Indentation Testing Protocol

Instrument and sample set-up

a. LVDT
   i. Make sure the LVDT is turned on. If not, turn it on and allow it to warm up while the rest of the set-up procedures are completed.

b. Air bearings
   i. Open, all the way, the air valve on the wall behind the indenter.
      1. Regulators (2) on wall should read approximately 40 psi
      2. Do not move the bearings without first opening the valve
   ii. Qualitative air bearing test
      1. Lightly tap the metal triangle directly upward allowing it to fall and bounce on the end of the micrometer – the motion should be smooth, and it should bounce several times.
      2. If the motion is not smooth, the bearings need to be cleaned and/or realigned.
      3. Clean the linear bearing slide using alcohol and cotton swabs or Kimwipes. Do not let alcohol flow on to the plastic deflector at the bottom of the bearing.
      4. Remove the tare load and string and gently spin the wheel at the top of the instrument. If the bearings are clean and the axel is aligned it should continue spinning without catching. The wheel should eventually begin to oscillate back and forth, and do so continuously.
      5. If the wheel slows down or stops, call Prof Mansour.

c. Adjusting the tare load
   i. Mount the cantilever beam load cell to the x-y-z slide on the base of the indenter.
   ii. Be sure it is connected to the signal conditioner, and a voltmeter is connected to the output of the signal conditioner.
   iii. To calibrate the beam, place a 1 g weight on its end, over the punch mark, and record the voltage output with and without the weight.
   iv. Repeat step iii at least three times, removing the weight each time.
   v. Using the screws in the x-y-z slide, position the indenter tip just above the punch mark near the end of the cantilever.
   vi. Using the micrometer, raise the indenter tip until it lifts off the cantilever.
   vii. Record the voltage before and after the tip is lifted.
   viii. Repeat step vii at least 3 times.
   ix. Using the calibration from steps iii and iv, compute the tare load.
   x. Add or remove shot from the "bucket" on the end of the string to decrease or increase the tare.

xi. Repeat the measurement of the tare load if changes are made.

xii. Tare loads should be set so that application of the tare load plus test load results in less than 20% strain of all samples.

1. Typical tare loads will be ≥ 0.3 g for tests with engineered cartilage, or 1 to 2 gm for native cartilage.

xiii. IF MEASUREMETS OF THE TARE LOAD ARE NOT REPEATABLE, THEN THE BEARINGS NEED TO BE CLEANED AND/OR ALIGNED.

d. Mounting and aligning a sample

i. Attach the test chamber, using the bolt to secure it to the x-y-z positioning system.

ii. Secure the sample in the chamber. Methods will vary depending on the sample.

iii. Add PBS to the chamber. It should be barely above the sample (1-2 mm) and should not wick up onto the thick part of the indenter head.

iv. Align the surface of the sample so that is perpendicular to the indenter axis.

Data collection

e. Open "Labview 8.6" and open "indentation" program file

f. In the secondary VI "GmailLV80.vi" set the email address and recipient name to be alerted when equilibrium is reached.

g. Application of tare load

i. In the indentation VI, Set the name of the tare data output file.

ii. Press the "run" button in the Indentation VI

iii. To apply the tare load, turn the micrometer to lower the indenter tip until it is resting on the sample. Be sure to lower the micrometer so that it is a millimeter or more below the metal triangle

iv. Run the program until equilibrium is reached. The "equilibrium" light will turn on when the change in position is less than 10 µm/min, if the program has run for more than five minutes.

v. When equilibrium is reached, hit the stop button in the Labview program.

h. Collect test data

i. Rename the output file to the desired name for the actual data file. See Section 3, Data Post processing, part b and c, for suggestions on constructing file names

ii. Run the program by pressing the start button

iii. Wait about 10 seconds

iv. Apply the test load

1. Lightly drop the load onto the metal triangle, careful not to touch the triangle

v. Wait until the program signals that the displacement has reached equilibrium

vi. Stop the program

vii. Lift the indenter off the sample using the micrometer screw.

i. Shutting down

        i.   After the last sample is finished, remove chamber, and sample from chamber.

      ii.   Rinse chamber with water to prevent salt build up.

     iii.   Turn valve on air bearing down so that pressure is slightly above zero.

Data post-processing

j.   The test data output file should be copied to C:\Program Files\Indentation\DevStudio\MyProjects \indentation

k.   Rename the copied file if needed such that the name is 6 characters long

l.   For a group of tests, it is recommended that the 6 character name contain a group and a sample identifier, i.e. 126-12 where 126 is the group, and -12 is the sample.

m.   Delete all header information in this file, i.e. it should contain only numbers

n.   Open the "indtctrl" file in a text editor, and make sure that all parameters are correct.

        i.   The key describing the parameters and their typical values is located within the same folder and is called "indentation control file key".

o.   Run the Jmmdvf.exe file in the folder where the output file was copied to

        i.   When asked, enter the appropriate values.

            1.   Group name and sample name are concatenated to give the full file name (minus the file extension)

      ii.   If the program runs successfully, the results will show up in files within the same folder, titled by the group name.

            1.   The "short" file contains the output and the thickness

            2.   The "long" file contains the inputs and outputs

     iii.   If the program doesn't run successfully, it is likely that the headers were not removed from the data file, or that the data file contains too many data points.

            1.   If the file contains too many data points, run the altdata.exe program to resample data at 1 Hz. This will create a new data file named x.alt, where x is the original file name.

            2.   Adjust the sampling period in the ctrl file

            3.   Rerun the Jmmdvf.exe file