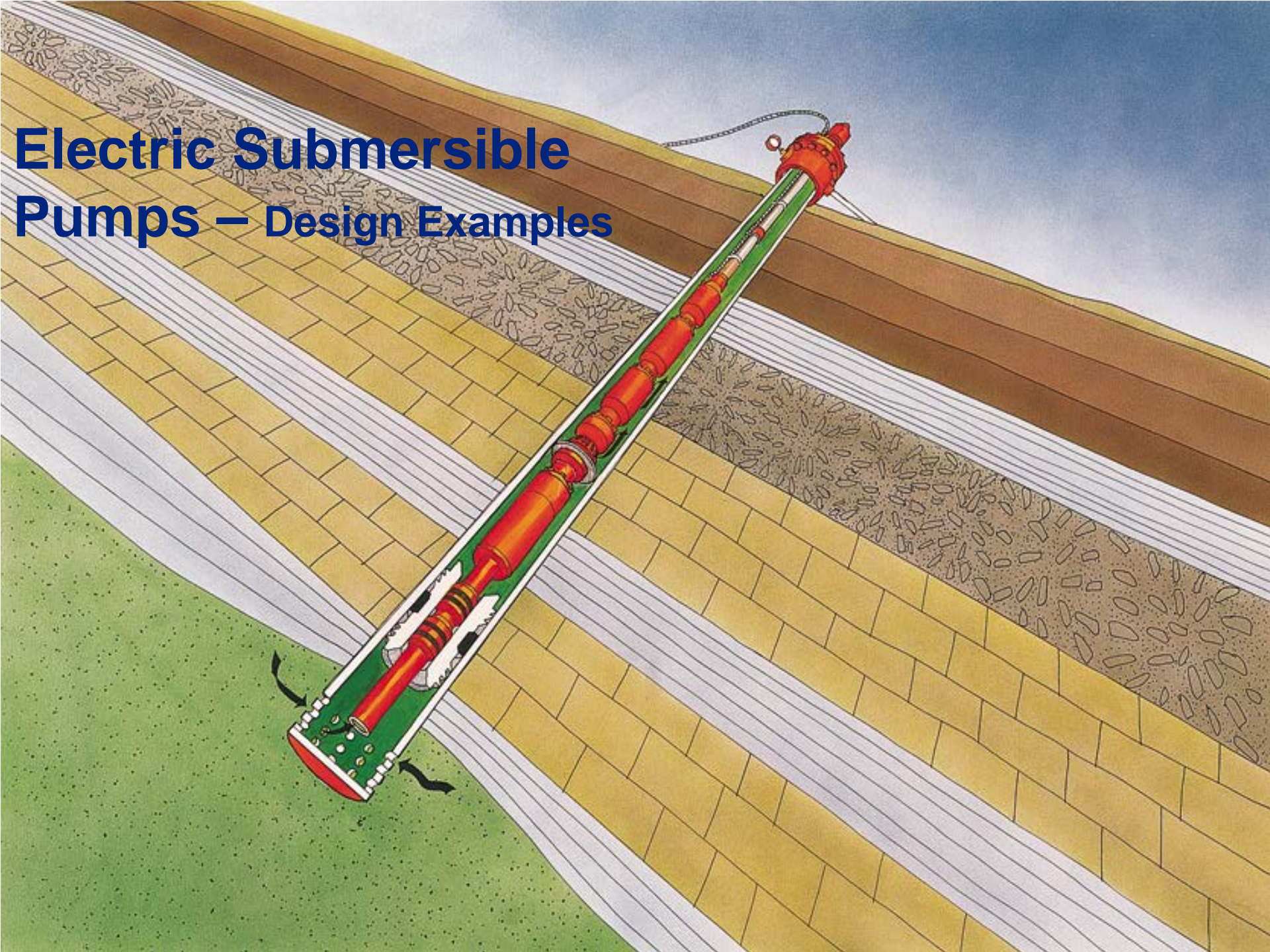


Electric Submersible Pumps – Design Examples



There are two methods of Calculating TDH for a pump

- Bottoms Up – Traditional Method Using Fluid Level
- Top Down – New Method Using Delta P Pump

Bottoms Up Formulas

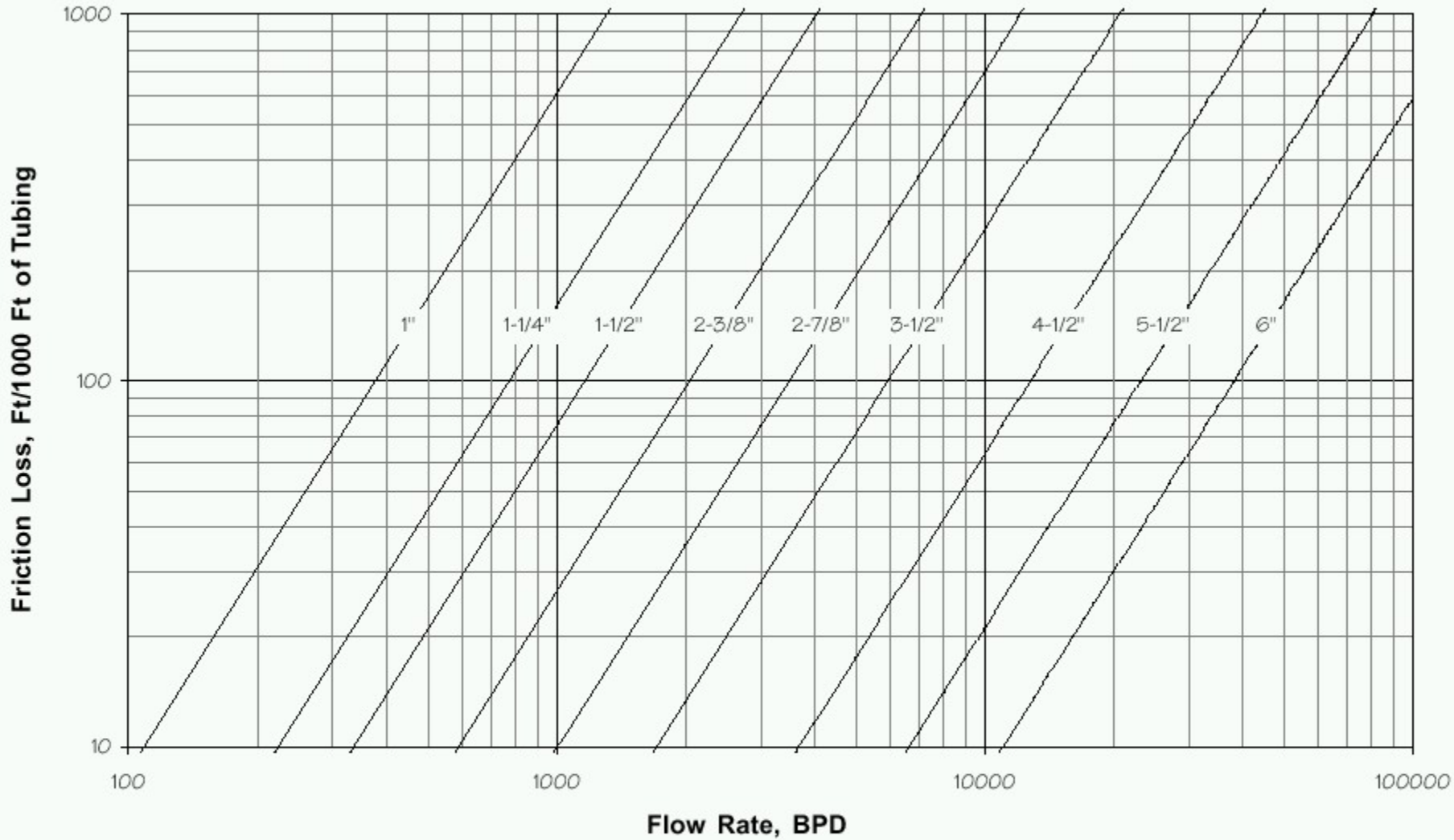
- Total Dynamic Head:

$$\text{TDH} = \text{Net Lift} + \text{Friction} + \text{Wellhead Pressure}$$

- $\text{Head}_{\text{Net Lift}} = \text{Fluid Level}$
- $\text{Head}_{\text{friction}} = \text{Rate vs. Tubing Size \& use graph}$
- $\text{Head}_{\text{WHP}} = \text{Wellhead pressure} / (0.433 * \text{SG})$
 $\text{SG} = 141.5 / (131.5 + \text{API})$

$$\text{Downhole flowrate (rb/d)} = Q_{\text{oil}}(\text{stbo/d}) \times B_o + Q_{\text{water}}(\text{stbw/d})$$

Friction Loss



Based on Hazen Williams Formula:

$$F = 2.083(100/C)^{1.85}(Q/34.3)^{1.85}/ID^{4.8655}$$

Where: $F = \text{Ft Loss} / 1000 \text{ Ft}$
 $Q = \text{BPD}$
 $C = 120$

Table 2C- Friction Loss in A.P. I. Tubulars

Example 1 - Bottom Up Calculation

- Flow (oil and water) 1850 BPD
- Pr 3625 psi
- Producing Fluid Level 1600 ft TVD
- Completion
- deviated well
- Pump set at 3200 ft MD
1880 ft TVD
- Perfs at 3700 ft MD
1900 ft TVD
- 2-7/8" Tubing
- 7-5/8" casing

PVT

Watercut 40%
Oil Gravity 30 API
Water sg 1.026sg
Bo 1.33 rb/stb

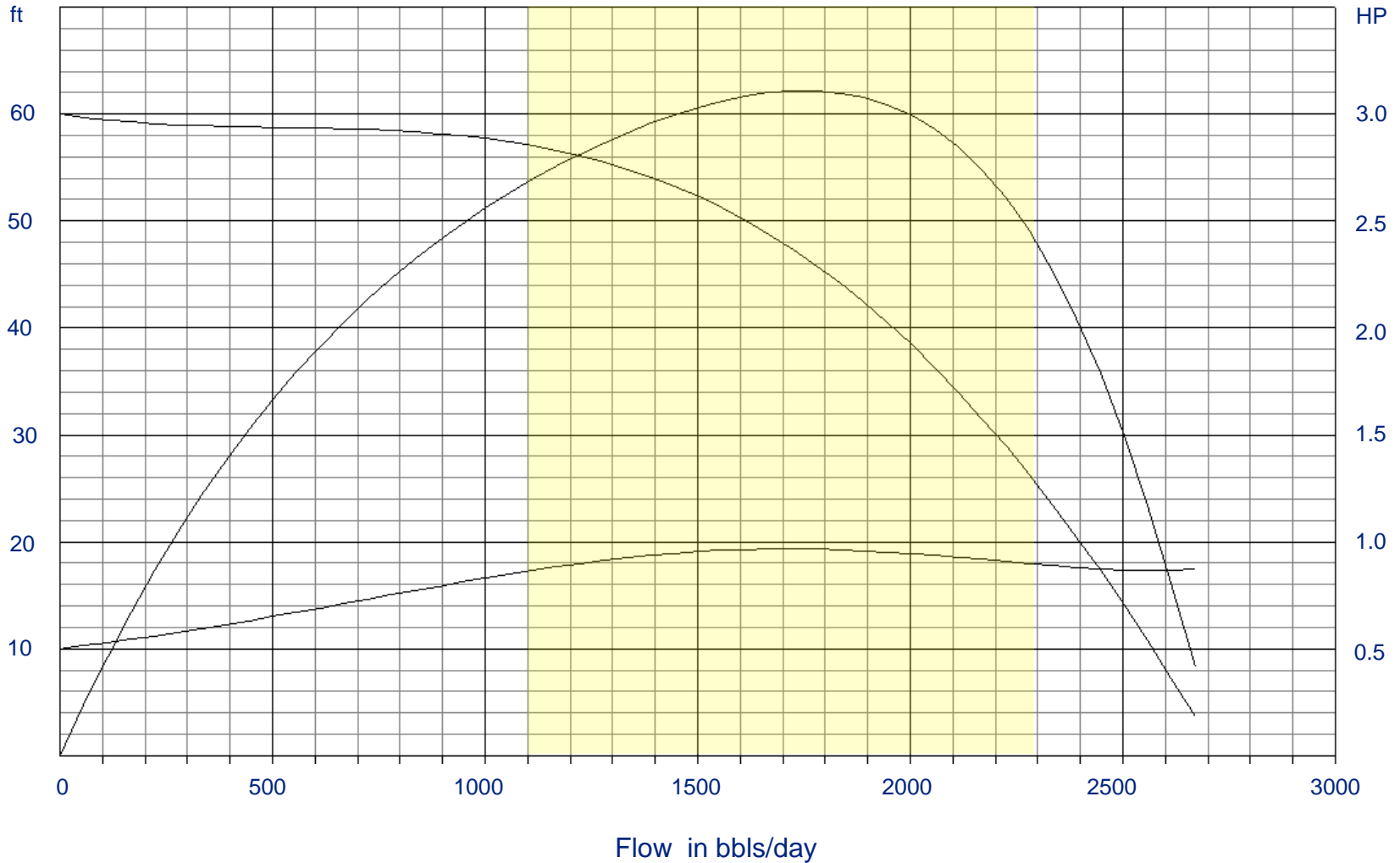
Operating

WHP 200 psi

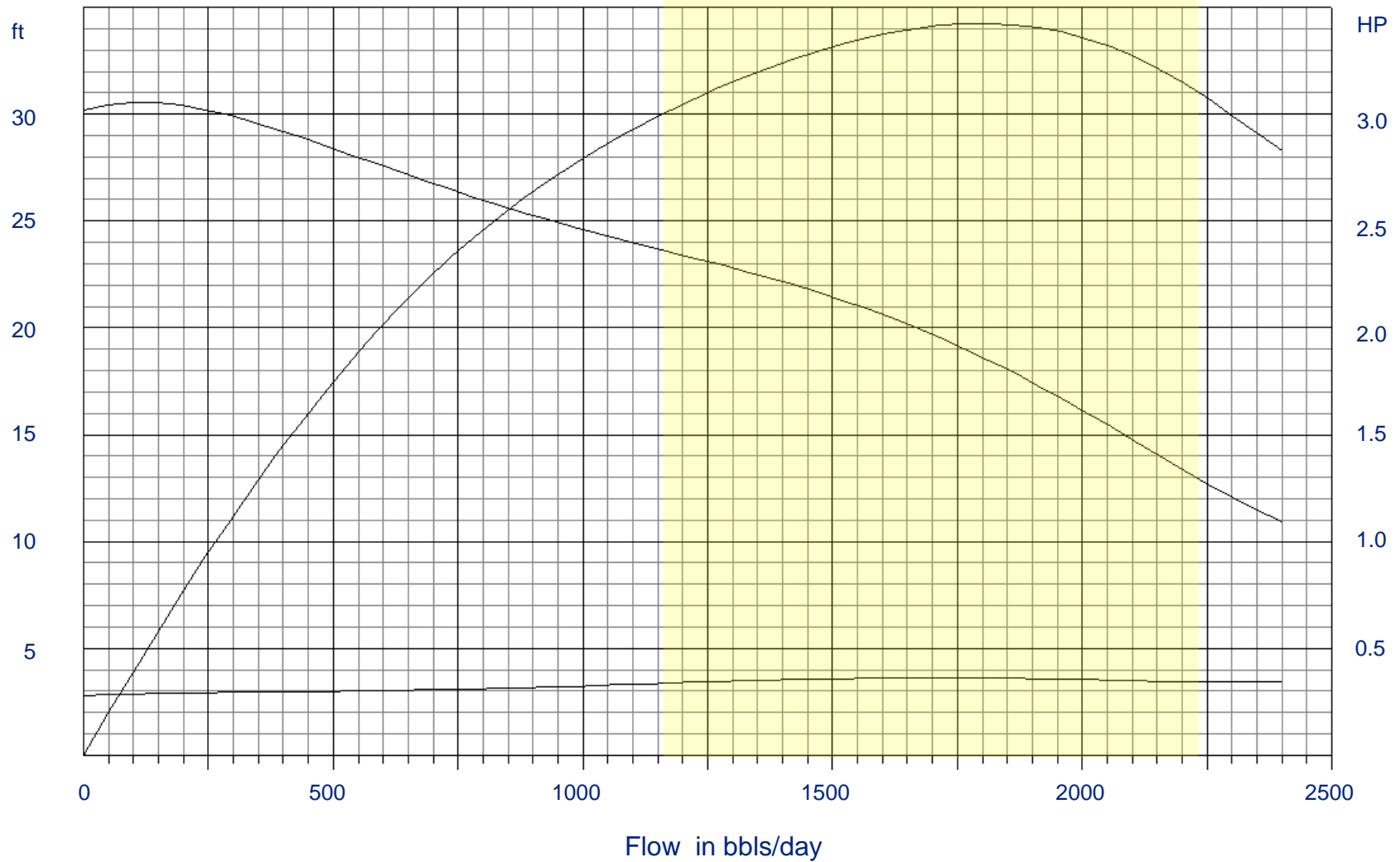


Calculate - TDH (ft), Recommend Pump - # of Stages, HP

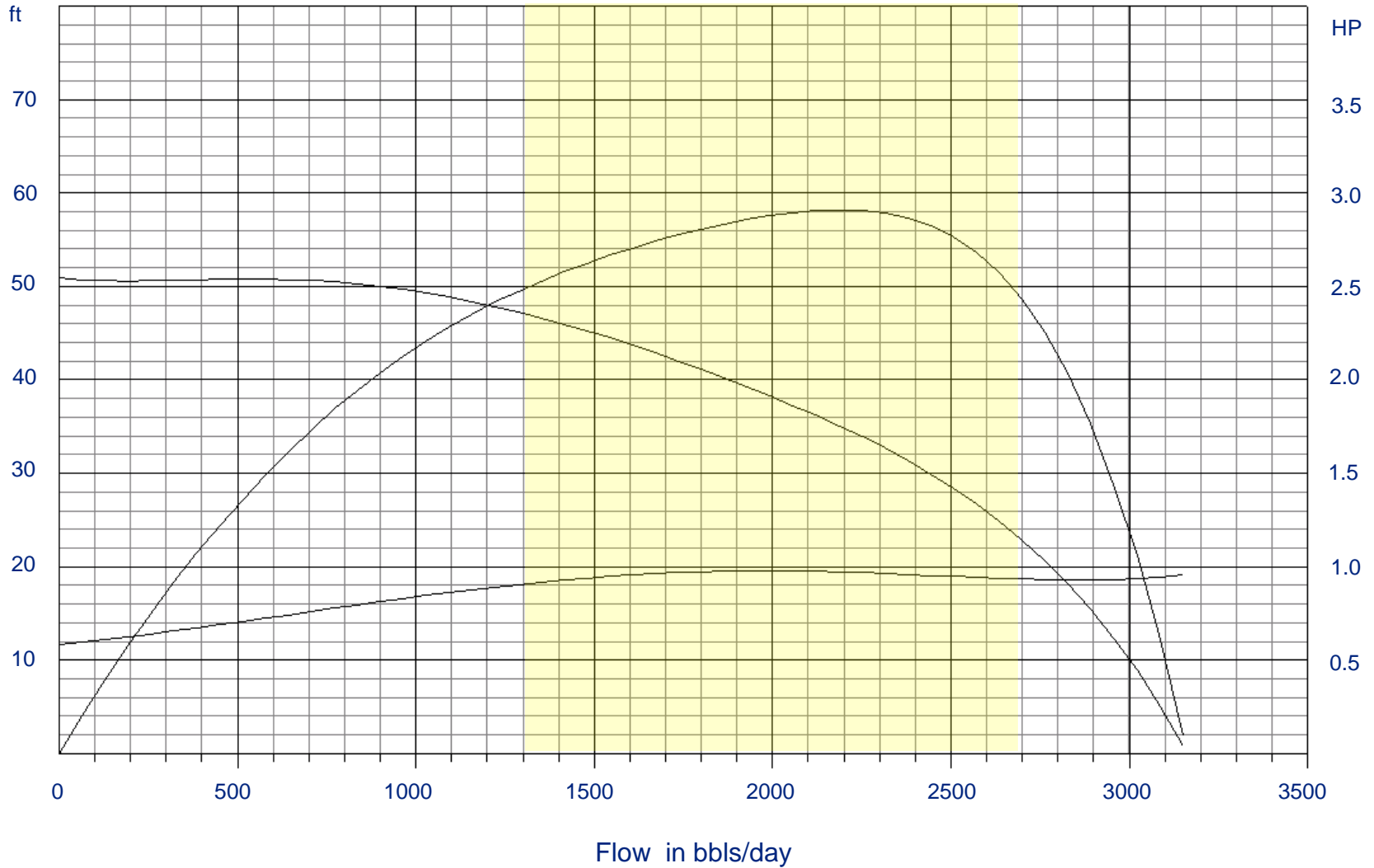
Centrilift: GC1700 1 Stage 60 Hz SG = 1.00



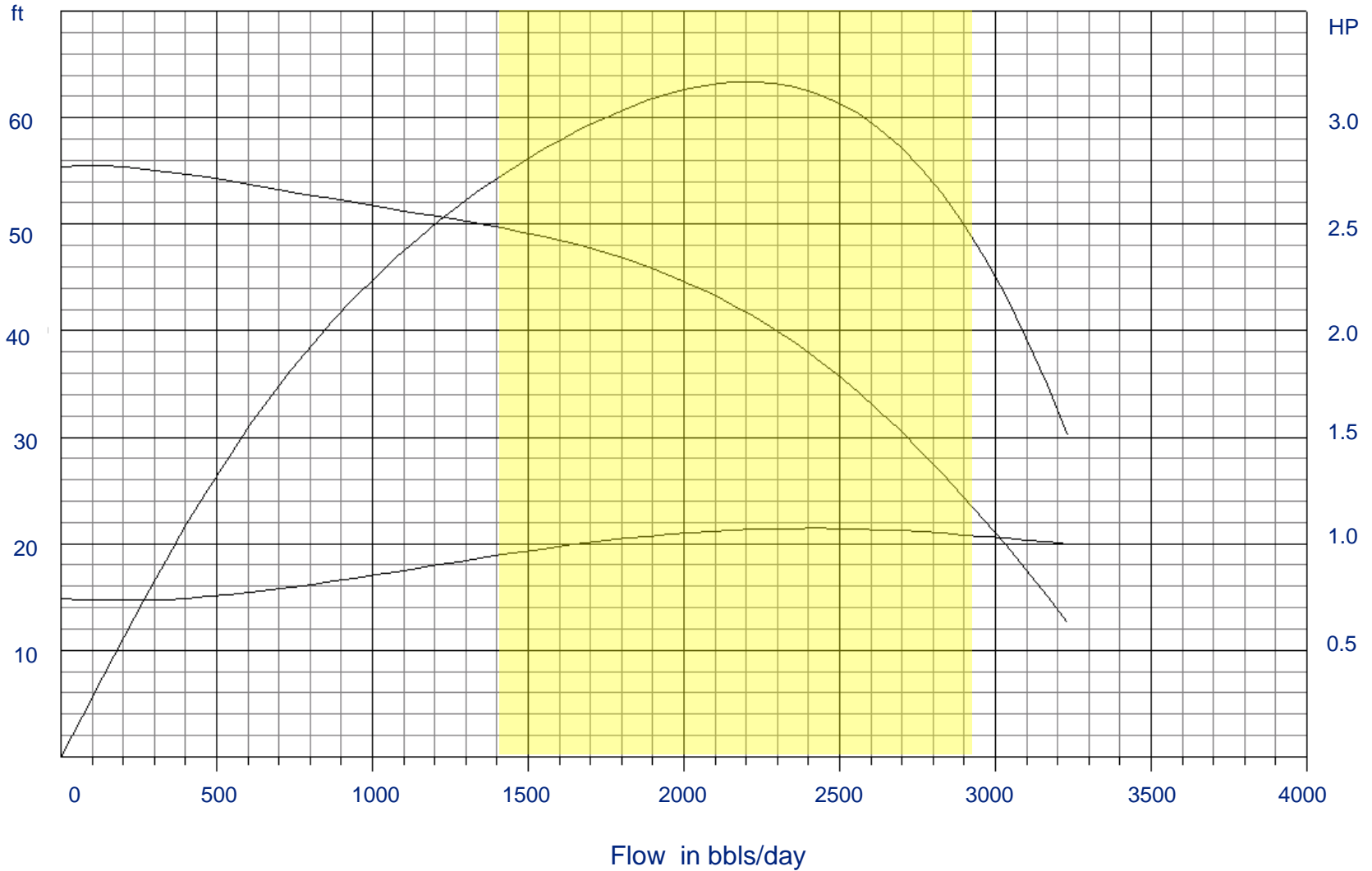
REDA: DN1750 1 Stage 60 Hz SG = 1.00



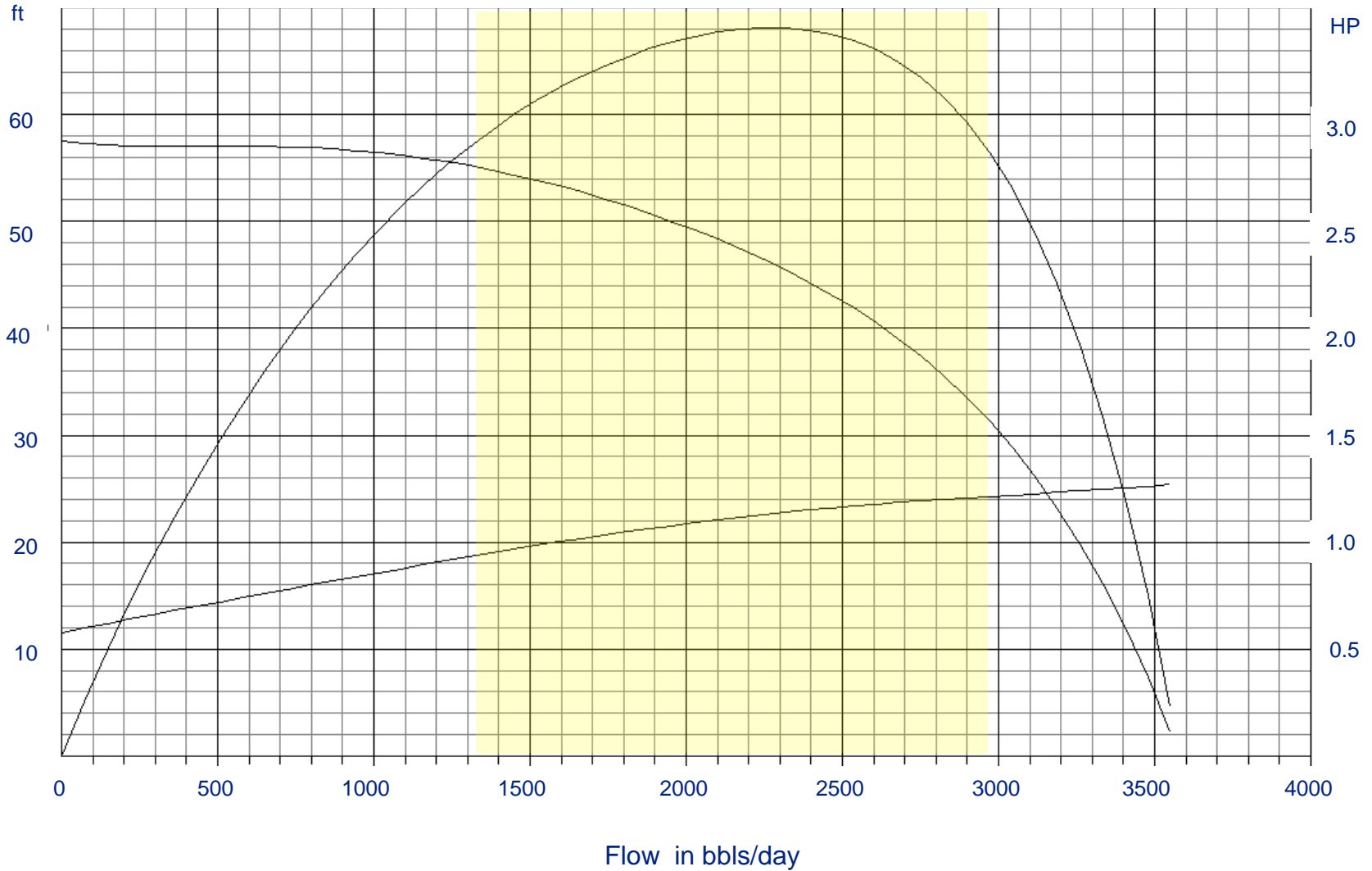
ESP: TG2000 1 Stage 60 Hz SG = 1.00



REDA: GN2100 1 Stage 60 Hz SG = 1.00



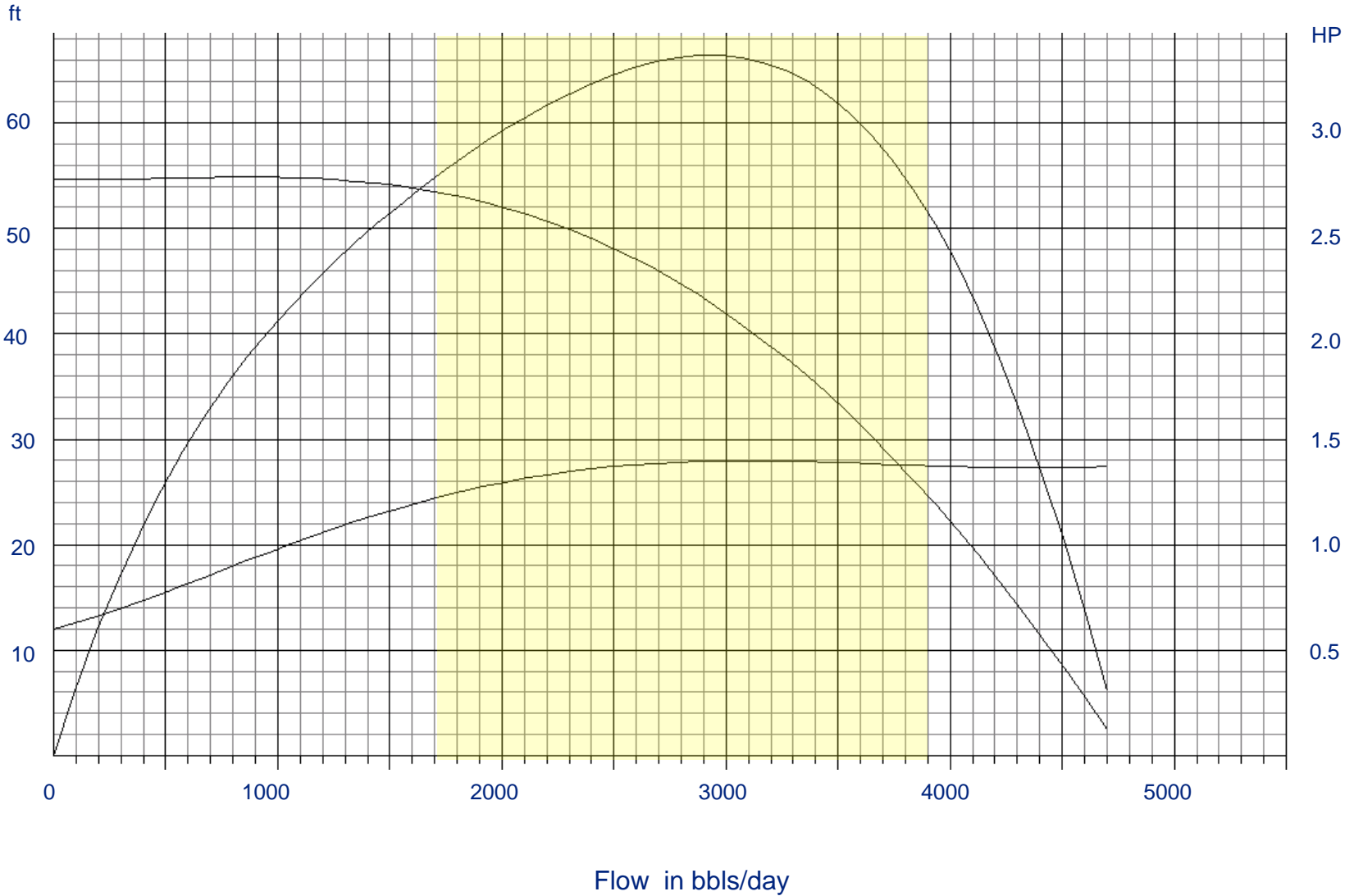
Centrilift: GC2200 1 Stage 60 Hz SG = 1.00



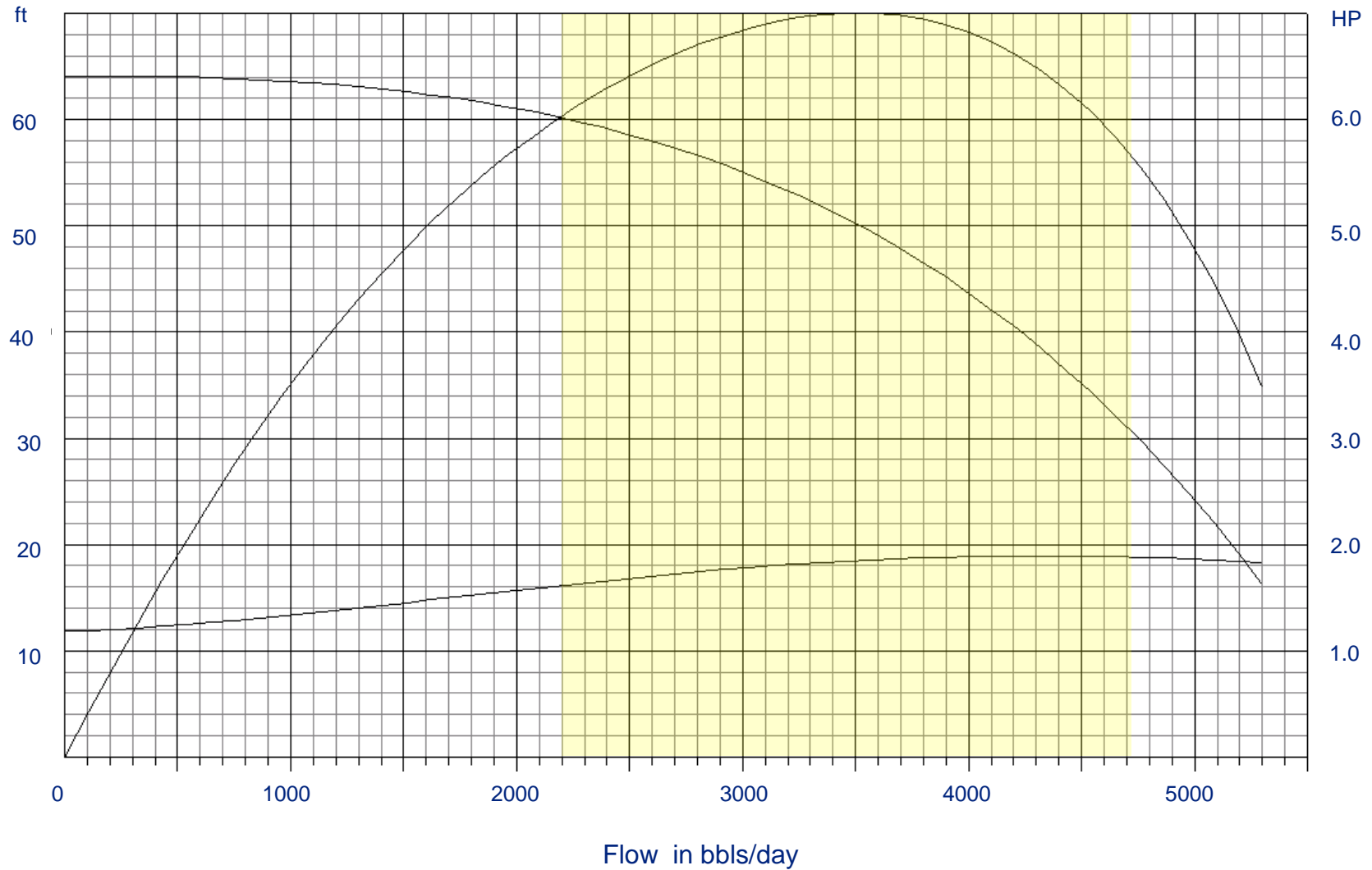
REDA: SN2600 1 Stage 60 Hz SG = 1.00



Centrilift: GC3000 1 Stage 60 Hz SG = 1.00



REDA: SN3600 1 Stage 60 Hz SG = 1.00



Gas Separator: Medium Volume

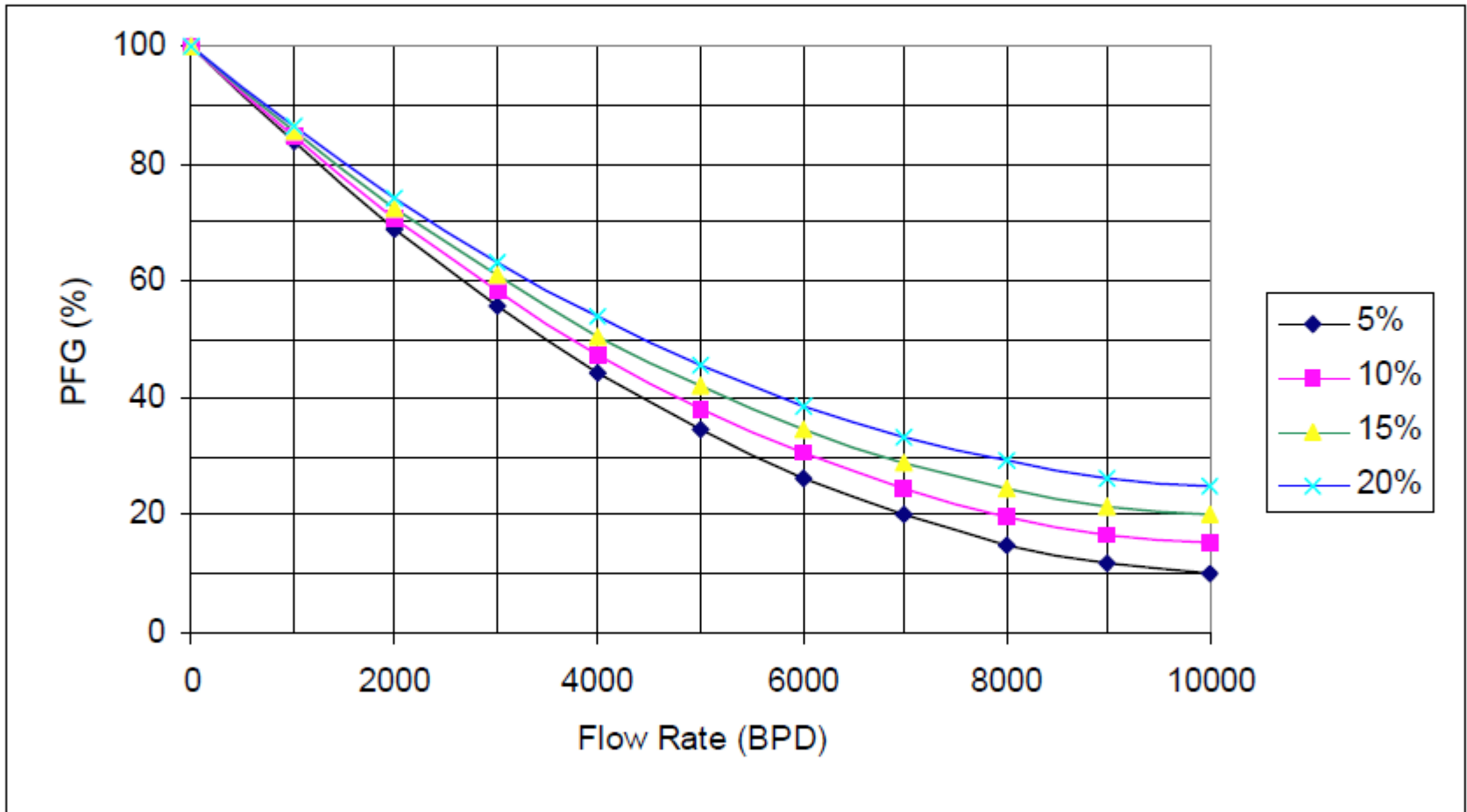


Figure 9. Application Guideline for New 2K-9K BPD Gas Separator
Percent of Free Gas at Intake vs. Liquid Flow Rate **Requires 23 HP**

Gas Separator : Large Volume

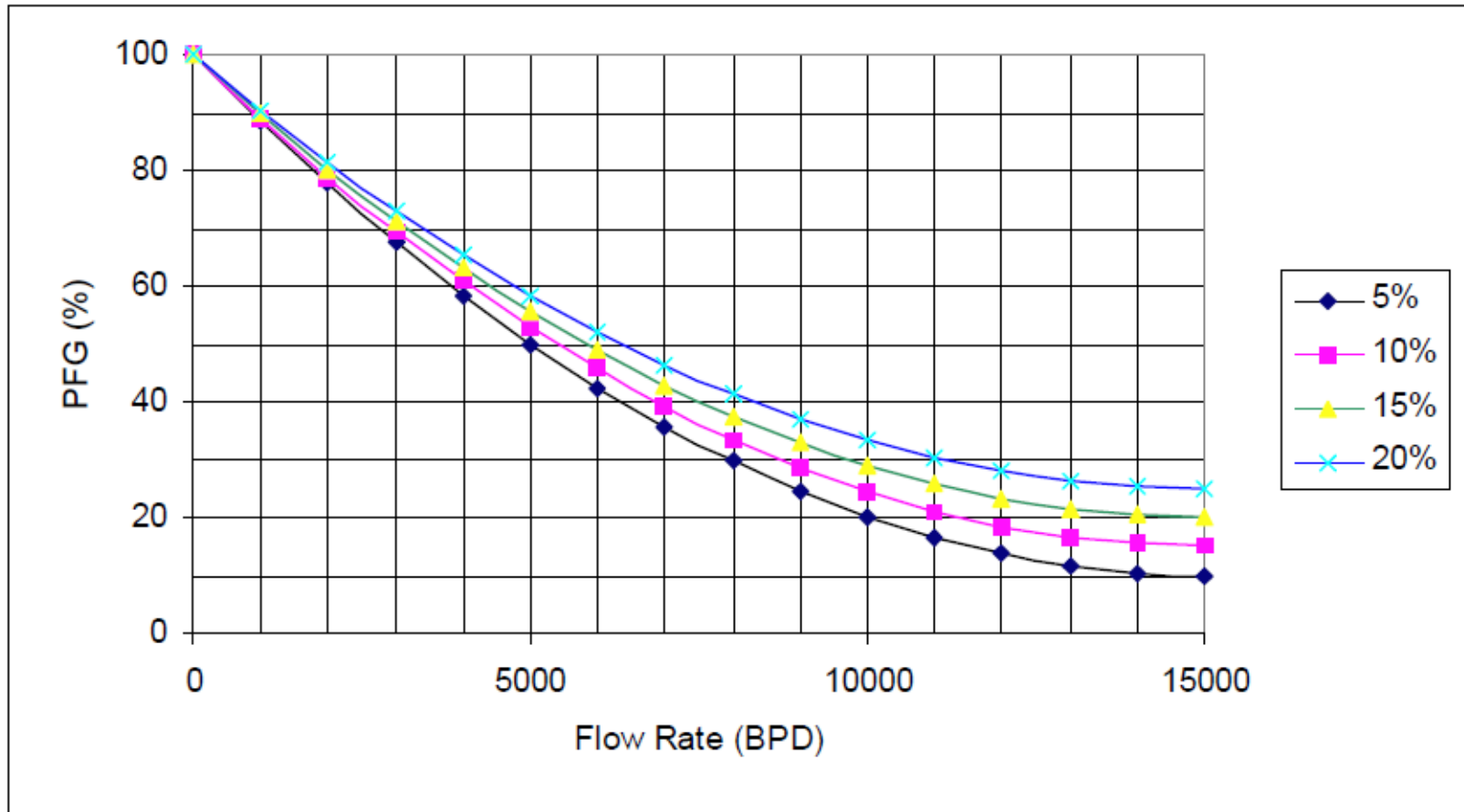


Figure 11. Application Guideline for New 7K-15K BPD Gas Separator
Percent of Free Gas at Intake vs. Liquid Flow Rate Requires 31 HP

Top Down Formulas

- Total Dynamic Head:

$$\text{TDH} = \Delta P_{\text{pump}} = P_{\text{discharge}} - P_{\text{intake}}$$

- Above the pump:

$$P_{\text{discharge}} = \text{WHP} + P_{\text{gravity (wellhead to pump)}} + P_{\text{friction (wellhead to pump)}}$$

- $P_{\text{gravity}} = 0.433 \times \text{SG} \times \text{Pump Setting Depth}$
- $P_{\text{friction}} = \text{Rate vs. Tubing Size \& use graph}$

Top Down Formulas

In the reservoir:

$$PI = Q / (P_R - P_{wf}) \quad \text{or}$$

$$P_{wf} = P_R - Q / PI$$

Below the pump:

$$P_{\text{intake}} = P_{wf} - P_{\text{gravity (pump to reservoir)}} - P_{\text{friction (pump to reservoir)}}$$

$$\text{Downhole flowrate (rb/d)} = Q_{\text{oil}}(\text{stbo/d}) \times B_o + Q_{\text{water}}(\text{stbw/d})$$

Example 2 – Top Down Calculation

- Flow 10063 BPD (HN13000)

PVT

- Pr 3625 psi
- PI 12.4 stb/d/psi

Watercut 90%
Oil Gravity 30 API
Water sg 1.026sg
Bo 1.33 rb/stb

- Completion

Operating

- vertical well
- Pump set at 8202 ft TVD
- Perfs at 9393 ft TVD
- 4-1/2" Tubing (3.958"ID)
- 9-5/8" casing (8.681"ID)

WHP 116 psi



Calculate TDH (ft), # of Stages, HP



1 stage HN13000 50 Hz SG = 1.00

B.E.P.
Q = 10467
H = 30.46
P = 3.72
E = 63.12

Hp Eff

