Compressive Yield Strength

Compressive yield strength data on SIFCO DALIC Process deposits would prove useful in determining whether they are suitable in these applications.

The compressive yield strength of SIFCO DALIC Process Deposits, however, has never been directly measured. One reason is that it would be very costly and time consuming. It, for example, would require, if done per ASTM E9, the plating of a deposit at least 1 inch thick, and then the machining of a test sample from it.

Estimates of the compressive yield strength,however, can be made from hardness data.

One reference[1] includes the following statement: "For metals this (P_0) is approximately equal to 3Y where Y is the yield point of the softer material determined in a tensile test, and is equal to the indentation hardness." A second reference[2] contains the following: "the mean loading pressure, which relates to the theoretical hardness values obtained by static indentation tests, may be expresssed as C x Y, where C is the constraint factor for the test, and Y is the uniaxial flow (true yield) stress of the material being tested, usually given in kPa or psi. The value of the constraint factor depends primarily on the shape of the indenter used. For many of the common indenters (sphero-conical diamond, Brinell, Vickers, and Knoop), which are all relatively blunt, the constraint factor is approximately 3."

The compressive yield strength of most metals is approximately equal to the tensile yield strength. To convert kg/sq mm to lb/sq in. requires multiplying by 1400. Thus, the two references indicate the compressive yield strength of a deposit can be estimated by using the following formula: Compressive Yield Strength = 1/3 x 1400 x HV

Copper 2050 deposits having a hardness range of 110 to 157 HV should, therefore, have a yield strength range of approximately 51,000 to 73,000 psi.

An estimate of the compressive strength of Copper 2050 deposits was made in a second manner. Data was found correlating microhardness and tensile yield strength in a third reference[3]. This was plotted out and a conservative line grouping the points was drawn; see Appendix I. Assuming Knoop equals HV and compressive yield strength equals tensile yield strength, Copper 2050 deposits having a hardness range of 110 to 157 HV should have a compressive yield strength of 29,000 to 41,000 psi.

Actual Load Bearing Capabilities of SIFCO DALIC Process Deposits

The lowest estimated yield strength value arrived at in the above for a Copper Code 2050 deposit was 29,000 psi.
The radial pressure arrived at in the previous textbook example was 3,620 psi. The yield strength value, therefore, is 8 times that of the radial presure, which indicates there would be an ample safety factor in this application.

Comparing estimated yield strength to the estimated pressure on the plating, however, is a very conservative approach. The reason is that the effect of frictional forces is not taken into account. Most compressive yield strength testing is done per ASTM E9 and on samples with a length to diameter ratio of at least 1.5. The purpose of this is to eliminate the effects of friction at the ends of the sample. The effect of friction, however, becomes significant when the deposit is "thin", the deposit is firmly boded, and the deposit to mating surface is not lubricated. The friction makes a significant difference.

"Strength and Structure of Engineering Materials"[4] gives the best math found to date on when a soft but dense plating can be expected to start squeezing out in load bearing applications. See Appendix II. Using the mathematical formulas completed on page 309, the following has been calculated for a Copper Code 2050 deposit.

Assume: A 1 in. length on a diameter, OD or ID, is plated with copper having a tensile yield strength of 43,210 psi, and the coefficient of friction is 0.18.

Thickness of Deposit - in.	Force for deformation on a 1 in. length of the circumference - lb
1.000	54,782
0.080	152,015
0.020	621,085
0.001	12,487,706

Indium is the softest SIFCO DALIC Process deposit and it has a hardness of 2 HV or 2 Brinell. This equates to a yield strength of 1,000 psi. Going through the same calculations as for copper, a 0.001 in. thick deposit of indium would require a pressure of 250,000 psi before it would squeeze out.

Summary

Materials softer than one might think should perform, and have performed, adequately on shrink and press-fit surfaces and bearing seat applications.