TABLE 4.6—SUMMARY OF FRICTIONAL PRESSURE LOSS EQUATIONS*

	Newtonian Model	Bingham Plastic Model	Power-Law Model
Mean Velocity, $\bar{v}$	Pipe		
	$\bar{v}=\frac{q}{2.448d^2}$	$\bar{v}=\frac{q}{2.448d^2}$	$\bar{v}=\frac{q}{2.448d^2}$
	Annulus		
	$\bar{v}=\frac{q}{2.448(d_2{}^2-d_1{}^2)}$	$\bar{v}=\frac{q}{2.448(d_2{}^2-d_1{}^2)}$	$\bar{v}=\frac{q}{2.448(d_2{}^2-d_1{}^2)}$
Flow Behavior Parameters	$\mu=\theta_{300}$	$\mu_p=\theta_{600}-\theta_{300}$	$n=3.32\log\frac{\theta_{600}}{\theta_{300}}$
		$\tau_y=\theta_{300}-\mu_p$	$K=\frac{510\,\theta_{300}}{511^n}$
Turbulence Criteria	Pipe		
	$N_{Rec}=2{,}100$	$N_{He}=\frac{37{,}100\,\rho\,\tau_y\,d^2}{\mu_p{}^2}$	N_{Rec} from Fig. 4.34
	$N_{Re}=\frac{928\,\rho\,\bar{v}\,d}{\mu}$	N_{Rec} from Fig. 4.33	$N_{Re}=\frac{89{,}100\,\rho\bar{v}^{\,2-n}}{K}\left(\frac{0.0416d}{3+1/n}\right)^n$
		$N_{Re}=\frac{928\,\rho\,\bar{v}\,d}{\mu_p}$	
	Annulus		
	$N_{Rec}=2{,}100$	$N_{He}=\frac{24{,}700\,\rho\,\tau_y\,(d_2-d_1)^2}{\mu_p{}^2}$	N_{Rec} from Fig. 4.34
	$N_{Re}=\frac{757\,\rho\bar{v}(d_2-d_1)}{\mu}$	$N_{Re}=\frac{757\,\rho\bar{v}(d_2-d_1)}{\mu_p}$	$N_{Re}=\frac{109{,}000\,\rho(\bar{v})^{2-n}}{K}\left[\frac{0.0208(d_2-d_1)}{2+1/n}\right]^n$
Laminar Flow Frictional Pressure Loss	Pipe		
	$\frac{dp_f}{dL}=\frac{\mu\bar{v}}{1{,}500\,d^2}$	$\frac{dp_f}{dL}=\frac{\mu_p\bar{v}}{1{,}500\,d^2}+\frac{\tau_y}{225\,d}$	$\frac{dp_f}{dL}=\frac{K\bar{v}^{\,n}\left(\frac{3+1/n}{0.0416}\right)^n}{144{,}000\,d^{1+n}}$
	Annulus		
	$\frac{dp_f}{dL}=\frac{\mu\bar{v}}{1{,}000\,(d_2-d_1)^2}$	$\frac{dp_f}{dL}=\frac{\mu_p\bar{v}}{1{,}000\,(d_2-d_1)^2}+\frac{\tau_y}{200\,(d_2-d_1)}$	$\frac{dp_f}{dL}=\frac{K\bar{v}^{\,n}\left(\frac{2+1/n}{0.0208}\right)^n}{144{,}000\,(d_2-d_1)^{1+n}}$
Turbulent Flow Frictional Pressure Loss	Pipe		
	$\frac{dp_f}{dL}=\frac{f\rho\bar{v}^2}{25.8\,d}$	$\frac{dp_f}{dL}=\frac{f\rho\bar{v}^2}{25.8\,d}$	$\frac{dp_f}{dL}=\frac{f\rho\bar{v}^2}{25.8\,d}$
	or	or	
	$\frac{dp_f}{dL}=\frac{\rho^{0.75}\bar{v}^{1.75}\mu^{0.25}}{1{,}800\,d^{1.25}}$	$\frac{dp_f}{dL}=\frac{\rho^{0.75}\bar{v}^{1.75}\mu_p{}^{0.25}}{1{,}800\,d^{1.25}}$	
	Annulus		
	$\frac{dp_f}{dL}=\frac{f\rho\bar{v}^2}{21.1\,(d_2-d_1)}$	$\frac{dp_f}{dL}=\frac{f\rho\bar{v}^2}{21.1\,(d_2-d_1)}$	$\frac{dp_f}{dL}=\frac{f\rho\bar{v}^2}{21.1\,(d_2-d_1)}$
	or	or	
	$\frac{dp_f}{dL}=\frac{\rho^{0.75}\bar{v}^{1.75}\mu^{0.25}}{1{,}396\,(d_2-d_1)^{1.25}}$	$\frac{dp_f}{dL}=\frac{\rho^{0.75}\bar{v}^{1.75}\mu^{0.25}}{1{,}396\,(d_2-d_1)^{1.25}}$	

*Alternate turbulence criteria are to assume the flow pattern which gives the greatest frictional pressure loss.

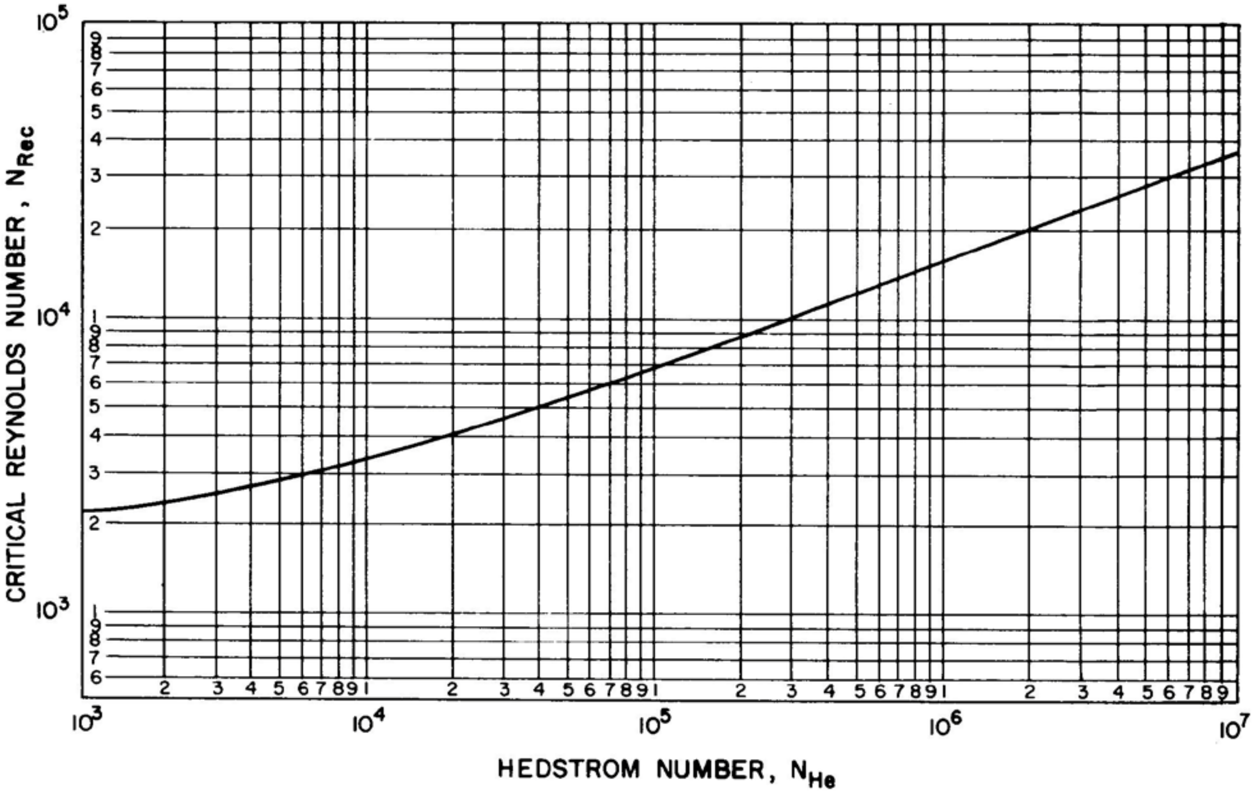


Fig. 4.33—Critical Reynolds numbers for Bingham plastic fluids.

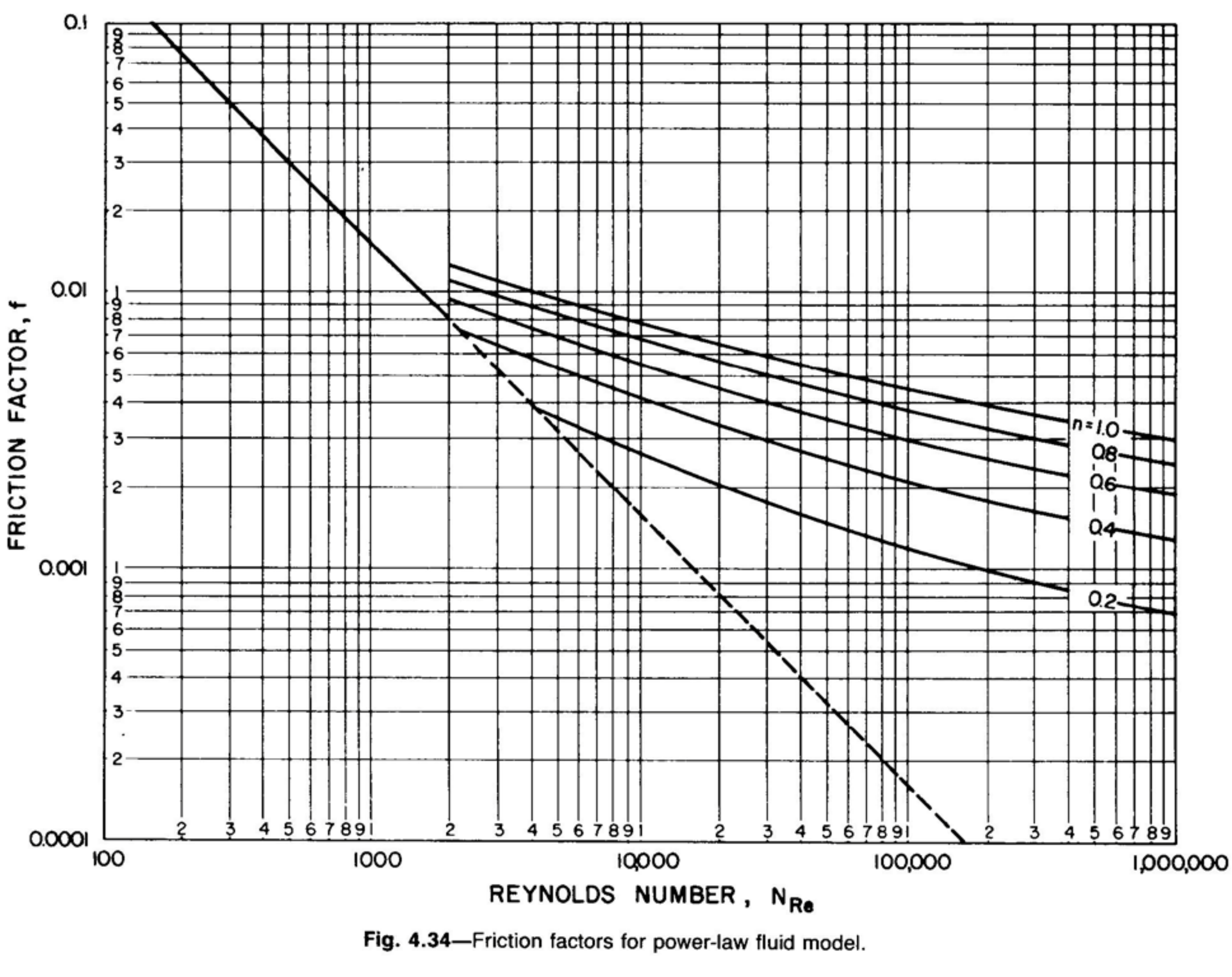
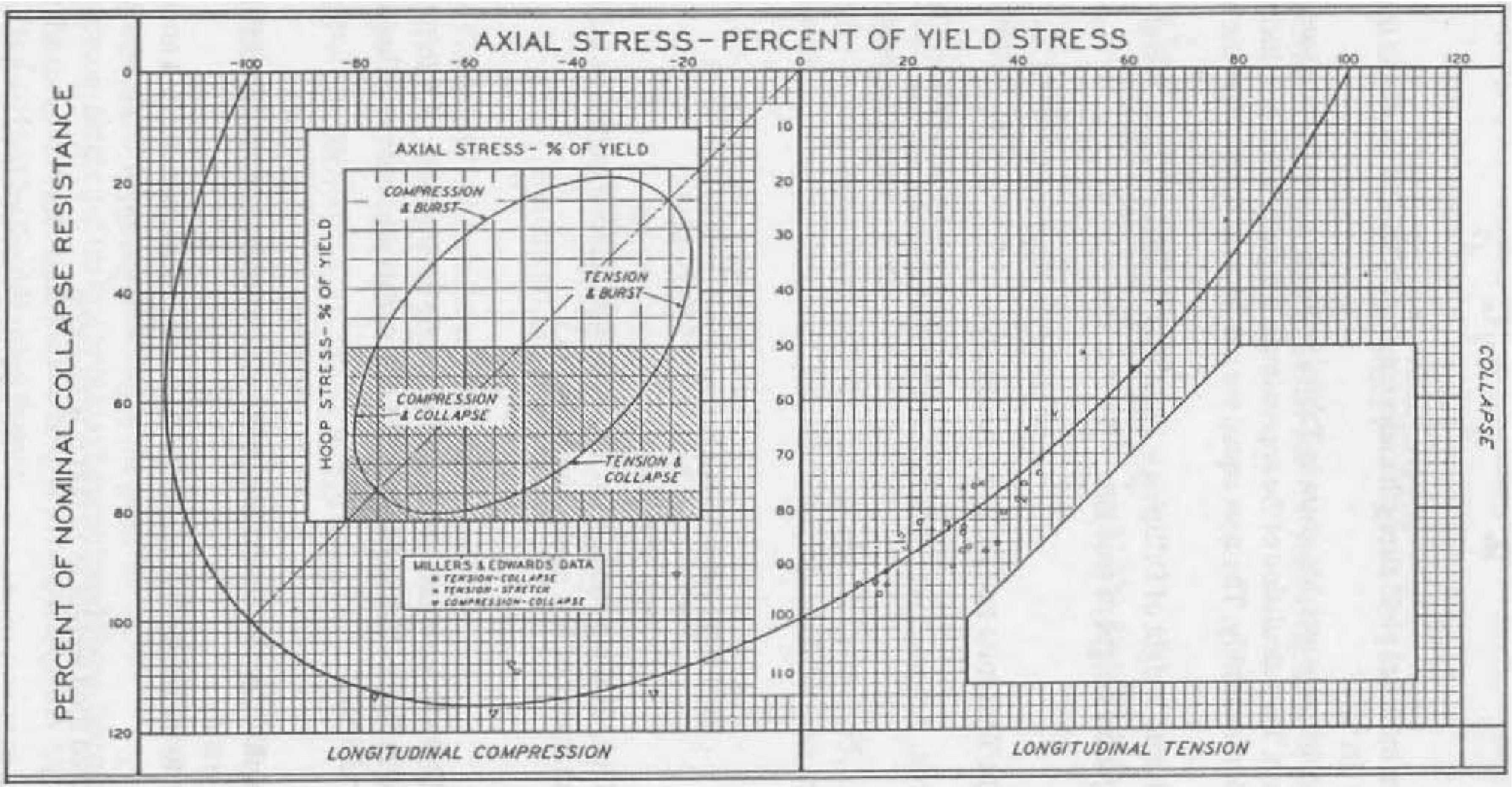


Fig. 4.34—Friction factors for power-law fluid model.


AXIAL STRESS - PERCENT OF YIELD STRESS
PERCENT OF NOMINAL COLLAPSE RESISTANCE
AXIAL STRESS - % OF YIELD
HOOP STRESS - % OF YIELD
COMPRESSION & BURST
TENSION & BURST
COMPRESSION & COLLAPSE
TENSION & COLLAPSE
MILLERS & EDWARDS DATA
TENSION-COLLAPSE
TENSION-STRETCH
COMPRESSION-COLLAPSE
LONGITUDINAL COMPRESSION
LONGITUDINAL TENSION
COLLAPSE