SOCIETY OF AUTOMOTIVE ENGINEERS, INC. • TWO PENNSYLVANIA PLAZA • NEW YORK, NEW YORK 10001

LAND SEA AIR SPACE

TECHNICAL REPORT J400

TEST FOR CHIP RESISTANCE OF SURFACE COATINGS—SAE J400

SAE Recommended Practice

Report of Nonmetallic Materials Committee approved July 1968.

1. Scope—This SAE Recommended Practice covers a laboratory procedure for testing and evaluating the resistance of surface coatings to chipping by gravel impact. The test is designed to reproduce the effect of gravel striking exposed painted or coated surfaces of an automobile and has been correlated with actual field results. The specific intent of the test is to evaluate organic surface coatings or systems on flat test panels; however, it may be possible to extend this type of testing to finished parts or other types of materials such as anodized aluminum or plated plastics if the results are interpreted with respect to the limitations and intent implied by the original testing procedure and rating system.

2. Summary of Method—The test consists of projecting a standardized road gravel by means of a controlled air blast onto a suitable test panel. The testing apparatus is contained in a box on wheels, called a gravelometer, designed to contain road gravel, a test panel holder, and a gravel projecting mechanism. The projecting mechanism, located in front of the test panel, consists of an air nozzle in the base of an inverted pipe tee. The stem of the pipe tee points upward and is connected to a funnel into which the gravel is poured. The gravel, falling into the air blast, is projected toward and impacts upon the test panel, which is usually held perpendicular to the impinging gravel. All testing is conducted under controlled temperature conditions, generally room temperature or 0 F. After gravel impact, masking tape is applied to remove any loose paint chips remaining on the panel, and the degree of chipping is determined by visual comparison with the SAE Chipping Rating Standards[1] or by counting the number and sizes of all chips.

3. Equipment and Materials

3.1 Gravelometer—A gravel projecting test apparatus which is constructed according to the design specifications shown in the Fig. 1.[2]

3.2 Gravel—The gravel for this test shall be water-worn road gravel,[3] *not crushed limestone or rock,* which will pass through 5/8 in. space screen when graded but be retained on 3/8 in. space screen. It is important to note that mesh screen is not a substitute for space screen. The gravelometer has 3/8 in. space screen in the bottom to separate out fractured pieces of rock and dust smaller than 3/8 in., so that the retained gravel on this screen may be reused; however, even this reusable gravel will tend to blunt or fragment after repeated impacts, so a periodic gravel change after reasonable service use is mandatory.

3.3 Masking Tape—Four inches wide, Minnesota Mining and Manufacturing Co., No. 202-2, or equivalent.

3.4 Temperature Conditioning Equipment—Gravelometer tests are usually run at room temperature or a lower temperature, generally 0 F, which shall be mutually agreed upon by supplier and purchaser. When tests are to be conducted at temperatures lower than room temperature, one of the following must be used:

3.4.1 A cold room (or freezer of sufficient size) in which the gravelometer and test panels both are maintained at the specified temperature of testing.

3.4.2 A freezer in which the test panels are cooled only to 10 F below the test temperature before they are individually transferred and tested immediately in a gravelometer at room temperature located nearby.

3.5 Tally Counter—A mechanical counter such as a Veeder Root Tally, Model No. SC-149000, four counters wide by one tier high, or an equivalent type, which is used to tally the number of chips of

[1] Available from Society of Automotive Engineers, Inc., Two Pennsylvania Plaza, New York, New York 10001.

[2] A similar type of commercial apparatus meeting these specifications can be obtained from: The Q-Panel Co., 15610 Industrial Parkway, Cleveland, Ohio.

[3] Gravel meeting these specifications can be obtained from: The Q-Panel Co., 15610 Industrial Parkway, Cleveland, Ohio.

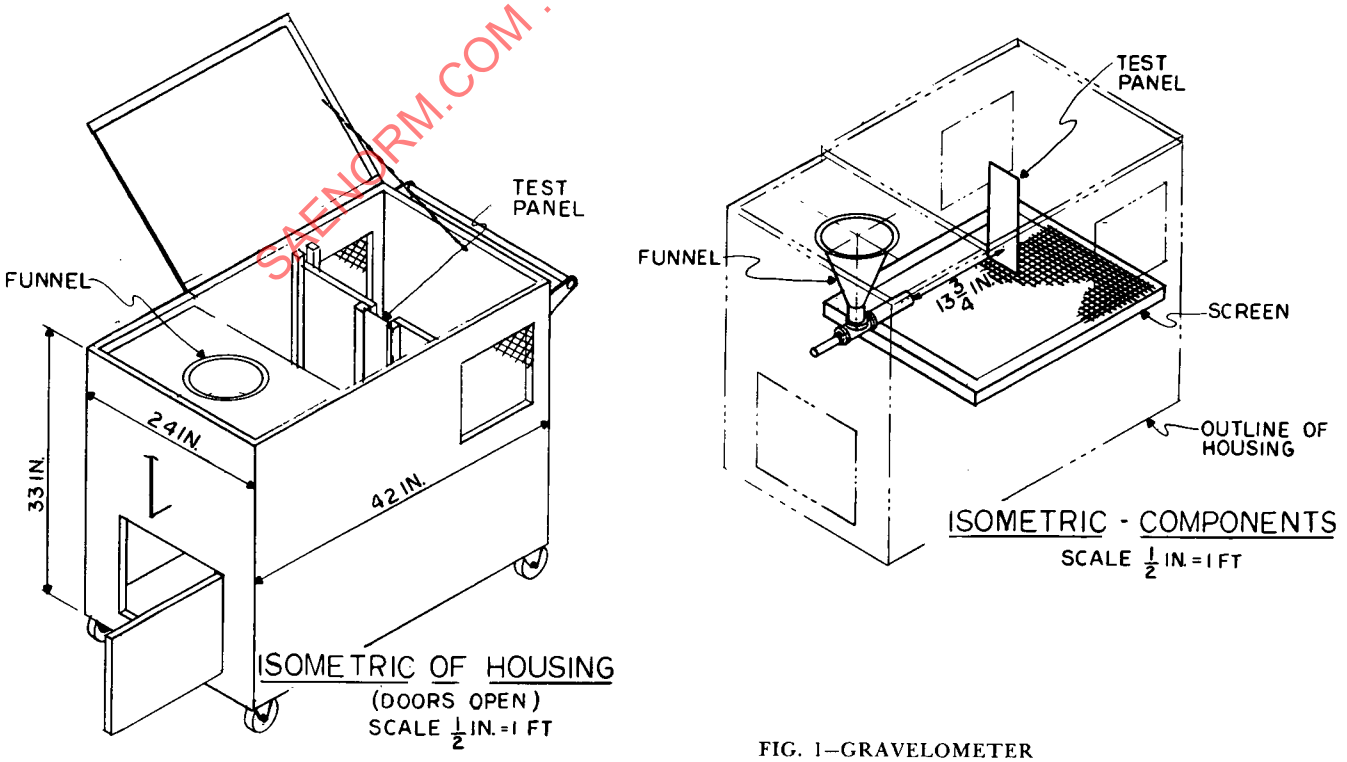

FIG. 1—GRAVELOMETER

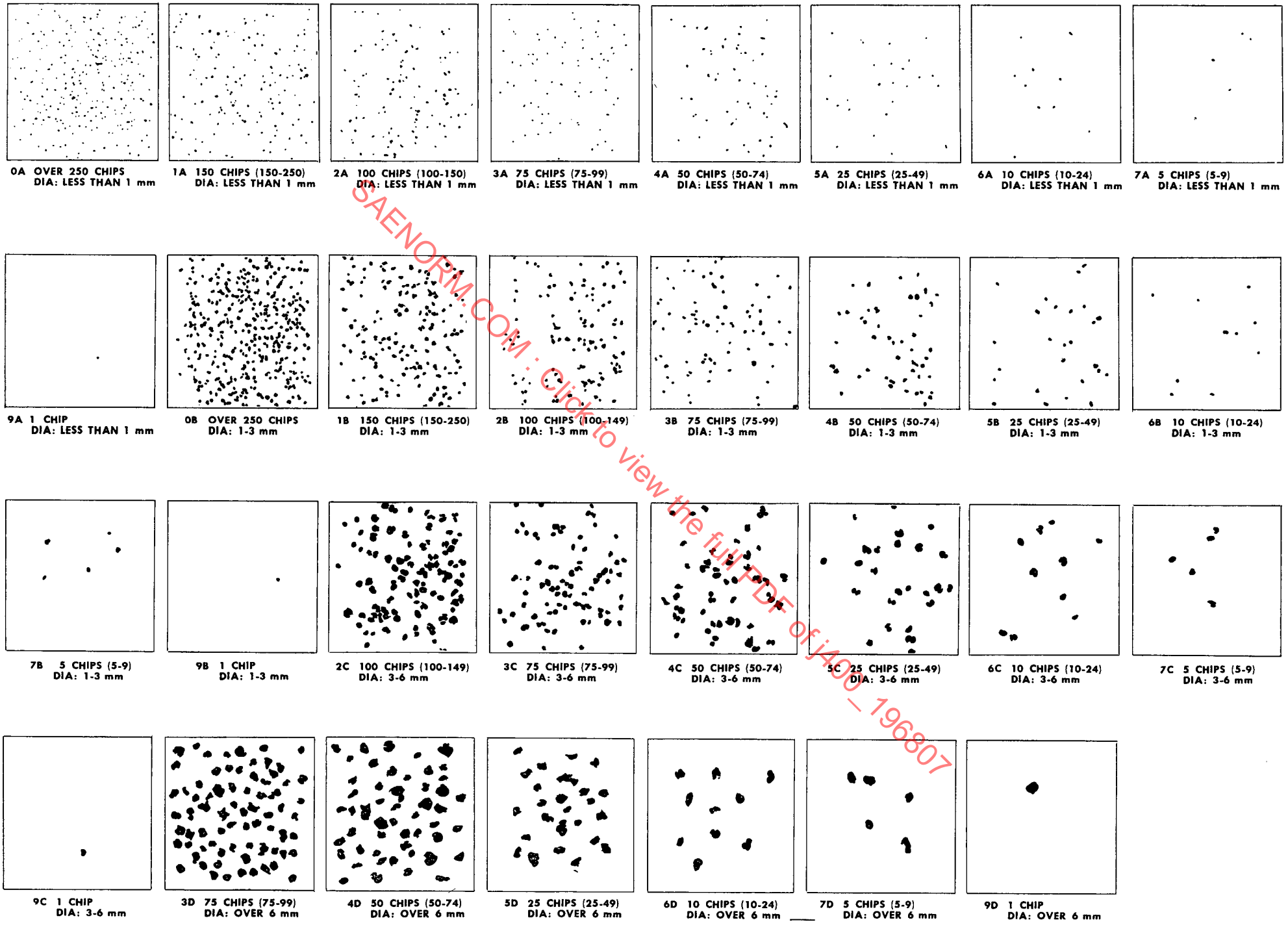

FIG. 2—CHIPPING RATING STANDARDS (REPRESENTATION ONLY)

four specified sizes on the tested panel.

3.6 Transparent Grid--A chip counting aid constructed of transparent plastic approximately 1/8 x 5 x 5 in., on which a 4 x 4 in. grid of 1 in. squares has been etched or scribed.

3.7 Chipping Rating Standards—A set of photographic transparencies, each depicting one size of chip and the fewest number of chips in each rating category.[3] See Fig. 2 for a representation of these transparencies.

3.8 Test Panels—The test panels should be flat and their size should be 4 x 12 in. in order to fit into the panel holder of the gravelometer. The test panel material, the panel's thickness or gage, and preliminary surface treatments (such as phosphatizing or anodizing) should be the same for all tests in any one series and as representative as possible of the actual part. Any deviations in these three parameters may produce misleading test results. Specification of these parameters shall be by mutual agreement between supplier and purchaser. A typical test panel specification would be: 4 x 12 in., 20 gage, phosphated, cold rolled steel.

4. Procedure

4.1 Paint or process the test panels as specified for the systems under test. It should be noted that gravelometer results will be dependent upon the nature of the coating's formulation, the method and degree of drying or curing of the various coats, and the film thickness involved. Uniformity of film thickness is extremely important, and each component of the system should be controlled to ±10% of the coating's thickness or ±0.1 mil, whichever is greater.

4.2 Age prepare test panels a minimum of 72 hr at room temperature before initiation of gravelometer testing.

4.3 Condition test panels for a minimum of 1 hr at the specified test temperature, mutually agreed upon by supplier and purchaser, in accordance with the appropriate method specified in paragraph 3.4. Make certain the test panels are separated and have free access to the conditioning environment so that optimum heat transfer is facilitated.

4.4 Adjust air pressure on the gravelometer to 70 ± 3 psi with the air valve open. Keep lid to gravel chamber on the gravelometer closed during this operation as a safety precaution.

4.5 After the air pressure is adjusted, shut off air valve, open the lid to the gravel chamber, and collect 1 pt of graded gravel (approximately 250-300 stones) in a suitable container. Gravel should be collected by scraping across the screen to allow fines to fall through.

4.6 Place one test panel conditioned at the desired test temperature in the panel holder with the coated side facing the gravel projecting mechanism, close lid to gravel chamber only. Open the air valve and feed 1 pt of gravel slowly over a period of 5-10 sec into the funnel.[4] Do not dump the gravel into the funnel because an instantaneous charge such as this may partially choke the pipe tee and lead to inconsistent results due to low particle velocity.

4.7 Shut off air valve, open lid to gravel chamber, and remove the tested panel. If necessary, allow panels to return to room temperature and dry to remove any condensed moisture.

4.8 Cover the tested panel with a 4 in. strip of masking tape, press down firmly, and then pull off slowly to remove chips of paint that have not been completely separated from the panel.

4.9 Determine the degree of chipping by one of the following methods of the Gravelometer Rating System.

5. Gravelometer Rating System

5.1 Methods Available

5.1.1 There are two methods available for determining the degree of chipping on the tested panel. In Method I, the exact number of chips in each size range is tabulated for the specified test area, while Method II utilizes a visual comparison of the tested panel with the SAE Chipping Rating Standards[3] which depict various degrees of chipping severity and are arranged sequentially from best to worst according to chipping size and frequency. Method I is the most precise and should be used where definitive accuracy is required or as the referee method in case differences arise between laboratories; however, it is more time-consuming than the visual comparison method. Method II is much faster and, while more of an approximation than the first method, can be used for many routine laboratory evaluations where the accuracy of Method I is not required. Method II also lends itself to field survey work where the chipped areas can be rated by direct comparison with the Chipping Rating Standards.

5.1.2 With both methods, the chipped area to be evaluated on the tested panel should be the 10 cm x 10 cm square (4 x 4 in.) that exhibits the worst degree of chipping.

5.2 Basic Structure of Rating System—Generally, the basic structure of the chip rating system consists of one or more number-letter combinations in which rating numbers 10-0 indicate the number of chips of each size and rating letters A-D designate the sizes of the corresponding chips. A point of failure notation may also be included in the rating if more descriptive refinement is desired.

5.2.1 NUMBER OF CHIPS—A whole rating number selected from the range of 10-0 in Table 1 is used to indicate the number of chips of each size in the 10 cm x 10 cm test area.

5.2.2 SIZE OF CHIPS—The size of the chips is specified by a rating letter selected from A through D in Table 2. Due to the irregular nature of chipping, the size cannot always be measured exactly so it has to be approximated. Two general types of chipping occur: glassy fracturing or flaking of the film from impact of the gravel and knife-like cut-throughs or gouges caused by sharp edges on the gravel. With true fracturing the longest average dimension of the chip is used for size measurements; with cut-throughs or gouges where little material is actually lost, the most representative shorter dimension or axis is used. Examples of chip size determination, expressed by dimension (d), are shown in Fig. 3.

5.2.3 POINT OF FAILURE—The coating layer at which the most predominant chipping failure occurs is designated as the point of failure. The notations in Table 3 can be used to designate this information if desired. In cases where multiple layers of different primers and/or sealers, multiple topcoats, or other more complex film/substrate combinations are encountered, the point of failure notation can be expanded accordingly in the sense of the descriptive terms of Table 3, once suitable agreement between vendor and purchaser has been established.

5.3 Details of Method I and Method II

5.3.1 METHOD I—Exact Counting Procedure

5.3.1.1 Counting can be facilitated by the use of a transparent overlay onto which has been etched a grid of 1 in. squares. The grid

TABLE 1—NUMBER CATEGORIES FOR CHIP RATING

Rating Number	Number of Chips	Rating Number	Number of Chips
10	0	4	50-74
9	1	3	75-99
8	2-4	2	100-149
7	5-9	1	150-250
6	10-24	0	>250
5	25-49		

TABLE 2—SIZE CATEGORIES FOR CHIP RATING

Rating Letter	Size of Chips (see "d," Fig. 2)
A	<1 mm (<approximately 0.03 in.)
B	1-3 mm (approximately 0.03-0.12 in.)
C	3-6 mm (approximately 0.12-0.25 in.)
D	>6 mm (>approximately 0.25 in.)

TABLE 3—POINT OF FAILURE NOTATION

Notation	Level of Failure	Failure Type
(S/P)	Substrate to primer	Adhesional
(S/T)	Substrate to topcoat	Adhesional
(P)	Prime	Cohesional
(P/T)	Primer to topcoat	Adhesional
(T)	Topcoat	Cohesional

FLAKING OR FRACTURING TYPE

CUT THROUGH OR GOUGE TYPE

FIG. 3—CHIP SIZE MEASUREMENT APPROXIMATION

[4] When the test panel has to be cooled to a temperature 10 F lower than the specified test temperature in a freezer located next to a gravelometer at room temperature, the total elapsed time between removal of the panel from the freezer and completion of the gravelometer run shall be no more than 15 sec. The 10 F lower conditioning temperature is to provide a working margin for the panel temperature rise toward the specified testing temperature during the transferring and testing interval.