HIDING POWER - WEIGHED DRAWDOWN METHOD

I. PRINCIPLE / OBJECTIVE

Specify a standard procedure for determining hiding power of paint using the weighed drawdown method. Include steps to determine hiding power of dry and oiled paint films.

II. APPLICABILITY / LIMITATIONS

Determination of the hiding power of paint can be no more accurate than the measurement of the thickness of the film. It is very difficult to make an accurate measurement of a paint film for which the hiding power is to be determined. This weighed hiding method, based on determination of wet film thickness is satisfactory when (a) the drying rate of the paint is slow enough to permit accurate weighing of the wet film and (b) the paint densities are known.

The method for determining hiding power uses the reflectance readings taken on paint films applied to Leneta opacity charts - readings of reflectance over the white area (R) and black area (R_o) of the chart, and the substrate reflectance (R_g). Substrate reflectance is the initial reflectance of the white area of the chart, measured prior to application of the paint film. The method incorporates calculations using the reflectance readings and the equations of Kubelka-Munk to calculate scattering power (SX) and R infinity (R_∞ , or the reflectance of a film of infinite thickness). Wet film thickness, X, expressed in mils, is calculated from the density of the paint, the area of the drawdown and the tare weight of the wet drawdown. From values of SX and X, the scattering coefficient *S* in units of scattering per mil of paint can be calculated. When the TiO_2 content of the paint is known, the scattering coefficient *S* may be expressed as $S(TiO_2)$ in units of square meter/gram of TiO_2. The web-based program "DTT Spread Rate Calculator" is used to perform the calculations using the reflectance readings from the dry or oiled drawdowns.

III METHOD / PROCEDURE

A. <u>Standard Procedure</u>

1. Check substrate reflectance (R_g) by selecting at least eight (8) randomly selected Leneta Opacity Form 14H "special cut' cards from the box, and measure tristimulus Y reflectance values on the bare white portion of the cards. The average Y reflectance value should be approximately 81.0, and all the charts in a series should be within ± 2.0 units of the average.
2. Mix test paints thoroughly using an air mixer or spatula. Shaking or agitating paint violently may cause air bubbles and a non-uniform film, which would change apparent hiding power.
3. Tare a Leneta Opacity Form 14H chart on any top loading balance that measures rapidly, having 0.01 gram precision.
4. Position the Lenata chart on the automatic drawdown vacuum plate such that it is securely fit, and held flat and in place by the vacuum plate. Place a 1" piece of chart material on the automatic drawdown vacuum plate aligned along the bottom edge of the chart and covers the lowest row of vacuum holes. The 1" inch piece will provide continuity of film as the blade travels off the chart and serves as a landing spot for the applicator blade and excess paint.
5. Select proper Bird film applicator for each paint in the series.
    a. Select a Bird film applicator with a clearance that yields a dry film contrast ratio of between 0.92 and 0.95. Some experimentation with different applicator sizes may be needed to find the most appropriate one. It is advisable to run an applicator ladder [0.0025, 0.0031, 0.0035, and 0.004" clearances] to determine the blade clearance required to obtain the necessary contrast ratio. Prepare one drawdown chart per applicator per paint.
    b. Dry charts overnight or use appropriate drying oven.

c. Calculate contrast ratio by dividing the average reflectance over the black area by the average reflectance over the white area, and select the applicator that yields a dry film contrast ratio of between 0.92 and 0.95. Note: Never go higher than 0.006" clearance, even if the contrast ratio is lower than 0.92.

6. Using the appropriate Bird film applicator, prepare four drawdowns with approximately equal film area and weight for each paint sample.
    a. Tare a Leneta Opacity Form 14H chart on top of a top-loading balance that measures rapidly and that has 0.01 gram precision.
    b. Place chart on vacuum plate.
    c. Position the Bird film applicator on the Leneta chart in exactly the same location for every drawdown so that a constant area (in square inches) of paint drawdown is achieved. A good reference for this location is to align the applicator "foot" along the black and white line at the top of the Leneta chart.
    d. Place the applicator carrier and weight of the drawdown apparatus on the positioned applicator.
    e. Apply paint immediately in front and under the open face of the applicator blade. If the paint viscosity is high, a spatula or a thin wire rod bent at a 90-degree angle can be used to apply the paint into the corners of the drawdown blade. Apply enough paint beneath the entire open face of the blade squaring off corners to get complete coverage over the entire length of the chart.
    f. Promptly engage automatic blade carrier to draw the paint down the entire length of the chart. Discard those drawdowns where paint has crawled under the Bird applicator feet, or where wet-film thickness is non-uniform. Place thumbs of each hand against the 1" piece of Leneta chart to hold chart when drawdown blade is pushed by the Bird film applicator carrier from the chart onto the 1" piece of chart material at the bottom of the chart.
    g. Remove the excess 1"piece of chart containing the excess paint from drawdown machine and discard in a trash receptacle.
    h. Remove chart from vacuum plate and place on the balance. Immediately weigh chart and record to nearest 0.01 gram.
    i. It is important to complete steps *g* and *h* in a consistent, contiguous, and efficient manner, since the tare weights must accurately reflect on the applied wet film thickness.
    j. Wipe drawdown machine top with wet paper towel to remove any excess paint.
    k. Repeat step 6a to step 6k as many times as necessary to obtain 4 quality drawdowns whose individual weights deviate from their mean $\pm$ 0.03 grams. [When using thicker films such as the 0.006" applicator, the tolerance of $\pm$ 0.03 grams may be difficult to achieve. In that case, a wider tolerance may be required.] Use consistency in technique when recording paint weights [number of seconds after paint drawdown before weighing.]. Average weights are required for hiding power calculations.
7. Dry test panels
    a. Allow drawdowns to dry in a horizontal position. Charts stacked one above the other on racks with a minimum vertical clearance of 4" between charts. Overnight drying is suggested.
8. Determine Reflectance values.
    a. The spectrophotometer should be standardized prior to each set of measurements.
    b. For all reflectance readings use tristimulus Y values.
    c. Take one measurement at the center of each "white" and "black" section of each chart.
    d. Continue readings on all four charts to obtain the average of the "white" sections and the "black" sections.
9. Proceed to Section C for the hiding power calculations.

B. Oiled Hiding Procedure

This method provides the capability to directly measure the titanium dioxide contribution to the total scattering power of a coating by eliminating air scattering. NOTE: *For oiled hiding studies, use the X-Rite VS450 Color Spectrophotometer for all reflectance measurements, dry and oiled readings over black and white, and the substrate reflectance on the bare, white area of the chart.*

1. Use the same Leneta Charts that have been coated with test paint and dried for weighed hiding in Section IVA (Standard Procedure).
2. Brush an excessive amount of mineral oil with a 3" brush on coated charts laid flat on brown Kraft paper. Be sure there are no brush strokes or "missed areas.
3. Allow panels to sit flat for one hour. After one hour, wipe excess oil from the charts using Kimwipes.
4. Measure reflectance on the white and black areas of the drawdown as previously done on the dried panels. If the readings on the dry charts were taken on the X-Rite spectrophotometer, use that instrument for the oiled charts. When using the X-Rite VS450, make sure to position the Leneta charts on the automatic drawdown vacuum plate such that they are secure, and held flat and in place by the vacuum plate. Take one reading per black / white area.
5. Keep excess oil away from the lights inside the spectrophotometer measurement head.
6. Calculations for contrast ratio and hiding power are done the same way they are done for Standard Procedure.

C. Calculations: DTT Spread Rate Calculator

A web-based program entitled "DTT SR Calculator" developed by Chemours can be used to perform the calculations.

1. Measure paint density
2. Calculate pounds of TiO_2/gallon or TiO2/liter
3. Open the DTT Spread Rate Calculator and enter the following:
    a. Paint density (lbs/gallon or grams/liter)
    b. TiO_2 content (lbs/gallon or grams/liter)
    c. R, Reflectance over white
    d. R_o, Reflectance over black
    e. R_g, Substrate Reflectance (note - the program corrects R_g to account for specular reflectance)
    f. Tare weight of the paint (grams)
    g. Area of drawdown (square inches)
4. Program output includes:
    a. As Drawdown:
        i. Contrast Ratio
        ii. X (mils), wet film thickness as drawn down
        iii. SX
        iv. S [1/mil]
        v. S [square meter/gram TiO_2]
    b. At complete Hide (CR=0.98):
        i. Reflectance over Black
        ii. Reflectance over White
        iii. SX
        iv. X (mils), wet film thickness at complete hide (CR=0.98)
        v. X (grams TiO_2/square meter)
        vi. Spread Rate (square feet/gallon or square meter/liter)

IV. SPECIAL EQUIPMENT

1. Leneta 14-H Opacity Charts, The Leneta Company, 15 Whitney Road, Mahwah, NJ, 07430-3129. This is a lacquered paper chart with dimensions of 11-1/4" x 17-1/4". The chart design area is 1.076 square feet, or 1000 square cm. Charts are ordered pre-cut to 16-1/4" x 5-5/8".
2. Mettler Balance Model K7 - VW&R Scientific, Inc., Philadelphia, PA. Any top loading balance that measures rapidly, preferably having .01 grams precision can be used.
3. Automatic Drawdown Vacuum Plate - (12" x 18") BYK-Gardner USA, 9104 Guildford Road, Columbia, MD 21046-2729 (301) 483-6500 (Other automatic drawdown machines can be used for preparing the drawdowns).
4. Bird Film Applicator Blade - BYK-Gardner USA, 9104 Guildford Road, Columbia, MD 21046-2729 (301) 483-6500. - when possible, clearance should be chosen to give a contrast ratio in the range of 0.92-0.95.
5. X-Rite VS450 Color Spectrophotometer – 4300 44th Street, Grand Rapids, MI 49512 (800)248-9748
6. Labscan Spectro Colorimeter - Hunter Associates Lab, Inc., Reston, VA. (Other spectrophotometers can be used for measuring reflectance).
7. Drying Rack.
8. Spatulas and plastic eye droppers - VWR Scientific, Inc., Philadelphia, PA
9. Paint Brush, 2", Good Quality - Mammele's, North Market Street, Wilmington, DE
10. Spread Rate Program – DTT Spread Rate Calculator

V. REAGENTS

1. Mineral Oil, White – Avantor Performance Materials Inc., Center Valley, PA 18034