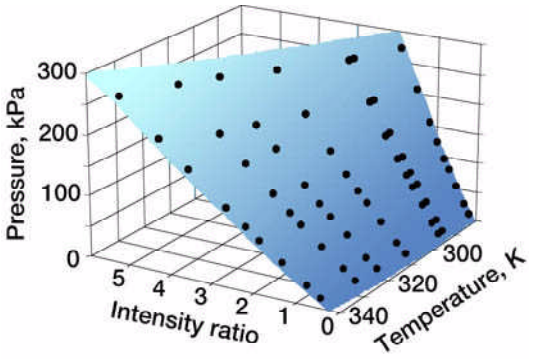
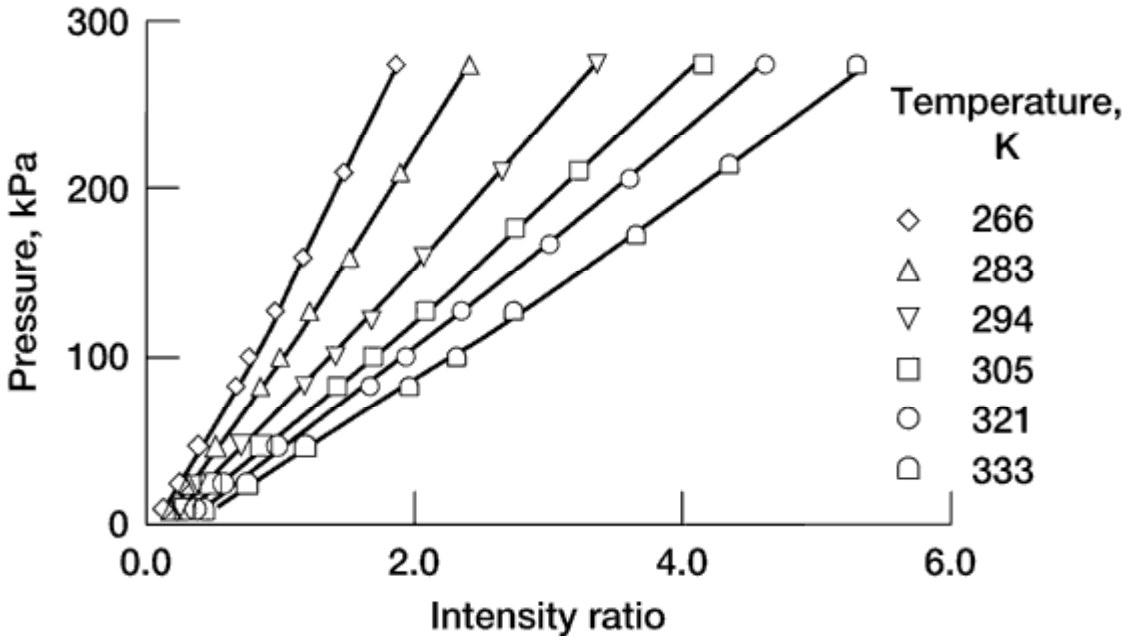
Temperature Correction of Pressure-Sensitive Paints Simplified

Pressure-sensitive paint (PSP) has become a useful tool to augment conventional pressure taps in measuring the surface pressure distribution of aerodynamic components in wind tunnel testing. Although PSP offers the advantage of nonintrusive global mapping of the surface pressure, one prominent drawback to the accuracy of this technique is the inherent temperature sensitivity of PSP's luminescent intensity. Typical aerodynamic surface PSP tests rely on the coated surface to be both spatially and temporally isothermal, along with conventional instrumentation, to yield the highest accuracy pressure mappings. In some tests, however, spatial and temporal thermal gradients are generated by the nature of the test, as in a blowing jet impinging on a surface. In these cases, high accuracy and reliable data cannot be obtained unless the temperature variations on the painted surface are accounted for. A new temperature-correction technique was developed at the NASA Glenn Research Center at Lewis Field to collapse a "family" of PSP calibration curves to a single curve of intensity ratio versus pressure. This correction allows a streamlined procedure to be followed whether or not temperature information is used in the data reduction of the PSP.

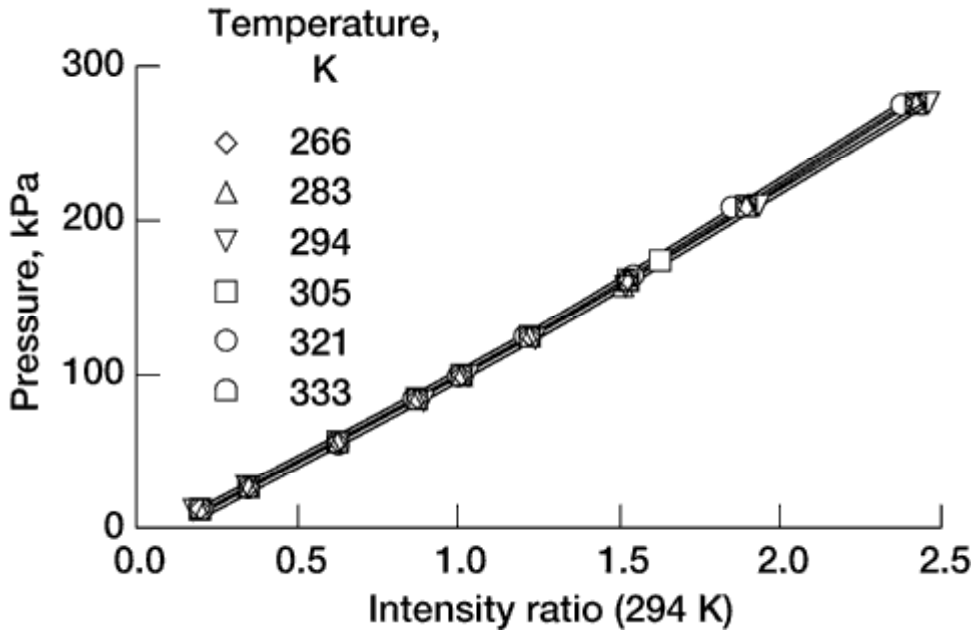


Calibration surface plot of PSP.

The old procedure for temperature correcting PSP images was to determine the intensity ratio and temperature at each pixel and then calculate the pressure by using the $I_{REF}/I_{CAL} = f\{P,T\}$ calibration surface, as shown in the preceding plot. The new simplified method goes one step further and assumes that, given the intensity ratio and temperature at each pixel, a corrected intensity ratio can be determined. The corrected intensity ratio is dependent on only temperature in the form of $[I_{RATIO}]_{Cor} = I_{RATIO}\{T\}$, since the intensity ratio is already pressure dependent. This correction collapses the family of curves in the following graph to a single curve at the reference, as illustrated in the final graph.



Calibration data shows temperature dependence of PSP.



Temperature-corrected PSP: calibration data collapses to the reference temperature curve.

The simplified temperature correction procedure streamlines the data reduction of PSP data by eliminating the need to use a three-dimensional lookup table for each pixel location. Once the corrected intensity ratio is computed, any number of traditional calibration techniques can be implemented to convert the normalized intensity images to pressure.

Glenn contact: Timothy J. Bencic, (216) 433–5690, Timothy.J.Bencic@grc.nasa.gov

Author: Timothy J. Bencic

Headquarters program office: OAST

Programs/Projects: IT Base