

Standard Operating Procedure

SOP089

Title: Use and Maintenance of Micro Centrifuges

Location: CBE Laboratories and T208b in Wolfson

1. PURPOSE

The intent of this SOP is to describe procedures for the operation and maintenance of the bench standing micro centrifuges. This document covers the following centrifuge models currently found in the CBE laboratories. Any additional equipment brought into the laboratories may require an additional SOP or a subsequent review of this SOP before use.]

2. SCOPE

This SOP applies to micro centrifuges only. This standard operating procedure describes a method for operating and maintaining the various micro centrifuges within the CBE laboratories. Certified and hermetically sealed accessories (e.g. rotors, buckets, or safety cups) Must be used for applications involving the centrifugation of infectious, toxic, or pathogenic material.

This SOP covers the following Micro centrifuges:

- Fisher Accuspin Micro 17 R (H23)
- Fisher Accuspin Micro 17 (H34)
- Fisher Accuspin Micro (H27)
- Sigma 1-14 (H21)
- Heraeus Pico 21 Micro (H34)
- Centrisart A-14 (H23)
- Minispin Eppendorf (T208b)

SPECIAL NOTES: HEALTH & SAFETY

Users **MUST** read all Precautionary Statements in the appropriate operator's manual and should refer to the Guidelines in Annex 1 for further recommendations on the safe use of centrifuges.

2.2 Hazards associated with use of centrifuge

- Mechanical failure of rotating parts (often violent).
- Contact with rotating parts.
- Sample leaks causing aerosols, stress corrosion, contamination.
- Sample imbalance causing machine movement/walking
- Fire/explosion.
- Contact with contaminated components/vapours.

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2.3 Safe Working practices (also refer to Safety Note in Operator Manual)

- (i) Ensure that the centrifuge is placed on level surface and there is a clearance of at least 30 cm around the centrifuge when in operation. Make sure that hazardous materials are not stored or placed within this area and there is sufficient ventilation.
- (ii) The centrifuge should not be placed in a safety cabinet unless an operator protection factor (KI Discus) test has been carried out with it running in situ and it is shown not to compromise operator protection.
- (iii) Always observe the start-up checks detailed in this SOP before using the centrifuge.
- (iv) Do not centrifuge toxic, pathogenic, or radioactive material without taking proper precautions for aerosol containment.
- (v) Do not centrifuge substances which could damage or affect the mechanical strength of the material of the centrifuge, the rotor or the buckets. See Operators Manual for details of chemical resistance to plastics.
- (vi) Do not centrifuge materials capable of developing flammable or explosive vapours.
- (vii) Never attempt to slow rotor by hand.
- (viii) Only use the rotors and accessories specified by the manufacturer. If unsure of which rotor or tube to use, ask Responsible Person or call the manufacturer.
- (ix) Never exceed the maximum speed for the rotor. NOTE: The centrifuge is equipped with an automatic rotor identification system. The system performs an automatic rotor check after the start. If a rotor other than the preselected one is installed, the system will display the installed rotor and the pre-selection speed will be corrected if necessary.
- (x) **Use only the correct designated tubes for the rotor.** Do not modify them to make them fit unless using attachments authorized by the manufacturer. **NEVER USE GLASS CONTAINERS IN THE CENTRIFUGE.**
- (xi) Avoid overfilling tubes or bottles.
- (xii) Place centrifuge vessels symmetrically so that the rotor is loaded evenly. Load vessels outside the centrifuge. Fill vessels carefully to same weight. Imbalance will result in increased wear of bearings.
- (xiii) Stay at the centrifuge until it is running smoothly. Shut the machine down immediately if there is any unusual noise or vibration. Report non-resolvable issues to the Laboratory Manager.

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- (xiv) Do not open the door until the rotor stops spinning.
- (xv) Always check for spills. If you find one, clean the centrifuge and rotor thoroughly (Refer to SOP038).
- (xvi) Always clean the equipment after used with salts or corrosives.
- (xvii) Check that the replacement of time-expired components are made according to the manufacturer's Instruction - use rotors or buckets which have exceeded their maximum operating life.
- (xviii) When centrifuging infectious materials, use capped or sealed containers and aerosol containment sealable buckets

3. RESPONSIBILITIES

3.1 CBE Laboratory Personnel:

- (i) Shall ensure that they are familiar with the centrifuge, its controls, requirements, and emergency procedures by reference to this SOP, and the Manufacturer's Operating Instructions.
- (ii) Shall be an experienced centrifuge user or will have received appropriate training. Before a new user is allowed to operate a centrifuge on their own, competence to operate the centrifuge must have been assessed by the responsible person or another experienced user.
- (iii) Shall ensure that the centrifuge is suitable for the work they intend to carry out.
- (iv) Shall record alarms, adverse events, nonconformances or malfunction on the Equipment Maintenance record and notify the Laboratory Manager/Responsible person.
- (v) Shall complete the cleaning/maintenance procedures as required and record in the relevant sections on the Equipment Maintenance Record.
- (vi) If applicable, shall notify Responsible Person when there remains only three months prior to the end of the maximum operating life of the rotors, buckets, and lids. Date of production for rotors and accompanying buckets is engraved on the rotor/bucket four-digit form (e.g. 10/98 October 1998).

3.2 The Responsible Person/Laboratory Manager:

- (i) Shall ensure laboratory personnel are given suitable Information, instruction, training or supervision in the safe use and maintenance of the equipment, providing the following:
 - information on the hazards and risks to health
 - instruction in safe procedures

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- training, where necessary; and effective supervision to ensure, so far as is reasonably practicable, that centrifuges are operated without risks to the health of employees and other persons, i.e. including students and visiting research workers
- (ii) Shall ensure that the centrifuge and rotors are properly installed and set properly according to the Operators Manual.
- (iii) Shall coordinate weekly maintenance duties to be performed by laboratory personnel as part of the lab duties.
- (iv) Shall regularly review maintenance logs and investigate and reported alarms, adverse events or non-conformances associated with the centrifuge.
- (v) Shall schedule servicing and preventative maintenance with authorized service representatives. External maintenance and servicing of the equipment can only be performed after it has been suitably disinfected (see SOP003) and a 'Decontamination Certificate' has been issued (a proforma is available on the CBE LEARN page).

4. EQUIPMENT AND MATERIALS

1. Fisher accuSpin Micro (H34) x3
2. , Micro 17, Micro 17R,(H34)
3. Hereus Pic021,
4. Minispin Eppendorf (T208b)
5. Sartorius Centrisart A-14, (H25)
6. Sigma 1-14.(H21)
7. Specified centrifuge vessels: 2.0 ml and 1.5 ml Eppendorf or micro centrifuge tubes (Maximum centrifugation RCF: 17,000 g)
8. 70%IMS/Chemgene
9. 2% detergent (Neutracon)

5. PROCEDURE

5.1 Pre-run checks

NOTE: A safety inspection outlined below must be carried out before each use.

NOTE: Lifetime of the Rotor: There is no limitation on the service life of the high-performance rotors.

CAUTION: Centrifuging can produce aerosols and therefore bio-hazardous material **MUST NOT** be centrifuged in open containers. Sealed containers provide initial protection but should be reinforced by the use of sealed buckets or rotors, which reduce hazard if the container collapses.

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Before each centrifuge run:

- (i) Inspect all the safety relevant parts of the centrifuge i.e. rotor and accessories (e.g. cover seal, adapters and rotor tie down screw) for cleanliness and visible signs of damage, or wear, abrasion or discolouration or wear e.g. cracks, nicks, chemical degradation, pitting or corrosion.
- (ii) Inspect buckets and centrifuge tubes for visible signs of damage, deformation, or wear (e.g. cracks, nicks, chemical degradation, pitting or corrosion).

CAUTION: If any sign of visible damage or wear is detected, DO NOT USE the centrifuge. Consult the Responsible Person and record the outcome of the inspection on the Equipment Maintenance record.

NOTE: Slight scratches and cracks can cause severe inner damage to the rotor materials, which are difficult to detect with the eye. If in doubt, DO NOT USE the rotor.

- (iii) Fill sample containers only within the range recommended by the manufacturer. Never fill sample containers when they are mounted in the centrifuge unless contained in a head specifically designed for this method of filling.
- (iv) Distribute the load symmetrically around the rotation assembly so that it is evenly balanced and complies with the manufacturer's instructions in this respect. Always consider all components when balancing.
- (v) Select a centrifuging speed up to the maximum recommended by the manufacturer according to the head and accessories to be used or to the recommended reduced speed if the sample has a high density.
- (vi) Follow the manufacturer's instructions for starting and (where the control is not automatic) for increasing the speed of rotation.
- (vii) Make certain the rotor tie down nut is secure before starting the centrifuge. Check that the rotor is seated on the drive hub correctly.
- (viii) Make sure the bowl is dry and that the drive spindle is clean. In the event of condensation water formation, dry the centrifugal chamber by wiping out with an absorbent cloth

5.2 Inserting and removing the rotor

NOTE: Rotors permitted for use in the micro centrifuge are detailed in the Operator Manuals. **It is not permitted to use any other rotor other than those designated by the manufacturer.**

To insert or remove the rotor follow the steps described in the Operators manual.

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CAUTION: The rotor may be inserted only if the temperature of the drive, the rotor and cap nut is between 10C and 30C

CAUTION: The rotors are only to be used within the temperature range from -4C to +40C. Pre-cooling in the freezer IS NOT permitted.

5.3 Loading the Rotor

CAUTION: Overloading may cause the rotor to explode! NEVER EXCEED THE MAXIMUM PERMISSIBLE LOAD OF 4 g PER PLACE

The safety system presupposes that the maximum permissible load of the rotor is not exceeded. If the user wishes to centrifuge samples that together with the adaptors exceed the maximum permissible load, the user **MUST** either reduce the sample volume or calculate the permissible speed N_{perm} according to the following formula:

$$N_{perm} = n_{max} * \text{SQRT}(\text{max permissible load/actual load})$$

5.3.1. Filling the Centrifuge Tubes

NOTE: The smaller the imbalance of the centrifuge, the better the separation since the separated zones are not perturbed by vibration. It is therefore important to balance the centrifuge tubes as well as possible.

- (i) Check carefully whether the sample vessels are permissible for the respective g value and reduce speed if necessary.
- (ii) Check that the sample containers are suitable for the centrifugal application desired.
- (iii) To minimise unbalance, fill the tubes as evenly as possible. This can be achieved by eye but must ensure that opposite tubes are filled to the same level.
- (iv) Observe the permissible filling volumes:

<u>Nominal volume:</u>	<u>Permissible Volume:</u>
2.0ml	1.5ml
1.5ml	1.0ml
Others	2/3 nominal volume

NOTE: Plastic sample vessels only have a limited service life — particularly when used at maximum rpm or temperature — and must be replaced when signs of damage or wear are observed.

5.3.2 Placing the tubes in the rotor

- (i) Always load the rotor symmetrically.

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- (ii) If partially loading the rotor, ensure that opposite bores always receive tubes of equal weight (when centrifuging a single sample, place a centrifuge tube filled with water opposite.)
- (iii) When loaded, fasten the rotor lid by screwing the cap nut centrally on it.
- (iv) Close the lid of the centrifuge by firmly pressing it down. Ensure that this is accompanied by a clicking sound and that the lid is locked so that it cannot be opened manually.

5.4. Selecting the run speed, time, and temperature

Refer to the Operators manual for instructions on setting the run speed, run time, and run temperature.

5.5. Starting and Stopping the Centrifuge

Once the rotor is in place, the main switch turned on and the lid closed the centrifuge can be started.

- (i) Press the "start" key in the control panel. The centrifuge will accelerate to the preselected value.

NOTE: The rotating light indicates that the centrifuge is running. The lid cannot be opened during the run.

- (ii) If a pre-selected run time has been selected; as the speed approaches zero, the display reads "End". Press the "open lid" key and remove the samples.
- (iii) If a continuous run operation has been selected; press the "stop" key in the control panel.

NOTE: Refer to the operator's manual for procedures for emergency (manual) lid release.

Stay at the centrifuge until it is running smoothly. Shut the machine down immediately if there is any unusual noise or vibration. Report non-resolvable issues to the Laboratory Manager.

6 Preventative Maintenance

- i. Pre-run checks include daily inspection of the rotor chamber, rotor and accessories before use.
- ii. Weekly safety checks must be done as part of weekly housekeeping tasks.
- iii. Refer to operator manuals for cleaning procedure. In brief, ensure the centrifuge is turned off, unplugged and all parts removed. Use warm water with neutral solvent (neutracon) and rinse with distilled water. Dry all parts with a soft cloth. Treat the entire surface of aluminum parts with anti-corrosion oil (including cavities).
- iv. For cleaning before and after use, use 1:50 Chemgene solution to wipe down all accessible surfaces, taking care not to remove the grease from the rotor bold and bucket hinges.
- v. Centrifuges must be inspected and serviced every 2 years by Centriservices.

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- vi. Any maintenance should be recorded in the equipment maintenance record sheets on door to respective laboratories.

6.1 . Rotor Care and Use

EVERY MONTH:

This should be done by the responsible person for the equipment and recorded on the equipment maintenance that it has been done.

- i) Check all of the safety-relevant parts of the centrifuge i.e. rotor and accessories, for any visible signs of damage, wear/abrasion, malformation, or discolouration (e.g. cracks, corrosion). If visible damage of the surface, a crack, or corrosion, is detected the part (rotor, etc.) must be replaced immediately.

NOTE: Chemical reactions as well as stress-corrosion (combination of oscillating pressure and chemical reaction) can affect or destroy the metals. Hardly detectable cracks on the surface expand and weaken the material without visible signs.

- ii) If the rotor is not kept clean and chemicals remain on the rotor, corrosion will result. Moisture left for extended periods of time can also initiate corrosion. It is important that the rotor is left clean and dry after use. (Wash with mild detergent and warm water using a nylon bottle brush, if necessary). Dry the rotor thoroughly and store upside down with the cover and tubes removed.
- iii) To avoid corrosion, do not expose aluminium rotor components to strong acids or bases, alkaline lab detergents, or salts (chlorides) of heavy metals (e.g., caesium, lead, silver, or mercury).
- iv) Check that the centrifuge chamber, drive spindle, and tapered mounting surface of the rotor are clean and free of scratches or burrs.

CAUTION: Damaged rotors MUST NOT be used

- v) Make sure rotor, tubes, and spindle are dry and that the rotor is properly seated and secured to the drive hub. Do not operate the centrifuge without the appropriate rotor cover securely fitted with seals in place.
- vi) If the temperature of the chamber is below room temperature, pre-cool the rotor to the lower temperature before securing the rotor (this will minimize the chance of it seizing to the tapered spindle).
- vii) Never exceed the stated maximum speed for any rotor.
- viii) Balance the rotor to within the limits specified (take care that materials of similar densities are in opposite positions of the rotor).
- ix) Check the concentricity of the motor shaft:

- Visual inspection: Slowly rotate the rotor by hand without the rotor fastening nut. If the motor shaft does not turn around on a perpendicular axis, the motor and motor shaft must be replaced.

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- Refit the rotor correctly after visual inspection (Refer to Operators Manual - Installation of Rotors and Accessories).
- x) Check the unit for atypical running noises.
- xi) Check that all screw connections are tight.
- xii) Record the outcome of the operator inspection in the Equipment Maintenance record on the door to respective laboratory. Consult the Responsible Person/Laboratory Manager if any signs of wear and tear, damage or corrosion are detected

6.3 Tube Care

- (i) Before use, tubes should be checked for cracks. The inside of cups should be inspected for rough walls caused by corrosion and adhering matter should be removed. Metal or plastic tubes (other than nitrocellulose) should be used whenever possible.
- (ii) Make sure each tube compartment is clean and corrosion free.
- (iii) Tubes must be properly balanced in the rotor.
- (iv) Check compatibility of the tube material to the solvent medium (some solvents may cause the tubes to swell or crack in the rotor).
- (v) Never fill centrifuge tubes above the maximum recommended by the manufacturer.
- (vi) Use only correctly fitting tubes.

6.4 Centrifuge Cleaning

- (i) This is the responsibility of the responsible person (or any laboratory user if the centrifuge is found in need of cleaning). All equipment maintenance or cleaning must be recorded on the equipment maintenance records on the door to the respective laboratory.
 - (ii) Any liquid spilt in the centrifuge should be removed immediately. Please refer to SOP038 Biological spill response.
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- At the end of each day's use of the centrifuge, clean (as below) and dry the inside of the centrifuge chamber, all parts of the rotation assembly and any head accessories used. In order to reduce

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corrosion, inserts and adaptors should be removed after use to allow adequate cleaning and drying. Ensure that the manufacturer's recommendations on cleaning materials are followed.

- The centrifuge should be cleaned every month and/or after 200 hours use (this is indicated by a message displayed in the centrifuge panel)

EVERY MONTH:

- (i) Open the lid of the centrifuge and disconnect the main power plug.
- (ii) Unscrew the rotor with the rotor key provided and clean separately.
- (iii) Clean and dry the rotor and inside of the centrifuge with 70% IMS solution and 2% detergent solution (Fisher Brand)
- (iv) After cleaning with detergent, rinse the rubber seals in the rotor chamber with water and then lubricate with glycerine. This prevents the seals from becoming brittle.
- (v) Check the rotor, housing, and rotor bores monthly for residue and corrosion. Clean the rotor with 2% detergent solution (Fisher Brand). As a reminder, the message "clean rotor" appears in the display of the centrifuge three times after every 200 runs.
- (vi) Lightly lubricate the buckets/accessories with the lubricant provided by the manufacturer (grease for pivots); although care must be taken to ensure that the buckets can still swing freely.

NOTE: Only neutral agents may be used for cleaning and disinfection.

NOTE: The rotor chamber should only be cleaned with moist absorbent paper.

6.5 Spill Response and sterilisation and Disinfection of centrifuge parts

NOTE: The centrifuges and the accessories consist of different materials and possible incompatibility must be considered. Before using detergents or decontamination agents, which have not been recommended by the manufacturer, the user should contact them to make sure that such procedure would not damage the centrifuge.

Where a spill, leak or breakage is detected within the centrifuge, the centrifuge **MUST** be disinfected immediately. The procedure will depend upon the risk group of the agent. If there is reason to believe that a breakage may have occurred whilst the centrifuge was running, adopt the following procedure:

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- i) If centrifuge contamination is identified after the lid of the centrifuge is opened, carefully close the lid and turn off the centrifuge.
- ii) If centrifuge contamination is identified whilst the centrifuge is running, turn off the centrifuge.
- iii) In both cases DO NOT open lid as the bowl may contain an aerosol if the centrifuge tube or its seals have failed. ADOPT THE FOLLOWING PROCEDURE:
- iv) Wait at least 30 minutes before opening the lid to allow aerosol to settle.
- v) Place notice on the lid to alert others and notify Responsible Person.
- vi) Put on clean disposable gloves and full-face protection. Respiratory equipment may be required — seek advice from Responsible Person.
- vii) After 30 minutes, transfer the centrifuge to BSC only if the external surface is dry. If the external surface appears to be wet, wipe the external surface with virkon solution followed by 70 % IMS solution. CAUTION: DO NOT EXPOSE METAL PARTS TO VIRKON FOR MORE THAN 10 MINUTES.
 - (viii) Carefully open the lid inside the BSC.
 - (ix) Carefully retrieve any broken tubes with forceps and place in sharps container.
 - (x) Remove the rotor, bucket, accessories, and the lid. If practicable autoclave or alternatively soak in Virkon solution for 10 minutes. Thoroughly wipe down with 70% IMS. Place the rotor back into the centrifuge after ensuring the rotor and the components are dry.
 - (xi) Remove PPE and contaminated clothing. Place all contaminated PPE in an autoclave bag/container for decontamination (reusable items) or disposal as biohazardous waste.
 - (xii) Wash hands and other potentially contaminated areas with soap and water.
 - (xiii) Inform lab staff when clean-up is complete.
 - (xiv) Inspect the centrifuge for defective and damaged components. Retain all components and debris for inspection. Do not use centrifuge or rotor again until authorised by the Responsible Person.

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6.7 Centrifuge Malfunction

- (i) If any part of the equipment fails or malfunctions, including faults or defects, indicated by vibration, noise or by failure to operate, the user should contact the Laboratory Manager/Responsible Person. With permission of the Laboratory Manager or Responsible Person the user should consult the Operator Instruction Manuals to access fault finding, error displays and troubleshooting procedures.

CAUTION: DO NOT ATTEMPT TO REPAIR THE CENTRIFUGE YOURSELF

- (ii) All problems and corrective actions should be recorded in the Equipment Maintenance record.
- (iii) If the equipment fails to work or malfunctions and cannot be rectified according to troubleshooting procedures detailed in the Operator and Users Manuals the Laboratory Manager must be informed and the centrifuge must be tagged and locked-out or "Do Not Use" notice posted on the equipment. Contact the manufacturer for advice and coordinate with the Lab Manager for external maintenance and servicing.

NOTE: Centrifuges in need of repair should be tagged and locked-out (or "Not in Use" label applied) while awaiting service.

- (iv) External maintenance and servicing of the equipment can only be performed after it has been suitably disinfected (refer to SOP003 for further details) and a 'Decontamination Certificate' has been issued (a proforma is available on the CBE LEARN page). NOTE: A 'Declaration of decontamination'; available in the Operators Manual may also be required. Permit to works must be completed for external co

6.8 Centrifuge/Rotor Decommissioning Checklist and Decontamination Procedures

- (i) If the centrifuge or rotor needs to be decommissioned, for example due to relocation or change of use, it is necessary to ensure no hazardous materials are left behind and that the unit has been decontaminated and made safe for future use or removal. A checklist that can be used to record that the centrifuge or rotor has been suitably decommissioned is provided in Section 6.
- (ii) On completion, the form should be forwarded to DSO or another responsible person to request its disposal. If multiple items need to be disposed of together from the same room, it may be possible to use one form — as long as each item is listed and each has a "Safe for Disposal" sticker / note on it to confirm that appropriate cleaning/disinfecting has been carried out. A completed decommissioning checklist precludes the need for maintenance staff and contractors to be issued with a Laboratory Permit to Work.

6 Documentation

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The following records are outputs of this SOP:

- 6.1. QS-From-006 Centrifuge decommissioning checklist
- 6.2. QS-Form-009 Generic equipment decontamination certificate.
 - Weekly Housekeeping sheet
 - Lab Equipment Maintenance Record.

These records will be filed in the equipment file or otherwise archived for future review or retrieval. The records following are outputs of this SOP:

SOP History

Version Reviewed	Date Revised/ Reviewed	Revision Summary	New Version Number
001	14.04.10 M. Win Naing & C. Kavana h	Annual Review — Minor editorial revisions. New version issue not required.	Not issued
001	09.05.11 p.Hourd	Revised record sheets according to actions identified in CAPA035	002
002	16th October 2012 C.Kavanagh	i) Added H27 to the title as another identical centrifuge is located in this area too. ii) Added 70% IMS and 2% detergent to equipment section iii) Transferred to the new lean SOP form iv) Added that the housekeeper is now responsible for the monthly centrifuge inspections v) Added that services occur every 2 years.	003
003	25/06/2018 J.Harriman	Changed to a general SOP for all micro centrifuges within the CBE.	004
004	02/06/2020	Updated SOP with all microcentrifuges within the CBE, and also removed the form for Preventative Maintenance of centrifuges	005

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Annex 1 : Safe Use of Centrifuges (Extracts from BS4402)

Moving parts in centrifuges can reach very high kinetic energies. Breakage of a rotor or accessories inside the centrifuge releases large amounts of energy, and debris can be expelled at high speeds from the centrifuge; bodily movement of centrifuges for a distance of several metres can also occur in this situation.

Modern centrifuges must be designed and manufactured to British Standard BS 4402: 1982, Safety Requirements for Laboratory Centrifuges. This Standard is intended to ensure that the casing of the centrifuge will contain the debris of components which break inside it and to ensure that centrifuges are fitted with necessary interlocks and other safety devices.

It is important that all users of centrifuges are properly trained in the safe use and maintenance of the equipment.

Appendix B of BS 4402 gives advice on the use of centrifuges and part of it reads:

'RECOMMENDATIONS ON THE USE OF CENTRIFUGES'

B.1 Recommendations applying to all centrifuges

B.1.1 Introduction: When running, a centrifuge has considerable kinetic energy and even a small 'bench centrifuge' not complying with the requirement of this British Standard can expel debris, or even move bodily, for a distance of several metres in the event of mechanical failure. While considerable effort goes into the design and construction of centrifuges to try to minimise the hazards, sensible use is also important for the safety of operators and others in the laboratory.

B.1.2 Installation: It is essential that all centrifuges be fixed to the working surface, following the specifications and recommendations of the manufacturer for suitable fixings and fixing details. Care should be taken to ensure that the working surface and its substrate are strong enough to withstand the maximum forces of rotation and translation expected at the fixings in the event of a disruption of the rotation assembly (see instruction manual) A centrifuge may move abruptly in the event of such a disruption, in spite of the fixings, but the distance will be limited if the centrifuge is correctly fixed.

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- B.1.3 Training of Operators:** Training in the operation of the centrifuge should be carried out by an experienced user or (by arrangement) by the manufacturer's representative, and should be given to all operators of the centrifuge before they are permitted to use the centrifuge.
- B.1.4 Precautions to be taken when using centrifuges:** Note: attention is also drawn to recommendations given in BS5345 and to the "User Guide for the Safe Operation of Centrifuges" published by the Institution of Chemical Engineers
- B.1.4.1. Inspect each sample container and head accessory and all seals (if any) before filling. Reject any which are damaged or not authorised by the manufacturer, since such components could cause unsatisfactory sealing, breakage or jamming in the centrifuge head.
- B. 1.4.2 Fill sample containers and head accessories only within the range recommended by the manufacturer and avoid contamination outside the seal of a sealed head or sealed bucket. Never fill sample containers when they are mounted in the centrifuge unless contained in a head specifically designed for this method of filling.
- B. 1.4.3 Distribute the load symmetrically around the rotation assembly so that it is evenly balanced and complies with the manufacturer's instructions in this respect. If more than one sample container is placed in a bucket, use an appropriate insert to ensure their correct positioning. It is essential that balancing buckets carry an identical load, and in particular are filled with a liquid of density not grossly dissimilar to that being centrifuged. Always consider all components (e.g. inserts and trunnion rings) when balancing.
- B. 1.4.4 Select a centrifuging speed up to the maximum recommended by the manufacturer according to the head and accessories to be used or to the recommended reduced speed if the sample has a high density (i.e. above 1200 kg/m³).
- B. 1.4.5 Follow the manufacturer's instructions for starting and (where the control is not automatic) for increasing the speed of rotation.
- B. 1.4.6 Allow the rotation assembly to come to rest before attempting to open the centrifuge lid. NEVER attempt to slow down a head by hand.
- B. 1.5 Maintenance**
- B. 1.5.1 any liquid spilt in the centrifuge should be removed immediately.
- B. 1.5.2 At the end of each day's use of the centrifuge, clean and dry the inside of the centrifuge chamber, all parts of the rotation assembly and any head accessories used. In order to reduce corrosion, inserts and adaptors should be removed after use to allow adequate cleaning and drying. Ensure that the manufacturer's recommendations on cleaning materials are followed.
- B. 1.5.3 periodically inspects the clean and dry rotation assembly for any signs of corrosion or mechanical defect. If such signs are seen, do not use it until advice has been obtained from the manufacturer or his representative

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B. 1.5.4 it is advisable to have the centrifuge heads, buckets and accessories checked by the manufacturer's representative, at the recommended intervals.

B. 1.6 Procedures after a disruption of the rotation assembly.

B. 1.6.1 Whenever a mechanical failure (other than the simple breakage of sample containers) of any part of the rotation assembly is suspected to have occurred, the procedure detailed in B. 1.6.2 to B.1.6.5 is the simplest procedure that should be followed. (For hazardous materials, a more extensive procedure applies.)

B. 1.6.2 Immediately isolate the centrifuge from the electrical supply. Do not attempt to open the centrifuge chamber until at least 30 minutes after all motion has ceased.

B. 1.6.3 Avoid moving defective and damaged components, unless it is necessary for decontamination of hazardous materials, and in any event retain all components and debris for inspection by the manufacturer's representative.

B. 1.6.4 Note all the details of the incident and any measures subsequently taken and inform the relevant authority of the laboratory.

B. 1.6.5 Do not use the centrifuge or the rotation assembly again until the necessary repairs and replacements have been completed and the manufacturer's representative has given an assurance that its safety is not impaired.' The Appendix of BS 4402 goes on to deal with extra precautions required when centrifuging hazardous materials (see below).

Rotors

It is essential that rotors are properly handled, used, and maintained.

An ultracentrifuge rotor, for example, experiences 600,000 times the force of gravity. Each gram of it will effectively weigh over 600kg. Under these conditions a small flaw in part of it y lead to failure and the virtual explosion of the rotor within the centrifuge.

The centrifugal forces cause rotors to stretch. At low and normal speeds, the change of size is elastic, and the rotor returns to its original size when stationary. At high or over speeds the elastic limit of the material may be exceeded and plastic deformation occurs. If this process recurs micro cracks may be formed and grow at high stress points within the rotor and subsequently cause catastrophic failure.

Corrosion of the rotor by moisture or chemicals greatly reduces the level of stress at which micro cracks form and grow. This increase the probability of early failure (by corrosion fatigue or stress-corrosion cracking). For these reasons it is essential to conform to the manufacturer's conditions on maximum rotor speeds and maximum running times, and to follow closely their cleaning and maintenance procedures

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Useful advice on the care of rotors is given in the cited references. The publication *Centrifuges* by L.W. Price, University of Cambridge, is particularly use the following list of some causes of rotor failure.

1. Misplaced trunnions on MSE Minors
2. Use of wrong accessories e.g. in horizontal rotors. In a laboratory where several makes of centrifuge are in use, it is possible to mix up accessories which are not interchangeable. Keep them separate.
3. Failure to reduce speed above specific gravity of 1.2.
4. Powdered glass in rotor.
5. Failure to use speed restriction curves to avoid recrystallisation with CsCl gradients.
6. Miss hooked buckets on swinging bucket rotors.
7. Over speeding because de rated over speed disc not fitted.
8. Running badly corroded and weakened rotors or buckets, stress corrosion failure.
9. Loose lid on angle rotor.
10. Incorrect installation of rotor on drive shaft.'

Bench Centrifuges

Although the kinetic energy attained by the components of bench centrifuges is lower than that involved in larger models their improper use can lead to dangerous failures.

Breakages of glass tubes or improper balancing can cause considerable vibration and 'wandering' of an unfixed centrifuge over the bench top. This may, in extreme cases, allow the mains cable to become wrapped around the centrifuge body with consequent strain and damage to the cable. The centrifuge may move completely off the bench-top to the floor. This may cause the chamber lid to open and the spinning rotor or buckets to be ejected at high speed.

A visual check should always be made to see that all tubes are filled to the same equal level and are not overfilled, that glass tubes are not cracked, and that a cushion is installed in each bucket.

Centrifuging Hazardous Materials

Hazardous materials must be centrifuged in the proper type sealed container. The basic principle of safe containment is an air-tight, leak proof seal.

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Most equipment is unsafe for the centrifuging of flammable materials. A sealed chamber is required, and the necessary design features are laid down in BS4402 which allows only approved centrifuges to be marked with 'sc' (sealed chamber).

Advice on sealed containers for centrifuging hazardous chemicals is given in BS 4402 and in the book by Price. These also mention biologically hazardous materials, and these are dealt with in greater detail in Laboratory-Acquired Infections, CH Collins, Butterworths, 2ndEdition 1988.

If pathogenic materials are used it may be necessary to sterilise parts of a centrifuge and its accessories. Price gives the following relevant advice.

Before sterilising **always** remove and disassemble tube cap assemblies. Tubes and bottles for autoclaving should be separated from cap parts to avoid damage and deformation. Cellulose tubes cannot be autoclaved, and they may explode if autoclaving is attempted. Polyallomer tubes distort.

Polycarbonate containers with join seams should not be autoclaved and this method of sterilisation is possible only for seamless polycarbonate containers. Even then severe distortion will probably render the container useless. Cold sterilisation is recommended.

Cold methods of sterilisation that can be used on container materials include ultraviolet radiation, zephiran chloride, ethylene oxide gas, and 70% ethanol (except cellulose)

Remember that it is important to follow the manufacturer's instructions in all aspects of centrifuge use. Only trained persons should use centrifuges. If in doubt about the operation of a centrifuge - ask somebody else.

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