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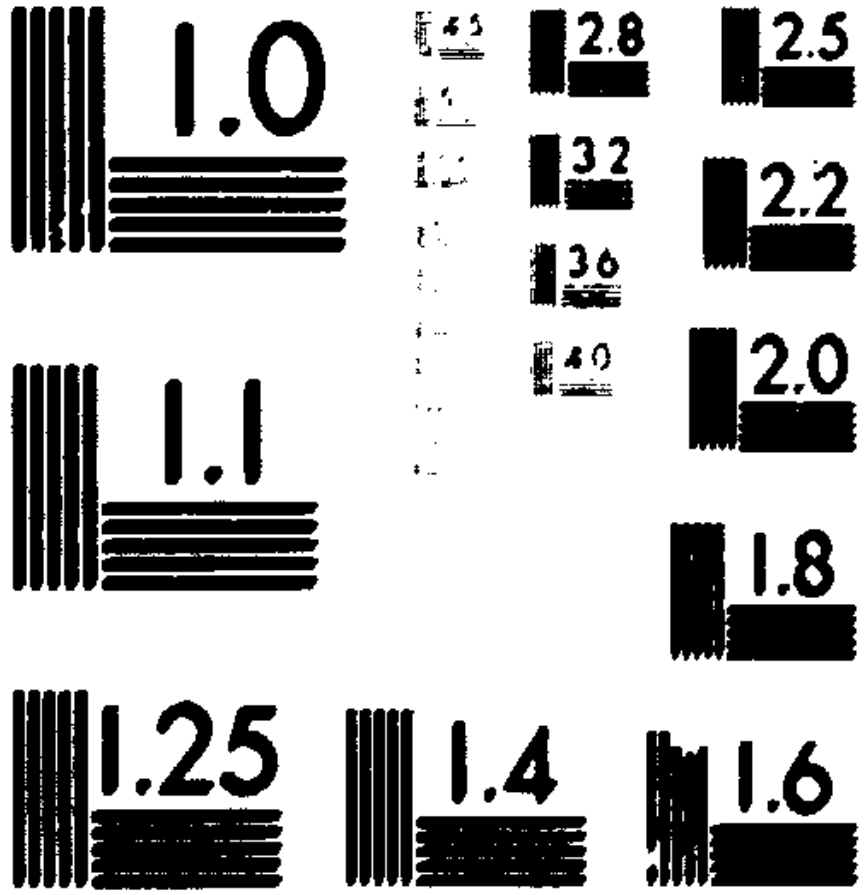

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DECORATING COLOURS FOR GLASS, CERAMICS AND CHINA WARE

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291

ABSTRACT

This is a brief description of the manufacturing technology of decorating colours for ceramics, glass and china ware.

It shows the basic assortment of the colours and temperatures at which they are to be fired. Firing temperatures for glass colours range from 530 to 630°C, for ceramics and china ware from 680 to 820°C.

The manufacture of the colours takes place in three stages:

- Production of fluxes - by melting preferably lead glasses due to their good meltability. High quality raw materials carefully weighed are required to achieve the correct composition and shade. Fluxes can be transparent, opaque or coloured.

- Production of pigments - the batches contain usually 3 to 7 components of carbonates and oxides which are to be dosed accurately, homogenized and fired well at as much as 1350°C temperature for 1 to 6 hour period. Kilns may be electric, gas or oil fired.

- Production of colours - is basically done by grinding about 60 to 95% of fluxes together with 5 to 20% of pigments. Weighing must be very accurate. The size of a batch is usually 30 to 50 kg per colour. However, smaller ones are not exceptional. In such cases the size of the equipment used for the small production must be chosen accurately.

This paper also gives an idea on the most essential production and laboratory testing equipment, average production and storage square areas, water and energy consumption and standard inspection conditions.

Accuracy, skill and carefulness of the workers in such a production plant are stressed as well as the risks they are exposed to and, hence, the basic protective aids required for them.

Moreover, the required quality and types of raw materials and chemicals are very important and, therefore, they are specified in detail in the Annex.

CONTENTS

I. INTRODUCTORY NOTE

Upon the interest of a company in India conveyed 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 decorating colours for glass, ceramics and china ware was explored.

Decorating colours for glass, ceramics and china ware are powder-like substances of various colour shades to be used for decorating ceramic, glass and china ware.

Most of the colours are composed of very fine-grained and colourless lead-borax glasses and ceramic pigments manufactured by proper technology. Some of the colours may be formed even directly by finely ground coloured glasses. The decorating colours firing temperature ranges from 530 to 820°C depending on the type and purpose of use.

These decorating colours, when made and applied, liberate a lot of harmful substances, e. g. Pb^{+2}, Cd^{+2}, Zn^{+2} and must not be used on surfaces coming into contact with food and workers handling with them must be well protected by rubber gloves, breathing masks, etc. and baths with showers must be made available to them. The workplaces must be equipped with exhaust fans and kept perfectly clean all the time.

II. DEFINITION OF PRODUCTS

Decorating colours for glass, ceramics and china ware are powder-like substances of various shades to be used for decorating glass, china ware and ceramic ware.

Fundamentally, the majority of the colours is a mixture of very finely ground colourless lead-borate glasses and ceramic pigments processed by due technology. Some colours can yet be formed directly by finely ground coloured glasses.

Those decorating colours for glass and china ware which, after application, give off large amount of harmful substances, i. e. Pb^{+2}, Cd^{+2}, Zn^{+2} must not be used on surfaces coming into direct contact with food.

Decorating colours for glass and china ware can be applied by brush painting, spraying, silk-screen printing or, indirectly, by means of transfer pictures.

Depending upon the application method the colours are mixed with water, spirit, turpentine, various volatile essential oils, silk-screen printing oils, etc. The decorating colours are often dusted in case of transfer pictures preparation. This process is done by the manufacturer himself.

Assortment of Basic Colours

Mixed shades are to be prepared by mixing of basic colours.

A. Decorating colours for glass

1. Covering colours for glass for the temperature of 530°C. Basic assortment consists of 14 colours.

2. Covering colours for glass for the temperatures of 530 to 560°C. Basic assortment consists of 14 colours.

3. Transparent colours for glass for the temperature of 530°C. Basic assortment consists of 4 colours.

4. Chemicals resistant colours for packing and jacketing structural glass for the temperatures of 600 to 630°C. Basic assortment consists of 10 colours.

5. Purple colours - 4 types.

Most colours of a certain type can be intermixed whereby a wide range of colour shades of a particular type can be obtained.

B. Colours for glazes of ceramics and china ware

1. Decorating colours for glazes for the firing temperatures of 680 to 820°C.
Large variety of colours containing a series of shades of the basic colour scale. The assortment includes about 30 colours.

2. Purple decorating colours for glazes and china ware for the firing temperatures of 760 to 820°C.
The assortment of 8 colours includes pink, violet, light, medium and dark purple colours.

3. Relief pastel colours for ceramics and china ware glazes for the firing temperatures of 720 to 800°C.
The assortment includes about 20 colours for china ware and enamels.

4. Chemicals resistant colours for glazes and china ware for the firing temperatures of 760 to 820°C.
Basic assortment includes 12 colours.

III. BRIEF DESCRIPTION OF THE MANUFACTURING TECHNOLOGY OF DECORATING COLOURS FOR CERAMIC, GLASS AND CHINA WARE

The technological manufacturing process of all types of colours consists of the production of semiproducts and of the colours production proper.

The semiproducts are a) fluxes
b) colouring components

The final colours usually contain 80 to 95% of fluxes and 5 to 20% of colouring components.

Manufacture of Fluxes

The principal manufacturing process is based on melting of glasses. The fluxes are easily meltable lead glasses of different compositions.

Each group of colours needs usually a special composition of the fluxes in view of the firing temperatures and development of required colour shades. Raw materials for the production of the fluxes must be commercially pure. The technical requirements for their quality are shown in the annexed table.

Always fine raw materials only are to be used for the production of the fluxes:

minium, ground silica, washed kaolin, boric acid, soda ash, ground limestone, borax, zinc white, sodium and potassium feldspar, titanium white, potassium saltpetre, potash, barium carbonate, antimony trioxide, sodium fluorosilicate, lithium carbonate, magnesium carbonate, fluorspar, cadmium carbonate, cryolite.

Material for batches must be weighed very carefully by skilled labour according to the recipes into vessels depending on the sizes of the batches and of the melting equipment.

The batches must be thoroughly mixed. Intensively mixing modern mixers, e. g. mixer of the Lödige system, are used for the mixing process. The time required for homogenization takes about 15 minutes.

The mixed batches in containers are to be transported to the melting equipment. The sizes of the mixers and containers depend on the volume of the production. The usual sizes of mixers are for 70 kg, 500 kg and 1000 kg batches.

Melting Process and Melting Equipment

Fluxes may be either transparent or opaque or coloured. Therefore, the melting equipment must be adapted to suit to these requirements. Two or three oil or gas fired revolving melting furnaces with easily replaceable linings are most suitable for a small production. In case of large production of the fluxes small discontinuous tank furnaces with special linings or continuous melting furnaces are used. When very small batches of special colours are to be made a crucible furnace is used.

The melting temperatures depend on the type of glass and are within the range of 1050 to 1300°C. The melting temperatures are to be watched by means of such instruments being suitable to the particular type of equipment, e. g. by optical pyrometers or Pt-PtRh thermocouples.

It is necessary to know the size of the production of the individual types of colours to be able to decide the type of the melting equipment. A larger equipment should be chosen for the production of transparent types of fluxes which usually form the main part of the production. Molten glass is discharged into vessels with cooling water where, due to the action of water and cooling, it gets disintegrated into a granulated product. The cooled-down glass granulated product is removed from the vessels manually into bags and left dried freely. When the granulated product has dried up it is to be tested and duly marked. The granulated product is put to the store of semiproducts. Every batch is to be tested. The quality of the fluxes is a decisive factor for the quality of the colours to be manufactured.

Manufacture of Ceramic Pigments

Ceramic pigments being the colouring components of the colours can be either made by the manufacturer himself or purchased from large producers of pigments. In case of small production of colours, except for the purple of Cassius, it is advisable to purchase all the required pigments.

Firing of the prescribed raw material mixtures at a certain temperature and for a certain time is the main process in the production of the ceramic pigments. The firing temperatures range from 800 to 1350°C. The firing time at the maximum temperature takes from 1 to 6 hours. Cadmium selenate pigments are fired at about 600°C temperature and require a special technology. Firing of pigments can be carried out either in electrically heated or gas or oil fired kilns. The size of the structure and output of the equipment depend on the size of the production. Nevertheless, a uniformly heated space in all the types of kilns is required during the peak temperatures.

Raw materials required for the production of pigments:

Zinc white ZnO, manganese carbonate $MnCO_3$, cobalt sulphate $CoSO_4.7H_2O$, cobalt oxide CoO, ammonium aluminum sulphate $Al_2(SO_4)_3.(NH_4SO_4.24H_2O$, tin dioxide SnO_2, selenium powder Se, cadmium carbonate $CdCO_3$, silver carbonate Ag_2CO_3, gold metal Au, tin metal Sn, lead chromate $PbCrO_4.PbO$, iron trioxide Fe_2O_3, chromic oxide Cr_2O_3, manganese dioxide MnO_2 (boric), sulphur S, cadmium sulphide CdS, ammonium vanadate NH_4VO_3.

The batches of ceramic pigments consist usually of 3 to 7 components. The raw materials are to be weighed by skilled labour carefully according to the recipe into vessels the sizes of which depend on the sizes of the batches.

The individual batches can be homogenized
a) in dry state
b) in wet state.

Dry homogenization is carried out in mixers provided with a very effective mixing device. The sizes of the mixers depend on the size of production

and they can be for 70 kg, 100 kg or 500 kg batches.

Wet homogenisation is carried out in ball mills of different sizes for 50 kg, 100 kg, 300 kg or 500 kg of ground material with porcelain linings. Flint or corundum pebbles are used for the milling. Water is used as milling medium. The slurry from the mill is dried in a car tray drier at 80 to 100°C temperature. The dry substance is pulverized in a mixer and made thus ready for firing. The dry homogenous batch is to be manually filled into fireclay closed saggers and fired. The fireclay saggers must be provided with a thin separation layer before filling. The fireclay saggers containing fired pigments are to be emptied manually by knocking out. The fired pigments are sorted according to the batches. Sintered types are to be crushed in a jew crusher.

Grinding of Pigments

The containers with fired and crushed batches of the individual pigments are to be put to the grinding plant. The pigments are ground in drum mills with porcelain or silex lining. Flint pebbles are used for the grinding process. Water is used as grinding medium. The sizes and number of mills depend on the size of the production. The commonly used sizes of mills are for 50 to 300 kg of ground material. At those types of pigments which need not be washed the slurry from the mills is drawn off straight to the trays of the drier cars and dried. Soluble salts are to be removed from some pigments. The salts are washed away by clean service water. The washing is carried out either in a filter press or, in case of low production, the washing process takes place in vats by decanting.

Pigments are to be dried in cabinet driers after washing, homogenized in a mixer, inspected and put into the store.

Manufacture of Colours Proper

From the technological point of view the colours for glass, china ware and ceramics can be classified as follows:

a) Non-calcined colours

b) Calcined colours

c) Colours melted as coloured glass

d) Special colours - purples

a) Non-calcined colours

Non-calcined colours are produced by grinding fluxes along with pigments. The ratio of pigments and fluxes varies and depends on the required deepness and shade of the colours. There are usually 80 to 95% of fluxes in the colours. There are often combined different fluxes and pigments in the recipes to obtain certain properties of the colours. Weighing of the batches to be put into the mill and adherence to the prescribed technology must be very accurate. Despite that some corrections in the recipes are still to be made time to time before the production process is completed. The corrections are based on the results found out from the inspection laboratory by skilled workers. The process of milling, shade and overall properties of the colours after firing are checked by a process control. Colours are ground in ball mills. The size of a batch is usually 30 to 50 kg of a colour. Colours are ground with denatured ethylalcohol. Flintstone pebbles, porcelain or steatite balls are used for the grinding. The mills are provided with porcelain lining.

The slurry of the ground colours is to be separated in centrifuges with textile lining and dried up. The alcohol filtrate is collected, returned to the production process and mixed with pure alcohol. Thickened slurry of the colours is dried in a steam or hot water heated cabinet drier of explosionproof design. The colours are dried on trays of drier cars at about 70 to 90°C temperature.

The manufacturer of colours usually cannot avoid making small batches ordered by some customers. Small batches of 5 to 10 kg are ground in small porcelain or glass drum mills. The slurry of the colours in such cases is not thickened but is to be dried on the trays in the drier directly. The dried colours are homogenized and pulverized in a high-speed mixer. When the product is ready it is to be tested in the laboratory again and if found satisfactory it may be despatched. The colours are packed in barrels or tins with a polyethylene lining.

b) Calcined colours

Fundamentally, the manufacturing process is similar to that of non-calcined colours. However, there are some additional operations in the technology which make the technological process longer.

Calcination is a process of melting fluxes with pigments together to obtain certain final colour shades and to prevent undesirable processes at the firing of the colours at the consumers. Some colouring components may partially enter the lattice of the glass during the calcination that may get coloured by ions (Co), or pigments which may get decayed easily are coated with glass whereby their further decaying is prevented (CaS).

When calcined colours are to be produced fluxes are ground along with pigments first. Grinding, centrifuging and drying of the slurry are made in the same equipment as in the case of non-calcined colours production. The dried slurry of the ground mixture is to be calcined (smelted) in fireclay dishes in an electrically heated furnace. The calcination temperatures vary from 600 to 850°C. The fireclay dishes are provided with a separation layer to prevent the colours from sticking to the walls of the dishes.

Chamber furnaces may be used for a low production of colours while well controllable channel furnaces of narrow cross-section should be used for a larger production.

The calcines of the colours are collected and inspected in the laboratory. Their further processing is similar to that of the non-calcined ones, i. e. they are ground in ball mills with alcohol, centrifuged, dried, homogenized and pulverised into a finished colour. The finished products are tested in the laboratory again and when found satisfactory they are despatched.

c) Colours melted as coloured glass

Coloured glass frits are made in the first phase of the technological process by melting batches according to the prescribed recipes. Mostly crucible furnaces are used for the melting because demands for these colours are rather limited. The melting is to be carried out by a skilled worker. Further step in the technological process comprises grinding of the coloured frits into powdered colours. The same technology as described above is applied afterwards.

d) Special colours - purples

Purple colours of all sorts from pink through violet up to deep purple red are made similar way as the calcined colours. It is very important to strictly keep to the technology.

Cassius purple is the colouring component of these colours. The Cassius purple is made by reducing the Au^{+3} solution by means of tin dichloride and tin tetrachloride and by the adsorbtion of the finely reduced particles of gold from the hydrosol into the precipitated $SnO_2.H_2O$.

The gold solution is prepared by solving the metal gold (99.99) in aqua regia. The required solutions of tin dichloride and tetrachloride are prepared by solving pure tin in the appropriate acids.

The production of Cassius purple takes place in earthenware or wooden or other vats and the precipitated fluid is washed by decanting at the same time.

The thickened slurry of the Cassius purple is converted by calculation into gold content (Au) and then dosed as admixture to fluxes into the grinding mill.

Most of the purple colours need a special composition of fluxes. Different shades of the purple colours are made by silver (Ag)compositions e. g. Ag_2CO_3, etc. Further steps of the technological process are similar to those of the calcined colours.

IV. LABORATORIES AND TESTING

Testing laboratories and technical inspection of products

Well equipped laboratories for process control, service to the customers and technical inspection are essential to provide for good quality of the products and to meet the variety of customers wishes in the production.

Basic laboratory equipment

1. In-coming raw materials inspection - a current laboratory equipment is required to make analytical inspection of all the raw materials for the production including ordinary basic instruments used for the analyses. A spectral photometer is very useful.
2. Process control, technical service and out-going inspection
   A laboratory for these purposes should be equipped with small laboratory electric furnaces for the firing of test pieces, small laboratory grinding ball mills and glass plates for the grinding of colours, an instrument for the measurement of particle sizes, inspection of grinding curves and viscosimeters. A colorimeter is useful, too. Labor tory three-cylinder and silk-screen printing equipment.
3. All the laboratories are to be manned with skille workers. One of them at least must be conversant with the application of the products.

Basic conditions for the production of ceramic colours

All places where dust occurs during the production must be provided with a dust collecting system.

Places where denatured alcohol is used:
ball mills, cabinet driers, centrifuges, electric power lines must correspond to respective standards.

Driers, centrifuges must be of explosionproof design. The grinding mill plant for colours must be well ventilated to ensure an ample air exchange.

Standards to Be Adhered to by the Manufacturer, Customer and Inspection Authorities

Colours for ceramic glass and china ware, when applied to surfaces supposed to come into contact with food, when kept in an extract of 4% acetic acid at 20°C for 24 hours, must not liberate more metals than

0.01 . mg Cd . dm^{-2}
5.- mg Zn . dm^{-2}
0.10 mg Pb . dm^{-2}

Technical requirements

Colours for glass and china ware must correspond to the following qualities:

Moisture content on delivery, max. % 1

Fineness of grinding residue on sieve 0.063 (10000 mesh/cm^2) max. % 0.1

Meltableness (firing temperature in °C)

glass 530-560
china ware 760-820

Colour shade ..... corresponding to the standard

Determination of standard specimen

Standard specimen is a colour for glass or china ware from one operation which meets all the requirements (as per technical requirements).

Determination of moisture content

Weighed specimen is to be dried at a prescribed temperature to reach constant weight and the lors in weight is to be found out.

Determination of fineness of grinding

About 100 g specimen dried at 110°C is to be weighed at the accuracy of 0.01 g and put to a porcelain dish in which it is washed on 0.063 mesh sieve (10000 mesh/cm2).

It is to be weighed after drying.

Meltableness and colour shade

Colour shade and meltableness are to be compared with the standard specimen.

- Colour being tested is to be ground on a glass plate or in a small laboratory ball mill and then applied to the glass or china subject either by spraying or by a brush. The standard specimen is to be processed identically. After firing at the appropriate temperature, depending on the type of the colour, the colour shades are to be compared after cooling.

Evaluation

The colour being tested is satisfactory if no difference is visually found out when the two samples are compared for shade and meltableness.

Inspection, packing, transportation and storage

The consignment is inspected both for quality and quantity at the customer s.

A sample is taken from each complete production batch. In case the customer s inspection detects that the colour does not meet the requirements such an inspection test is to be repeated at the presence of the supplier s representative. The supplier is obliged to send his representative to be present at the repeated testing within 15 days after receiving the written claim.

In case the consignment is found unsatisfactory even by the test carried out at the presence of the manufacturer s representative the customer has the right to return such a consignment.

The colours are filled into despatch wrappings of various sizes as per customer s requirements.

Every packing must read:

a) Supplier s name and address or a trade mark

b) Name of the product

c) Weight

d) Production operation No. and date

e) Warning sign

Poisonous and dangerous when dust is inhaled or in contact with complexion!

Custody of standards

The standard specimens of each type of colour weighing 500 g each are kept both at the customer s and at the supplier s. They are used for comparison tests. When the standard specimen runs out of stock the manufacturer shall supply the standard specimens of identical quality as the former ones.

Health Safety and Protection at Work

The above described products contain fused-in lead oxide (PbO). Lead compositions may cause acute chronic intoxication. They attack especially red blood corpuscles and nerve system.

While handling with the product such technical measures should be taken to prevent any harmful concentrations in the atmosphere exceeding the maximum admissible limits (e. g. lead 0.05 mg . m^3 as an average, 0.2 mg . m^3 as an extreme one).

Workers must be provided with personal protective aids particularly to protect hands (rubber gloves) or breathing masks in case of spraying, etc.

The work place must be kept perfectly clean. While handling with the colours any eating, drinking and smoking are prohibited. There must be bath provided for the workers to enable them to wash themselves thoroughly after work (have a shower).

The workers must be outfitted with working dresses as protective aids. These dresses must be changed regularly for clean ones.

Cleaning of the workplace must be arranged in such a way so that no secondary dustiness should be increased there.

Since both the products and the production process have been declared as risky ones by the health service authorities the workers must be subjected to regular preventive medical examinations.

In case of acidproof colours for glass (used for structural glass for outside tiling of buildings) they should be tested for resistance against acids, bases and hydrogene sulphide.

V. ORIENTATION DATA ON PRODUCTION AREAS, ENERGY AND WATER CONSUMPTION

Since the intended extent of production is unknown some orientation data are shown here for a yearly production of 50 t of colours.

1. Production area proper approx. ..... 1000 sq.m
2. Raw material, semi-products and final products storage area approx. ..... 600 sq.m
3. Process control and inspection laboratories area approx. ..... 100 sq.m
4. Offices approx. ..... 100 sq.m
5. Combustibles store situated at a safe distance from the production area.. 20 sq.m
6. Underground tank for used alcohol - content ..... 2 cu.m

Consumption of energy and denatured alcohol

1. Maximum electric power consumption per hour incl. lighting; ..... 300 kW
2. Heating oil for the firing in the melting furnaces ..... 21000 kg/year
3. Consumption of denatured alcohol per year ..... 16000 kg/year
4. Service water consumption ..... 600 cu.m/year

VI. FINAL NOTE

The brief description of the manufacturing technology of decorating colours for ceramic, glass and china ware represents an informative summary of their production, assortment, raw materials, conditions and equipment required for the production.

Though the extent of the manufacture is rather small an utmost care is to be paid to it. Raw materials to be used in the production must be of good standard quality. Laboratories must be well equipped and the personnel skilled. Since harmful volatiles and poisonous pulverised materials are to be handled with the production premises must be equipped with proper dust collecting system to protect the health of the workers and they must wear protective dresses, gloves and breathing masks. All safety and operating instruction must be strictly observed by all the personnel.

The inspection must be carried out starting from the raw materials through the process control up to the final products and despatch to ensure good quality of the products.

All the equipments in the plant, i. e. both in the production and in the laboratories, must be kept in a reliable condition by skilled operation and maintenance to prevent any harm to the people or damage to the plant and to manufacture products meeting the customer's requirements.

Quality Requirements on Raw Materials

Raw material	Principal characteristics - testing	
Minium	chemical formula	Pb_3O_4
	molecular weight	685.63
	maximum moisture	0.5%
	maximum residue on sieve (4900 mesh/cm^2)	3.0%
	minimum lead dioxide (PbO_2) content	29.0%
	minimum lead (PbO) content	97.0%
	residue insoluble in nitric acid and in hydrogen peroxide	0.3%
	water soluble salts	0.3%
Ground Silica	chemical formula	SiO_2
	SiO_2	99.5%
	Al_2O_3	0.5%
	sieve residue on 4900 mesh/cm^2	7.0%
Ground Washed Kaolin	chemical formula	$Al_2O_3.2SiO_2.2H_2O$
	content of Al_2O_3 min.	37.0%
	content of $Fe_2O_3+TiO_2$ max. ...	1.2%
	content of TiO_2 max.	0.3%
	moisture content max.	10.0%
	sieve residue on 0.063 mm	0.05%
Boric Acid	chemical formula	H_3BO_3
	content of boric acid min. ...	98.5%
	content of water max.	1.0%
	content of sulphates (SO_4) max.	0.6%
Soda Ash	chemical formula	Na_2CO_3
	content of sodium carbonate (as Na_2CO_3) min.	98.5 97.5%
	content of matters insoluble in water max.	0.08 0.1%
	content of chlorides (as NaCl) max.	1.20 2.0%
	content of sulphates (as Na_2SO_4)	not determin
	content of iron (as Fe_2O_3)	0.008 0.03
	loss on ignition	0.5 0.8%

Ground Limestone	chemical formula	$CaCO_3$
	$CaCO_3+MgCO_3$ min.	93.0%
	out of that: $MgCO_3$ max.	6.0%
	SiO_2 max.	4.5%
	$Al_2O_3+Fe_2O_3$ max.	3.5%
	out of that: Fe_2O_3 max. ...	0.5%
Crystalline Borax commercial	chemical formula	$Na_2B_4O_7.10H_2O$
	content of anhydrous sodium tetraborate ($Na_2B_4O_7$) min.	51.7%
	residue insoluble in water (annealed) max.	0.3%
	sodium carbonate (Na_2CO_3) max.	0.7%
Zinc white	chemical formula	ZnO
	content of zinc oxide min.	98.2%
	content of lead compositions as PbO max. ..	0.5%
	metal zinc max.	0.1%
	moisture content max.	0.5%
	residue insoluble in HCl max.	0.2%
	whiteness /MgO=100/ min. ..	91.0%
	sieve residue on 10000 mesh/cm^2 max.	0.7%
Sodium - Potassium Feldspar	chemical formula	$K_2O.Na_2O.Al_2O_3.6SiO_2$
	content of K_2O approx. ...	10.0%
	content of Na_2O approx. ...	3.0%
	content of CaO approx. ...	1.3%
	content of Al_2O_3 approx. ..	19.0%
	content of SiO_2 approx. ..	66.0%

Titanium white in powder	chemical formula	TiO_2
	titanium dioxide TiO_2 min.	98.0%
	iron (Fe)max.	0.07%
	salts insoluble in water max. ...	0.4%
	moisture content max.	0.3%
	loss of ignition max.	0.35%
	Practically, it is tested as a 10% admixture in the fluxing agent made as a colour for glass. It should be covering white after firing without yellowish shade.	
Commercial Potassium Saltpeter	chemical formula	KIO_3
	content of potassium nitrate min.	99.0%
	water content max.	0.5%
	content of chlorides (NaCl) max.	0.5%
	content of carbonates (K_2CO_3) max.	0.15%
	content of matters insoluble in water max.	0.10%
	content of iron (Fe3+) max.	0.10%
Hydrated Potash	chemical formula	$K_2CO_3 \cdot 1.5H_2O$
	content of potassium carbonate (K_2CO_3) min.	82.0%
	content of potassium sulphate (K_2SO_4) max.	0.18%
	content of iron (Fe) max.	0.03%
Commercial Barium Carbonate	chemical formula	$BaCO_3$
	content of barium carbonate ($BaCO_3$) in anhydrous specimen min.	95.0%
	water content (H_2O) max.	1.0%
	It is poisonous.	

Antimony Oxide	chemical formula	Sb_2O_3
	content of Sb_2O_3 min.	99.0%
	impurities max.	1.0%
	out of that: As max.	0.5%
	Pb max.	0.25%
	Fe max.	0.05%
	moisture content max.	0.5%
	sieve residue on 0.063 mm (10000 mesh/cm2) max.	0.5%
Manganese (II) Carbonate	chemical formula	$MnCO_3$
	content of manganese carbonate ($MnCO_3$) min.	90.0%
	matters insoluble in hydrochloric acid (HCl) max. ..	0.1%
	content of SiO_2 max.	0.1%
	content of calcium (as CaO) max.	0.2%
	content of alkalis (K_2O, Na_2O) max.	0.3%
	content of higher manganese oxides (as MnO_2) max.	0.5%
	content of sulphates (as SO_3) max.	0.5%
	content of chlorides max. ...	0.05%
	content of iron (as Fe_2O_3) max.	0.2%
	content of heavy metals (as Cu) max.	0.5%
	content of magnesium (as MgO) max.	0.1%
	content of barium (as BaO) max.	0.1%
	CaO+MgO max.	0.3%

Nickel Oxide	chemical formula	NiO
	content of nickel and cobalt (as Ni) min.	76.0%
	cobalt (Co^{2+}) max.	1.6%
Practical firing test in 5% concentration in lead glaze or in fluxing agent	sulphates (SO_4^{2-}) max.	0.1%
	magnetic active impurities max.	0.2%
	loss by drying max.	0.5%
	bulk density kg/cm^3 min.	2.4%
	sieve residue 0.1 mm max.	0.5%
Copper Oxide commercial	chemical formula	CuO
	content of Cu in.	72% = 90.1 CuO
	content of chlorides (Cl) max. .	1.0%
	content of iron (Fe^{3+}) max.	0.2%
Practical test of colouring (lead) glaze or fluxing agent		
Commercial Aluminum Oxide	chemical formula	Al_2O_3
	content of Al_2O_3 min.	96.3%
	content of SiO_2 max.	1.0%
	content of Fe_2O_3 max.	0.05%
	water (H_2O) content max.	1.0%
	loss on ignition max.	35.0%
	other impurities max.	0.2%
Commercial Sodium Fluorosilicate	chemical formula	Na_2SiF_6
	content of Na_2SiF_6 min.	97.2%
	free acids calculated into hydrochloric acid HCl p. a. max.	0.2%
	content of sodium chloride NaCl max.	1.0%
	content of iron (Fe) max.	0.1%
	insoluble residue max.	0.5%
	moisture content max.	0.5%
	grain size on 0.1 mm mesh size max.	15.0%

Commercial Crystalline Cobaltous Sulphate	chemical formula	$CoSO_4 \cdot 7H_2O$
	content of cobaltous sulphate $CoSO_4 \cdot 7H_2O$ min.	95.0%
	content of insoluble matters max.	0.1%
	content of chlorides (Cl^-) max.	0.05%
	content of iron (Fe^{3+}) max. ...	0.15%
Ammonia Alum	chemical formula	$Al_2(SO_4)_3 \cdot (NH_4)_2SO_4 \cdot 24\ H_2O$
Tin Dioxide	chemical formula	SnO_2
	bulk density	250 g/l
	particle size	0.5 to 5 microns
	content of SnO_2 min.	99.9%
	content of Fe_2O_3 max.	0.005%
	content of CuO max.	0.001%
	content of MnO_2 max.	0.005%
	content of Cr_2O_3+CaO	0
Lithium Carbonate	chemical formula	Li_2CO_3
Dolomite	chemical formula	$CaCO_3 \cdot MgCO_3$
	content of CaO	30%
	content of MgO	23%
Magnesium Carbonate	chemical formula	$MgCO_3$
Ground Fluorspar	chemical formula	CaF_2
Black Selenium	chemical formula	Se
	Practical test - laboratory production of bright red pigment	

Cadmium Carbonate	chemical formula	$CdCO_3$
Silver Carbonate	chemical formula	Ag_2CO_3
Cryolite	chemical formula	Na_3AlF_6
Gold Metal	chemical formula	Au
Granulated Tin	chemical formula	Sn - chemically pure
Lead (II) Hydroxide Chromate	chemical formula	$PbCrO_4.PbO$
Cobalt Oxide	chemical formula	Co_2O_3
	content of Co	71.0%
	content of Ni	0.25%
	content of Fe	0.025%
	content of Mn	0.015%
	grain size sieve residue on 6400 mesh/cm^2	0.3%
Ferric Oxide	chemical formula	Fe_2O_3 - red FB 130
	Practical test for colouring in transparent enamel frit - by firing as steel sheet enamel	
Chromic Oxide	chemical formula	Cr_2O_3 - GX
	content of Cr_2O_3	99.0%
	content of SiO_2	0.11%
	content of Al_2O_3	0.10%
	salts soluble in water	0.20%
	loss on ignition	0.30%
	grain size 16000 mesh/cm^2 sieve residue max.	0.1%
	Practical test for colouring in transparent enamel frit - by firing as steel sheet enamel	
Manganese Dioxide	chemical formula	MnO_2
	content of MnO_2	87.0%

Ground sulphur (flowers of sulphur)	chemical formula	S
Cadmium Sulphide	chemical formula	CdS
	Practical test by firing of colours for glass fluxing agent containing CdO + 5% CdS	
Ammonium Vanadate	chemical formula	NH_4VO_3
	min. 76.0% of V_2O_5