Last updated: November 20, 2012

UT GeoMechanics Lab

CRS Procedure (in accordance to ASTM D0422-63R07)

1. Before you start.

We want to minimize the amount of time cores spend outside of the refrigerator and exposed to air, so it helps to have everything you'll need ready to go before you get the sample out.

1.1. Prepare Load Frame

[ ] **Turn off** load frame, pump(s), network module, external power supply, and computer.

[ ] **Turn on** power supply, load frame, pump(s), network module, and computer.

[ ] **Start** Sigma-1 CRS **software**.

[ ] **Open Cell Pump** Screen

[ ] Point pump valve to DI water carboy

[ ] **Fill pump** with water

[ ] **Purge** any **air bubbles** back into carboy

[ ] Point pump valve to the CRS system.

1.2. Prepare the CRS chamber

[ ] Select **cutter ring (also called specimen ring)**, either 5.0 cm (1.96') or 6.35 cm (2.5") diameter, depending on the width and condition of your sample and the desired maximum stress.

[ ] **Clean** inside of CRS **chamber and base** if necessary

[ ] Make sure that **Platten** in CRS chamber is same **size** as the chosen cutter ring

[ ] Get two clean **porous stones and one filter paper** of the proper size for your cutter ring and place them in a beaker filled with DI water. Set the beaker in the ultrasonic bath to clean and fully saturate the stones and filter paper.

[ ] **Grease** the square-sided rubber O-ring generously with a grease sealant such as Dow Corning compound 111 valve lubricant & sealant. (there is usually a tube of this in the drawer with the trimming tools).

[ ] Grease the outer edge of the circular structure on the CRS base that the cutter ring will rest on.

[ ] **Grease** the inner surface of the cutter ring. Be careful not to use too much grease. You should barely be able to leave a mark with your fingernail on the greased inner surface.

[ ] **Weigh** the greased cutter ring along with the moist (not dripping) piece of filter paper, and **record** the mass under "Mass of Ring + FP (g)" on the sample data form in the CRS binder. If there is no hardcopy available, you can find the sample data sheet on the server under this location:

\shannon\All_Access\GeoMechanics_Lab\Tests\Test_Worksheets\

[ ] Also, **save a digital copy of the worksheet** in a new folder with the test number as its name, for example, \shannon\All_Access\GeoMechanics_Lab\Tests\CRS\UT\CRS105\CRS105.pdf if this is CRS test # 105.

1.3. Round up supplies for sample preparation

(See illustrations on the next page to identify)

*In the GeoMechanics Lab we deal with two types of samples: 1) intact cores still contained in a core tube and 2) reconstituted samples that are not in a core tube, instead in the consolidometer (Resedimentation device). Preparation tools and preparation is slightly different for both. If you are using a sample that is not still in a core tube, you will only need the items in **bold**.*

[ ] Deburring tool (1)

[ ] Wire and guide tube (2)

[ ] Acrylic discs and cut pieces of wax paper (3)

[ ] Wire saw (4)

[ ] Trimming tools (5)

[ ] 50 mm cutting ring and acrylic recess tool (6) or 63.5 mm cutting ring and recess tool (7) *Note, the new 50 mm recess tool is opaque white acrylic and has a larger recess than the one shown in the picture.*

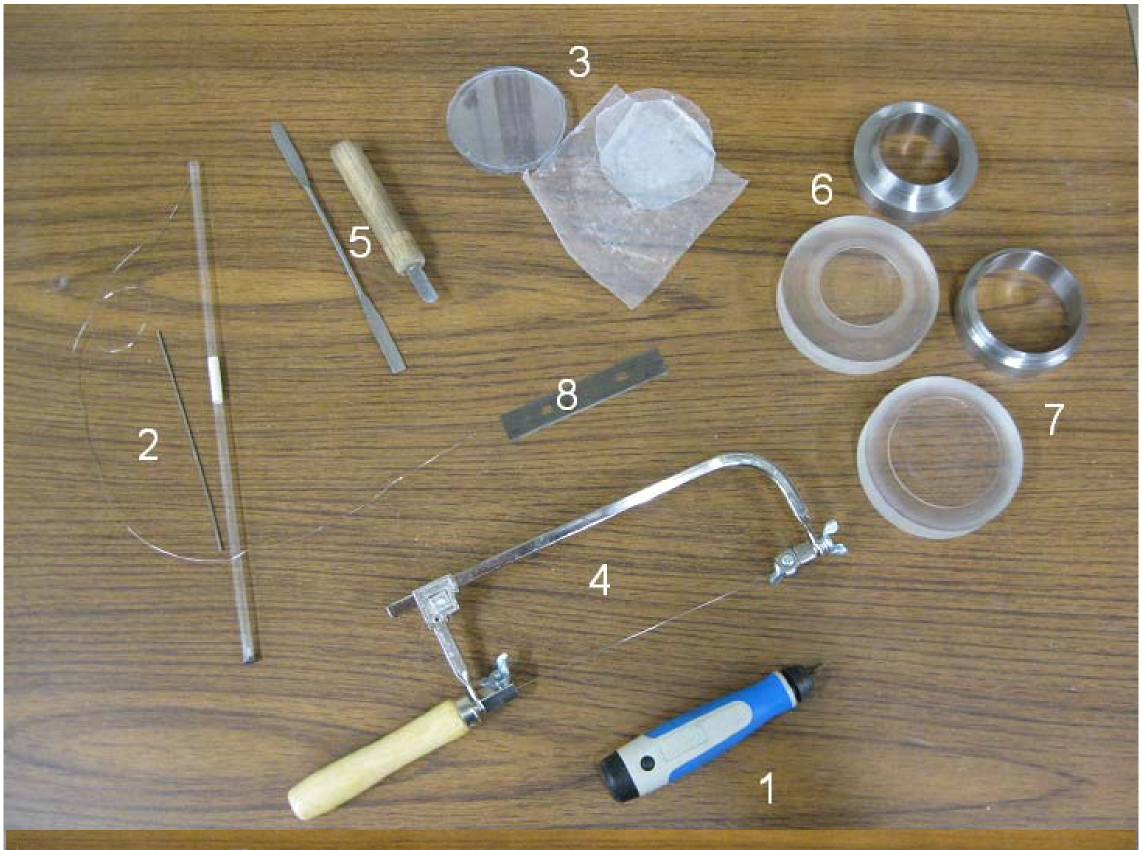
[ ] Straight razor blade (8)

[ ] Extruding jig (A) and disc (a')

[ ] Trimming jig (B)

[ ] Trimming Block (C)

*You may also find that **C-clamps, pliers, and wooden blocks** come in handy during the extruding and trimming process. For instance, the wire can be locked to the table at one end with a C-clamp and wooden blocks, freeing up a hand for other work while it is in use. The extruding jig can also be clamped to the table with blocks to make it easier to handle and to lift it up higher above the working table.*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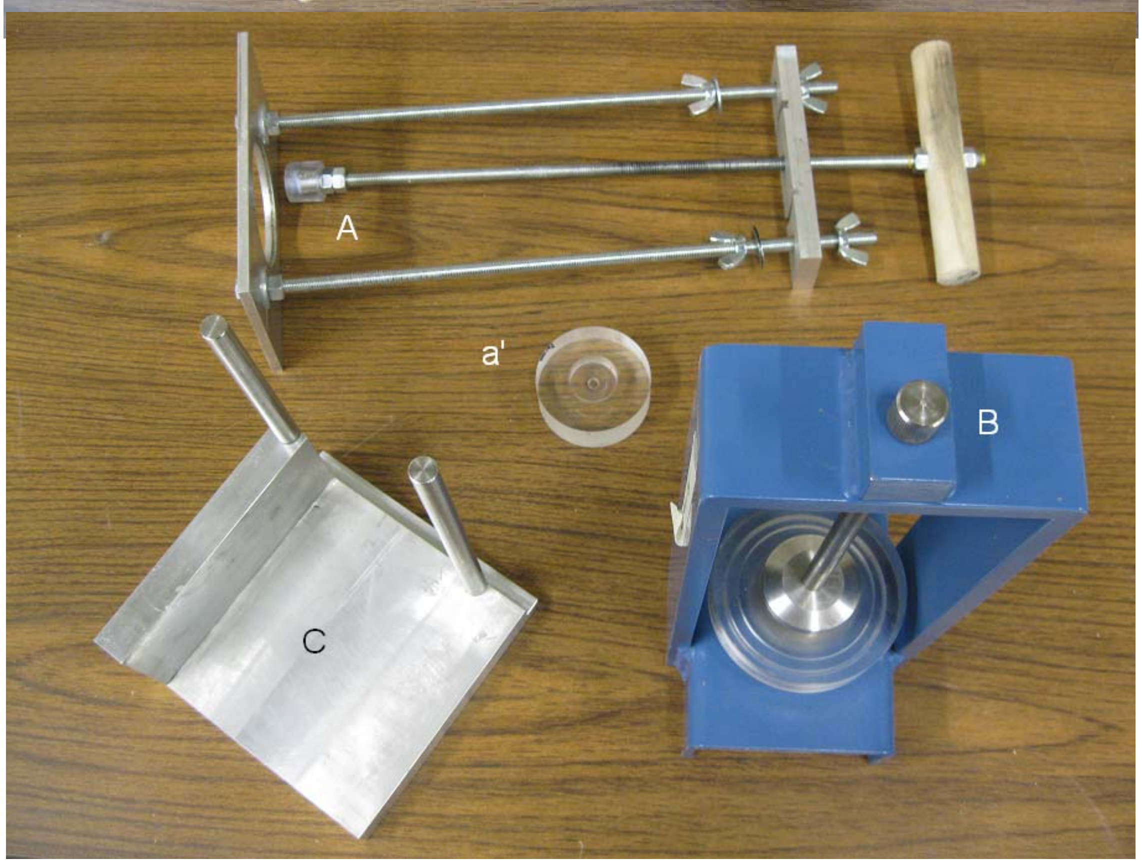

A
a'
B
C

1.4. Initial measurements, data sheet and miscellaneous.

[ ] **Fill out** sample name, project, date, etc on CRS **data sheet**

[ ] Measure the diameter and height of cutter ring at 4 positions using a caliper and calculate an average number for both values. Make sure that for the height measurement you only measure the height down to the recess tool. Note both numbers on data sheet under “Height of Specimen (cm)” and “Diameter of Specimen (cm)”.

[ ] Label and **weigh four tares** for trimmings and record their label numbers and masses in data sheet under “Tare Number” and “Tare Mass”.

[ ] Label a plastic Ziploc **bag for trimmings** with CRS test number and contents (type of sample).

[ ] Gather a **vacuum sealer** and plug it in if you are taking your specimen from a longer piece of core and will need to return the remainder of the core to the freezer.

2. Sample Preparation

2.1. Extract sample from core

*As with section 1.3, if you are using a sample which does not need to be extruded from its tube, you will only need to do the items in **bold** below.*

[ ] Retrieve core sample from refrigerator or extrude from consolidometer (for details see procedure for Resedimentation).

[ ] Open core packaging by cutting off the top, just below the seal, with scissors or razor blade. Save bag.

[ ] Determine which end of the core is up. Usually some indicator like an arrow or label will be on the tube**. *Be sure to keep track of this*** *throughout the preparation process!*

[ ] Using a large, black sharpie, write “up” arrows all along the length of the core tube so that any interval cut from the core will have an up indicator.

[ ] If necessary, remove end caps and tape from sample tube so you can inspect core.

[ ] If you are doing a CRS test on an intact core specimen, choose an interval of core, 5 cm in length for vertical samples, 7.5 cm for horizontal samples. *The ideal interval will be as homogeneous as possible and without cracks.*

[ ] Using band saw, cut the desired interval of core and tube.

[ ] Recap core tube and seal with black electrical tape.

[ ] Return core to its original bag (with label)

[ ] Put core bag within Vacuum seal bag with a **wet** paper towel, vaccum and seal.

[ ] **Debur specimen tube** (this means strip off splintered or jagged bits from the cut edge and inside of the tube using the **deburring tool**. To do so, lay the core tube on the table with the cut surface facing you. Hold it with your left hand. Debur only a quarter from about 3 o'clock to 6 o'clock. Then rotate the sample by a quarter of a rotation clockwise and repeat until the entire cut surface is deburred. (It may not be necessary to do this if the tube is made of plastic, as ours usually are. It is crucial for metal tubes though.)

[ ] Place the sample up right on the table ("up" arrow pointing to the ceiling) with only a small portion of the sample protruding over the edge of the tabletop. At that point, slowly and carefully push the steel guide tube downward through the sample between specimen and tube. Pull the thread wire through the steel guide tube till both ends of the wire are sticking out of both ends of the sample. Then remove the steel tube while you keep the thread wire in place.

[ ] Use a C-clamp to fasten one end of the wire to the countertop. Pull the wire taut (with pliers, for example) and then **rotate the tube** in its own location around the long axis. This will loosen the sample from the tube.

[ ] Place the sample and tube into the extruding jig, making sure that the bottom of the sample is sitting on the base of the extruding jig. Do not flip the sample which would result in applying pressure opposite to the direction in which it is applied in-situ.

[ ] Put a round piece of wax paper and then the disc (a') on the top end of the sample.

[ ] Use the extruding jig and disc to push a few millimeters of sample out of the tube.

[ ] Use the wire saw to **cut off the bottom edge** of the sample where the saw blade may have strained or disturbed it.

[ ] Now use the **extruding jig** and disc to gently **push** the rest of the sample out of the tube and on to an acrylic disc with wax paper above it.

After the sample is out of the tube, be careful not to forget which end is the top and which end is the bottom. You may wish to mark the acrylic discs or round pieces of wax paper and keep them on or near the top or bottom as reminders.

2.2. Trimming the Sample

Your goal here is to have the cutter ring completely filled with the sample, without cracks or voids, and smooth top and bottom surfaces.

[ ] If the top of the sample has been in contact with the band saw or otherwise strained, cut it off by laying the sample in the trimming block with the top few millimeters extended off the edge, and cutting down along the posts with the wire saw.

[ ] Use an ungreased cutter ring of the same diameter as your greased cutter ring (if available), press down gently into the top of the sample to make a shallow circular impression which will be a guide to you in trimming the sample.

[ ] Place the sample facing upward (with the circular impression visible) on the trimming block with one side overlapping the recessed edge.

[ ] Cut a strip off the side by sliding the wire saw down the guide posts on the trimming block. Use the circular impression on the top as a guide and leave a couple of millimeters around it.

[ ] Rotate the sample and repeat process until you have formed a solid with top and bottom surfaces that are at least octagonal, and with about 2-3 mm of excess material on the sides surrounding the circular impression on the top.

[ ] Turn the sample upside down on a wax-paper-covered acrylic disc, and place in the **trimming jig** with the top facing down.

[ ] Insert the **cutter ring –** tapered end facing downward - in the top of the trimming jig, carefully lower the trimming jig with cutter ring till it reaches the sample and let it rest on the sample.

[ ] Push the ring slowly down into the sample (~1 mm).

[ ] Trim off the excess material around the edge of the ring that was produced by pushing the cutter ring into the sample.

[ ] While trimming rotate the specimen by turning the plastic spacer of trimming jig that holds cutter ring (do not turn cutter ring directly).

[ ] Iterate the above three steps until the ring is filled, and a bit of trimmed core protrudes above the top. Be careful not to undercut the ring. If this happens, fill the gap with material you have previously scraped off. This is a delicate job. It can take up to an hour depending on the sample condition.

[ ] Lift the plastic spacer so it detaches from the cutter ring and specimen. Remove the specimen and ring from the trimming jig.

[ ] Using the wire saw or the straight blade knife, make a flat cut that removes any excess material beyond the cutting edge at the bottom of the cutter ring.

[ ] Flip the sample over so that the top end faces up, setting it on a wax paper –covered acrylic disk. Use the straight razor blade, plane off the top surface of the specimen. Scraping gently with the blade inclined at about 45^o is likely to be easier than cutting. Make sure the entire razor blade rests on the specimen ring as you pull it across the top surface towards you while holding the specimen ring in place. Don't put too much pressure on it or the razor blade will bend, causing an uneven top surface.

[ ] When you have a smooth surface, place the filter paper on top of it, making sure not to leave any air bubbles underneath. Then overturn the sample and cutter ring (cutting edge down) onto the recess tool and push it down so that excess material comes out of the bottom end of specimen ring.

[ ] Now, using the straight razor blade and if necessary, the wire saw, remove excess material from the bottom side of the cutter ring and scrape the surface flat.

3. Setting up your test

[ ] Take mass of specimen, sample ring, and filter paper, and write the measurement down on the data sheet under "Mass of Ring + FP + Spec. (initial) (g)".

[ ] Remove the top of the CRS chamber.

[ ] **Lock the piston** in the **upright** position.

[ ] Put a 2.5" DI water saturated porous stone in the base of the CRS chamber

[ ] Make sure **base** water line is **closed.**

[ ] Wipe off any excess water.

[ ] Add a little bit of grease along the bottom edge of the cutter ring; at the contact points with the CRS base.

[ ] Put the specimen into the CRS chamber, with the ring overlaying the raised circular area in the base which contains the porous stone, and with the cutting edge of the ring facing up.

[ ] Place a porous stone of the appropriate size and saturated with DI water on top of the specimen and filter paper, partially recessed inside the cutting edge of the ring.

[ ] Slowly put on the top of the CRS chamber.

[ ] Lock down the top of the CRS chamber. Screw the three bolts in and make them more than hand-tight but don't overtighten them. Use a torque wrench and apply 60 inch-pounds of torque to each nut.

[ ] Make sure the **Base Valve** is **open** on the chamber. [ ] Make sure the top **drain valve** is **open** on the chamber.

[ ] Unlock the piston and slowly lower it until the platen (the foot at the base of the piston) is resting atop the porous stone.

[ ] Make sure that the pump is full of water and that the pump valve is pointed in the direction of the CRS chamber.

[ ] Open the Cell Pump window in your Sigma-1 CRS software, if it is not already open.

[ ] Select the Volume Control tab, if it is not already selected in the main right-side area of the cell pump screen.

If you are using saline chamber fluid, modify the following three steps by adding saline brine to the reservoir attached to the load frame, instead of using the pump to fill the chamber.

[ ] Set the pump to 10 ml/minute, 50 ml volume, and click the up arrow button (the second one, not the one that looks like this but the one that looks like this ).

[ ] Now fill the chamber the rest of the way, still at 10 ml/min. Water will flow out the top drain valve when it's full (So the end of the drain tube should be in a bucket or something).

It is likely to be necessary to re-fill the pump at some point. Do this by stopping the pump, turning the valve towards the DI water carboy, and clicking the maximum rate down arrow  *in the volume control area of the screen. Then, turn the pump valve back* *towards the CRS system, reselect the controlled-rate up button, , and return to filling the chamber at 10 ml/min.*

[ ] Once water is flowing out the top drain line, the chamber is full. **Stop the pump and close the top drain valve**. *If you can see large air bubbles trapped within the chamber, you may wish to try to drive them out by gently tilting the chamber (while holding it securely) to let them escape up the piston and into the top drain valve. This should be done after stopping the pump, but before closing the top drain valve.*

[ ] Take the CRS chamber, and put it on the load frame platform, with the piston underneath the load cell. *It may be necessary to lower the load frame in order to do this. Go to the "tools" menu in the Sigma-1 CRS window and select manual mode. Then use the or buttons to lower the platform.*

[ ] The **shear break**, a short metal cylinder with a flat surface on the top and a concave surface on the bottom end, should now be placed over the top convex end of the piston, which it is machined to fit. Then slide the CRS chamber until the shear brake is underneath the corresponding metal cylinder at the bottom of the load cell.

Exception: the 50,000 lb load cell in its current configuration does not require a shear brake. The bottom surface of the load cell is concave and the chamber should be aligned so that the convex tip of the piston fits into this recess.

[ ] **Make sure that the piston is locked**.

[ ] Using the button in the manual mode box, and a **very slow** rate of displacement (such as 0.05 in/minute to close the last little gap of space), carefully move the load frame up until the shear brake top is just touching the bottom cylinder on the load cell. *Be very careful not to let the load cell put significant force on the piston, you are just raising the chamber so that you can make a final alignment.*

[ ] Make sure that the piston and shear brake are exactly lined up with the load cell.

[ ] Zero your DCDT sensor and your pressure transducers. Select the "setup" menu, then "sensors". In the sensors window, click on each sensor in turn and then "test" and "take zero".

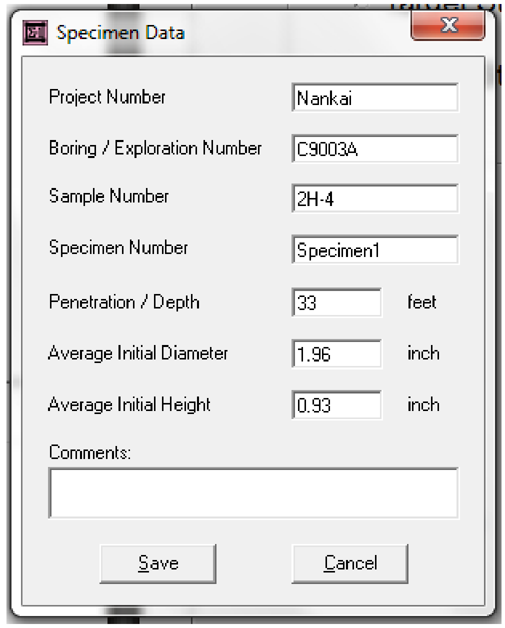
[ ] Lower the load frame a few mm, then zero the load cell using the same procedure as you did for the other sensors.

3.1. Test configurations

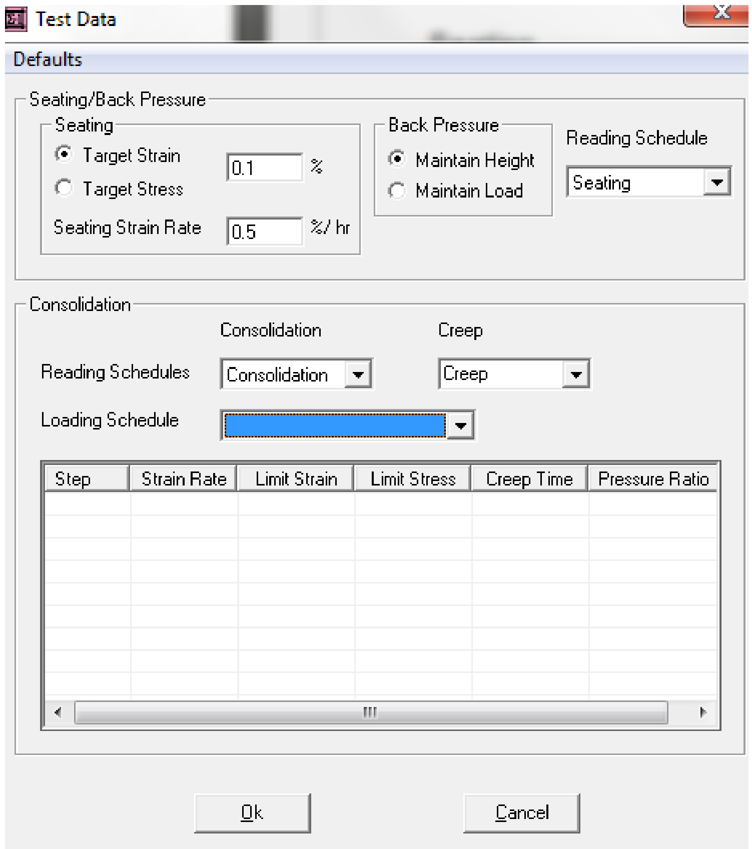
[ ] Go to the **File** menu and select **Specimen Data**.

Fill out the form which pops up with enough information to identify the specimen. Use the test number such as CRS0105 as Specimen Number.

Make sure that the specimen diameter is correct. For the smaller rings it should be about 1.96, for the larger rings, 2.49.



[ ] Return to the **File Menu** and select **Test Data**. Fill out the form which pops up. Recommended Settings follow:



[ ] in the test data window, select a **loading schedule** appropriate for your test specimen, testing plan, and apparatus configuration. If an appropriate loading schedule is not already set up, you will need to create one yourself (*Appendix to be written*).

4. Starting your test

[ ] Raise the platform slowly and carefully until the shear break (or top of the piston if you are using the 50k setup) is almost touching the bottom of the load cell.

[ ] Click the **Make Contact** button. This will slowly raise the platform and make contact between the shear break and the load cell. When contact is made, click the **OK** button in the dialog window. **Note:** The Dialog window says to unlock the piston here before clicking **OK, but** our procedure as it currently stands is to wait until after the backpressure phase starts to unlock the piston. So don't unlock the piston. After you've clicked OK in the dialog box, the **Make Contact** button will change into a **Start Test** button. Click it.

[ ] Start a manual datafile for the backpressure saturation phase of the test. In the **Tools** menu, click **Data Acquisition,** then **New Task**. Type in a filename for it to save as. Then, select your reading schedule from the drop-down menu. *(The recommended*

*reading schedule is one reading every 4 minutes. If there isn't an available 4 minute schedule, or you'd like to set up a custom schedule, then go to the **File** menu, then click on **Reading Schedules,** and **Add Schedule,** and set one up using the dialog box).*

[ ] Go to your **Cell Pump** window. Select the **Pressure Control** tab. Set it to **Ramp Pressure** to 56 PSI over 180 Minutes.

[ ] Once the system reaches a couple of PSI, **unlock the piston.** (1/4 turn counterclockwise).

[ ] Now, you're pretty much done with this for today. Leave the chamber to pressure up, which will take three hours. Then, **leave it to sit at backpressure overnight**, or for at least 8 hours. In this time, the high pressure should drive any remaining air bubbles into solution and fully saturate your sample.

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[ ] After leaving it at backpressure overnight, click **Pause** (at the bottom of the screen), then **Done** (lower right hand corner), then **Yes** (in the dialog box, when it asks if you want to start the consolidation portion of the test).

[ ] Start a new manual data acquisition file for the consolidation test. In the **Tools** menu, click **Data Acquisition,** then **End Task** to close your backpressure datafile. Then go back to the **Tools** menu and the **Data Acquisition** option, and select **New Task**. Type in a filename for it to save as. Then, select your reading schedule from the drop-down menu. *(The recommended reading schedule is one reading every 4 minutes. If there isn't an available 4 minute schedule, or you'd like to set up a custom schedule, then go to the **File** menu, then click on **Reading Schedules,** and **Add Schedule,** and set one up using the dialog box).*

[ ] The program will move to the Consolidation tab. Check your loading schedule, which appears in the right-hand side of the screen. *If you need to make any changes, right-click on the part you want to change and then select Edit from the menu, which appears.*

[ ] Click **Start** (bottom middle of screen), and let your test run.

[ ] add: frequent checking on test and ensuring PPR is in desired range (please explain and specify… like ASTM suggests 5-12, however, in our lab we use 2-5) note: not sure on exact numbers – you will have to look these up.

5. Ending your test

[ ] Go to the **Tools** menu, and click on **Data Acquisition** and **Close Task** to end your manual data acquisition. Click **Yes** in the Dialog that appears asking for confirmation.

[ ] Lock the Piston.

[ ] Hit the **Pause** button, then **Done** (bottom right).

[ ] Program will exit. Relaunch the program.

[ ] Open bottom valve on chamber.

[ ] Take the pressure off the chamber by going to **Cell Pump** window, **Pressure Control** tab, and selecting **Ramp Pressure** to 0 PSI over 10 minutes.

[ ] Mark and weigh a tare for final specimen measurement, and record the measurement in the CRS data sheet.

[ ] Stop pump when pressure = 0 PSI.

[ ] Turn off pump valve (point straight up).

[ ] Lower load frame (in manual mode, accessible from the tools menu) until there is a visible gap between the shear brake and the load cell.

[ ] Remove the chamber from the load frame.

[ ] Close the bottom valve.

[ ] Open the top drain valve.

[ ] Remove the top of the chamber (carefully).

[ ] Weigh the sample in the cutter ring, along with the porous stone and filter paper.

[ ] Extrude the sample onto your recently labled-and-weighed tare by pressing against the porous stone on the top of the specimen. Then, remove the porous stone and filter paper from the top of the specimen.

[ ] Weigh the tin and sample, and record the measurement in the CRS data sheet in the logbook.

[ ] Put the tare with the specimen in the oven (80^{o} C) and dry for at least 24 hours before weighing it again.

Appendix 1: Processing your data.

[ ] Copy and paste the raw datafile into the spreadsheet found at \All_Access\Geomechanics_Lab\Tests\Data_Templates\CRS_Template_March2012.xlsx

[ ] Look at your backpressure datafile. The base pressure and cell pressure sensors should have equal readings throughout the backpressure phase, since they valve is open and pressure communicates between them. If there is a difference between the readings at 56 PSI, adjust the zero value for the cell pressure transducer until its pressure output is identical to the pore pressure transducer. This will improve the accuracy and precision of your permeability measurements, particularly in the early stages of the consolidation test.