Overview

This procedure establishes a method of locating and defining scratches, digs, chips, coating defects, cosmetic blemishes and contamination/debris found on optical surfaces and coatings.

The purpose of this procedure is to systematically accept or reject scratches, digs, chips, coating defects, cosmetic blemishes and contamination/debris on optical surfaces and coatings by using a visual inspection technique and a Surface Quality Scratch and Dig Standard per MIL-PRF-13830 and C7641866.

Definitions

Scratch

- Any marking or tearing of the surface. Scratch types are identified as follows:
  1. **Block Reek** - Chain like scratch produced by polishing.
  2. **Runner-Cut** - Curved scratch caused by grinding.
  3. **Sleek** - Hairline scratch.
  4. **Crush or Rub** - Surface scratch or a series of small scratches, generally caused by mishandling.
  5. **Fracture** - An obvious crack or split in an optical element that is visible because there is an air space separation where the material has not flaked or broken away from the main substrate and is still attached.

Dig

- A small rough spot on the optical surface similar to pits in appearance, generally caused by mishandling.

Clear Aperture (CA)

- A circular or elliptical area of specified diameter that is equivalent to the largest beam (i.e.; bundle of light rays) incident on the specified surface. Diameter of the CA is specified as an optical element design parameter.

Coating

- **Evaporation Lot** - An evaporation lot is that group of parts which has coating applied in the same chamber at the same time.
- **Normal** - An imaginary line forming right angles with a surface or other lines. It is used as the basis for determining angles of incidence,
reflection and refraction.

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**Edge Chip**
A fracture or break located along a physical edge of an optical part which has broken out and left a smooth “shell-shaped” area.

**Stoned**
A surface which has been roughened to a gray appearance using a stone abrasive material.

**CCC-C-440**
Cloth, Cheesecloth, Cotton Bleached and Unbleached

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**Approach**
This procedure establishes a method of locating and defining scratches, digs, chips, coating defects, cosmetic blemishes and contamination/debris found on optical surfaces and coatings.

This document contains four (4) separate procedures related to the cleaning and surface coating inspection of laser optics. These procedures are described as follows:

- **Paragraph**
- **Title**
  - 3.1 Laser Optics Cleaning Procedure
  - 3.2 Scratch, Dig and Coating Defects Inspection Procedure
  - 3.3 Chip/Fracture inspection Coating and Cosmetic Blemish Inspection

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**3.1 Laser Optics Cleaning Procedure.**

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**3.1.1 Scope and Purpose**
Optical surfaces shall be clean, in accordance with the requirements of this procedure, prior to performing surface coating quality inspections.

The purpose of this procedure is to assure that the optical component surfaces are cleaned, prior to subsequent processing, in a controlled and repeatable manner.

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**3.1.2 Material and Equipment List**

- **a.** Nitrogen or dry filtered shop air blow-off equipment consisting of pressure regulator with gauge and filter gun with filter disc, Teflon, 13mm, 3 micron, Millipore #FSLW01300 or equivalent or dry, filtered shop air.
- **b.** Glass or Teflon dispenser bottles.
The following materials are required for use by this procedure:

a. Methyl Alcohol, Spectroscopic Grade, American Scientific 230-4L or equivalent.
b. Acetone, Spectroscopic Grade, American Scientific 010-46 or equivalent.
c. Dry air or nitrogen, 76°F Dew Point, 1 ppm total hydro-carbons.
d. Polyethylene Squeeze Bottle, 500 ml, Fisher Scientific (#03-409-10E).
e. Finger Cots, Cleanroom Approved Washed Latex.
f. Lens Tissue

3.1.3 Cleaning Procedure

NOTE: CLEANING UPON RECEIVING INSPECTION SHALL BE DONE ONLY TO REMOVED MATERIALS FROM OPTICAL SURFACES THAT MIGHT BE VIEWED AS SURFACE DEFECTS. CLEANING IS DONE AT TIME OF SURFACE QUALITY INSPECTION.

3.1.3.1 Handling

Clean talc-free surgical rubber finger cots shall be worn when performing any operation in this procedure.

3.1.3.2 Detailed Cleaning Process

3.1.3.2.1 Remove wrapping materials.

NOTE: OPTICAL ELEMENTS SHALL BE SET DOWN ONLY ON CLEAN LENS TISSUE.

3.1.3.2.2 Remove loose dirt and dust particles from all optical surfaces with filtered nitrogen or dry shop air.

- CAUTION - LASER OPTICS SHALL BE CLEANED ONLY WHEN NECESSARY. EVEN THE MOST GENTLE CLEANING WILL DEGRADE SURFACE QUALITY. COATED OPTICAL SURFACES ARE PARTICULARLY SUSCEPTIBLE TO DAMAGE. SPECTROSCOPIC GRADE REAGENTS DO NOT LEAVE A RESIDUE AFTER DRYING. USE ONLY SPECTROSCOPIC GRADE SOLVENTS WHEN CLEANING OPTICS. DO NOT USE REAGENT GRADE SOLVENTS.
3.1.3.2.3 Apply a few drops of spectroscopic grade methanol or acetone from glass or Teflon dispenser to a piece of lens tissue.

3.1.3.2.4 For square or rectangular surfaces start at one edge of a surface work the cleaning solvent completely from one edge to the opposite edge using lens tissue. Do not use “scrubbing” motion.

3.1.3.2.5 For circular surfaces wrap lens tissue around glass rod in a manner to ensure that the glass rod does not come in contact with the optics. Start at the center and with a gentle circular motion rotate to the outer edges. At no time should a “scrubbing” motion be used.

3.1.3.2.6 If visually observed residues remain & repeat.

3.1.3.3 **Acceptance Criteria**

Laser optical components will be completely free of any visible contamination or debris. Any cleanliness irregularity visible under specular illumination shall be cause for rejection.

3.2 **Scratch, Dig and Coating Defect Inspection Procedure**

3.2.1 **Scope and Purpose**

This procedure establishes the method for locating and defining scratches, digs and coating defects found on the optical surfaces and coatings.

The purpose of this procedure is to classify optical surface scratches, digs, and coating defects using visual inspection and comparison for acceptance to the Surface Quality Scratch and Dig Standards of MIL-PRF-13830 and C7641866. High intensity specular illumination will be used as necessary to assist in visual defect evaluation for coating. The inspection criteria used for coating, is based on MIL-F-48616.

3.2.2 **Material and Equipment List**

a. Black Box per MIL-PRF-13830 and MIL-C-675.
b. 3X to 10X Stereo Microscope with High Intensity Lamp
c. Latest Revision C7641866 Surface Quality Standards for Optical Elements when MIL-PRF-13830 is applied to the contract, otherwise, the latest revision applies.

References cited may not be applicable to all locations; use site specific documents in these instances.
d. Finger Cots, Cleanroom Approved Washed Latex

e. Industrial Microscope, Leitz Model SM-LUX-HL with Toolmakers Translation Stage or equivalent; or 7X or greater optical eyeloop with measurement reticle.

f. High Intensity Lamp, American Optical, Model 655 or equivalent.

g. Pulse Laser, YAG, 170±10mj output at 10±1 PPS with a pulse-width of 20±5ns.

h. Goggles, Laser-Gard, LGS-NDGA, Glendale Optical Company or equivalent or goggles having 14 O.D.

3.2.3

Scratch and Dig Inspection Procedure

3.2.3.1

Handling

Clean talc-free surgical rubber finger cots shall be worn when performing any operation in this procedure

3.2.3.2

Preliminary Screening

To facilitate speedy surface quality inspection, high intensity specular illumination with £ 10x microscope may be used to screen out acceptable components with superior surface and coating quality. Components with questionable surface quality may then be subjected to the following inspection procedure for acceptance/rejection.
3.2.3.3 Visual Inspection Procedure

For transparent optics use 40 watt illumination - view in transmission.

For opaque optics: Use 2 cool white 15 watt fluorescent lamps - view in reflection.

For mirror coated optics: Use 40 watt illumination - view in reflection. See Figure 1.

![Diagram showing test component and light sources]

NOTES
1. THE ONLY ILLUMINATION IN THE TEST AREA SHALL BE FROM THE LIGHT SOURCE USED FOR TEST.
2. TILT AT AN APPROPRIATE ANGLE TO SEE THE COATED SURFACE.

FIGURE 1.

3.2.3.3.1 Visually examine each optical surface of the component.

References cited may not be applicable to all locations; use site specific documents in these instances.
3.2.3.3.2 Classify each scratch, dig or coating defect observed by comparison with the standards of C7641866.

3.2.3.3.3 Assign a “Scratch Number” to each scratch as compared with the standards of C7641866. Record this number. Isolated or singular circular chips along a scratch shall be evaluated as digs and shall not be considered in assigning a scratch number.

3.2.3.3.4 Assign a “Dig Number” to each dig as compared with the standards of C7641866. Record this number. The diameter of irregular shaped digs shall be taken as one half the sum of the maximum length and the maximum width.

3.2.3.4 Moderate Abrasion Test

The optical component, selected per paragraph 3.2.4.6 shall be subjected to a moderate abrasion by rubbing the coating surface area of concern (i.e.; blemished or discolored area) with a 1/4 inch (6.4mm) thick by 3/8 inch (9.5mm) wide pad of cheesecloth. The cheesecloth pad shall be rubbed across the coated surface from one point to another over the same path for 25 complete cycles (50 strokes). The pad shall be loaded (weighted) to provide a constant force of 1.0 pound (0.045 kg) minimum. The stroke length shall be longer than the area of concern at its greatest dimension. The pad shall be held normal to the surface under test during the rubbing activity.

Subsequent to the rubbing operation, the optical component shall be cleaned in accordance with section 3.1, and then subjected to the inspection procedures for any evidence of coating damage. If no coating damage is found, consult laser engineering regarding necessity for Laser damage resistance testing per P708-APK-G01.

3.2.4 Acceptance Criteria

3.2.4.1 Scratches or Coating Defects

Cumulative scratch number is calculated as followed:

\[ S = \frac{N \times L}{D} \]

S is cumulative scratch number
N is scratch number of individual scratches.
L is the corresponding length of individual scratches.
D is diameter of the element’s clear aperture (CA).

Surface scratches are permissible provided the scratch widths do not exceed the specified scratch number. In addition, the following constraints must be satisfied.
3.2.4.2 For an Element With No Maximum Size Scratch or Coating Defects Observed
The cumulative scratch number for elements with no maximum size scratch observed must not exceed the specified scratch number.

3.2.4.3 For an Element With Maximum Size Scratch or Coating Defects Observed
The cumulative scratch number for elements with one or more maximum size scratches must not exceed 1/2 of the specified scratch number and the sum of the lengths of maximum size scratches must not exceed 1/4 the diameter of the element’s clear aperture.

3.2.4.4 Digs or Coating Defects
No dig or void shall exceed the specified dig number. The number of permissible maximum size dig is one per circle of 20mm diameter. The sum of dig number of all digs per circle of 20mm diameter shall not exceed twice the specified dig number.

3.2.4.5 Coating Inspection
Each surface CA shall be examined for evidence of flaking, peeling, cracking, etc. by reflection or transmission. Spatter, sputter, or holes in the coating shall be evaluated as a dig.

3.2.4.6 Blemish Inspection
Blemishes found shall be evaluated in accordance with the criteria of Visual Inspection Procedure (3.2.3.3). One sample component that exhibits discoloration or blemishes that are typical of the evaporation lot shall be subjected to the abrasion test. Evidence of streaks, smears, strains, blotchiness or discoloration shall be cause for rejection if:

a. The optical component fails the abrasion test or
b. The optical component fails the laser damage resistance testing per P708-APK-G01.

3.3 Chip/Fracture Inspection

3.3.1 Scope and Purpose
This procedure establishes the method for locating and defining chips/fractures found along the physical edges of the optical components. The purpose of this procedure is to classify edge chips/fractures using low power magnification visual inspection and criteria based on MIL-PRF-13830.

3.3.2 Equipment List
a. 7X - 10X eyeloop with measurement reticle or, microscope and dial caliper.
3.3.3 Inspection Procedure

3.3.3.1 Handling
Clean talc-free surgical rubber finger cots shall be worn when performing any operation in this procedure.

3.3.3.2 Visual Chip Inspection
Visually examine each edge of the glass element using the eyeloop, dial caliper or Leitz Microscope. Compare each chip observed that is larger than 1/2 mm (0.020 inch) to the acceptance criteria below (Paragraph 3.3.4).

3.3.4 Acceptance Criteria
a. Edge chips which do not encroach on the CA of a surface shall be allowed. Edge chips that intrude into the CA of surface shall be evaluated as digs per paragraph 3.2.3.5.4.
b. Edge chips larger than 1/2 mm (.02 inches) as measured at the chips largest extremity should be stoned to lessen the possibility of additional chipping.
c. The sum of the chip widths larger than 1/2 mm (.02 inches) as measured at the edge shall not exceed 30% of the perimeter, on which the chip is located.
d. Fractures visible to the unaided eye on any surface or edge and not permitted. Fractures shall be ground out, ground out areas shall remain within the applicable stoned chip limits.

Responsibilities
Northrop Grumman Laser Systems
Definition of testing parameters.
Accept/Reject Criteria. The provisions for acceptance of a particular component are the parameters and tolerances called out on the respective drawing for that component.

Supplier
Performance of testing in accordance with the requirements defined within this guideline.

References
Forms
MIL-PRF-13830
Optical components for Fire Control Instruments: General specs governing the manufacture, assembly and inspection of

MIL-F-48616
Filter (Coatings), Infrared Interference: General Specification for

C7641866
Latest Revision Surface Quality Standards for Optical Elements when MIL-PRF-13830 is applied to the contract, otherwise, the latest revision applies.