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METHODS FOR TESTING PAINTS AND RELATED MATERIALS

A. SCOPE

The procedures used for the chemical and/or physical testing of paints, varnishes, enamels, and the raw materials used in the manufacture of these protective coatings, are described in this test method.

Samples of protective coatings submitted for analysis may be broadly classified as field samples and stock samples.

Stock samples from the manufacturer's batch of prepared material are sampled prior to shipment to the job. If the coating meets specifications, the manufacturer is notified that he may ship the material.

Field samples are submitted by resident engineers from the job site where the coating is being used to determine if there has been any significant change in the product since it was manufactured. Field samples are usually examined for a few basic characteristics such as viscosity, weight per gallon, volatile content, drying time, and working properties. Such tests indicate if there have been any changes in the material's properties since leaving the factory.

However, field samples may not always be representative of the material supplied, as the possibility exists that the material was not thoroughly mixed before sampling. Test results on field samples must be evaluated with this factor in mind.

This test method is divided into the following parts:

1. Reagents
2. Paints and Enamels
3. Pigment Analysis
4. Raw Materials, Pigments
5. Resins
6. Solvents and Thinners
7. Drying Oils
8. Aluminum Paste

B. REFERENCES

- Federal Test Method Standard 141 "Paint, Varnish, Lacquer and Related Materials: Methods of Inspection, Sampling and Testing".
- Federal Test Method Standard 141, Method 3011.3 'Condition in Container'
- California Test 421 "Method of Identification of Pigments and Extenders in Paints and Coatings".

- ASTM D 2371 “Standard Test Method for Pigment Content of Solvent-Reducible Paints”.
- ASTM D 2698 “Standard Test Method for Determination of the Pigment Content of Solvent-Reducible Paints by High-Speed Centrifuging”.
- ASTM D 3723 “Standard Test Method for Pigment Content of Water-Emulsion Paints by Low-Temperature Ashing”.
- ASTM D 1475 “Standard Test Method for Density of Liquid Coatings, Inks, and Related Products”.
- ASTM D 2369 “Standard Test Method for Volatile Content of Coatings”.
- ASTM D 562 “Standard Test Method for Consistency of Paints Measuring Krebs Unit (KU) Viscosity Using a Stormer-Type Viscometer”.
- ASTM D 185 “Standard Test Methods for Coarse Particles in Pigments”.
- ASTM D 480 “Standard Test Methods for Sampling and Testing of Flaked Aluminum Powders and Pastes”.
- ASTM E 1347 “Standard Test Method for Color and Color-Difference Measurement by Tristimulus Colorimetry”.
- ASTM E 308 “Standard Practice for Computing the Colors of Objects by Using the CIE System”.
- ASTM D 1210 “Standard Test Method for Fineness of Dispersion of Pigment-Vehicle Systems by Hegman-Type Gage”.
- ASTM D 523 “Standard Test Method for Specular Gloss”.
- ASTM D 4587 “Standard Practice for Fluorescent UV-Condensation Exposures of Paint and Related Coatings”.
- ASTM D 2244 “Standard Practice for Calculation of Color Tolerances and Color Differences from Instrumentally Measured Color Coordinates”.
- ASTM D 5146 “Standard Guide to Testing Solvent-Borne Architectural Coatings”.
- ASTM D 1640 “Standard Test Methods for Drying, Curing, or Film Formation of Organic Coatings at Room Temperature”.
- ASTM D 711 “Standard Test Method for No-Pick-Up Time of Traffic Paint”.
- ASTM D 522 “Standard Test Methods for Mandrel Bend Test of Attached Organic Coatings”.
- ASTM D 3359 “Standard Test Methods for Measuring Adhesion by Tape Test”.
- ASTM D 4541 “Standard Test Method for Pull-off Strength of Coatings Using Portable Adhesion Testers”.
- ASTM D 1308 “Standard Test Method for Effect of Household Chemicals on Clear and Pigmented Organic Finishes”.
- ASTM D 3363 “Standard Test Method for Film Hardness by Pencil Test”.
- ASTM D 4017 “Standard Test Method for Water in Paints and Paint Materials by Karl Fischer Method”.
- ASTM D 2621 “Standard Test Method for Infrared Identification of Vehicle Solids From solvent-Reducible Paints”.
- ASTM D 3168 “Standard Practice for Qualitative Identification of Polymers in Emulsion Paints”.
- ASTM D 6886 “Standard Test Method for Determination of the Individual Volatile Organic Compounds (VOCs) in Air-Dry Coatings by Gas Chromatography”.
- ASTM D 521 “Standard Test Methods for Chemical Analysis of Zinc Dust (Metallic Zinc Powder)”.
- ASTM D 1394 “Standard Test Methods for Chemical Analysis of White Titanium Pigments”.
- ASTM “Standard Test Methods for Chemical Analysis of Zinc Yellow Pigment (Zinc Chromate Yellow)”.
- ASTM D 891 “Standard Test Methods for Specific Gravity, Apparent, of Liquid Industrial Chemicals”.

- ASTM D 1218 “Standard Test Method for Refractive Index and Refractive Dispersion of Hydrocarbon Liquids”.
- ASTM D 86 “Standard Test Method for Distillation of Petroleum Products at Atmospheric Pressure”.
- ASTM D 3539 “Standard Test Methods for Evaporation Rates of Volatile Liquids by Shell Thin-Film Evaporometer”.
- ASTM D 3278 “Standard Test Methods for Flash Point of Liquids by Small Scale Closed-Cup Apparatus”.
- ASTM D 3643 “Standard Test Method for Acid Number of Certain Alkali-Soluble Resins”.
- ASTM D 464 “Standard Test Methods for Saponification Number of Navel Store Products Including Tall Oil and Other Related Products”.
- ASTM D 1965 “Standard Test Method for Unsaponifiable Matter in Drying Oils, Fatty Acids, and Polymerized Fatty Acids”.
- ASTM D 1545 “Standard Test Method for Viscosity of Transparent Liquids by Bubble Time Method”.
- ASTM D 1541 “Standard Test Method for Total Iodine Value of Drying Oils and Their Derivatives”.
- ASTM D 1959 “Standard Test Method for Iodine Value of Drying Oils and Fatty Acids”.
- ASTM D 56 “Standard Test Method for Flash Point by Tag Closed Cup Tester”.

C. PROCEDURES

PART 1. REAGENTS

Unless otherwise indicated, all reagents shall conform to the specifications of the Committee on Analytical Reagents for the American Chemical Society, where such specifications are available.

PART 2. PAINTS AND ENAMELS

1. Condition in container: Refer to Method No. 3011.3 of Federal Test Method Standard 141.
2. Pigment - percent by weight:
 - a. Extraction method: Follow ASTM Designation: D 2371, using appropriate amounts of paint sample and a suitable extraction mixture (a mixture or a single solvent which will be the best solvent for the resin components).
 - b. Super centrifuge method: Follow ASTM Designation: D 2698.
 - c. Ignition method: Follow ASTM Designation: D 3723.
3. Density: Follow ASTM Designation: D 1475.
4. Volatile and non-volatile content: Follow ASTM Designation: D 2369 or D 3723.
5. Consistency (viscosity): Follow ASTM Designation: D 562.
6. Coarse particles: Follow ASTM Designation: D 185. For aluminum paste, follow ASTM Designation: D 480.
7. Dry opacity: On a black/white Leneta chart, Form 2A Opacity, draw down a film of the sample covering both black and white portions of the chart. Unless otherwise

specified, use a 10 mil gap draw-down blade. Dry the specimen 24 hours at 25°C. Using a suitably calibrated filter photometer conforming to ASTM Designation: E 1347, measure alternately the 45°/0° daylight luminous directional reflectance of the specimen over the white and black portions of the chart. Calculate dry opacity as follows:

Dry Opacity = Reflectance over black / Reflectance over white

Similar results may be obtained from spectrophotometers conforming to ASTM Recommended Practice E 308.

8. Dispersion (fineness of grind): Follow ASTM Designation: D 1210.
9. Gloss and reflectance: Refer to ASTM Designation: D 523 and E 1347. Use a suitable Gloss and Reflectance Meter.
10. Accelerated weathering and color change: Refer to ASTM Designation: D 4587. Expose two properly prepared sample panels for 300 hours using conditions specified in Table 1 of ASTM Designation: D 4587, using cycle 2, and UVA-340 fluorescent lamps. Evaluate the total color difference ΔE^*_{ab} of the samples before and after exposure using (10° observer) and standard illuminant D65. Refer to ASTM Designation: D 2244, CIE 1976 L*a*b*, uniform color space and color difference equation.
11. Working properties: Refer to ASTM Designation: D 5146, Table-1, for procedures listed under Coating Application and Film Formation.
12. Drying time, set to touch, dust free, etc.: Refer to ASTM Designation: D 1640.

For traffic paint Dry to No Pick Up without Beads, follow ASTM Designation: D 711. For traffic paint Dry through Time, use the same draw down sample prepared for ASTM Designation: D 711. Perform the test as outlined in ASTM Designation: D 1640 except that no thumb pressure is used. The thumb is turned through an angle of 90° while in contact with the film. The time at which this rotation does not break the film is recorded.
13. Flexibility: Follow ASTM Designation: D 522, Method-B.
14. Adhesion: Follow ASTM Designation: D 3359, Method A or ASTM Designation: D 4541.
15. Gasoline and water resistance: Follow ASTM Designation: D 1308, section 7.4, unless otherwise directed.
16. Pencil hardness of paint films: Follow ASTM Designation: D 3363.
17. Percent water (Karl Fischer Method): Follow ASTM Designation: D 4017.
18. Infra red spectrum of vehicle solids: Follow ASTM Designation: D 2621 for solvent reducible paints and ASTM Designation: D 3168 for emulsion paints.
19. Analysis of paint solvents by gas chromatography/mass spectroscopy: Follow ASTM Designation: D 6886.

20. Analysis of pigments in dried paint films by X-ray diffraction: Follow California Test 421.

PART 3. PIGMENT ANALYSIS (EXTRACTED PIGMENT)

1. Metallic zinc: Follow ASTM Designation: D 521.
2. Zinc pigments by the Ethylenediamine Tetraacetate Method: This can usually be used in place of a variety of older methods for determining Zn in the presence of Ca, Mg, Ba, Fe, Cr. See the procedure below.

3A. APPARATUS

1. Buffer solution (pH 10): 54 g of ammonium chloride and 350 mL of concentrated ammonium hydroxide are diluted to 1 L of water.
2. Erichrome Black T (0.5 %): Dissolve 0.25 g of Erichrome Black T and 2.2 g of hydroxylamine hydrochloride (as stabilizer) in 50 mL of methanol.
3. Disodium ethylenediamine tetraacetate dihydrate 0.2 N: Dissolve 37.2 g of the reagent in water and dilute to 1 liter. Standardize against standard zinc oxide solution.
4. Standard zinc oxide solution: Weigh approximately 3 g of oven-dried zinc oxide of known purity and dissolve in the buffer solution. Then dilute to 500 mL with buffer.

3B. PROCEDURE

1. Test a small amount of pigment for sulfides by the addition of dilute hydrochloric acid. If the odor of hydrogen sulfide is detected, the modified procedure is followed.

2. Procedure in absence of zinc sulfide:

Weigh approximately 1.000 g of the isolated paint pigment into a 250 mL Erlenmeyer flask. If the sample is believed to contain more than 10 % zinc oxide, proportionately smaller samples may be used. Add 25 mL of the buffer solution, stopper the flask, and shake frequently and vigorously for 30 minutes. Filter into a 400 mL beaker. Wash the paper and flask well with distilled water. Discard the undissolved residue. Dilute the filtrate to 300 mL with water. Add ten drops of the Erichrome Black T indicator and titrate with 0.2 N ethylenediamine tetraacetate solution. As it becomes apparent that the end point is near, add five more drops of indicator. In the absence of chromium, the color change at the end point is from wine-red to blue; if much chromium is present, the color change is from orange-red to green.

3. Procedure in presence of zinc sulfide:

Weigh approximately 1.000 g of the isolated pigment into a 250 mL beaker. Add 25 mL of 6 N hydrochloric acid. Heat gently for 30 minutes on a hot plate. Finally, boil without cover for a few minutes to expel the hydrogen sulfide. Cool, add 2 mL of 85 % phosphoric acid, followed by 35 mL of concentrated ammonium hydroxide and 25 mL of the buffer solution. The resulting mixture should be alkaline

(approximately pH 10). Filter and wash well. Discard the paper and residue. Dilute the filtrate and titrate as above. Treat 25 mL of the standard zinc oxide solution in a similar manner, i.e., 2 mL of phosphoric acid, 25 mL of 6 N hydrochloric acid, 35 mL of concentrated ammonium hydroxide. Dilute and titrate as above. Calculate % zinc oxide as:

$$\% \text{ ZnO} = (\text{mL of reagent} \times \text{normality of reagent} \times 4.069) / \text{weight of pigment sample}$$

4. Titanium dioxide and chromic oxide in ignited pigment:

Because it is not always possible to separate TiO_2 and Cr_2O_3 from paints by extraction, it becomes necessary to resort to ignition. Such ignited pigments are extremely resistant to solution by the usual methods. The following method gives accurate results with a minimum of difficulty.

- a. Weigh 0.200 g (more if a considerable amount of filler is present) of the ignited pigment and transfer to a 30 to 50-mL silver crucible.
- b. Add approximately 0.5 g of KNO_3 and 2 g of NaOH pellets.
- c. Cover the crucible and heat at a low red heat for about 5 minutes, swirl occasionally.

NOTE: Silver melts at a bright red heat, 960°C .

- d. After cooling, place the crucible and its contents in a beaker of hot distilled water. Boil a few minutes, remove the crucible, and wash adhering TiO_2 and chromate into the beaker.
- e. Allow the mixture in the beaker to settle and cool. Filter by suction through a glass filter paper in a Gooch crucible. If the mixture is not cold, suction may cause it to boil and some may be lost. Filtration is not difficult if the clear solution is carefully decanted into the filter, then the precipitate is transferred to the filter with a stream of hot water from the wash bottle. Wash the precipitate on the filter with hot distilled water.
- f. Transfer the precipitate to a 250 mL beaker, using a minimum amount of wash water, and determine TiO_2 as specified in ASTM Designation: D 1394. Fifteen mL of H_2SO_4 is better than the 25 called for as the TiO_2 dissolves with little fuming.
- g. Transfer the chromate solution from the suction flask to a 600 mL beaker; add 15 mL of 1:1 H_2SO_4 , 10 mL of 1:1 H_3PO_4 , and 10 mL of 1 % AgNO_3 . Heat to boiling, remove from the hot plate, and while stirring carefully add about 2 g of ammonium persulfate. Boil a minute or two, remove from the hot plate and, again, add about 2 g of ammonium persulfate. Return to the hot plate and boil vigorously for at least ten minutes to destroy any remaining persulfate. Thorough oxidation of the chrome and also of KNO_2 , which is present, is necessary. Any unoxidized KNO_2 will destroy the indicator which is used later.
- h. Determine the Cr_2O_3 as specified in the Dichromate Method in ASTM Designation: D 444, except substitute barium diphenylamine sulfonate for orthophenanthroline.

5. Red iron oxide and titanium dioxide in mixed pigments:

a. Isolation of pigment:

Weigh 15 g of the thoroughly mixed paint into a large porcelain crucible and evaporate the volatile matter in a 100°C oven. Then place crucible and contents in a 700°C muffle furnace for at least two hours in order to completely destroy all organic matter. Transfer the pigment residue to a mortar and grind to a uniform product.

b. Separation of pigment components:

Weigh a 0.300 g sample of the pigment into a 600-mL beaker, add 30 mL of concentrated sulfuric acid and 30 mL of concentrated hydrochloric acid. Heat over a flame to copious SO₃ fumes, constantly swirling the beaker to prevent bumping. If there is any unreacted iron oxide residue in the bottom of the beaker, add an additional 30 mL of hydrochloric acid, and again heat to fumes until no black residue is noted in the bottom of the beaker. Add 8 g of ammonium sulfate to the beaker and fume again for several minutes. Cool the solution, dilute to about 300 mL, and heat for several minutes to obtain a clear solution. Add ammonium hydroxide until the solution is alkaline; then add 3 mL of 1:1 sulfuric acid. Dissolve 1.2 g of tartaric acid in the solution and pass a stream of hydrogen sulfide through it for several minutes until all of the iron has been reduced to a ferrous state (this may be noted by the disappearance of the yellow color). Heat the solution to boiling, add an excess of ammonium hydroxide to precipitate the iron, and pass hydrogen sulfide through the hot solution for several minutes. Let the solution cool to room temperature and, again, saturate with hydrogen sulfide. Allow the precipitate to settle for a half hour and filter through a No. 41 Whatman filter paper. Wash the beaker and precipitate with a dilute solution of ammonium sulfide, made by passing hydrogen sulfide through dilute ammonium hydroxide. Save the filtrate for the titanium analysis.

c. Determination of iron oxide:

Place the filter paper and contents from the hydrogen sulfide precipitation in a 400-mL beaker; add 25 mL of concentrated hydrochloric acid, and macerate the paper with a stirring rod while heating the beaker to dissolve the ferrous sulfide. Dilute to about 250 mL and boil to remove hydrogen sulfide. Cool, add a few drops of barium diphenylamine sulfonate indicator, 10 mL of 1:1 phosphoric acid, and titrate with standard potassium dichromate solution, 1 mL = 4.0 mg Fe₂O₃.

$$\% \text{Fe}_2\text{O}_3 = 0.4 \times \text{mL K}_2\text{Cr}_2\text{O}_7 \text{ solution} / \text{sample weight.}$$

d. Determination of titanium dioxide:

Evaporate the filtrate from the iron precipitation to about 25 mL over a hot plate; direct a stream of air over the liquid surface to prevent bumping. Add 30 mL of concentrated sulfuric acid, heat to fumes, and add small amounts of nitric acid to completely destroy organic matter. Cool, wash sides of beaker with 3 to 5 mL of water, and heat to SO₃ fumes. Repeat, as necessary, with 3 to 5-mL portions of water to expel all nitrogen oxides. Cool, dilute, and proceed with the analysis of titanium as outlined in ASTM

Designation: D 1394, Total Titanium by the Jones Reductor Method, beginning with the sentence: "Cool the solution, dilute with..." Alternatively, determine the titanium dioxide content by Atomic Absorption Spectrometry following the procedures in ASTM Designation: D 4563.

6. Other extracted pigments:

Follow the analysis procedures in appropriate ASTM standards.

PART 4. RAW MATERIALS, PIGMENTS

1. Zinc pigments, general: Refer to Ethylenediamine Tetraacetate Method described under Part 3, Pigment Analysis (Extracted Pigment).
2. Other pigment raw materials. Follow the analysis procedures in appropriate ASTM Standards.

PART 5. RESINS

Follow the procedures in appropriate ASTM Standards.

PART 6. SOLVENTS AND THINNERS

1. Specific gravity. Follow ASTM Designation: D 891.
2. Refractive index. Determine on a refractometer according to ASTM Designation: D 1218.
3. Distillation range. Follow ASTM Designation: D 86.
4. Evaporation rate. Follow ASTM Designation: D 3539.
5. Flash point. Follow ASTM Designation: D 3278.
6. Other properties. Follow the procedures of appropriate ASTM Standards.

PART 7. DRYING OILS

1. Specific gravity: Follow ASTM Designation: D 891.
2. Refractive index: Determine on a Refractometer according to ASTM Designation: D 1218. correct for temperature (+0.0004 per °C above 25°C for tung oil and +0.00038 per degree C above 25°C for other oils).
3. Acid value: Follow ASTM Designation: D 3643.
4. Saponification value: Follow ASTM Designation: D 464.
5. Unsaponifiable matter: Follow ASTM Designation: D 1965.
6. Viscosity: Follow ASTM Designation: D 1545.
7. Drying time: Follow ASTM Designation: D 1640.

8. Iodine value: Follow ASTM Designation: D 1541 or D 1959.
9. Other properties: Follow the procedures of appropriate ASTM Standards.
10. Flashpoint: Follow ASTM Designation: D 56 or D 3278.

PART 8. ALUMINUM PASTE

Leaving properties: Follow ASTM Designation: D 480. When comparing aluminum paste for use in a solvent borne paint, it will be sufficient to mix the paste with a suitable vehicle at the ratio of 100 g of paste per 417 mL of vehicle. When comparing aluminum paste for use in a waterborne paint, mix 0.1 g of paste with 10 mL of water. Leaving grade paste will uniformly cover the surface with a reflective film of aluminum.

D. SAFETY AND HEALTH

It is the responsibility of the user of this test method to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use. Prior to handling, testing or disposing of any materials, testers must be knowledgeable about safe laboratory practices, hazards and exposure, chemical procurement and storage, and personal protective apparel and equipment.

Caltrans Laboratory Safety Manual is available at:

http://www.dot.ca.gov/hq/esc/ctms/pdf/lab_safety_manual.pdf

Users of this method do so at their own risk.

**End of Text
(California Test 402 contains 9 pages)**