

44. (a) Current is the transport of charge; here it is being transported “in bulk” due to the volume rate of flow of the powder. From Chapter 15, we recall that the volume rate of flow is the product of the cross-sectional area (of the stream) and the (average) stream velocity. Thus, $i = \rho Av$ where ρ is the charge per unit volume. If the cross-section is that of a circle, then $i = \rho \pi R^2 v$.

- (b) Recalling that a Coulomb per second is an Ampere, we obtain

$$i = (1.1 \times 10^{-3} \text{ C/m}^3) \pi (0.050 \text{ m})^2 (2.0 \text{ m/s}) = 1.7 \times 10^{-5} \text{ A} .$$

- (c) The motion of charge is not in the same direction as the potential difference computed in problem 57 of Chapter 25. It might be useful to think of (by analogy) Eq. 7-48; there, the scalar (dot) product in $P = \vec{F} \cdot \vec{v}$ makes it clear that $P = 0$ if $\vec{F} \perp \vec{v}$. This suggests that a radial potential difference and an axial flow of charge will not together produce the needed transfer of energy (into the form of a spark).
- (d) With the assumption that there is (at least) a voltage equal to that computed in problem 57 of Chapter 25, in the proper direction to enable the transference of energy (into a spark), then we use our result from that problem in Eq. 27-21:

$$P = iV = (1.7 \times 10^{-5} \text{ A}) (7.8 \times 10^4 \text{ V}) = 1.3 \text{ W} .$$

- (e) Recalling that a Joule per second is a Watt, we obtain $(1.3 \text{ W})(0.20 \text{ s}) = 0.27 \text{ J}$ for the energy that can be transferred at the exit of the pipe.
- (f) This result is greater than the 0.15 J needed for a spark, so we conclude that the spark was likely to have occurred at the exit of the pipe, going into the silo.