor provides the power to turn the rotor. Usually, a secure cabinet surrounds and supports these parts. The operating controls and indicator dials for speed and time are mounted on the cabinet. Most centrifuges have a brake system to bring the rotor to a standstill shortly after the run isfinished. Many centrifuges are also refrigerated to prevent delicate biological samples from getting warm, since samples tend to heat up during the centrifugation process. There are both low-speed and high-speed instruments for centrifugation. Centrifuges which operate at speeds up to 10,000 rpm are considered low-speed instruments, while high-speed instruments operate at speeds up to 21,000 rpm. Ultracentrifuges can exceed rotation speeds of 30,000 rpm.

Due to the high speed at which a centrifuge operates, it can cause serious injury to the user if mishandled. The hazards caused by centrifugation are connected primarily either to mechanical failure or dispersion of aerosols. The centrifugal force on the rotor causes a load on the rotor of the centrifuge, leading to small change in the dimensions of the metal. Rotors are designed to withstand a stress threshold and be able to return to their original resting-state dimensions. However, if this threshold stress is exceeded, the rotor maybe permanently deformed. Cracks and other wear will lead to deterioration of the rotor over time, compromising safe operation of the centrifuge. If a hazardous material leaks within the rotor or body of the centrifuge, it can pose potential hazards to the user and others present in the surrounding area. Hence, it is important for all users to follow standard steps for the safe operation of centrifuges and to be trained to handle situations in case of operation failure or other hazards. The user should never become complacent when working with low-speed instruments. They can still cause significant injuries to the user.

PROCEDURE

1. General Protocol for Safe Centrifuge Usage

1. The laboratory supervisor or laboratory safety officer should ensure all users are properly trained in the selection of the rotor, sample tube, and proper operation of the centrifuge.
2. Any new user should be closely supervised by a trained user until he/she is confident on how to properly use the instrument.
3. Prior to using the instrument, each user should carefully read and understand the safety instructions for the specific centrifuge.
4. Depending on sample, compatible rotors should be used.
5. The rotor, tube, and spindle should be clean, dry, and free from cracks or deformities.
6. The O-rings should be checked for any wear or cracks.
7. It is important to make sure that the tubes used for centrifugation are compatible with the sample and the rotation speed (low, high, or ultra).
8. The centrifuge tubes should not be filled more than three-fourths of their maximum fill level.
9. The tubes should be capped tightly.
10. It is extremely important to balance the tubes opposite to each other. Failure to do so may lead to incomplete separation and, in extreme cases, can cause dispersion of the tube contents in the housing of the centrifuge.
11. Before turning on the centrifuge, the rotor should be checked to ensure it is correctly seated on the drive and the lid is properly closed.

12. The lid should be kept closed at all times when the centrifuge is in operation, and should never be open until the rotor completely stops.
13. The operator should remain in the vicinity of the centrifuge until it has safely reached the target operation speed. In the case of unusual sounds or vibrations, the instrument should be immediately turned off. The speed limit of the instrument should never be exceeded. Upon turning off, allow sufficient time for the rotor to slow down to a stopped position. Modern centrifuges have indicators that will signify that it is safe to open the centrifuge.
14. Once the centrifugation is over, samples should be removed and the instrument should be checked for any spills or leaks. If necessary, the rotor should be cleaned thoroughly.

2. Additional Precautions While Handling Hazardous Chemicals or Infectious Materials

1. When using hazardous chemicals or biological samples that might be infectious, it is important to label the instrument while in usage to alert other workers to the danger.
2. Appropriate gloves[1] should be worn to handle hazardous samples.
3. Sealed safety tubes should be used. It is preferable to use secondary confinement, if available, for the centrifuge tubes. These are usually in the form of plastic or glass inserts that are placed directly in the sample buckets of the centrifuge.
4. Once the centrifugation is over, the tubes should be removed from the rotor and opened only in the fume hood or biological safety cabinet, as applicable.
5. Cleaning, if required, should be done with extreme care, so as to not expose the operator to hazardous chemicals or infectious materials. In case of spills of such samples, see step 3, Emergency Situations, below.
6. For specific types of hazardous samples, it may be preferable to maintain standard procedures and cleaning protocols in laboratory. These should be reviewed and updated accordingly, as necessary.

3. Emergency Situations and Their Safety Measures

An emergency situation may arise if the rotor malfunctions or if there is a spill in the centrifuge due to tube breakage or mishandling. In such situations, the following steps should be taken.

1. The centrifuge should be turned off immediately and the lid should be kept closed until others are notified and evacuate the location. The power should be terminated at the power button on the instrument. The button will be located either on the front, side, or back of the instrument. The user should familiarize themselves with its location. If the power button is malfunctioning, then the user should remove the main power plug from the wall socket.

2. To reduce the risk of aerosols, it is sometimes better to leave the centrifuge untouched for at least 0.5 h. Consult with the centrifuge technical document.
3. For cleaning up spills, the operator should be well acquainted with the sample being used and should wear proper attire including lab-coat, gloves, facial shield, and safety glasses.
    1. Once cleaned, the spilled material should be properly disposed of and the contaminated protective clothing should be disposed of or cleaned properly. Hands and any exposed skin should be washed thoroughly.
4. If overtly exposed to highly hazardous materials, 911 should be called or immediate medical attention should be administered to the afflicted person.

4. Maintenance of the Centrifuge

NOTE: The body of the centrifuge is usually made from metals that can corrode in the presence of moisture, chemicals, or strong cleaning agents. For proper maintenance of the centrifuge, it is recommended to carefully follow the manufacturer's instructions for cleaning and maintenance. Other than that, a few general measures for maintenance to be kept in mind are as follows.

1. The centrifuge should always be kept clean and dry.
2. Any kind of spills should be immediately cleaned.
3. The rotor should be decontaminated after use with biological and radioactive materials. It is recommended to use 10% bleach for 30 min followed by 70% ethanol, letting the rotor air dry.
4. Abrasive brush wires should never be used to clean the rotor and associated parts.
5. The rotor should be inspected after each use by the operator and at least annually by manufacturer inspector.
6. A log book should be maintained for each centrifuge to keep a record of users, samples, and service history. Additionally, copies of any warranty-related materials can be included in this log book.

APPLICATIONS AND SUMMARY

With the increased usage of centrifuges in laboratories and industry, the risk of hazards for using centrifuges has also increased. However, careful handling of the apparatus and proper knowledge of its use and safety measures can substantially mitigate accidents. A basic guideline for working with centrifuges is provided here. Nonetheless, procedures may vary marginally depending on the particular centrifuge machine used. Hence, it is always recommended to carefully read and understand the user manual of the particular machine before starting to use it.

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