In the October 2014 column, we discussed how to design a standpipe to move fluidized particles from an upper vessel to a lower vessel in a fluidized-bed process. In this month’s column, we’ll discuss how to design a dipleg to transfer fluidized particles from a cyclone to a fluidized bed. [Editor’s note: For information on obtaining previous columns, see “For further reading” later in this article.]

Particle flow in a dipleg

A dipleg is often used as the fluidized overflow “standpipe” for a cyclone. The dipleg is typically installed at the cyclone bottom, as shown in Figure 1, and terminates in a fluidized bed (or the dilute region of a fluidized bed’s freeboard, a hopper, or a container). For smooth dipleg operation, the downward-flowing particles must be fluidized. While adding aeration to the dipleg will fluidize the particles, this isn’t always practical because a cyclone is often installed inside another vessel. The best way to ensure that the downward-flowing particles are fluidized is to correctly design the dipleg.

Designing the dipleg for fluidized flow

How to design your dipleg to achieve the desired particle flow behavior depends on the cyclone the dipleg is installed on — that is, whether the cyclone is the primary, secondary, or tertiary unit in a series (Figure 1).

Dipleg diameter. We’ll start by considering how to design a dipleg for a primary cyclone (or for a process’s lone cyclone). In this dipleg, the solids flux — that is, the particles’ mass flowrate divided by the dipleg’s cross-sectional area — typically must be between 75 and 150 lb/ft²-s. This means, for example, that if the cyclone collects particles at 100 lb/s, then the dipleg’s cross-sectional area needs to be at least 100 lb/s / 75 lb/ft²-s, or 1.33 square feet. This corresponds to a maximum dipleg diameter of 15.6 inches. A more common design criterion for the solids flux in a primary cyclone dipleg is simply 100 lb/ft²-s, which corresponds to a 13.5-inch dipleg diameter. So, when it comes to dipleg diameter, bigger isn’t always better. With a correctly designed primary cyclone dipleg, an added benefit is that little or no gas from the vessel below flows into the cyclone.

The dipleg diameter for a secondary cyclone (and a tertiary cyclone, if
required) typically is 8 inches or more, mostly to allow larger pieces of debris, such as refractory, to flow through the dipleg. This dipleg’s solids flux is often too small to match the primary cyclone dipleg’s flux design criterion, so gas tends to flow upward in the secondary cyclone’s dipleg. To prevent excessive upward gas flow, especially during startup, the secondary cyclone’s dipleg is often terminated with a trickle valve or flapper valve, as shown in Figure 2. The trickle valve (Figure 2a) consists of a movable plate mounted on hanger rings over the dipleg outlet; a mechanical stop limits the degree of plate opening. The flapper valve (Figure 2b) consists of a movable plate (or flapper) mounted on a hinge over the dipleg outlet; in this case, a counterweight limits the degree of plate opening.

Unfortunately, both of these valves can present problems. The trickle valve can function when submerged in a fluidized bed, but the flapper valve works only in a dilute region, such as a fluidized bed’s freeboard. Neither valve works when immersed in a packed bed. Both valves can also periodically stop the particle flow and cause defluidization. This may plug the dipleg, which can make the secondary cyclone useless. To prevent this, you can maintain fluidization by adding aeration to the dipleg’s lower portion. You also need to ensure that your trickle or flapper valve has a tight seal because even a small gas leak can cause entrained particles to significantly erode the seal. Maintaining a sufficiently tight seal is difficult, however, so you’ll need to regularly inspect and service the valve.

**Dipleg length.** Regardless of how the dipleg is terminated, it must be long enough to seal all the pressure drops in the system’s pressure loop (that is, the particles’ path or loop through the fluidized-bed process and cyclone).

[Editor’s note: For more information on a fluidized-bed process pressure loop, see the February 2014 column.] For a cyclone in a fluidized bed, the dipleg needs to be long enough to have enough pressure build (that is, height of solids in dense phase) to seal against the pressure drops in the system (that is, the pressure difference between the higher-pressure gas in the fluidized bed and the lower-pressure gas in the cyclone).

**For further reading**

Find more information on this topic in articles listed under “Fluid-bed processing” in *Powder and Bulk Engineering*’s article index in the December 2014 issue and in the Article Archive on *PBE*’s website, www.powderbulk.com. (All articles listed in the archive are available for free download to registered users.) You can also find books and webinars on this topic in the website Store.

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