

A PROPOSED ALTERNATIVE TO THE SUBJECTIVE EVALUATION OF SCRATCHES PER MIL-PRF-13830B AND OP1.002 BY USING AN OBJECTIVE MEASUREMENT OF SCRATCH WIDTH

1.0 Designation of Scratch and Dig Imperfections

Surface imperfection tolerances shall be specified by two letters separated by a hyphen (e.g., F–F). The first letter of the pair is the maximum scratch value; the second letter is the maximum dig value.

1.1 Scratches

The scratch letter defines the width of the scratch in accordance with Table 1. When the width of a scratch i is between the width of two scratch letters in Table 1, its scratch letter, s_i , shall be that of the higher scratch letter for the purposes of paragraph 1.1.1.

Table 1 Scratch Designations

Scratch Letter	Scratch Width, microns	Disregard Scratch Widths Less Than, microns
A	5	1
B	10	2.5
C	20	5
D	40	10
E	60	10
F	80	20
G	120	20

1.1.1 Maximum Combined Length of Maximum Size Scratches

Unless otherwise specified, the combined length of all maximum allowable scratches on each surface of an optical element shall not exceed one quarter of the diameter of the element. Portions of scratches extending beyond the clear aperture shall not be considered when applying the formula.

$$\sum_i L_i \leq \frac{\phi}{4},$$

where L_i is the length of a maximum allowable scratch i
 ϕ is the diameter of the element or appropriate zone

1.1.2 Maximum Combined Length of All Scratches

When a maximum allowable scratch is present, the sum of the products of the actual scratch widths to be considered times the ratio of their length to the diameter of the element or appropriate zone shall not exceed one half the maximum allowed scratch width.

$$\sum_i \left(s_i \times \frac{l_i}{\phi} \right) \leq \frac{S}{2},$$

where S is the scratch tolerance (maximum scratch number),
 s_i is the actual width of scratch i ,
 l_i is the length of scratch i
 ϕ is the diameter of the element or appropriate zone

When a maximum allowable scratch is not present, the sum of the products of the actual scratch widths to be considered times the ratio of their length to the diameter of the element or appropriate zone shall not exceed the maximum allowed scratch width.

$$\sum_i \left(s_i \times \frac{l_i}{\phi} \right) \leq S ,$$

where S , l_i , s_i and ϕ are defined as above.

Portions of scratches extending beyond the clear aperture shall not be considered when applying the appropriate formula.

1.1.3 Concentration of Scratches

Areas of surfaces with a specified scratch letter of B or C shall have no more than four separate scratches in any 6.35 mm diameter circular area.

1.1.4 Coating Scratches

Coating scratches, scratches which do not penetrate the substrate surface, shall be assessed per the limits specified in paragraphs 1.1 through 1.1.3. Coating scratches shall be considered separate from the substrate scratch requirements.

1.2 Digs

The dig letter defines the average dig diameter in accordance with Table 2.

Table 2 Dig Designations

Dig Letter	Dig Diameter, mm	Disregard Digs Smaller Than, mm
A	0.05	0.010
B	0.10	0.025
C	0.20	0.050
D	0.30	0.050
E	0.40	0.100
F	0.50	0.100
G	0.70	0.200
H	1.00	0.250

1.2.1 Number of Maximum Size Digs

The number of maximum size digs allowed per surface shall be equal to the element diameter in millimeters divided by 20 mm, rounding up to the next whole number.

$$N = \frac{\phi}{20} , \text{ rounding up.}$$

where N is the number of maximum size digs allowed,
 ϕ is the element diameter in mm

1.2.2 Allowable Dig Total

The sum of all the dig diameters to be considered on a single surface shall not exceed twice the product of the maximum size dig specified and the number of maximum size digs allowed per paragraph 1.2.1.

$$\sum_i d_i \leq 2 \times N \times D ,$$

where N is the number of maximum size digs allowed,
 D is the diameter of the maximum dig allowed,
 d_i is the average diameter of dig i .

1.2.3 Concentration of Digs

For any 20 mm diameter area anywhere within the clear aperture the sum of the diameters of all digs to be considered shall not exceed twice the diameter of the maximum dig specified.

$$\sum_i d_i \leq 2 \times D ,$$

where D is the diameter of the maximum dig allowed,
 d_i is the average diameter of dig i .

On surfaces having dig specifications less than or equal to B, the digs shall be separated edge to edge by at least 1 mm.

1.2.4 Coating Imperfections

Coating spatter, voids, and other point defects not removable by cleaning shall be considered to be digs and shall not exceed the allowable tolerance limits on dig size and quantity stated on the component drawing or procurement document. These coating imperfections shall be considered separate from the substrate imperfections.