

Software Assisted Scratch Visibility Measurements

The SavvyInspector™



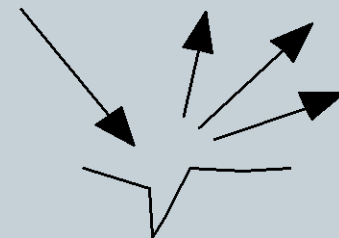
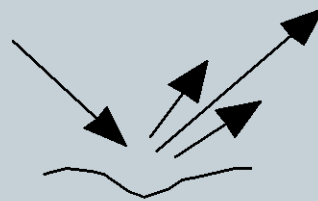
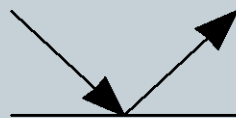
DAVE AIKENS
SAVVY OPTICS CORP.

OCTOBER, 2010

...scratch standard is only a cosmetic standard...the scratch standard is only a cosmetic standard...the scratch standard is only a cosmetic standard...the scratch standard is...



- MIL-PRF-13830B is the de facto standard method of specifying cosmetic surface quality
 - Specification of “**visual appearance** of defects on optical parts”
 - Uses a pair of numbers, the first for scratch, the second for dig (e.g., 80-50; 40-10)
 - **Arbitrary numbers** referenced to a set of **master scratches and digs**
- May be adequate for cosmetic defects, but cannot be used to control functional defects
- This is not a secret; Matt Young published a series of papers in the 1980's making this quite clear
- There is little correlation between the appearance or visibility of a scratch and its measured width. The *shape* of a scratch has a lot to do with its visibility.



Situation today



- There is extensive confusion in the industry as to the meaning and interpretation of surface quality specifications
 - e.g. “80/50 Scratch-Dig”
 - Based on inspector evaluation of “visibility”
 - Subjectivity of test is the killer
 - ISO 10110-7 is gathering momentum, but still has issues
- Surface imperfections by far the most cited cause of optics rejection
 - Almost all are cosmetic or workmanship specifications only
- The confusion about surface imperfections costs our industry tens of millions of dollars each year
 - MRB decisions
 - Returned optics
 - Reworked optics
 - Overmanufactured parts

Conventional visibility inspection is performed by a skilled operator under controlled lighting conditions

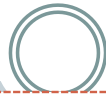


- The trained human eye is quite good (repeatable) in making accurate side by side comparisons.
- Disagreements from inspector to inspector and shop to shop due to differences in:
 - Training
 - Interpretation
 - Illumination
 - Visibility of comparison standards.
- Due to geometry, reflectivity of optics, most inspections actually done in reflection rather than transmission, as shown.



Photo from "taking variability out of scratch inspection," presentation to OEOSC by Ari B. Siletz

Geometry for standard reflectance visibility measurement from OP1.002:2009



- Illumination with a broad spectrum of angles
- Viewed with a small band of angles
- Part is rotated to achieve maximum visibility

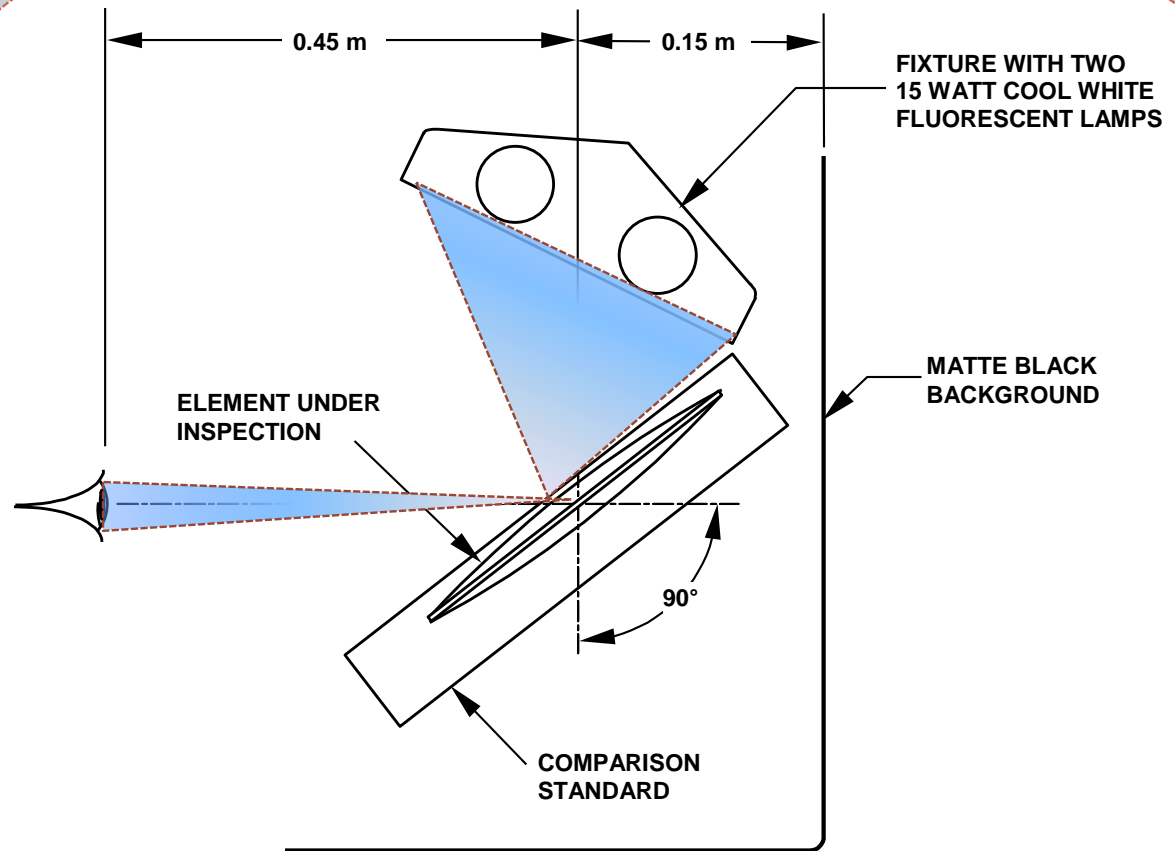


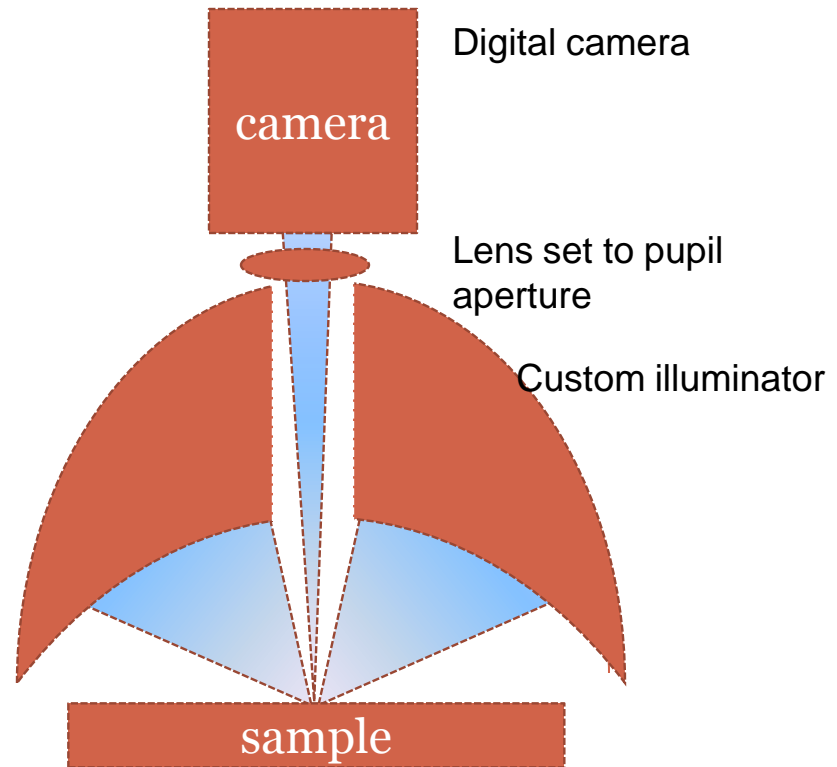
Figure 4 Reflected Light Inspection

This is just an evaluation of integrated scatter for specific angles!

SavvyInspector™ recreates the reflection visibility conditions, over 360 degrees of rotation



- Same illumination and detection angles
- Illuminates in a ring to eliminate part orientation
- Tailored brightness and integration to make #10 just visible on camera



Software assisted scratch inspection



- **CCDMetrix and Savvy Optics have developed an instrument to remove the subjectivity from scratch visibility inspection**
- **Simulates the visibility test from MIL-PRF-13830B**
 - Based on digital CCD, custom illumination
 - Angles of detection close to human observer
 - Angles of illumination to highlight differences between small scratches
- **Factory calibrations based on Jenoptik paddle, and Davidson Optronics and FLIR/Brysen standards**
 - Both clear and metalized
 - Can calibrate in situ with any standard set
- **Allows operator to move sample beneath integral head**
 - Unit reports dig value, scratch value, scratch length for selected artifact
 - Data is exported to a spreadsheet for accumulation
 - Spreadsheet provides quick calculation of pass/fail
 - Image and data files saved for future reference

The Model SIF-4 Savvy Inspector™



The Savvy Inspector™ Software is the key to the inspection



Scratch window

Dig window

Scratch or dig value

Scratch standard visibility

Scratch visibility bar

Active calibration file

Save image button

Image field

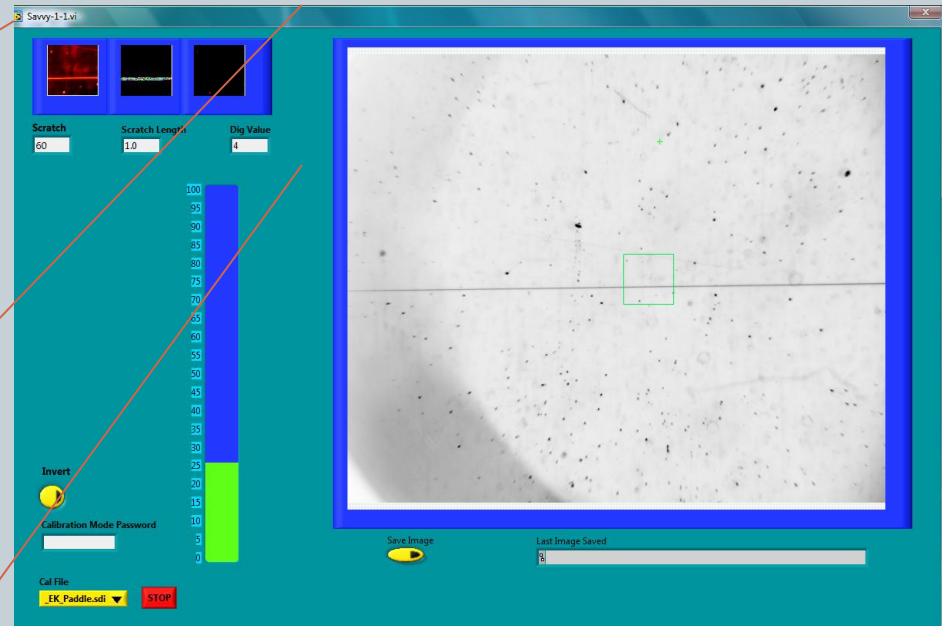
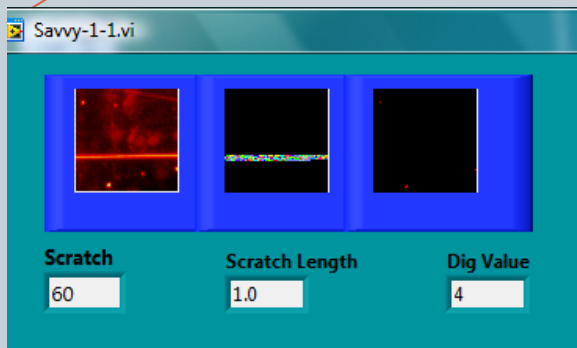
Inspector window

Saved image location

Inspection mode



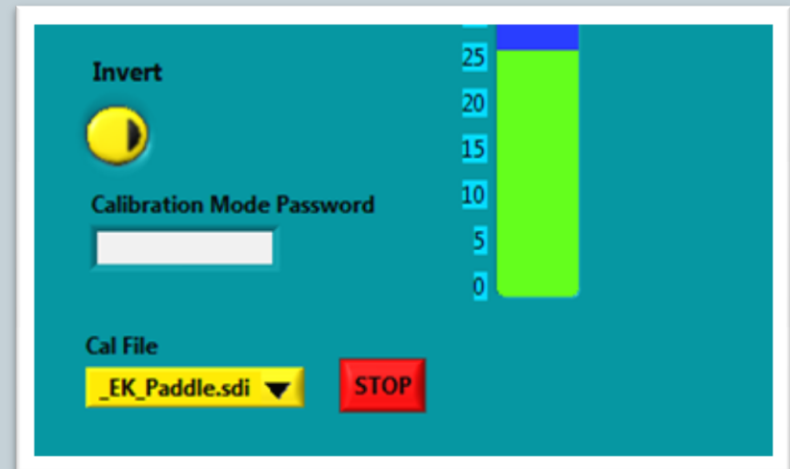
- Part is visually inspected to generate rough map
- Imperfections are viewed with Savvy Inspector™
- SavvyInspector™ is used to determine scratch and dig values



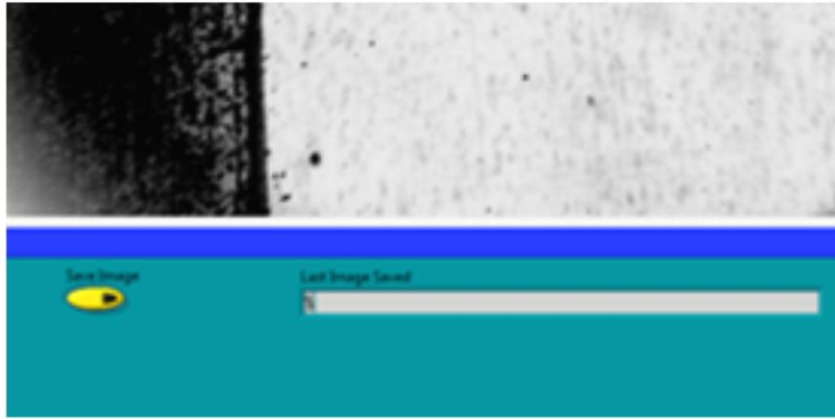
Inspection mode, continued



- User can select from menu of calibration files for scratch evaluation
 - Factory calibrations which cannot be altered
 - Custom calibrations generated by tool owner
- Factory calibrations based on sequestered set of all important comparison artifacts
 - Davidson, transmissive and reflective
 - Brysen, transmissive and reflective
 - Jenoptik (current revision paddle)
 - Eastman Kodak paddle



Inspection mode, continued



- Image files are saved to a folder with part information for future reference
- Values for scratches and digs entered into Savvy Accumulator spreadsheet for pass-fail determination

Scratch and Dig Accumulation Spreadsheet © 2009 Savvy Optics Corp

Part number

Serial number

Comment

Specification (e.g. 80-50) Scratch Dig

Part diameter in mm

allowed digs

Allowed dig sum over part

Allowed max scratch total length in mm

Allowed total scratch accumulation if max scratch present

if no max scratch present

Allowed concentration in 20 mm

Concentration rule

← leave this cell blank

Scratches	Scratch grade	length in mm	relative length
Scratch #1	80	0	0.00
Scratch #2	60	0	0.00
Scratch #3	40	0	0.00
Scratch #4	20	0	0.00
Scratch #5	10	0	0.00
Scratch #6	0	0	0.00
Scratch #7	0	0	0.00
Scratch #8	0	0	0.00
Scratch #9	0	0	0.00
Scratch #10	0	0	0.00

Digs	Dig grade	within worst 20mm dia?
Dig #1	50	n
Dig #2	40	n
Dig #3	30	n
Dig #4	20	n
Dig #5	10	n
Dig #6	5	n
Dig #7	0	n
Dig #8	0	n
Dig #9	0	n
Other digs	0	n

Max scratch

Max scratch length

Scratch Accumulation

Concentration

Scratch pass/fail overall

Max dig

Dig accumulation

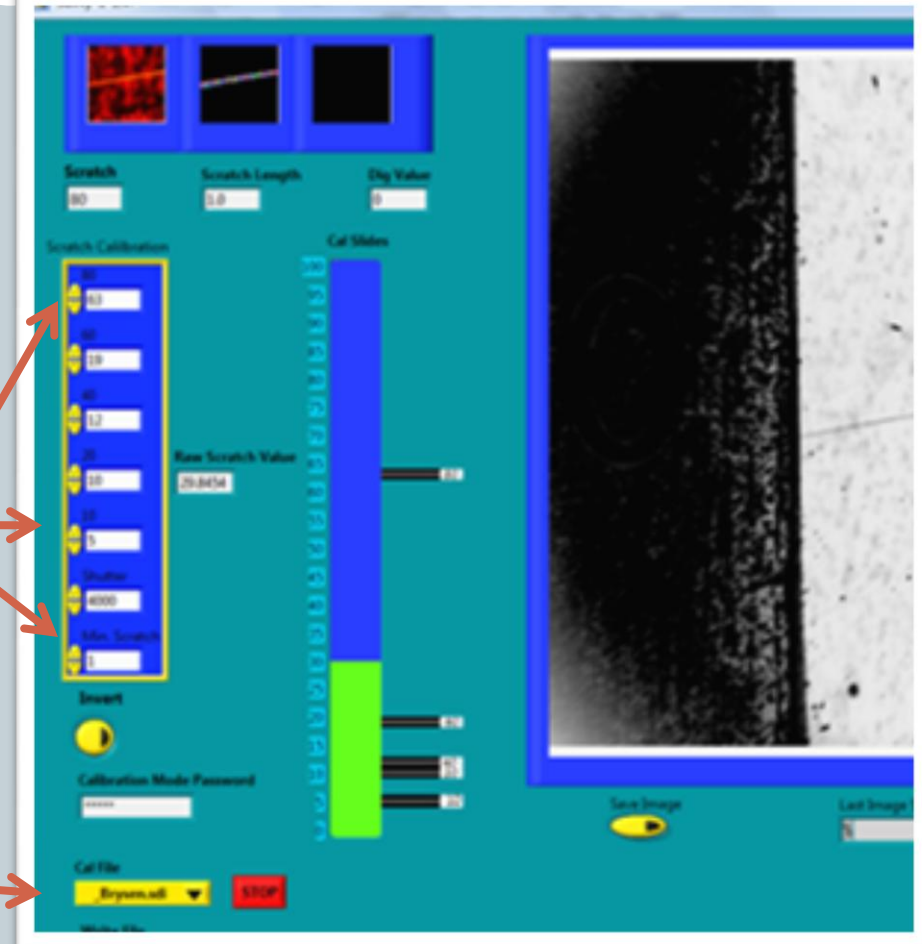
Dig concentration

Dig pass/fail overall

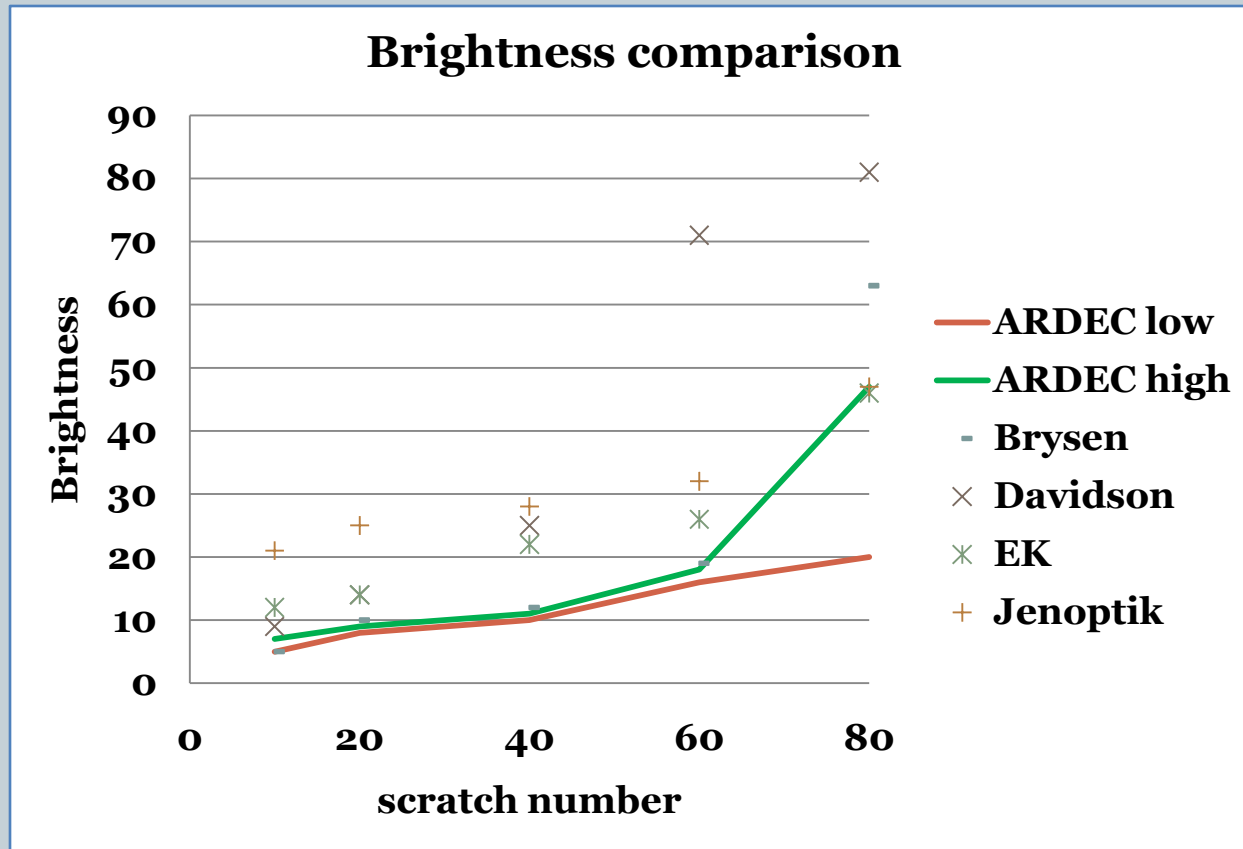
(user enters data in all cells marked in green:)

Calibration Mode

- User can enter calibration mode password to create new calibration files
- A comparison artifact of a given number (e.g. #20) is loaded, and the relative visibility is recorded here
- The calibration file is stored
- The new calibration appears on the calibration file pull-down menu



Comparison of artifacts using SavvyInspector™ SIF-4 SN 001



- Data presented at OF&T, June 2010

We're trying to change our world



"Now that we have a SavvyInspector™ in the factory, we don't think about scratch and dig the same way. We really consider it a competitive advantage, since we know exactly what we have for surface quality, where our competitors have to guess, or rely on expert opinion. I wouldn't want to do a scratch and dig evaluation any other way."

Flemming Tinker

President, Aperture Optical Sciences, Inc.

"...when one of our most important customers sent parts back that our inspectors said were ok, we knew we had to do things differently. We had a critical need, and the SavvyInspector™ was essential to sorting out exactly what was acceptable and what wasn't. We were able to make the case to our customer that, not only did we understand scratch and dig, but the parts he had sent back really did meet the specification."

Mark Mulhern

Metrology and Quality Assurance Manager, ISO Optics, Inc.

"This is important on many levels. Not only is it important to the defense community, but also for the commercial optics community at large, which now has access to the same technology used by ARDEC."

Allen Krisiloff

President, Triptar Lens Company, Inc.

Chairman, Optics and Electro-Optics Standards Council.

Summary



- Software assisted scratch inspection is an excellent solution to the scratch visibility problem
 - Very repeatable
 - Easy to calibrate
 - Easy to operate
 - Permanent record and traceability
- Software assisted scratch inspection technology can be applied to additional measurement applications
 - Easily integrated into multi-axis test systems
 - Motorized version can allow automated inspection of large optical surfaces
- SavvyInspector™ takes the subjectivity out of the scratch inspection process