TABLE 5.2 (Continued)
Typical Unit Operations, Process Parameters, and Potentially Impacted Quality Attributes

Pharmaceutical Unit Operation	Process Parameter	Quality Attributes
Coating (fluid bed and pan)	Product temperature	Weight of core tablets
	Total pre-heating time	Appearance
	Spray nozzle type/number/pattern/configuration	Visual attributes
	Individual gun spray rate	% Weight gain
	Total spray rate	Film thickness
	Pan rotation speed	Color uniformity
	Atomization air pressure	Hardness
	Pattern air pressure	Thickness
	Inlet airflow, temperature, and dew point	Friability
	Exhaust air temperature and airflow	
	Product temperature	
	Total coating time	

Source: Adapted from Yu, LX. Pharmaceutical quality by design: Product and process development understanding and control. *Pharm Res* 2008 April; 25.

and the remaining $2n$ in pairs along the coordinate axis. An example of a central composite design is given in Table 5.3. In this orthogonal composite design, the value of 1.215 (axial point) at the six composite points (Experiments 9–14) depends on design specifics such as number of factors and experiments. Table 5.4 shows the total number of experiments and the values of axial points for several designs. It also shows the benefit of a composite design over a three-level factorial design. The increase in the number of experiments due to an increase in the number of factors is significantly higher in the case of a three-level factorial design compared with a fractional composite design.

Details of experimental design are available in various publications [26–29]. It is recommended that some initial screening trials be performed to gain an understanding of the effect of each variable and the ranges of parameters to be evaluated in a DOE. This adds tremendous value in developing a design with a minimal number of experiments yet capturing the target formulation and processing conditions.

Scale-Up Characterization of Manufacturing Process

High-speed production of large-scale batches using modern technology has become essential in minimizing manufacturing costs to improve the profit margin in today's competitive market. Increases in batch size or scale-up are accomplished by using larger, high-speed equipment that may require adjustments to the process parameters