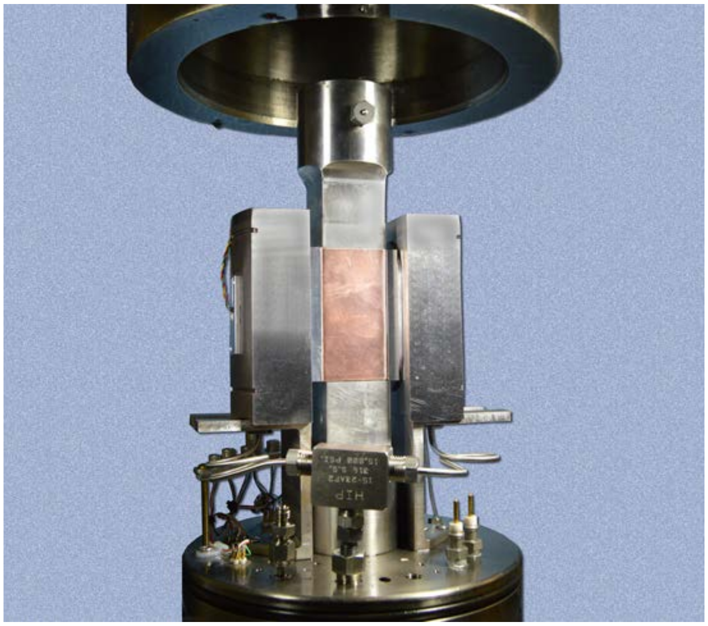
True Triaxial Loading

In most discussions of high pressure rock testing equipment, triaxial deformation means that a cylindrical test sample is jacketed, inserted into a pressure vessel, and pressurized. This produces a *hydrostatic state of stress*. The stress in any orientation is identical. When an additional stress is superimposed parallel to the core axis, a biaxial state of stress results. The greatest principal stress direction is parallel to the core axis and the minimum and intermediate principal stress directions are normal to the core axis. This is a *biaxial state of stress* since the intermediate and minimum principal stresses are equal. The stresses vary with orientation within the sample. This condition is commonly (and technically incorrectly) referred to triaxial compression.



As the requirement to understand the anisotropic behavior of rocks becomes important for well log interpretation and advanced geomechanics, a *true triaxial state of stress* greatly aids in evaluating the deformation of such samples. In this loading condition the values of the three principal stresses are not equal. To generate a *true triaxial state of stress* in an existing pressure vessel, modifications to the loading system and the sample geometry are required. First, the sample geometry is changed. The samples are machined as rectangular prisms, with a square cross section. The normal to each surface is a principal stress direction. Next, the sample is jacketed and positioned between two flat jacks as shown (above, right). The flat jacks are supported on mounts secured to the base plug. Spacers (not shown) are positioned on the outside of the flat jacks so the outside diameter of the sample-flat jack assembly is 0.0.075 inches (1.9 mm) less than the bore of the pressure vessel. Finally the sample-flat jack assembly is inserted into the pressure vessel. The confining pressure and an axial stress are exerted on the sample. The sample is now in a state of biaxial stress. To develop a state of triaxial stress, the flat jacks are pressurized to a pressure greater than the confining pressure. The flat jacks expand. Once the gap between the vessel wall and the flat jacks closes and the pressure in the flat jack continues to increase, a stress is exerted on the faces of the sample. The reaction force for the principal stress is developed at the vessel bore. The sample is now in a *state of true triaxial stress*.

Throughout the pressurization sequence strains are monitored and recorded. In addition, compressional and shear wave velocities and/or permeability can be measured to determine the effects of triaxial stress on the rock properties. For true triaxial tests the specimen is often instrumented with velocity transducers on the free surface of the specimen. In this configuration velocities can be measured parallel and normal to the long axis of the sample.

The loading configuration described above produces a true, well defined state of stress in the rock. However in some instances, an intermediate principal stress may be used only to force a hydrofracture to initiate and grow parallel to the intermediate principal stress direction. For this application, a focused stress on the surface of a cylindrical sample is sufficient. The faces of the flat jack are machined to match the radius of the sample. The width of the contact area is adjusted depending on the elastic and strength properties of the rock. It is important to note, in this configuration the state of stress is not well prescribed throughout the sample.