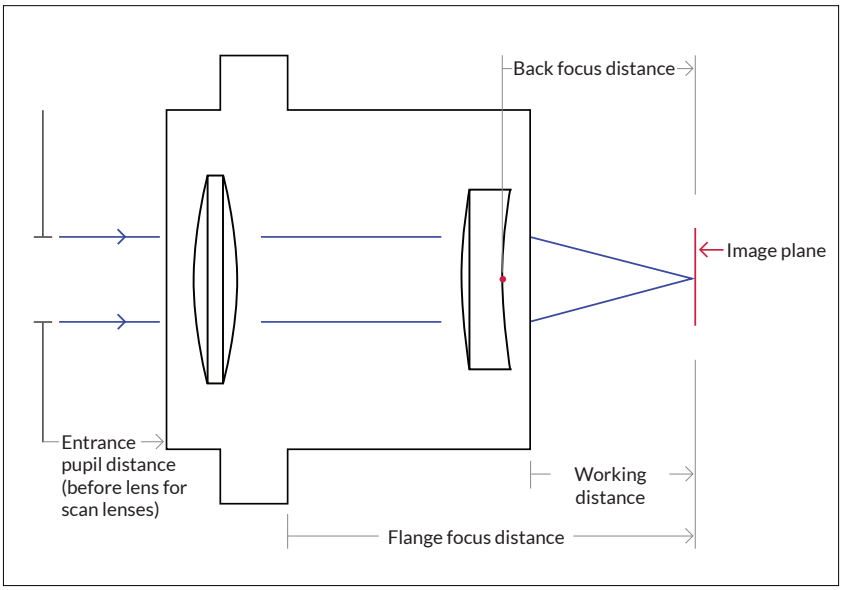
General Guide for Specifying Lenses

We commonly design lenses to a customer's given specifications. In many cases, development of those specifications can be a critical first step in finding a lens design solution. In this paper, we outline many of the commonly required specifications, along with an explanation of their importance.



Focal length (often called effective focal length, or EFL) – A measure of how the optical power of a lens, or how strongly the lens focuses. EFL is important since the field of view of a lens, for a given sensor size at the image plane, scales inversely with the focal length.

F-number (f/#) – The ratio of the focal length to the entrance pupil diameter. Lower values for f/# will, in general, form brighter images. If the lens is well-corrected, lower values for the f/# will form smaller spots.

Back focus distance – The distance from the rear vertex of the last element to the image plane.

Working distance – The distance from the last physical surface of the assembly to the image plane. This is an important consideration for many objectives.

Flange focus distance – The distance from a mounting flange, which serves as a mechanical datum, to the image plane. This is not an intrinsic optical property but used to locate the assembly properly in the system.

Entrance pupil location – For scan lenses where the scanning mechanism is in front of the lens (pre-objective scan), the scanning mechanism is located at the entrance pupil. The entrance pupil needs to be sufficiently in front of the lens to allow clearance.

Performance – Methods of specifying performance vary with the application. Here are commonly used methods:

rms wavefront error – used for diffraction limited or near-diffraction limited lenses

MTF (modulation transfer function) – often used for lenses used with image sensors. MTF is frequently specified as a given contrast level at one or two spatial frequencies.

Blur spot size – May be used for lenses that are not diffraction limited.

Field curvature – Commonly required on scan lenses, where the focused spot must stay within a given depth of focus with respect to the image plane over the given scan range.

Distortion – Distortion relates to a mapping error between the object and image planes of a lens. The term can loosely be used to describe either the mapping or the deviation from the expected mapping. For example, laser scan lenses often are specified to have f-θ distortion, where the input angle is given by θ, and the output image height is given by $h=f\theta$.

Wavelength range and weighting – The system wavelengths are typically specified in nm. The wavelength weights are critical for optimizing the performance of the application and are relative weights to each other.

Weight (mass) – This is critical for applications where the lens is moved, as in an autofocus system.