a) $V = 1.5\frac{m}{s}$

$$\text{Re} = \frac{V \cdot D \cdot \rho}{\mu} = \frac{1.5 \cdot (0.25) \cdot 102}{1.2 \cdot 10^{-4}} = 318750$$

318750>2000 (Turbulent)

$f = 0.0205$ (From the Moody Diagram)

We can also calculate f by Swamee-Jain,

$$f = \frac{0.25}{\left[\log\left(\frac{k_s}{3.7D} + \frac{5.74}{\text{Re}^{0.9}}\right)\right]^2}$$

This has some limitations,

- k_s/D < 2 x 10-2
- Re >3 x 103
- less than 3% deviation from results obtained with Moody diagram

The advantage of this formula is easy to program for computer or calculator use.

$f = 0.021488716$

We will use the Moody Diagram,

$$J = \frac{f}{D} \cdot \frac{V^2}{2g} = \frac{0.0205}{0.25} \cdot \frac{(1.5)^2}{19.62} = 0.00940367$$

$$\tau_0 = \gamma \cdot R_H \cdot J = 1000 \cdot \left(\frac{0.25}{4}\right) \cdot 0.00940367 = 0.587729358$$

$$u_* = \sqrt{\frac{\tau_0}{\rho}} = \sqrt{\frac{0.587729358}{102}} = 0.075908185$$

$$11.6 \cdot \frac{\nu}{u_*} = 11.6 \cdot \frac{10^{-6}}{0.075908185} = 0.000152816 < 0.0003$$

$$70 \cdot \frac{\nu}{u_*} = 11.6 \cdot \frac{10^{-6}}{0.075908185} = 0.000922167 > 0.0003$$

Therefore, the behavior of the pipe is <u>transitional turbulent</u>.

b) $V = 15\frac{m}{s}$

$$\text{Re} = \frac{V \cdot D \cdot \rho}{\mu} = \frac{15 \cdot (0.25) \cdot 102}{1.2 \cdot 10^{-4}} = 3187500$$

3187500>2000 (Turbulent)

$f = 0.0197$ (From the Moody Diagram)

$f = 0.020662739$ (From Swamee-Jain)

We will use the Moody Diagram,

$$J = \frac{f}{D} \cdot \frac{V^2}{2g} = \frac{0.0205}{0.25} \cdot \frac{(15)^2}{19.62} = 0.940366972$$

$$\tau_0 = \gamma \cdot R_H \cdot J = 1000 \cdot \left(\frac{0.25}{4}\right) \cdot 0.940366972 = 58.77293578$$

$$u_* = \sqrt{\frac{\tau_0}{\rho}} = \sqrt{\frac{58.77293578}{102}} = 0.759081849$$

$$11.6 \cdot \frac{\nu}{u_*} = 11.6 \cdot \frac{10^{-6}}{0.759081849} = 1.52816 \cdot 10^{-5} < 0.0003$$

$$70 \cdot \frac{\nu}{u_*} = 70 \cdot \frac{10^{-6}}{0.759081849} = 9.22167 \cdot 10^{-5} < 0.0003$$

Therefore, the behavior of the pipe is <u>rough turbulent</u>.