EFFECT OF OXYGEN CONCENTRATION ON THE STRUCTURE 
AND PROPERTIES OF SINTERED SILVER–CADMIUM OXIDE 
COMPOSITE CONTACTS

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The structure, corrosion resistance, and resistance to welding of silver–cadmium oxide contacts fabricated 
by sintering powder compacts in an inert gas containing a low concentration of oxygen were studied. Sintering 
in the absence or deficiency of oxygen produced structural changes in the material, accompanied by a 
reduction in the volume fraction of cadmium oxide and formation of a solid solution of cadmium in the silver 
matrix. Lowering the oxygen concentration and raising the sintering temperature resulted in a redistribution 
of cadmium and oxide phase in the solid solution, and impairment of the contact properties of the material. 
It appears that the effects observed are due to the decomposition of cadmium oxide. New technology for the 
manufacture of contacts by the powder metallurgical method is proposed, based on control of the oxygen 
concentration of the sintering atmosphere.

The unique properties of silver–cadmium oxide contacts are attributable to the structure of the material, which consists 
of a silver matrix with uniformly distributed particles of cadmium oxide [1]. This structure is obtained by internal oxidation 
of semi-finished or finished silver–cadmium alloy contacts, or by traditional powder metallurgy methods using mixtures of 
silver and cadmium oxide powders.

It is known that in making use of internal oxidation the atmosphere has an important effect on the structure and final 
properties of the material, and its oxygen concentration is a most important factor. In the fabrication of composite 
silver–cadmium oxide contacts by the powder metallurgy method the effect of atmosphere has not been sufficiently well 
studied, since sintering has always been carried out in air. However, improvements in the manufacturing processes, in particular 
the introduction of contacts with sublayers of non-precious materials, and the use of mainly non-oxidizing sintering atmospheres 
in producing these, have made it desirable to investigate the effect of oxygen concentration on the structure and properties of 
silver–cadmium oxide composites.

The effect of oxygen content on the sintering of powder silver–15 wt.% cadmium oxide contacts in argon over the 
temperature range 750-900°C was studied in the present work. Sintering was carried out in a unit of the “Argal” type in a 
quartz reactor; high quality argon with an oxygen content below 0.0007 vol.% was used as the principal atmosphere. Constancy 
of the gas composition in the reactor was guaranteed by its size (diameter 160 mm, length 4000 mm), and also by constant 
replacement of the gas (the delivery of gas to the working atmosphere in the reactor was 1.05 liter/min). The temperature in 
the operating zone of the reactor was maintained constant within ±2°C. A small excess (above atmospheric) gas pressure in 
the reactor during sintering, equal to 5·10² Pa, was provided by a water seal. The oxygen concentration in the specially 
prepared argon-based mixtures was monitored calorimetrically to an accuracy of ±10%.

*SOK15m — composite Ad — 15 wt.% CdO (or 18 vol.% CdO).
Ingots for sintering, 10 mm in diameter and 2 mm high, were prepared from grade SOK15m* powder (TY 48-1-107—82) by compacting. These had a residual porosity of 26-27%. The sintering time was one hour. After sintering the ingots were finish pressed to contacts under a pressure of 9.8×10^8 Pa (~10 ton/cm²), and annealed at 450°C for one hour.

The corrosion resistance, evaluated as the magnitude of the specific (for one discharge) weight loss of contact material, was determined on the special stands MAK B and MAK O [3]. The resistance to welding was evaluated on the first stand by the force required to separate contacts which were welded by closing on a current of 300-1200 A, and in the second stand by the force to separate after passing a current through the contacts of 1100-3000 A. Ten contact pairs were tested in each regime.

Certain regularities are seen in the test results for contacts prepared from ingots which were sintered at various temperatures in argon containing various concentrations of oxygen (Table 1). Decreasing the concentration of oxygen below 0.53 vol.% in the investigated temperature range was accompanied, as a rule, by decrease in the corrosion resistance and resistance to welding (the specific weight loss and separating force increased). Changing the oxygen concentration from 0.53 to 20 vol.%, a value close to that in air, had practically no effect on the properties of the contacts. The properties of contacts sintered at 850-900°C and those of production contacts of the same composition (KMKA10m), sintered at the same temperature, were practically identical.

The effect of sintering temperature on contact properties is dependent to a large degree on the oxygen concentration. At 0.53 vol.% and higher, increasing temperature Improves contact properties. (Some diminution in the rate of increase of erosion resistance, or even a decrease, with increasing temperature between 850 and 900°C was also noted in [2, 3], connected with embrittlement of the cadmium oxide particles.) At oxygen concentrations below 0.53 vol.% the erosion resistance and resistance to welding, as a rule, decreased with increasing temperature.

Contact materials sintered in highly pure argon containing less than 0.0007 vol.% oxygen in the range 750-900°C, actually used for the sintering of silver—cadmium oxide contacts, have properties substantially inferior to those of the production material KMKA10m, as well as those of contacts sintered in argon containing more than 0.12 vol.% oxygen.

In order to clarify the reasons for the observed regularities, the structure of the contact materials was studied by optical and scanning electron microscopy, and x-ray diffractometry. It was found that the structure is substantially dependent on the concentration of oxygen in the argon. If this exceeds 0.53 vol.% the contacts are two-phase throughout the entire cross-section, just as after sintering in air. The volume fraction of cadmium oxide, determined by the method of random secants [5] on photographs of the microstructure obtained in an electron microscope at 4000× magnification, was of the order of 18%. The structure was fairly uniform. At oxygen concentrations below 0.53 vol.% the volume fraction of cadmium oxide particles decreased from the interior to the surface, leading to the formation of a surface layer containing no oxide particles at all (Fig. 1). The thickness of this single-phase layer was greater, the lower the oxygen concentration in the argon, and the higher the sintering temperature. When sintering was carried out in highly pure argon, a fairly thick layer of practically single-phase