

# **UNDER PRESSURE**

by  
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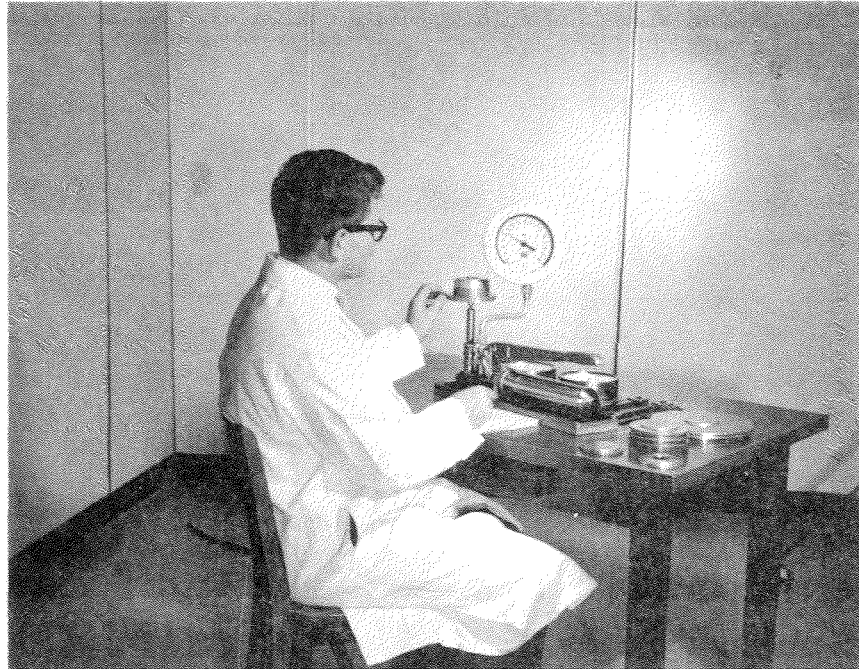
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Calibrating a pressure gauge on a dead weight tester. Disc weights, seen at the right of the table, are added to the platform by the operator's left hand. This platform rests on a free piston which transmits the resultant pressure through a hydraulic fluid in the tester to the gauge. The gauge reading can thus be compared to a known pressure.

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## UNDER PRESSURE

It is frequently said that people do their best work when under pressure; machines on the other hand may break down under too much pressure. Nevertheless, pressure and its measurement is often a requirement in many research projects. Pressure, of course, is measured by a pressure gauge. There are several types of gauges on the market and a vast range of sizes and qualities. With a little care it is possible to choose one which meets the requirements of a particular experiment.

The most common type, see Fig. 1, uses a Bourdon tube to activate the gauge mechanism in response to changes in pressure. This curved, flattened tube, closed at one end, is made of brass, bronze or stainless steel, depending upon requirements. It is forced to straighten out as gas or liquid pressure is applied through the base of the gauge to the open end. This causes the free end of the tube to move and this in turn is linked to the needle on the dial which thus indicates pressure changes.

### BASIC MECHANISM OF PRESSURE GAUGE

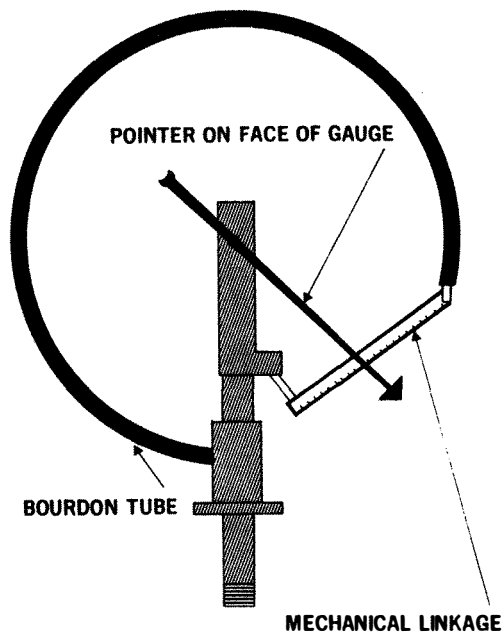


FIG. 1

Like many other cases of measuring, it is not always easy to know what one is measuring. The dial on the gauge may read x psi\* but is this really the pressure in the system supposedly being measured? If an ordinary gauge is used to record pressure in a liquid-filled system, some air will be trapped in the Bourdon tube. This may cause a slight variation between pressure as read and the actual pressure in the system. If desired, the gauge may be ordered "liquid filled" with the system fluid. For very accurate results gauges are made with a removable threaded plug at the closed end of the Bourdon tube. This may be removed to bleed gas or liquid from the system and gauge before starting to read pressure.

Although very simple in design the gauge presents problems for the user. Like any piece of equipment used to measure a variable quantity it must first be calibrated and provided with some form of readable scale. The manufacturer naturally calibrates the instrument and affixes a scale which normally reads in pounds per square inch or grams per square centimeter. However, the graduations on the dial are not necessarily uniform for all gauges. One may read from 0-100 psi in one pound steps, another from 0-100 in 10 or 20 pound steps.

The user must therefore first select a gauge which is graduated in suitable divisions which will enable him to read readily to the degree of accuracy he desires. The finer the graduation, the more expensive the gauge. To ensure accuracy at small scale readings, it is best to choose a gauge with the largest diameter dial that is feasible for the particular installation.

A second point to bear in mind in selecting a gauge also concerns its basic design. The Bourdon tube must stretch and flex under pressure, yet it must be strong enough to avoid rupturing at the peak pressure or even accidental overpressure in the system. Naturally the tube and linkage have a certain inertia and when low pressure is first applied the tube may not flex. It is common to find gauges in the 0-500 psi range with the first graduation at 10 or 20 psi and the balance of the dial graduated in 5 lb. intervals. As pressure is increased to near the gauge limit, there is a tendency for the tube to flex too much. Thus, gauges are likely to be most accurate at the mid point of their range. This should be kept in mind in selecting a gauge. If working pressure in the system will vary in the range 100 to 200 psi, a gauge reading 0-300 psi would be a logical choice. The gauge should always be mounted in a vertical position unless specifically designed for use in a horizontal position.

If a gauge is to be used to record pressure in a system containing oxygen, it must be free of any trace of organic material. The gauge should be order "cleaned for oxygen" or "for oxygen service". It should be handled carefully and care should be taken not to get oil or grease on the gauge threads.

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\* Pounds per square inch.

Like any precise measuring instrument, pressure gauges are subject to error because of damage. A reading from a gauge that has been dropped or subject to severe vibration is naturally suspect. A more difficult damage to detect results from subjecting the gauge to excess pressure. A gauge which reads to 400 psi will usually safely stand pressures up to 500 psi, but there is a danger that the Bourdon tube will be permanently stretched and its accuracy at lower pressures impaired.

Excessive vibration is another obvious source of trouble. If pressure in the system fluctuates rapidly, it may damage the gauge. This is often the case where a piston-type pump is used to generate pressure. Hydraulic snubbers, needle valves, safety valves, air chambers and other devices may be built into a system to protect the gauge. System design is outside the scope of this brief report but the author would be pleased to assist with this at any time, or gauge suppliers are usually willing to advise on specific applications.

Where accurate pressure readings are required, it is helpful if pressure in the system can be varied from time to time. If the pressure remains constant at 100 psi, for example, for long periods the Bourdon tube may develop a "set" at that point. A good practice is to vary the pressure above and below the normal before taking a reading but this is not possible in all systems. One manufacturer recommends first increasing pressure to gauge limit for a brief period, then allowing it to return to normal before reading. An alternative arrangement is a pair of cut-off valves which isolate the gauge and allow pressure to bleed from the gauge between readings. Where such cut-off valves are used or in any other system care should be taken never to admit or release the pressure suddenly as the jar might shift the indicator needle on its shaft.

Even the best of gauges with the best of care may eventually get out of calibration. They can be checked by comparing their reading with a standard or reference gauge. A more satisfactory method is to check the gauge on a dead weight tester.

The dead weight tester, Fig. 2, consists of a reservoir which contains a hydraulic fluid - oil or water, a pump, one outlet for the pressure gauge being calibrated, and another holding a free piston which may be loaded with predetermined weights to produce a given pressure in the system. Hydraulic fluid is pumped into the system until the piston floats at equilibrium. In many of these the cross section area of the free piston is 1/10 square inch. Thus, if a 1-lb. weight is put on the piston it creates a pressure of 10 psi in the hydraulic fluid and the gauge being calibrated or checked should read 10 psi.

### DEADWEIGHT PRESSURE GAUGE TESTER

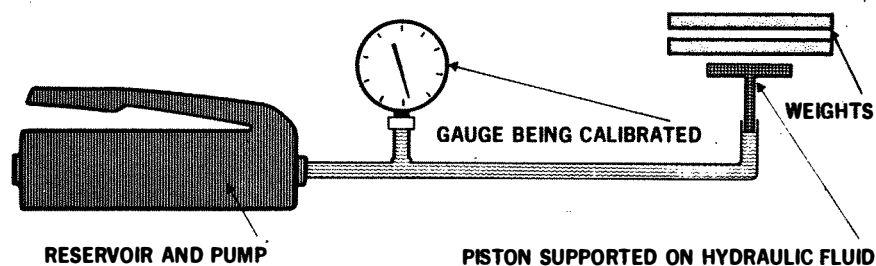


FIG. 2

To check or calibrate a gauge, weights are added one at a time to the free piston until maximum pressure is reached. The pressure recorded on the gauge is noted at each step. The weights are then removed one at a time and the pressure on the gauge again noted at each step. During this process it is necessary to pump additional hydraulic fluid into the system as weights are added to compensate for compression of the fluid, as weights are removed fluid is bled from the system. The increasing and decreasing pressure readings at each stage are averaged to give a true pressure reading at that point. If the gauge is badly out of calibration it can be usually adjusted to give a correct reading at the mid-point or other critical range on the scale.

Dead weight testers are expensive and require careful use and maintenance, thus most gauge users do not consider their purchase unless many pressure gauges are in use.

The Forest Fire Research Institute has a dead weight tester in its Hydraulics Laboratory at the Petawawa Forest Experiment Station. The Institute can calibrate gauges for other units of the Department at no charge. This calibration can naturally only be done at a time when it will not interfere with other work at the Laboratory but, normally, satisfactory scheduling can be arranged by mutual agreement between gauge users and the Institute.

It should be noted, however, that because we use an oil-filled tester we can not calibrate gauges which are used in an oxygen system.

Gauges to be calibrated should be carefully packed to protect them from shock during shipment. The package should be sent by express to:

Forest Fire Research Institute  
Department of Forestry and Rural Development  
161 Laurier Avenue West  
Ottawa 4, Ontario

A covering letter describing and identifying the gauges by make or serial number, and giving any time limit, should be sent to the Institute. Naturally, the address to which the calibrated gauge and test report should be sent should be included.