Table 16.8 Spectral responsivity error sources for measurement of the light power

I. Filament or Xe-arc light source
   A. Intensity fluctuations, change in spectrum with age and current,
II. Real-time calibration
   A. Source-light polarization with a glass beam splitter, signal to noise, detector characteristics, calibration drift with time of monitor detector
III. Stored calibration file
   A. Monochromatic source calibration drift with time
IV. Stray light
   A. Detector sees light that cell does not see, area of detector different from device area, different field of views
   B. Monochrometer – incomplete attenuation of higher and lower grating orders, single versus double grating
   C. Narrow bandwidth filters – pinholes in the filter, degradation of blocking filter, insufficient blocking of light ($>10^{-4}$)
V. Detectors and associated electronics in general
   A. Calibration, resolution, accuracy, gain, phase, offset, linearity, spatial uniformity of detector element,
   B. Drift in temperature of room, change in the detector's field of view, degradation of detector,
   C. Spectral response of detector
VI. Pyroelectric detector
   A. Time constant of detector, microphonics, signal to noise, phase-angle adjustment, waveform factor (square wave assumed)

absorption coefficient for PV devices can be sensitive to the polarization angle. The light reflected from a glass surface will have a different polarization than the light reaching the test plane and will be of much lower intensity. These effects are minimized if a calibration is performed with the detector in the test plane and the file is stored to the disk. This procedure is required at least once for real-time calibrations. Real-time calibrations account for the change in spectrum with lamp age, current, and time.

If the beam is larger than the sample, then the spatial uniformity of the monochromatic beam is important. For the NREL filter monochrometer system, spatial nonuniformities of $\pm 10\%$ are typical and, more importantly, these errors can change with wavelength because of variations in the transmission of the filter and spatial variation in the output of the Xe-arc lamp. Electrically calibrated pyroelectric detectors are spectrally flat from the UV to far-infrared and have a low broadband error of less than $\pm 2\%$, but are sensitive to microphonics, temperature changes within the detector's field of view, and have noise at the 0.01 μWcm^{-2} level. Semiconductor-based detectors are not sensitive to light outside their relatively narrow response range and can be measured with the same electronics used to measure the test device, eliminating any wavelength-independent multiplicative error sources. Semiconductor-based detectors can drift with age [158] and have temperature coefficients exceeding 1%/°C near their band gap. Table 16.9 summarizes the error in the *QE* that can occur because of the monochromatic light. The bandwidth of the monochromatic light can contribute to the error near the band gap or when the light transmitted through a band-pass filter is highly asymmetric [156]. These errors have a small effect on the spectral correction factor when the full width at half-maximum bandwidth of the interference filters are less than 10 nm [156], as is commonly found in practice.