MATERIALS AND PROCESS CONTROL TESTING

The testing of materials and complex assemblies is such a vast field that it is impossible to cover all aspects of it completely in this manual. In this section, we will give an overview of the different types of material tests and other specialized tests using force as a variable, with some examples of the most common applications.

Force Versus Deflection

In the determination of the force versus deflection characteristics of a raw material, a fabricated part, or an assembly, it is usually necessary to control the position and orientation of the *UUT* (Unit Under Test), to control the direction and magnitude of the applied force, to measure one or more displacements, and to measure any other parameter which may vary with the force or displacement. For these reasons, a large market has developed over the years for sophisticated testing machines and their associated fixtures, transducers, and signal conditioning and recording equipment.

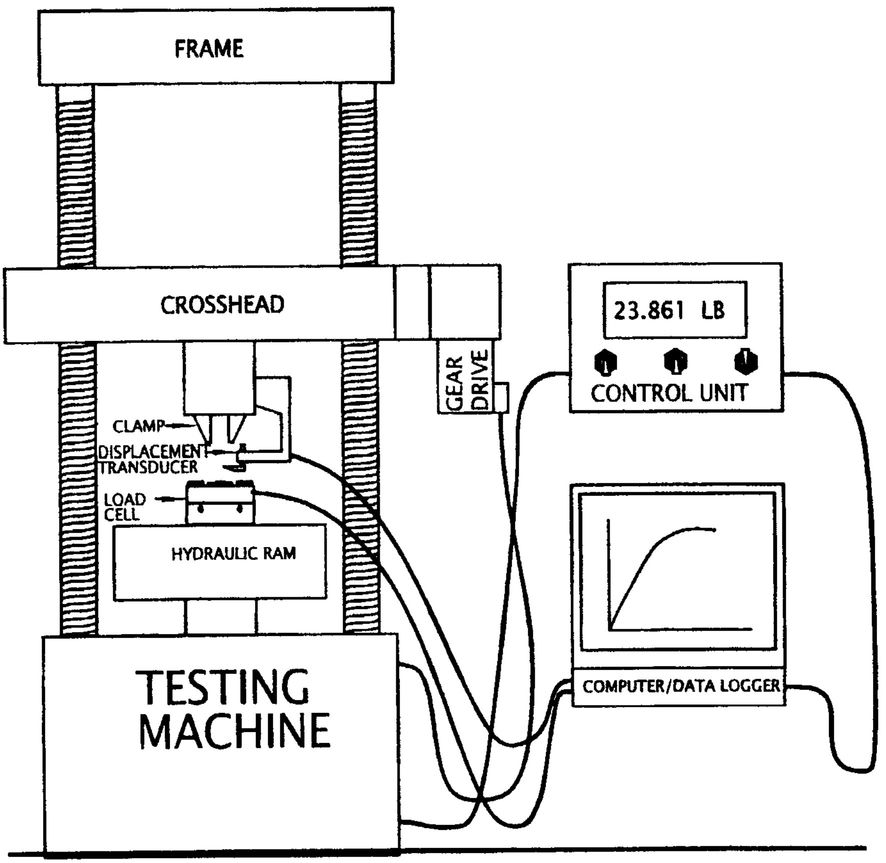

Figure 42. Typical Materials Testing Machine Setup

In the typical materials testing machine shown in Figure 42, where the clamp is shown, various other fixtures can be attached to hold, or even rotate, the UUT during the test. Other transducers can be mounted to measure torque, angle, pressure or any parameter the customer is willing to pay for. It is not unusual to test for torque and linear force concurrently, and the Interface Low Profile cells are eminently suited for this because of their high rejection of extraneous loads.

With the hydraulic ram at a solid stop, the gear drive can be servo-controlled to advance the displacement at a very accurately controlled rate, to determine the time dependency of a material's characteristics. Or, with the gear drive locked, the hydraulic ram can apply a precise force profile, as controlled by the load cell.

In general, any modern test machine is programmed and controlled by its own internal microprocessor, with facilities for accepting large volumes of control information and transmitting high rates of measured data either to a local datalogger or to a network server for further processing.

Shear Force Versus Compaction

In the determination of shear strength versus compaction of soils or construction materials, the object is to determine the shear strength as the material is used at different depths underground or at different levels in the construction of a high-rise building. Usually, a special test block is designed to test a particular type of material in conformance with a specification.

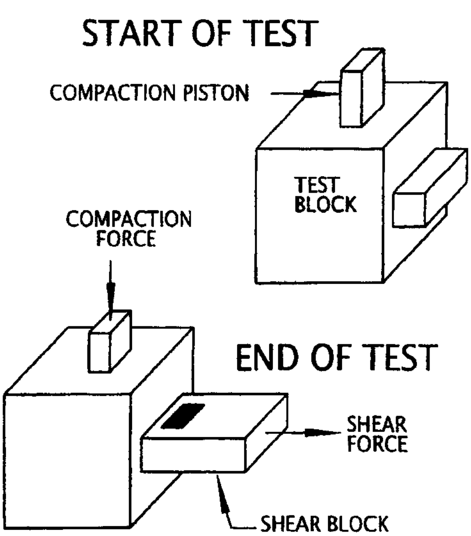

Figure 43. Soil Shear Versus Compaction

The test block is designed with a rectangular hole going through it, into which the tested material is inserted. To set up for the test, the shear block is put into position in the test block so that the hole in the shear block lines up with the rectangular test hole. The material under test is then packed into the hole, up through the hole in the shear block, and almost to the top of the test block. Finally, the compaction piston is inserted, and the material is evenly pressed down to fill the hole and remove air pockets and voids.

The actual test is performed in a test frame much like a materials test machine, except that it has an additional capability to pull out the shear block while measuring the shear force and shear deflection. To perform the test, the compaction force is first applied on the top of the compaction piston by a compression load cell, and then the tension shear force is applied to the shear block by another load cell. The test is repeated for a range of compaction forces, and the output from the test is a table of figures or a graph of shear force versus compaction force.

Peel Force

A common test for adhesives, adhesive-coated tapes, and paints is the peel test. The test parameters are usually detailed in a government or industry specification, and the rate of pull is most often closely controlled. Adhesive-backed tapes are tested this way. Also, paint adhesion is tested by applying the paint according to instructions, applying a specified adhesive-backed tape to the painted surface, and then pulling the tape off in a specified way.

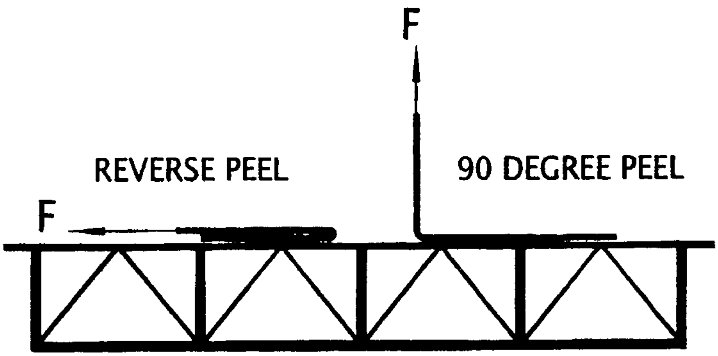

Figure 44. Adhesive and Paint Peel Test

Adhesive or Bonding Shear Force

There are literally thousands of adhesives and bonding agents which are used to assemble parts into assemblies. In addition to their bonding characteristics, they may be required to have a certain elasticity, resistance to chemicals, electrical conductivity, temperature coefficient, or other controlled parameter.

In addition to the general-purpose shear test machines on the market, many testers are designed and constructed in-house to perform specific tests on unique assemblies.

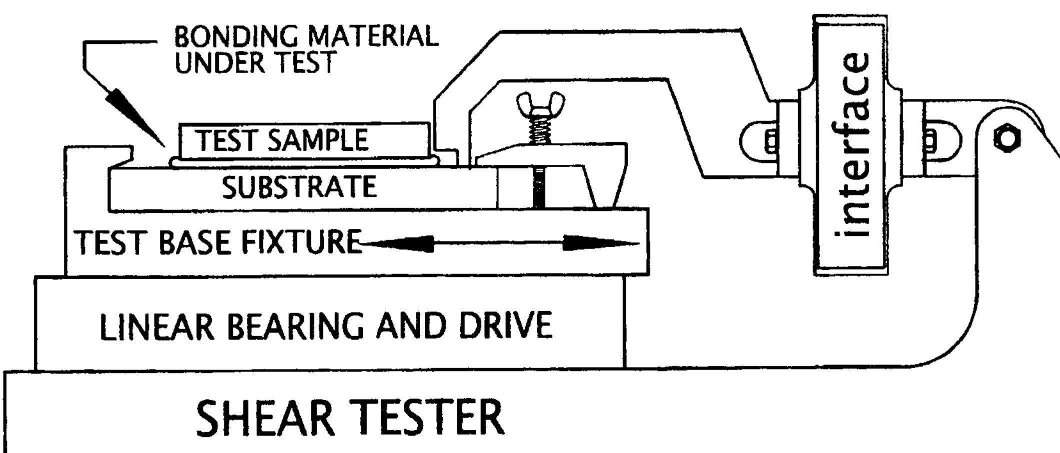

Figure 45. Adhesive Bond Shear Tester

The design of a shear tester is relatively straightforward, as long as the following conditions are met:

1. The line of action of the primary axis of the load cell should be aligned with the contact point on the test sample, to minimize moment loads on the load cell.
2. The linear bearing motion should be carefully adjusted to run exactly parallel with the primary axis of the load cell, to avoid a side load into the load cell.
3. The load cell's capacity should be at least twice the expected maximum load to be applied during a test cycle, to provide enough extra capacity to protect the cell when a sudden failure of the test sample impacts the load cell.
4. The linear drive should have a wide range of controlled speeds and a high resolution displacement measuring capability, including an automatic adjustable stop with fast braking to protect the load cell from damage. A stepper motor drive with precision high-ratio reduction gear is the usual system of choice.

Safety: Proof Testing and the Compression Cage

Many industry and government specifications require testing the components of a system at many times the rated or nameplate loading, where the failure of the component could result in costly damage to equipment or injury to personnel.

The most sensitive product liability area for load cell manufacturers is the use of a load cell in tension on a crane which lifts loads where it is possible that a person could be

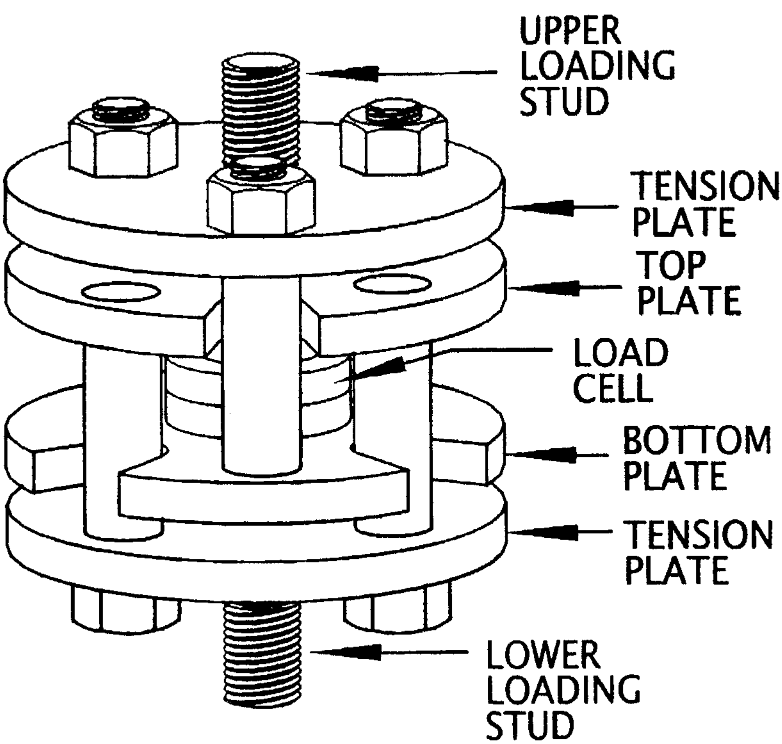

Figure 46. Compression Cage

under the load, even by mistake. Proof testing in this case usually requires that the equipment be proof tested at five times its rating. Obviously, a tension load cell could never survive such a test. Interface never recommends using a tension load cell in this type of application.

The most straightforward solution, where it is necessary to measure the load in a tension cable subject to safety considerations is to enclose the load cell in a compression cage, which converts tension into compression. The compression cell is trapped between the two plates. Thus, the load cell's only overload failure mode is in compression, which allows a motion of only 0.001" to 0.010" before the load cell becomes solid. Even if the load cell is totally destroyed, the compression cage cannot drop the load unless it fails itself. Therefore, the cage can be proof tested with a dummy load cell, or an overload-protected cell, and the risk of injury to personnel is avoided.

Finding Center of Gravity

One of the critical tests on missile assemblies is the determination of the center of gravity, because variations in the weight distribution in a missile can have a disasterous effect on its flight stability.

The test stand shown in Figure 47 typifies the elements which need to be addressed to optimize the test.

1. Three cells instead of four will simplify the design, construction, and use of the test stand immeasurably.
2. The mounting ring should be as close as possible to the level of the center of gravity of the UUT. The farther the reference hard pads are displaced from the center of gravity, the more the test stand will be subject to errors due to levelling, misalignments, and temperature effects.
3. A calibration dummy load should be constructed which has the same weight as the UUT, and whose center of gravity is at exactly the required location. This will dramatically decrease errors due to non-linearity of the load cells.
4. The test stand should be levelled each time it is used, and the cells should be carefully exercised with the dummy load and checked for calibration.

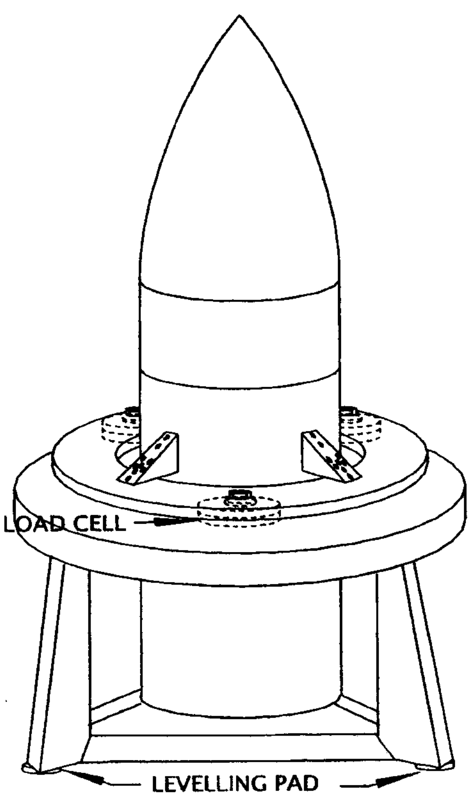

Figure 47. Center of Gravity Test Stand