

## HIGH SPEED CENTRIFUGE INCIDENT

In April 2009, a catastrophic rotor failure occurred at a University location with a Sorvall Discovery 90 centrifuge. The failure emphasizes the importance of exercising extraordinary caution in the use of such equipment. Although the centrifuge utilized a Surespin 630 Rotor, a swinging-bucket rotor, **user caution should be directed towards all high-speed centrifuges, regardless of brand**, particularly when swinging buckets are used.

The incident occurred immediately after the principal investigator had instructed a graduate student in a protocol where DNA extraction utilizing cesium chloride was to occur. The lab's established protocol required two people to be present, where one individual witnessed each step of the protocol the other researcher was following. Once all the preparation work was completed and each tube's weight was verified to be the same, the tubes were seated in the bucket of the rotor, the centrifuge door was closed, the speed and time were programmed into the centrifuge, and the cycle begun. Since this rotor was rated at 30,000 rpm, the estimated time for the spin was determined to be 72 hours. After a few minutes of operation the unit got to the established speed. Approximately 8 minutes later, the rotor failed.

Sorvall Discovery 90 Centrifuge



Damaged Surespin 630 Rotor



Basket of Centrifuge



**Fortunately, this centrifuge's door was designed to contain the tubes, bucket and rotor in the event of a catastrophic failure. The unit operated as designed and contained these materials inside the unit. Fortunately, no one was injured.**

Although the sales brochure for the Surespin 630 states the unit is ideal for use with cesium chloride, their information sheet says the rotor can be run at 30,000 rpm with a sample "design density" of 1.2 g/ml. The operating manual of the Surespin 630 provides several warning/cautions statements. The pertinent ones for this situation included:

- Never exceed the maximum rated speed of the installed rotor; to do so can cause rotor failure.
- Always reduce (derate) rotor speed whenever:
  - The load exceeds the maximum allowable compartment mass (the average fluid density is greater than 1.2 g/ml). See chapter 2, Operation.
- When compartment loads exceed design mass, the maximum rotor speed must be reduced using one of the formulas provided. Failure to do so can result in rotor failure.
- This method is not appropriate for calculating reduced speeds when running gradient materials that could precipitate, such as cesium chloride. Precipitation of crystallized cesium chloride produces stresses far in excess of the design limits of the bottom of the rotor buckets.

The calculation for the maximum rotor speed, especially when cesium chloride is used, is as follows:

$$\text{Reduced Speed} = 30,000 \times \sqrt{\frac{1.2}{\text{Average Fluid Density (g/ml)}}}$$

For the procedure resulting in the rotor failure, 0.98 g/ml of cesium chloride was used. The MSDS for cesium chloride states that the chemical has a density of 3.99 g/ml. Inserting this information into the equation gives:

$$\text{Reduced Speed} = 30,000 \times \sqrt{\frac{1.2}{3.99}} = 16,500 \text{ rpm.}$$

Note: manufacturers also recommend that rotors be derated by about 10% after the rotors are used for 1000 runs. Had this rotor been used extensively, the maximum allowable speed would have been even less (in this case, 14,850 rpm).

## LESSON LEARNED

Many manufacturers can provide researchers with special programs to determine the maximum speed for a rotor. In a University setting, it is especially important to make sure newer personnel understand the hazards of the equipment and materials being used. In addition to the hazard recognition and training of personnel for the safe operation of rotors in centrifuges, EH&S recommends a warning be placed in a prominent location on their centrifuge stating:

**DANGER**  
ALWAYS determine the  
 maximum allowable speed for the  
 density gradient of the material  
 (cesium chloride, sugars)

Whenever a high-speed centrifuge gives off sound different from normal, the centrifuge should be stopped immediately. Even though the dynamic brake will be disabled, such an emergency shutdown should be performed remotely (e.g. stopped at the electrical breaker feeding the centrifuge). Do not go near the machine until it is stopped, or nearly so. This may take considerable time, depending on aerodynamic drag.

Although all high-speed centrifuges are heavily armored for protection from horizontally propelled rotor pieces, some have covers that can resist only minimal vertical forces and could fly open, permitting violent escape of rotor parts or liquids. No one should have a workstation adjacent to the centrifuge; there should be an exclusion area of 15 feet or more in radius. (Some of the missiles from the failed centrifuge bounced and ricocheted even further than this.)

Fixed angle rotors are recommended for dense gradients because the stresses of cesium chloride gradient and possible precipitation is distributed along the centrifugal wall (a larger area) of the tube cavity instead of the bottom of the bucket (a small area) of the swinging bucket rotor.

If you need any assistance in high-speed centrifuge safety, call EH&S at x5-3241.