2.0 FACTORS AFFECTING PERFORMANCE OF DEAD WEIGHT PISTON GAGES

The performance of dead weight loaded piston gages should not limit the accuracy of measurements made with the instrument. At low pressures the uncertainty of the value of the area A_o is usually the limitation, and at high pressures the uncertainty in the value of the pressure coefficient of area b, may be the limitation. The reproducibility of a piston gage in good working condition should be better than one part in twenty thousand in order to achieve the greatest possible accuracy.

2.1 Eccentric Load Error. Erratic behavior has sometimes been observed if the weights are stacked off center. There may be a fluctuation of pressure in synchronism with the rotation, or a change of the mean pressure which depends on the speed of rotation, but not on the direction. These troubles are worse for instruments in which the weights are stacked in a tall pile on top of the piston. The "eccentric load error" is the most common cause of poor performance of piston gages. Errors in the pressure exceeding one part in a thousand have been observed. The magnitude of eccentric load error has been observed to be a function of the speed, but not of the direction of rotation of the weights, and depends on the eccentricity and magnitude of the load, the alignment of the piston, cylinder, and guide bearing and the clearance between the piston and cylinder and in the guide bearing, and the leveling of the instrument.

Design of the weights are an important consideration in reducing eccentric load error. The diameter should be large, so that the height of the stack does not exceed the diameter. Individual weights should be balanced and should nest or index on the piston so that the load is balanced.

Some techniques for reducing eccentric load error are as follows:

1. Level the piston gage so that the piston rotates about a vertical axis. This is done by placing a bubble level on the piston and adjusting the instrument so that the piston and bubble level can be rotated together to any position without any change in indication.

2. Stack the weights so that they are centered on the axis of rotation.

3. Avoid excessive speed of rotation.

2.2 Corkscrewing. A helical scratch or tool mark on the piston, cylinder or guide bearing of a piston gage may result in an error known as "corkscrewing". This is a function of the speed and direction of rotation of the piston. It is usually negligible, but in severe cases may amount to

as much as one part in a thousand. Corkscrew error can be reduced by avoiding excessive rotational speed. The user should not fall into the habit of making all observations with the piston rotating in one direction. About half of the observations should be made with the piston rotating in each direction. The observer will then be in a position to notice the corkscrew error if it appears. He can, if he wishes, average readings taken with the two directions of rotation.

2.3 Liquid Buoyancy. The buoyancy of the pressure transmitting liquid acting upon the piston assembly can be accounted for if it is constant and not too large. In some cases the secondary guide piston passes through a cavity that may be partially or entirely filled with liquid. As the piston moves up and down and the oil level lowers and rises, the effect of buoyancy may vary from zero to as much as 0.5 psi. Use of a piston gage having variable buoyancy necessitates a technique whereby the buoyancy can be made reproducible and known.

2.4 Drive Error. There are numerous ways by which the piston may be driven in a rotational or oscillatory manner. Nearly all methods may impart a vertical component of force to the piston. This vertical component will be proportional to the torque required to drive the piston and will be a function of load, eccentricity of load, speed, friction, and level. The resultant error may be negligible or may be very large. One test to determine the magnitude of drive error is to compare the results obtained with the drive in operation, with the results obtained when the piston and load are coasting free from the drive. A suspended, non-rotating load may oscillate abnormally when the piston is rotated or oscillated at a particular speed. Such speeds should be avoided.

2.5 Weights. The weights should be nonmagnetic, solid, and preferably of a hard, nonporous metal, such as brass or stainless steel. The surface finish should be smooth, preferably polished. Other considerations such as balance, diameter, and indexing are discussed above in connection with eccentric load effect.

2.6 Friction. Friction in a piston gage reduces the sensitivity and reproducibility of the instrument to a marked degree. Excessive friction results from eccentric loading, improper leveling, misalignment of the piston-cylinder-guide bearing assembly and either excessive or insufficient clearance between the piston and cylinder. Friction in the bearing between the piston and yoke of a suspended, nonrotating load may also be excessive.

When the weights are loaded on the piston and set into rotation, they should continue to rotate for several minutes. The simplest and most revealing criteria of performance is the coasting time of a freely spinning loaded piston.