A Robust Peak-to-Valley Specification?

Does this sound familiar? The drawing says 10th wave, peak-to-valley, or PV. The shop interferometer measurements look like 11th or 12th wave, but the measurements on the brand-new interferometer in the QA laboratory look more like 8th or 9th wave. Trying a third instrument just gets a third answer. Your engineers try swapping references, checked settings, trim, filtering and temperatures, but the numbers just don't agree. Why can't we just get the same answer?

The reason is in the definition of PV. In the days before digital interferometry, we used Newton's test with poorly resolved fringes and some very good judgment, and we were mostly all on the same page. Now we have computers processing the fringe patterns, digitized anywhere from 100,000 to 4,000,000 data points across the surface, and the meaning of "Peak" and "Valley" are subject to more than just interpretation, with interferometer resolution, point exclusion, and test noise skewing the data. If you don't exclude enough points, you can quickly find yourself judging the quality of a six inch, tenth wave flat by the height of a phase feature smaller than a #10 dig.

One solution, according to a proposal to ASC/OP last year by Dr. Chris Evans of Zygo Corporation, is to redefine the Peak-to-Valley specification for use with digital interferometers. The new definition, dubbed PVr for "robust", is based on the PV of a 36 term Zernike fit to the interferometric data, plus three times the RMS of the residual. The results are impressive; regardless of the resolution of the interferometry, the PVr result is remarkably, well, robust. At OSA's Optical Fabrication and Testing conference in 2008, Dr. Evans reported[1,2] that while the PV term is still all over the map, everyone seems to get the same PVr result in round robin tests.

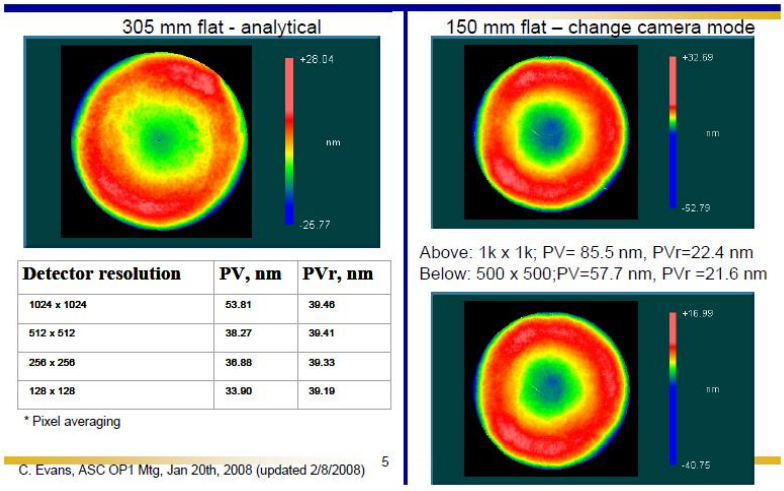

Figure from ASC/OP meeting minutes,
showing the stability of PVr compared to PV
for various interferometer resolutions

Dr. Evans is quick to point out that it is far better to use statistical surface descriptions like RMS or even PSD. Such parameters are inherently robust and in most applications far more informative in about the performance of the optic. But when you're asked to quote a job and the drawing says 10th wave PV, re-writing the specification in terms of RMS is not an option. But including a clarification regarding interpretation will usually be acceptable. People have been doing this for scratch and dig for years. When I need to respond to a PV, I use the following language:

PV specifications are interpreted as PVr with 1% total area clipping following the mathematical definition given in: C. Evans, “PVr - a robust amplitude parameter for optical surface specification” Optical Engineering, Volume 48, Issue 4 (2009).

It may not be as good as using an RMS spec, but it’s good to know we can at least get the same answer.

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1. C. Evans, "Robust Estimation of PV for Optical Surface Specification and Testing," in *Optical Fabrication and Testing*, OSA Technical Digest (CD) (Optical Society of America, 2008), paper OWA4.
http://www.opticsinfobase.org/abstract.cfm?URI=OFT-2008-OWA4

2. C. Evans, “PVr - a robust amplitude parameter for optical surface specification” Optical Engineering, Volume 48, Issue 4 (2009)