

Performance-based Optical Surface Imperfection Standard

A. Background

1. Optical parts and systems are designed and produced to meet specifications satisfying minimum customer's requirements functionally and non-functionally. Although imperfection tolerances to date have been based almost exclusively on visual (non-functional) appearance, their functional performance effects have not yet been covered.

2. Imperfection standards/specifications are more than 50 years old, and even a new (pending) ISO appearance standard (OP1, 2005) is impractical to use because of lack of/and or expense of comparison panels. Even if comparison panels could be used, their accept/reject criteria could not be justified!

3. Specifying imperfections non-functionally is fully covered in ANSI/PIMA IT3.617-1999. These imperfections are graded in terms of their visibility under specified illumination, viewing distance (un-aided and aided eye) when viewed "as used" in their application. Although optics are expected to reflect "good workmanship", imperfections not visible to a user after assembly should not be cause for rejection.

4. As long as we don't have an imperfection standard for imperfections on optical surfaces (as well as within optical components), the common sense criteria described in the foregoing paragraph (3) should apply.

5. All imperfections (as well as unclean surfaces) generate stray light, also known as Veiling Glare. The only standard (DIN 3140) that tolerances this functional effect is in a paper from Rodenstock (German Opt. Co.). It relates stray light to a "clean" lens (1.2%) and, as an example, limits acceptance of production lenses to 2%. It should be noted, that surface texture (degree of polish) is also a stray light contributor.

B. Optical Imperfection's Functional Effects

1. The level of today's optoelectronic technology enables testing and evaluation of imaging- and non-imaging-performance characteristics of any optical refractive/reflective components and assemblies. Solutions for measuring, evaluating and specifying optical imperfections seem readily available and beg to be developed for objective, functional inspection of this long-awaited (and avoided), last attribute of functional effects from imperfect optics.

2. One suggested test method is briefly described and illustrated on the attached page "Dual-Beam Machine Vision Comparator" (R. Hartmann, 9/24/02 Orlando Meeting). Since then, detector arrays have been vastly improved (>7MB) and could even read MTF (resolution) effects of imperfections – besides veiling glare (contrast of large areas).

C. Conclusion

In today's global economy it is more important than ever to apply the right technologies for the most cost effectiveness and achieve highest quality at lowest cost.

Dual-Beam Machine Vision Comparator

Inspection of **transmissive** optical parts for imperfections with specular front- or diffuse-illumination:

Specular beam 1 illuminates samples at ports 5,6; with either white or black diffuser at ports 7, 8. DSC 11, focused on samples, records/displays imperfections (pixel count and densities).

Diffuse rear illumination:

Specular beam 1 illuminates integrating sphere 4 by placing white diffuser plate 16 at its center, blocking specular illumination of samples at ports 7, 8. A detector array 13, placed closely behind samples, maps imperfections by shadow projection (pixel count and densities).

Inspection of **reflective** optical parts for imperfections with specular illumination:

Specular beam 1 illuminates samples at ports 7, 8. DSC, focused on samples, records/displays imperfections (count and intensities).

Diffuse illumination:

Integrating sphere is illuminated with auxiliary light source 14 with shield 15 (blocking specular light) to generate diffuse illumination of samples at ports 7, 8. DSC, focused on samples, records/displays imperfections (count and intensities).

- | | | | |
|------|--|--------------------------|-------------------|
| Key: | 1 collimated light | 9 detector, T&R tests | 15 light shield |
| | 2 rotating mirror to generate reference & sample paths | 10 beamsplitter | 16 diffuser plate |
| | 3 plane fold mirrors | 11 Dig. Still Cam. (DSC) | |
| | 4 integrating sphere | 13 detector arrays | |
| | 5, 6, 7, 8, test ports | 14 aux. Light source | |

