Geotechnical Centrifuge Standard Operating Procedure

Reed Laboratory
ESSIE
University of Florida
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1. Materials Handling

A. Lifting

Overhead Cranes

a. *Operations & Use:*
Using an overhead crane is a responsibility that you must be approved to hold. There are rules you must obey and responsibilities you must accept.

***Any Time Operating a Crane*:**

- **You MUST notify the other lab personnel.**
- **Hard hats MUST be worn at all times.**
- **Student MUST be examined for the qualifications below upon accepting responsibility to use the crane and every 3 years after.**

b. *Training:*
You must be trained and tested before you can operate an overhead crane. Upon passing this test and meeting other operator requirements (including demonstrating proficiency in running the crane), you will be allowed to operate the overhead cranes.
- Capacities of equipment and attachments.
- Purpose, use and limitation of controls.
- How to make daily checks.
- The energizing sequences, including pneumatic, hydraulic, and electrical sequences.
- Start-up and shutdown procedures.
- Emergency shutdown procedures.
- General operating procedures.
- All basic signaling procedures, including hand, radio, or telephone signals, where required.
- Practice in operating the assigned equipment through the mechanical functions necessary to perform the required task.
- Maximum rated capacity of the crane.
- Rigging procedures.
- Company rules and regulations.

c. *Safety Check:* Periodically, a visual inspection must be made in accordance with Table 1 below. A visual inspection is limited to that which can be made from a catwalk or other safe observation point. Any defects must be reported to a supervisor.

TABLE 1.1 Shift/operator inspection checks

Inspection Item	Description of Inspection Check Points
Tagged Crane or Hoist	Check that crane or hoist is not tagged with an out-of-order sign.
Control Devices	Test run that all motions agree with control device markings.
Brakes	Check that all motions do not have excessive drift and that stopping distances are normal.
Hook	Check for damage, cracks, nicks, gouges, deformations of the throat opening, wear on saddle or load bearing point, and twist. Refer to the manual furnished by the original manufacturer of the crane.
Hook Latch	If a hook latch is required, check for proper operation.
Wire Rope	Check for broken wires, broken strands, kinks, and any deformation or damage to the rope structure.
Reeving	Check that the wire rope is properly reeved and that rope parts are not twisted about each other.
Limit Switches	Check that the upper limit device stops lifting motion of the hoist load block before striking any part of the hoist or crane.
Oil Leakage	Check for any sign of oil leakage on the crane and on the floor area beneath the crane.
Unusual Sounds	Check for any unusual sounds from the crane or hoist mechanism while operating the crane or hoist.
Warning and Safety Labels	Check that warning and other safety labels are not missing and that they are legible.
Housekeeping and Lighting	Check area for accumulation of material, trip or slip hazards, and poor lighting.

d. *Rules:*

- A hoisting limit switch on a crane or hoisting device must not be used as an operating control, unless the crane is also equipped with a backup limit switch.
- A load must not be lowered below a point where less than 2 full wraps of wire rope remain on the hoisting drum. If there is doubt concerning the safety of a crane or hoisting means, the operator must immediately stop the crane, and report the condition creating the doubt to the supervisor.
- In the event of power failure, the operator must place all controllers in the "off" position.
- When an operator leaves a crane unattended he or she must land any attached load, place the controllers in the "off" position, and open the main switch. Before closing a main switch the operator must make sure all controllers are in the "off" position. The main switch does not need to be opened on a pendant-controlled crane if the crane is left unattended for short periods.
- An operator must not carry a load over another person.
- A crane must not be used to make a side pull (except where it has been specifically authorized by a qualified person after making specific determinations).
- Compressed gases can only be lifted by a cradle or enclosed platform.

- An employee cannot ride a hoisting device, such as a magnet, hook, ball, or load.

e. *Attaching or moving a load:*
   - The hoisting rope or chain is free of kinks or twist and not wrapped around the load.
   - The load is attached to the load block hook by means of a sling or other approved device.
   - The sling and load will clear all obstacles or obstructions.
   - The load is balanced and secured before lifting the load more than a few inches.
   - Multiple lines are not twisted around each other.
   - The hook is brought over the load in a manner to prevent swinging.
   - There is no sudden acceleration or deceleration of the moving load.

2. Chemicals and Hazardous Materials

Where chemicals and hazardous materials are used in the centrifuge laboratory a chemical hygiene plan must be developed according to the University of Florida Division of Environmental Health and Safety (EH&S). The University's recommended guidelines can be found in the ESSIE Safety Manual at www.essie.ufl.edu/facilities/safety_manuals/

A. Compressed Gas Cylinders

Those individuals working with compressed gas cylinders should request a copy of the UF Safety Rules for Storage and Use of Compressed Gas Cylinders. These rules must be posted in a prominent place wherever compressed gases are used and stored.

Documented hydrostatic testing is mandated for all cylinders and will be the responsibility of the department. If a cylinder has past the deadline for hydrostatic testing, it must be taken out of service until it has been tested and recertified for use. It is important that caps are not misplaced. Cylinders cannot be transported or returned to the vendor without a valve cap.

The use of medical grade gases will require registration. Contact EH&S for assistance.

Cylinder Safety

The following rules are intended to highlight and summarize the most common safety concerns regarding the handling and storage of compressed gas cylinders.

Please consult the UF Safety Rules for Storage and Use of Compressed Gas Cylinders or MSDS for specific information on the gases used in your lab.

1) Know the chemical and physical properties of the gases.
2) Cylinders must be secured by use of chains, straps, racks, base plates or carts (regardless of cylinder size) anytime they are in use, being moved or stored. Securing straps must be used in the upper 1/3rd of the cylinder.
3) All cylinders must be labeled with contents (do not rely on color codes) and stage of use (e.g., "full," "in use," "empty").
4) Store and use in well ventilated areas, away from heat or ignition sources.
5) Store oxygen away from flammable gases. Reactive gases should be stored separately
6) The use and storage of flammable gases must be minimized. Please contact EH&S for a consultation.
7) Do not strike or allow cylinders to strike against one another.
8) Metal cylinder caps for valve protection should be kept on at all times when the cylinders are not in use.
9) A proper pressure regulator is required during use; improvised adapters are not allowed
10) Use regulators specific for the type of gas contained in a cylinder; they are not interchangeable.
11) Do not use Teflon tape or lubricants on regulators.
12) Release pressure and close valve at the end of the day's use; do not rely on a regulator to stop the gas flow.
13) Handle empty cylinders with the same care as full cylinders.
14) Transport cylinders only on a hand truck or other cart designed for such purpose; cap valve must be in place when transporting cylinders.
15) Do not handle more than one cylinder at a time unless a cart designed for such purpose is utilized.
16) Store full cylinders in a cool, well ventilated and protected area, away from emergency exits
17) Cylinders should never be stored horizontally.
18) Do not let the temperature of the cylinders exceed 38° C (100° F).
19) Do not store corrosive gases for more than 6 months.
20) Never attempt to refill a cylinder.
21) Do not put cylinders into freezers.
22) Report all cylinders found in a questionable condition to the lab supervisor or EH&S.

Cylinder Disposal

The centrifuge lab uses gas cylinders that are leased from and serviced by vendors. Empty gas cylinders should be scheduled for pickup by contacting the appropriate vendor. The vendor information is usually on the cylinder. AirGas in Gainesville, FL is the vendor which supplies most of the gas cylinders. Abandoned cylinders must be picked up by EH&S Hazardous Materials Management (352-392-8400).

3. Housekeeping

A. Housekeeping Fundamentals

Cleanliness and order of the centrifuge laboratory is essential to keep a safe work environment and for work efficiency. It is the responsibility of any employee, student, and faculty to keep the laboratory floor and equipment clean and materials in their appropriate place. A walking path should be clear at all times. Materials (e.g., soil, aluminum, steel, etc.) should be placed in their appropriate locations and not remain on the lab floor in a walking path or work area. Objects should not be left suspended from the crane at any time.

B. Basic Housekeeping Rules

- Walking and working surfaces should be clean, dry and unobstructed.
- Aisles and exits should be clearly marked and unobstructed.
- Approved trash receptacles should be provided to assure proper waste disposal.
- Splash guards and oil pans should be available for machinery as needed.
- Work area floors should be kept free of pallets, parts, equipment, extension cords and hoses.
- Floors, platforms and stairways should be kept in good repair.
- Walls and ceilings should be free of hangings and temporary wiring.
- Materials should be stacked in a stable manner; limit height as necessary to maintain stability.
- Overhanging or protruding storage should be eliminated.
- Storage areas in and around buildings should be free of garbage and debris.
- Materials should be stored in a manner that will not obstruct sprinklers (18- inch clearance for ordinary combustibles, 36-inch clearance for flammable liquids).
- Keep chemicals stored in appropriate cabinet.
- Production equipment should be arranged to prevent overcrowding.
- Adequate lighting, both natural and artificial, should be provided to assure good visibility for work activities and to reveal dirt, obstructions and poor housekeeping conditions.
- Leaks from hoses, pipelines and valves should be repaired immediately.

4. Centrifuge Maintenance

At its highest RPMs, the centrifuge generates forces up to 100 times earth's gravitational force. The structural integrity of every component of the centrifuge is paramount and should be regularly inspected. Before each test, the personnel should look over the centrifuge beams, container, balance weights, motor housing, floor, and walls for indications of compromised integrity. If there is an indication of compromised integrity, the lab supervisor should be contacted and the test put on hold. Annually, the motor housing should be removed and the motor and frame visually inspected.

The centrifuge is built beneath the natural ground water table and controlled by a sump pump located under the north east corner of the centrifuge. In the past, sump pump failure has led to standing water beneath the floor that was about 5 inches deep. As part of routine maintenance, the operation of the sump pump should be verified.

A Centrifuge Maintenance Checklist should be maintained by the lab supervisor.

5. Lockout/Tagout Procedure

The purpose of this policy is to prevent the injury or death of staff, faculty, students and visitors by providing a set of minimum requirements designed to prevent the unexpected release of stored energy during the servicing or maintenance of the centrifuge. The lab supervisor must notify all persons utilizing the lab space that the centrifuge will be shut down and be locked out.

A. Applying Lockout/Tagout

Lockout is the practice of putting a lock on the switches that controls the energy to the centrifuge. In Reed 106, this is a set of breaker switches located on the south wall. Following shutting down the centrifuge using the normal procedure, ensure the switch is in the off position, then place the lockout device (padlock) on the handle to keep the switch in the off position. Then verify all pneumatic valves are closed and gas is evacuated from the lines in the appropriate manner. Verify that any gas storage tanks are secured to prevent them from being knocked over.

B. Removing Lockout/Tagout

The equipment needs to be verified that it is safe to use by all of the employees before the lockout/tagout should be removed. Prior to beginning work, verify that the padlock is in place on the breaker switch and is locked. Before removing the padlock, verify that the work area is in order, the centrifuge is assembled and all

tools have been removed. Notify everyone in the area that the lockout is being removed and to stay clear of the energy source (centrifuge motor). Only an authorized employee or the supervisor shall remove the lockout (padlock). The following guidelines should be followed:

1. The equipment is completely assembled and all tools have been removed
2. Everyone in the area needs to be notified that the lockout/tagout is being removed and they need to stay clear of the main energy source
3. Remove the padlock and store it away properly
4. The machine shall be restarted in a logical order, checking for any errors while doing so.

6. Lab Equipment Safety Procedure

A. Model and Model Container

The centrifuge has payload capacity of 12.5 G-Tons which spans the simulated G-level environment (1 to 100 Gs). So as not exceed the capacity at the intended test G-level, the balancing (payload versus dead load) of each test must be documented. All model tests must be designed, documented and reviewed, by the lab supervisor, prior to the initial test of the model.

The model containers vary in weight, from 50 lbs to 150 lbs without soil and will typically weigh more than 200 lbs with soil and model. It is loaded onto the centrifuge carriage with the crane (see Section 1A for operation of crane). The container is hoisted above the centrifuge carriage and then lowered into position to be secured with high strength bolts. All lab personnel should be wearing a hard hat during the loading and unloading of the container. The following procedure for loading and unloading the model container should be followed.

B. Loading

1. After the model has been completed and the container and model weight has been determined, attach the hoisting chains to the container. Two hoisting chains should be used at all times.
2. Move the crane over top of the container, lower lifting hook and place hoisting chains into the hook. Make sure the safety latch on the hook is closed to prevent the chains from sliding off the hook.
3. At all times while the container is being hoisted and moved, it is necessary that personnel do not walk, stand, place arms or legs underneath the container. All personnel in the lab should be notified that the container is going to be hoisted and moved.

4. Using the pushbutton control, lift the container to a height that just clears the top of the centrifuge and use one hand to stabilize and prevent swinging.
5. Pull the crane so that the container is hoisted above the opening in the centrifuge.
6. Lower the container while the second lab personnel is in the centrifuge and guides it onto the carriage.
7. Once the container is in place and the carriage is carrying the full weight of the container, remove the lifting chains and draw the hoist back up and away from the centrifuge.
8. Make sure the hoist and crane are moved such that the hoist system is not a hazard to personnel in the lab.

C. Unloading

The unloading procedure is opposite the loading procedure with the exception that it is done following the use of the centrifuge. Therefore, personnel must follow the Lock Out/Tag Out procedures (See Section 5) to guarantee that the centrifuge energy source is interrupted and the gas lines have been evacuated before accessing the centrifuge. Even before the container is removed, personnel typically enter the centrifuge to view the model and verify all components are intact. The following is the container unloading procedure:

1. After the test has been completed and the lock out of the centrifuge has been performed, the top panels to the centrifuge can be removed for access to the container.
2. At all times while the container is being hoisted and moved, it is necessary that personnel do not walk, stand, place arms or legs underneath the container. All personnel in the lab should be notified that the container is going to be hoisted and moved.
3. Make sure all external electronics and instrumentation frames have been removed from the container. Tape down lead wires.
4. Attach the hoisting chains to the container.
5. Move the crane over top of the access point, lower the hoist and place the hoisting chains into the hook. Make sure the safety latch on the hook is closed to prevent the chains from sliding off the hook.
6. Using the pushbutton control and with guidance from a second lab personnel, lift the container from the carriage to a height that just clears the top of the centrifuge. Make sure to stabilize the container during hoisting to prevent swinging.
7. Move the hoist and pull the crane so that the container is near the desired location where it will rest.
8. Lower the container while guiding it to a rest position.
9. Once the container is fully supported by the lab floor or a support table, draw the hoist down and remove the hoist chains from the container.

10. Draw the hoist back up.
11. Make sure the hoist and crane are moved such that the hoist system is not a hazard to personnel in the lab.

D. Centrifuge Spin

Before spinning the centrifuge and running the test, a few steps are required. Following loading and securing the model container onto the carriage, the following steps should be followed in order to correctly use and operate the centrifuge in a safe and reliable manner. It is of the utmost importance that these steps be followed to prevent a hazardous incident and guarantee the safety of the lab personnel present during the test. Specific attention should be paid to the balancing which requires that the weight and location from the center of rotation be known for each component put on the centrifuge.

1. Each model container has been designed to allow clearance for the carriage rotation during the spin up. Additionally, each has the alignment holes for it to be secured with nuts and bolts to the carriage arm. After loading the container these should be placed and tightened to the correct torque. The clearance between the container sidewalls and the carriage arms varies between each container; however, each has been designed with at least 1 inch of sidewall clearance.
2. Place and secure external instrumentation. Measure each piece's relative distance between its centroid and the center of rotation.
3. Tape down lead wire slack that is not necessary.
4. Connect tubes for any pneumatic loading piston and secure tube slack on the centrifuge main support arm.
5. Perform the final balance calculations to determine the dead weight required to be added opposite the payload side. The balancing spreadsheet (UF_large_balance.xls) on the main computer should be used and a record of each test's balancing should be kept. The balancing requires the use various weights secured opposite the payload side and at measured distances from the center of rotation.
6. Verify all tools have been removed from inside the centrifuge.
7. Vacuum the centrifuge floor.
8. Check the electronics to verify proper operation and take initial readings of the instrumentation.
9. Assign the instrumentation names to the correct channels on the software program.
10. Close and secure the two access points, which are used to move the container into and out of the centrifuge and the personnel access point.
11. Notify all lab personnel that the centrifuge is about to be turned on and they must clear the area or enter the control room.
12. Make sure the "Centrifuge In Use" sign is on and visible, then close the lab door.
13. Remove the lock out (padlocks) and turn the power on.

14. Turn the control system on through CICADA and activate the warning system.
15. Make a folder on the main computer for the test and save all the initial reading from the instrumentation.
16. Begin a new file for the data collection, making sure to name it as the “Test”.
17. After these steps have been taken, the centrifuge can be spun and the test can be conducted.
18. The centrifuge control system (CICADA) can now be programmed to achieve the intended G-level for the test to be conducted. Two authorized personnel need to be present in the control room and monitoring the centrifuge and test the entire time the centrifuge is spinning.
19. Monitor the camera feed for any unusual or suspect issues on the centrifuge arm or model container. Verify that instruments are reading and show expected output.
20. At the conclusion of the test, the centrifuge should be spun down to 1 G and all authorized personnel should remain in the control room until the centrifuge is at rest and the control system has stopped the drive motor.
21. Save data files.
22. Turn the main power switches off and lock with padlocks.
23. Turn off the air supply, close any gas cylinder valves, and evacuate lines to pneumatic devices.
24. Enter the centrifuge to inspect model, container, and equipment.

7. Centrifuge Entry/Exit Procedure

Personnel should enter the centrifuge through the stairway only.
In the event that personnel has entered the centrifuge testing space and is not able to exit, the following steps must be followed:

1. Call fire/medical emergency at 911.
2. Inform the personnel that the fire/medical personnel have been notified and stay within a distance to make voice and visual contact with the personnel, permitting you are not endangering yourself.

Once fire/medical arrive, notify them of the personnel location, show them the access point, and inform them that the whole ceiling of the centrifuge testing space can be removed to access the personnel.

8. Centrifuge Hardware and Software

Authorized and approved hardware and software specialists that enter the centrifuge lab for work must check in with the lab supervisor (Scott Wasman). Any changes to the hardware on the control side or on the centrifuge, addition of electronic components, changes to the software used to operate the centrifuge

and/or mechanisms on the centrifuge must be approved by the lab supervisor (Scott Wasman). All source code for any custom software (i.e, GUI, executable, etc.) used to operate the centrifuge and/or a mechanism on the centrifuge will be provided to the lab supervisor (Scott Wasman).

9. Centrifuge Laboratory Personnel

Authorized personnel are the only ones permitted to operate the centrifuge and at least 1 is required to be present when the centrifuge is operated and a test is performed. The purpose of an authorized personnel to be present is to guarantee the standard operating procedures are followed in a safe and appropriate manner. Two approved personnel, a minimum of one authorized personnel and another personnel (may be a secondary personnel that has been or is being trained), must be present in order to run the centrifuge and conduct a test. There are no exceptions to this policy.

Authorized personnel have the most experience at running the centrifuge and are the most qualified in managing a test. Currently, the authorized personnel are the following:

1. Michael McVay, Professor, mcm@ce.ufl.edu
2. Scott Wasman, Research Assistant Professor, scott.wasman@essie.ufl.edu
3. Stephen Crawford, PhD student, stephencrawford@ufl.edu

The secondary personnel can be a faculty member or student who has been trained and approved by the lab supervisor (Scott Wasman). Students working on research projects may become secondary personnel. This only occurs after the appropriate training both in and out of the centrifuge have taken place. The person being trained must demonstrate an understanding of the operation of the centrifuge, this Standard Operating Procedure and the ESSIE Laboratory Safety Manual.

Prior to beginning each test, both personnel must inspect the centrifuge and model container for any loose items and verify that equipment is secured. The centrifuge cannot be turned on and run until both personnel have performed this inspection and agree to proceed. When the personnel are not in agreement, the test must be placed on hold until the issue is resolved.