OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.

DISCLAIMER

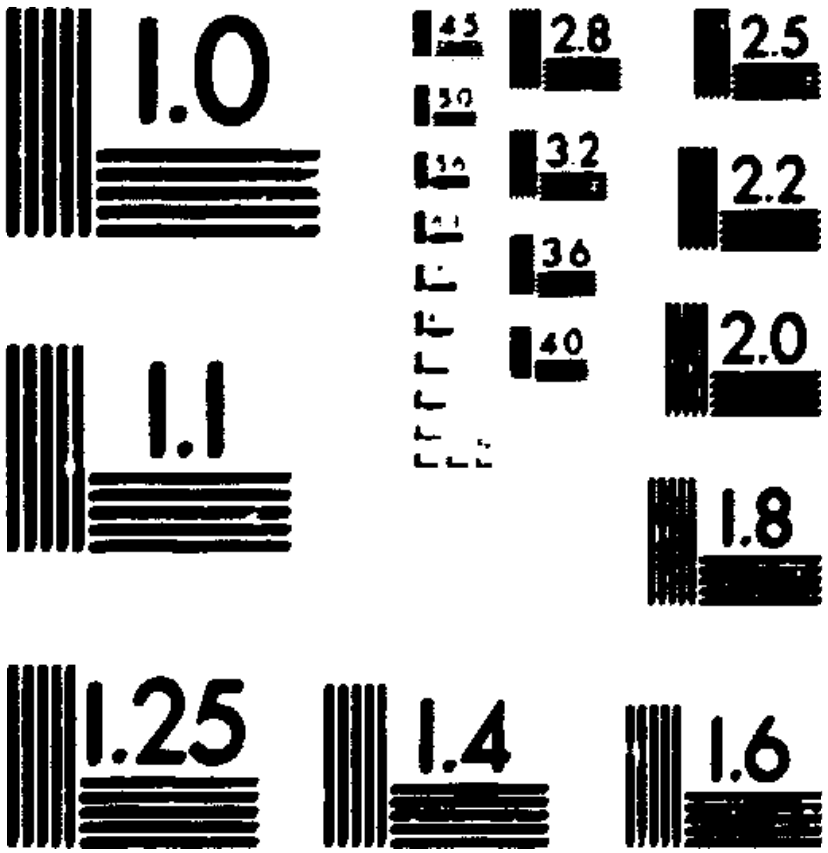
FAIR USE POLICY

CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org



96.

JP/49/80

UNIDO-Czechoslovakia Joint Programme
for International Co-operation in the
Field of Ceramics, Building Materials
and Non-metallic Minerals Based Industries
Pilsen, Czechoslovakia

→ Maria Dietrich

14105

SILVERING SUSPENSIONS FOR ELECTROTECHNICAL INDUSTRY AND ELECTRONICS

By: Emanuel Příhoda +
Milan Grotte

Special consultant: Z. A. Engelthaler

2870

July 1980

+ Glazura, Roudnice

ABSTRACT

This paper gives a brief description of the manufacturing technology of silvering suspensions to be used in the electrotechnical industry and electronics.

The silvering suspensions are blends of metal silver and silver oxide powders finely dispersed in baking varnish. Some of them to be used in electronics contain even metal gold, platinum and palladium. These coatings are well solderable. They are applied as pastes to ceramic parts by brush and baked at temperatures ranging from 760 to 800°C.

First of all precious metals and oxides powders are prepared to be blended with adhesive components and varnish afterwards.

The precious metal powder is usually made by reduction in a warm solution of a reducing agents in enamelled, glass or ceramic vessels with agitators or by precipitation in a lye. The slurry so obtained is to be washed and dried at 60 to 80°C. The dry precious metal powder then is ready to be blended with admixtures and varnish to form a paste.

Adhesive admixtures are made of pulverized lead glasses, bismuth trioxide and cadmium borate.

Varnish components are made by using appropriate thinners in cold or warm state in enamelled vessels. They must be viscous and must add good application properties to the blend.

The recipes for final silvering blends must be adhered to very carefully and testing must be carried out during the entire process. The final products must be tested for precious metal content and application properties.

All residues and wastes must be collected, reworked and used in the production process again.

The production shop and laboratories must be provided with fume hoods and effective ventilation system to protect the personnel against harmful and unpleasant volatiles and fumes from the organic

thinners. The personnel must be well trained and skilled and outfitted with proper protective aids.

All the production equipment such as electric motors in mills and exhausters, chamber driers, agitators, etc. are to be of explosionproof design.

The production and storage areas in total for the yearly production of about 1000 kg of silvering suspension amount to approximately 400 sq.m. Yearly consumption of water and electric power is about 500 l and 30 000 kWh respectively.

CONTENTS

I. INTRODUCTORY NOTE

Based upon the interest of a company in India passed over to the UNIDO-Czechoslovakia Joint Programme for International Co-operation in the Field of Ceramics, Building Materials and Non-metallic Minerals Based Industries by the UNIDO Vienna Industrial Inquiry Service, Industrial Information Section, the manufacturing technology of silvering suspensions for electrotechnical industry and electronics was investigated.

Silvering suspensions to be applied in the industries of electrotechnics and electronics are blends of fine metal silver powder and silver oxides dispersed in baking varnish. The suspensions contain various admixtures to improve the properties and adhesivity of the silver coatings. They can be applied either by brush painting or by silk-screen printing. Some of the solutions for electronics contain also finely dispersed platinum or gold powder. Such solutions are then made into pastes.

These suspensions are applied to ceramic products to form silver coatings after baking in electrically heated kilns at temperatures ranging from 760 to 800°C.

Production of the precious metal suspensions is divided into several phases and may be defined as a large scale laboratory manufacture. All the metal powders can be made by the producer except for platinum metal powder and palladium which should be purchased ready made.

It is essential to keep accurately to the prescribed technology and recipes. The production shop itself should be equipped with precise device for perfect dosage of materials and provided with a laboratory to check the quality of raw materials, semi-products and final products.

The production shop equipment should necessarily be supplemented with good exhauster system to provide for a perfect air exchange in the production premises because of harmful vapours and dust accompanying the manufacturing process.

All the personnel must be skilled and well conversant with the work hazards and operation of the machinery and equipment. They must wear protective dresses and aids.

II. DEFINITION OF PRODUCTS

Silvering suspensions for electrotechnics and electronics are suspensions of finely dispersed metal silver, silver oxide or their mixture in a varnish component. The suspensions contain various admixtures which influence the properties and adhesivity of the silver coatings. They can be applied by brush or by silk-screen printing. Silvering suspensions for miniature circuits in electronics contain also a certain proportion of dispersed platinum metals. Some special suspensions contain finely reduced metal gold and admixtures in the varnish component. All the metal coating suspensions for electronics are supplied in the form of pastes to be applied by silk-screen printing method.

All the suspensions are used to form baked silver coatings on ceramic products.

The coatings are well solderable by solders used for soldering silver layers on ceramics to lend good adhesivity to a bisque.

Basic types of silvering suspensions

a) Silver suspension for the silvering of capacitors to be applied by brush - baking temperature being 780 to 800°C.

b) Silvering pastes for electronics - baking temperature being 760 to 800°C.

c) Gold pastes for electronics - baking temperature being 760 to 800°C.

III. BRIEF DESCRIPTION OF MANUFACTURING TECHNOLOGY OF SILVERING SUSPENSIONS

All the types of silvering suspensions are made by dispersion of very fine powder substances of precious metals and admixtures in varnish components.

Main raw materials required for the production of silvering suspensions and pastes

Chemically pure silver nitrate ($AgNO_3$), palladium powder (Pd), platinum powder (Pt), chemically pure potash lye (KOH), chemically pure soda lye (NaOH), chemically pure ammonia (NH_4OH), chemically pure nitric acid (HNO_3), chemically pure hydrochloric acid (HCl), commercially pure hydrogen peroxide (H_2O_2), commercially pure sodium carbonate (Na_2CO_3), commercially pure glucose, commercially pure organic solvents, commercially pure plasticizers, commercially pure polystyrene, commercially pure methylalcohol, commercially pure ethylalcohol, commercially pure minium (Pb_3O_4), commercially pure boric acid (H_3BO_3), silica (SiO_2), commercially pure bismuth trioxide (Bi_2O_3), demineralized or distilled water, clean service water.

Main phases of the manufacturing technology

a) Preparation of metal silver powder (Ag)
b) Preparation of silver oxide powder (Ag_2O)
c) Preparation of gold powder for special compounds
d) Preparation of adhesive admixtures
e) Preparation of varnish components
f) Blending and dispersing in varnish components in compliance with the recipes for the individual products

Fine platinum powders, platinum and palladium are to be purchased.

Production of fine metal silver powder (Ag)

Silver powder is made by reducing silver nitrate in a solution of reduction agents.

The reduction takes place in warm state in about 100 l enamelled, glass or ceramic vessels provided with agitators. When the mother liquor has been separated the slurry of the reduced silver is to be washed by decantation or by washing in a laboratory filter press by means of demineralized or distilled water. The thickened slurry is to be dried in a chamber drier at 80°C temperature after the washing process. The dry silver powder is used then for the preparation of various blends.

Production of silver oxide

Silver oxide is made by precipitation of silver nitrate solution ($AgNO_3$) by means of lye (KOH, NaOH). Precipitated silver oxide (Ag_2O) is to be washed by decanting or in a laboratory filter press by means of demineralized water.

The thickened slurry is to be dried in a chamber drier at 60 to 80°C temperature after the washing process. Silver content (Ag) in the dry substance of silver oxide (Ag_2O) is to be determined analytically.

Production of fine gold powder

Fine gold powder is made by reducing auric chloride solution by means of reducing agents. The slurry of the finely reduced gold so obtained is to be washed by decanting with demineralized water first, then with alcohol and dried afterwards. The dry substance is used for making a paste.

Production of adhesive admixtures

Adhesive components are formed by easily meltable lead glasses, bismuth trioxide (Bi_2O_3) and cadmium borate. All the components are to be used

in very fine particle sizes.

Lead glasses are made by melting of batches in a crucible furnace. When the glass has been melted it is to be finely ground in laboratory porcelain mills. Cadmium borate is made by the precipitation of borax solution by means of cadmium chloride. The precipitate so formed is to be washed, dried and pulverized. Pure bismuth trioxide (Bi_2O_3) is to be purchased.

Production of varnish components

The varnish components of various compounds form the coating properties of the suspensions. Varnishes are made by solving various varnishing components in appropriate thinners. Varnishes are produced either in cold or warm state in glass or enamelled vessels.

Varnishes should be inspected for viscosity, drying time and application properties.

Manufacture of final products

Recipes are specified for the individual products. Depending on the size of the production the individual components are to be weighed for the charges according to the specified recipes accurately.

Homogenization and dispersion of the individual charges depend on the character of the suspension and they are made in laboratory porcelain mills or in small three-cylinder attrition mills.

Flake silver is to be ground in a small vibrating mill before dispersion. Every charge must be tested before the dispersion process is completed. It is to be tested for application properties and precious metals content. The required final properties of the products are to be adjusted after the testing if necessary. Final products are to be checked again for the content of precious metals and required application properties. The products are packed in tightly closed bottles or crucibles and despatched.

Processing of silver and other precious metal residues

Various residues containing silver and other precious metals fall off during the production process. Such residues are to be collected separately and reworked into precious metals. The residues containing precious metals are to be incinerated and fired first. The silver residues are to be smelted with admixtures after the firing. The metal silver then is to be separated from the slag, purified and used in the production process again. The residues of the other precious metals are to be processed by wet separation method.

Wastes

Various wastes occur in the production. First of all there are various solutions of soluble salts (KNO_3, $NaNO_3$, NH_4NO_3) which are discharged into rivers after having been diluted.

Out of gaseous wastes volatiles of various organic thinners such as ammonia (NH_3), nitrogen oxides and acid vapours are exhaled into open air.

The production shop therefore must be provided with fume hoods and effective exhausting equipment. There must be due air exchange arranged in such shops. The production shop personnel must be skilled and outfitted with necessary protective aids.

Production control and laboratories

The entire production of semi-products and final products must be carefully checked by skilled workers. For the control purposes the production shop must be equipped with a laboratory where the quality of raw materials, semi-products and final products is to be inspected.

Apart from a current analytical equipment the laboratory must be equipped with small electric baking furnaces and a device for the testing of products application.

Production equipment

The production of the silvering suspensions may be characterized as a large laboratory production process from which also the character of the equipment ensues. Below mentioned are some pieces of equipment being generally used in such a production process:

Large fume hoods with efficient exhausters, equipment for dispersion in small porcelain mills, electric chamber drier of explosionproof design with a thermostat, laboratory washing filter press, 50 to 100 l vessels with agitators, precise technical balances, small three-cylinder attrition mill for the production of pastes, equipment for making demineralized or distilled water, small crucible melting furnace, incinerator furnace for the incineration of residues, laboratory muffle kilns, equipment for the testing of painting materials, small silk-screen printing machine, current glass and porcelain dishes, etc.

IV. ORIENTATION DATA ON PRODUCTION SHOP SQUARE AREAS, ENERGY AND WATER CONSUMPTION

The required extent of production being unknown approximate data are given as an example of a yearly production of 1000 kg of silvering suspensions.

Production and storage areas

1. Production sq. area proper	250 sq.m.
2. Raw material, semi-products and products storage sq. area	60 sq.m.
3. Separate storage of combustibles sq. area	20 sq.m.
4. Laboratories sq. area	80 sq.m.

Energy	yearly consumption	max. per hou
1. Electric power	30 000 kWh	25 kW
2. City gas of 15000 kJ/cu.m. calorific value	3 000 cu.m.	15 cu.m.
3. Clean service water	500 cu.m.	
4. Demineralized water	40 cu.m.	

V. FINAL NOTE

The brief description of the manufacturing technology of silvering suspensions for the electro-technical industry and electronics gives a summerized view on the production process, types of raw materials required, conditions and equipment needed for the production.

This production being of the laboratory nature deserves great care and precision from all the personnel. The workers must be skilled in handling with chemicals and in operating the machinery and equipment. Lack of skill may cause losses in production since precious metals are processed into the required form of metal powder suspensions and careless handling with materials may cause serious wounds to the personnel due to the chemicals liberating harmful vapours and dust. Protective dresses and aids are to be issued to the workers to prevent health hazards.

Laboratories situated at the production shop should enable an efficient inspection of the entire production process i. e. to check the quality of raw materials, semi-products as well as of the final products before despatch to customers.

The raw materials used in the production process are rather expensive and, hence, all residues and wastes should be processed to enable their re-using in the production and avoid losses and to prevent air and water pollution.