The National Board

of Boiler and Pressure Vessel Inspectors

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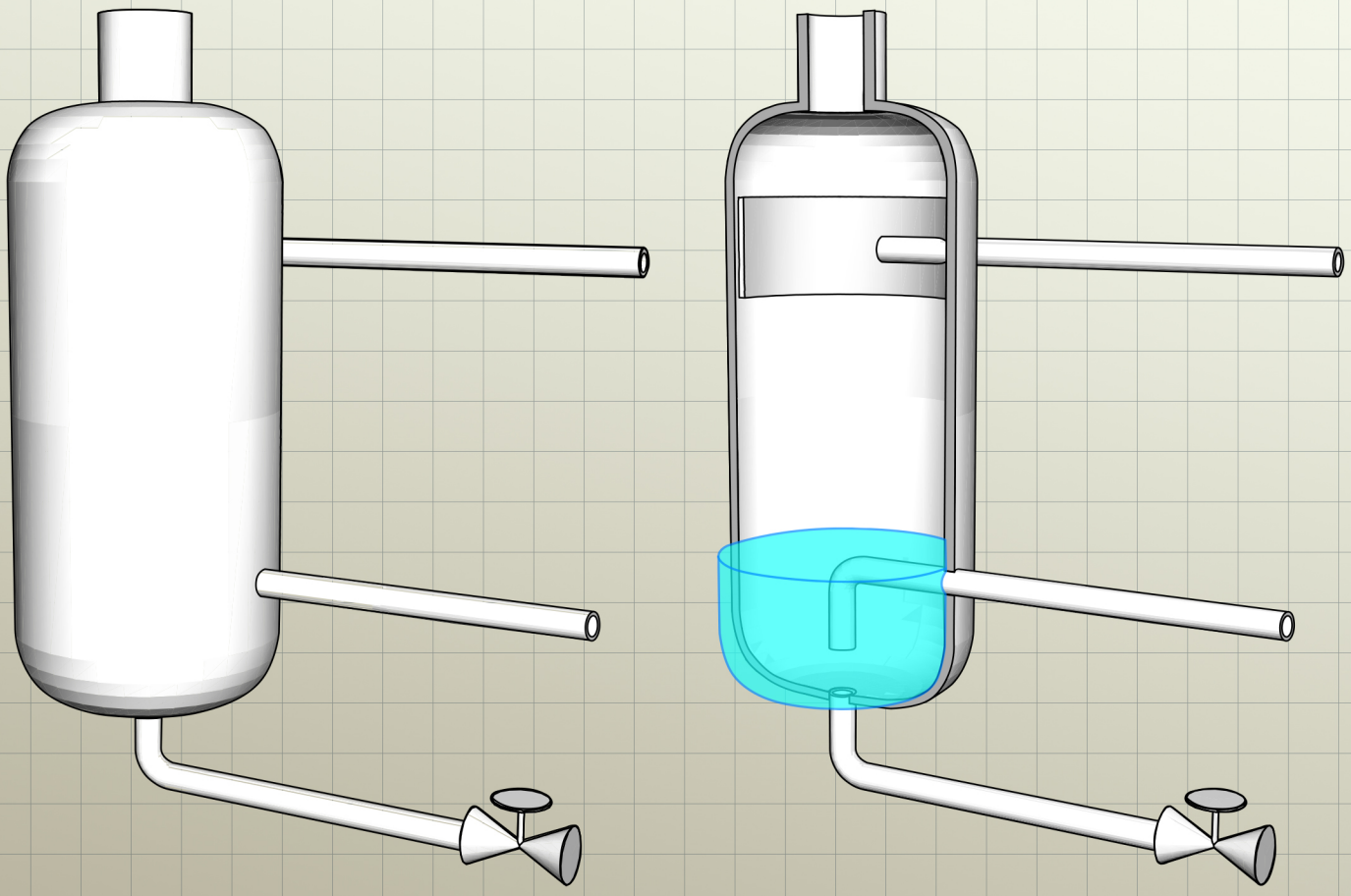


NB-27:
A Guide for Blowoff Vessels

2012 Edition

Foreword

This publication is intended to provide design information and guidance for boiler blowoff systems. It does *not* address details for all possible arrangements of boiler blowoff equipment. If the design of boiler blowoff equipment is not covered in this publication, guidance should be obtained from both a competent engineering firm and the inspection authority of the jurisdiction in which the equipment is to be installed.

General

The treatment of boiler water is an integral part of boiler operation, used to control scaling, corrosion, and deposits. Boiler water treatment often leads to the formation of solid particles that are initially suspended in the boiler water. Solids concentrated in boiler water tend to promote foaming and scaling with a resultant loss of heat transfer which may result in overheating of the boiler tubes. Solids also may settle to the bottom of the boiler to form sludge. "Blowing off" part of the boiler water is a means of removing solids from the water while controlling boiler water levels.

It is common for the terms "blowdown" and "blowoff" to be used interchangeably. In this publication, the term "blowoff" is preferred. Boiler blowoff may be continuous or intermittent, and may be a surface blow or a bottom blow. Continuous blowoff is normally a surface blow, and is defined as a method where a portion (between 1 and 10 percent) of the boiler water is continuously removed by skimming the surface of the water in the steam drum to remove the entrained solids. A bottom blow is normally an intermittent blowoff (e.g., once per day), which lowers the water level by a few inches. Discharge point is the bottom of the boiler, or in the case of a two-drum system, the lower "mud" drum.

The primary function of the blowoff system is to provide a safe means of controlling boiler blowoff water. This includes reduction in both pressure and temperature to limits acceptable for safe discharge into a sewer, drain system, or other area. The usual practice, therefore, is to discharge the water into a vented vessel where it may be allowed to cool, or mixed with cold water to reduce the temperature and pressure to acceptable discharge levels.

Discharge of high temperature water from a boiler blowoff system can present a hazard to personnel and may also damage sewers or drains. Blowoff pressure should not exceed 5 psig. Typically, the maximum acceptable water temperature for discharge into a sewer system is 140°F. Requirements of the Environmental Protection Agency, or local ordinances, may require lower temperatures.

The system, with regard to intermittent blowoff, is subjected to severe service conditions resulting from:

- thermal shock
- vibration
- rapid pressurization
- erosion/corrosion

Components of the system must be designed to withstand such shock loading conditions. As a result, piping must be adequately supported and designed with large radius bends. All piping to and from the blowoff vessel, including the lines defined there, shall be designed in accordance with Section I and B31.1 of the ASME Code. The blowoff vessel shall be designed and manufactured in accordance with Section VIII, Div. 1 for a maximum allowable working pressure (MAWP) of 50 psig.

The vessel shall be fitted with the following connections and appurtenances as appropriate:

- blowoff line inlet
- water outlet
- vent
- drain
- inspection openings
- cold water supply (optional)
- pressure gage
- thermometer well
- gage glass

The vent size, to a large degree, determines the pressure rise within the vessel. The vent should be of sufficient size to release the flashing water (steam) that occurs during blowoff. Some of the factors which must be considered are:

- size and operating pressure of the boiler
- size and length of the blowoff piping

The vent connection shall be located in the uppermost part of the vessel, shall be open to the atmosphere without intervening stop valves, and shall discharge at a point of safety away from walkways and equipment.

The blowoff line inlet shall be located between the high water level in the vessel and the top of the vessel (see Figure 1). It is recommended that the blowoff enter a vertical vessel tangentially to maximize separation of steam from water. A wear plate or baffle should be placed in the vessel to protect the shell from fluid impingement.

Under normal operation, the blowoff vessel discharge connection shall be connected to the vessel so that it retains the water from a single blowoff cycle (see Figure 1). The discharge connection shall have a water seal included in its design. The vertical leg of the water seal shall be located in the center of the vessel, and extend to within 6 inches of the bottom. The top of the water seal shall have a 3/8-inch opening to serve as a siphon breaker. The discharge line size shall be NPS 2 inches, minimum.

Scale and sediment blown from the boiler (no longer remaining suspended in the water) will be deposited in the blowoff vessel. The vessel must be drained and cleaned at a frequency that will prevent sediment accumulation from reaching a point that would block the vessel outlet. A drain connection shall be provided. The drain should contain fittings that facilitate cleaning.

A pressure gage, graduated to read from 0 to 50 psig, shall be installed. A thermometer well should be located close to the water discharge connection and in contact with the retained water in the vessel. Two gage glasses (1/2 inch in diameter, minimum) should be provided, and must comply with Section I requirements of the ASME Code.

Lower connection of the lower gage glass shall be located at a point about three inches below the normal water level line, and the upper connection located 3 inches above the normal water level line (see Figure 1). Lower connection of the upper gage glass shall be located about 3 inches below the high water level line, and the upper connection located 3 inches above the high water level line.

When multiple boilers are blowing off consecutively to a single blowoff vessel, an automatic cooling water-control device should be attached to the vessel or water discharge line to permit the mix of cold water with the blowoff water to reduce the temperature to 140°F or lower.

Multiple blowoff vessels (more than one vessel or receiver used in a boiler blowoff line for the purpose of reducing temperature and pressure of the blowoff) are not prohibited. Multiple vessel systems usually consist of a receiver or separator that discharges into one or more additional receivers, heat exchanger, sump, or cooling pond before flowing to a sewer or other point of discharge.

The tank receiving blowoff directly from a boiler shall be designed with a blowoff inlet, water outlet, vent, and drain connection. It is recommended that the drain line contain fittings that will facilitate cleaning. Size of these openings shall be such that pressure within the tank or receiver will not exceed 5 psig. This tank shall be designed in accordance with Section VIII of the ASME Code for MAWP of 50 psig. Inspection openings shall be provided as required in Section VIII, Div. 1, Paragraph UG-46 of the ASME Boiler and Pressure Vessel Code. When multiple vessels are used, a gage glass, thermometer well, and cooling water supply lines are not required.

The discharge from the first vessel to the second vessel shall be arranged so that it will not be a hazard to life and property. The final discharge of the water when entering a sanitary sewer shall not exceed 140°F.

Closed blowoff vessels are permissible provided they are constructed in accordance with Section VIII, Div. 1 of the ASME Code for a MAWP at least equal to the MAWP of the boiler to which they are connected.

Steam separators are also permissible.

Continuous blowoff is typically discharged through a heat exchanger that cools the flow and then discharges to a drain.

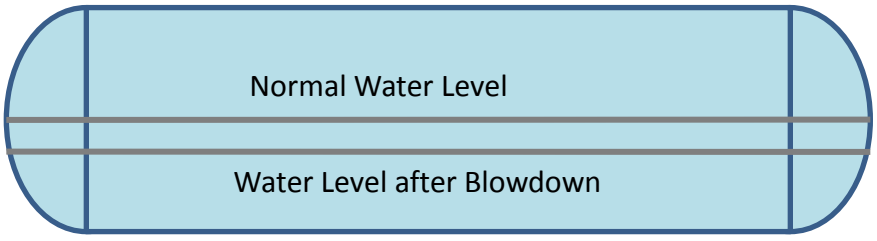
The following sections will define and illustrate the design of typical blowoff vessels, and include sample calculations. Blowoff vessels are normally used for intermittent boiler blowoff.

BOILER BLOWOFF VESSEL SIZING

The size of a blowoff vessel is based on the quantity of water discharged from the boiler during the blowoff cycle, and the quantity of water from the previous blowoff retained in the blowoff vessel. As the water exits the boiler and flows through the blowoff pipe, pressure in the blowoff pipe decreases and some water flashes to steam. More of the water flashes to steam when the water-steam mixture enters the blowoff vessel. The steam is vented from the blowoff vessel, and the water remains in the blowoff vessel to cool. Typically, the water is discharged to a sewer after cooling to a temperature not exceeding 140°F.

Volume of Boiler Discharge Water

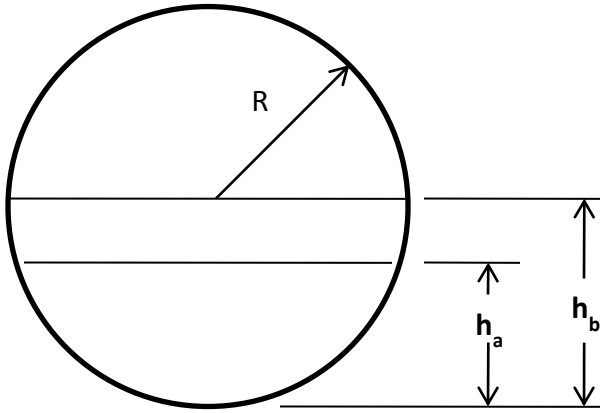
The quantity of water discharged from the boiler during a blowoff cycle drops the water level in the steam drum as shown below.



Steam Drum

The volume of water discharged from a steam drum with 2:1 ellipsoidal heads can be determined from equations 1, 2, and 3.

1) $$V_D = V_{fb} - V_{fa}$$



Water Cross Section

2) $$V_{fb} = \left[R^2 \cos^{-1}\left(\frac{R - h_b}{R} \right) - (R - h_b)\sqrt{2Rh_b - h_b^2} \right] L + \pi \frac{R}{2} h_b^2 \left(1 - \frac{h_b}{3R} \right)$$

3) $$V_{fa} = \left[R^2 \cos^{-1} \frac{R - h_a}{R} - (R - h_a)\sqrt{2Rh_a - h_a^2} \right] L + \pi \frac{R}{2} h_a^2 \left(1 - \frac{h_a}{3R} \right)$$

Where,

L = length of cylindrical part of boiler drum, ft

R = inside radius of the boiler drum, ft

V_D = volume of water discharged from the steam drum during blowoff, ft^3

V_{fa} = volume of water in drum after blowdown, ft^3

V_{fb} = volume of water in drum before blowdown, ft^3

h_a = height of water in drum after blowoff, ft

h_b = height of water in drum before blowoff, ft

π = constant, 3.142

$\cos^{-1}$ is in radians

Blowoff Time

Blowoff time is the time required to lower the water level in the drum to a specified level. The estimated blowoff time is:

4) $BT = \frac{M}{m}$ where

5) $M = V_D \rho_D$

Where,

BT = time required for blowoff, sec

M = total mass of water discharged from the boiler during blowoff, lbm

V_D = volume of water discharged from the steam drum during blowoff, ft^3

m = mass flow rate of fluid in the blowoff pipe , lbm/sec

ρ_D = density of the water in the boiler during blowoff, lbm/ft^3; from ASME steam tables.

The actual blowoff time should always be determined by measurement.

The mass flow rate of the fluid (m) in the blowoff piping is found from either the appropriate graph or equation in Appendix A. **Note that all terms and all digits in the equations must be used for meaningful results**. Note also, the graphs and equations should not be used for very short or very long equivalent lengths of pipe. An equivalent length of pipe is resistance to fluid flow of a valve or fitting expressed as a length of straight pipe with the same resistance to fluid flow. The total equivalent length of pipe for a piping system is the sum of equivalent lengths of pipe added to the total length of straight pipe in the system. Converting the effects of a valve or fitting to the equivalent straight length of pipe provides a simple way to calculate the pressure drop and mass flow rate across a complex piping assembly which is a mix of straight pipe sections, valves and fittings.

The fluid at the exit of the blowoff pipe is a mixture of steam and water. As the fluid mixture exits the blowoff pipe, additional water flashes to steam. The percentage of water discharged from the boiler that flashes to steam is:

6) $F = \frac{h_{1B} - h_{1T}}{h_{fg}}$

where,

F = fraction of water that flashes to steam, dimensionless

h_{fg} = latent heat of vaporization, Btu/lbm

h_{1B} = enthalpy of water in the boiler, Btu/lbm

h_{1T} = enthalpy of water in the blowoff vessel @ 212ºF, Btu/lbm

When the pressure in the blowoff vessel reaches steady state flow conditions, approximately 2 psig, the accumulation of steam in the blowoff vessel ceases. In steady state conditions, steam exits the blowoff vessel through the vent at the same rate as steam enters the vessel. The steam in the vent is assumed to be 100% saturated steam.

Sizing Vent Pipe

The size of the vent pipe is the same for a vertical or horizontal blowoff vessel because the size of the vent pipe is based on the rate of steam entering the vessel (once steady state flow is established). The velocity of the steam in the vent (V_{sv}) should be limited to approximately 50 ft/sec to minimize the quantity of water entrained in the steam and the noise of the flowing steam in the vent pipe. (Note that chemical carryover also increases as the quantity of water entrained in the steam increases.) The required area of the vent pipe (A_v) is:

7) $$A_v = \frac{m_s}{\rho_{sv} V_{sv}}$$ where

8) $$m_s = mF$$

and the resulting inside diameter is (D_v):

9) $$D_v = \sqrt{\frac{4A_v}{\pi}}$$

The pressure drop across the blowoff tank vent pipe should be limited to 1.0 psi to ensure the pipe is of sufficient size to vent the steam, and to prevent an increase in pressure in the blowoff vessel. If the pressure drop exceeds 1.0 psi, then a larger diameter vent pipe should be considered. The calculated pressure drop (ΔP_v) in the vent pipe is:

10) $$\Delta P_v = f \frac{L_v}{12 D_v} \upsilon_{sv} \left(\frac{3600 G}{10^5} \right)^2$$

and the friction factor (f) is:

11) $$f = \frac{0.25}{\left(Log \left[\left(\frac{1}{3.7} \right) \left(\frac{\varepsilon}{D_v} \right) + \frac{5.74}{\mathrm{Re}^{0.9}} \right] \right)^2}$$ (Log denotes logarithm to base 10)

The Reynolds Number is given by:

12) $$\mathrm{Re} = \frac{\rho_{sv} V_{sv} D_v}{\mu}$$

Where,

A_v = cross-sectional area of the vent pipe, ft^2

D_v = vent pipe diameter, ft

G = m_s/A_v mass flux, lbm/sec-ft^2

L_v = equivalent length of vent pipe, ft

Re = Reynolds Number, dimensionless

V_{sv} = velocity of steam in the vent pipe, ft/sec

f = friction factor, dimensionless

m_s = mass flow rate of steam, lbm/sec

ρ_{sv} = density of steam in the vent pipe, lbm/ft^3

ν_{sv} = specific volume of steam in vent pipe, ft^3/lb

ΔP_v = pressure drop across the vent pipe, psi

μ = dynamic viscosity, lbm/ft-hr

ε/D_v = relative roughness of the inside diameter of the vent pipe, dimensionless

π = constant, 3.142

Sizing Blowoff Vessels

The blowoff vessel is sized to contain the quantity of water from two boiler blowoff cycles plus space for the fluid (M) above the water. The steam space is sized so the fluid can expand and slow to a velocity permitting the water to drop out of the flow; approximately 11 ft/sec.

Sizing Vertical Blowoff Vessel (Figure 1)

Based on the velocity and density of the steam, the minimum cross-sectional area of a vertical blowoff vessel is:

13) $$A_R = \frac{m}{\rho_S V_S}$$

and the minimum diameter is:

14) $$D_{t\,min} = \sqrt{\frac{4A_R}{\pi}}$$

Where,

A_R = required cross-sectional area of steam space, ft^2

D_{tmin} = minimum diameter of the blowoff vessel, ft

V_s = velocity of steam in the blowoff vessel, ft/sec

m = mass flow rate of fluid, lbm/hr

ρ_s = density of steam in blowoff vessel; lbm/ft^3

π = constant, 3.142

After calculating the minimum diameter (D_{tmin}), it may be necessary to select a larger diameter for design (D_t) to decrease the height of the vessel.

The height of water in the vessel from one blowoff cycle is the normal water level. The height of water in the vessel from two blowoff cycles is the high water level. The vessel discharge connection is located at the normal water level as shown in Fig. 1.

For a vessel with a 2:1 ellipsoidal bottom head, the normal and high water levels are:

15) $$H_N = \frac{4V_D(1-F)}{\pi D_t^{\,2}} + \frac{D_t}{6}$$ normal level

16) $$H_h = \frac{8V_D(1-F)}{\pi D_t^{\,2}} + \frac{D_t}{6}$$ high level

Where,

D_t = design diameter of blowoff vessel, ft

F = fraction of water that flashes to steam, dimensionless

H_N = normal water level in blowoff vessel, ft

H_h = high water level in blowoff vessel, ft

V_D = volume of water discharged from the steam drum during blowoff, ft^3

π = constant, 3.142

The length of the cylindrical part of the vessel (H_t) from tangent line to tangent line can be defined as:

17) $$H_t = H_h + 1.75 D_t$$

Where,

D_t = design diameter of blowoff vessel, ft

H_h = high water level in blowoff vessel, ft

H_t = length of vessel between tangent lines of head, ft

The diameter of the vessel may be modified to change the height of the water and the height of the vessel as required.

The distance from the bottom head to the blowoff pipe is:

18) $$D_2 = H_h + D_t$$

Where,

D_t = design diameter of blowoff vessel, ft

D_2 = location of blowoff pipe, ft

H_h = high water level in blowoff vessel, ft

Time to Cool

When the water below the normal water level (H_N) cools to the specified temperature (typically 140ºF), the water is discharged from the vessel. The water remaining in the blowoff vessel after discharge continues to cool until the next blowoff cycle.

Assuming the water is stratified, and the quantity of water to be cooled lies below the normal water level line. The quantity of heat to be dissipated as this quantity of water cools is:

19) $$Q_1 = M(1-F)(h_t - h_s)$$

The time required to cool the water is determined by the rate heat is transferred to the surrounding air. Note that the temperature of the air surrounding the blowoff vessel may be highly variable over any period of time. To be conservative, the maximum expected temperature of the air around the blowoff vessel may be used to determine the heat transfer rate (q_r).

20) $$q_r = h_c A_t \Delta T$$ where

21) $$\Delta T = \frac{T_b + T_d}{2} - T_a$$

Then, the time to cool the water is:

22) $$t = \frac{Q_1}{q_r}$$

Where,

F	=	fraction of water that flashes to steam, dimensionless
M	=	total mass of water discharged from the boiler during blowoff, lbm
Q_1	=	quantity of heat to be removed from the water, Btu
h_s	=	enthalpy of the water cooled to discharge temperature, Btu/lbm
h_t	=	enthalpy of the water in the blowoff vessel before cooling, Btu/lbm
A_t	=	inside surface area of vessel up to the normal water level; ft^2
h_c	=	average heat transfer coefficient, Btu/hr-ft^2-°F
q_r	=	cooling rate, Btu/hr
T_a	=	temperature of ambient air, °F
T_b	=	water temperature in vessel at end of blowdown, °F
T_d	=	water discharge temperature, °F
t	=	time to cool the retained water to discharge temperature, hrs
ΔT	=	difference between average water temperature and ambient air temperature, °F

The heat transfer area (A_t) is the inside surface area of the vessel up to the normal water level line (H_N). For a vessel with 2:1 ellipsoidal heads, the inside surface area of the cylinder (A_{sc}) from the bottom head to the normal water level line is:

23) $$A_{sc} = \pi D_t \left(H_N - \frac{D_t}{4} \right)$$

The inside surface area of an ellipsoidal head is:

24) $$A_h = 0.5 \left[2\pi a^2 + \pi \frac{c^2}{e} \ln\left(\frac{1+e}{1-e} \right) \right]$$ where (ln denotes natural logarithm)

25) $$e = \sqrt{1 - \frac{c^2}{a^2}}$$

For a 2:1 ellipsoidal head, e = 0.866, and

26) $$A_h = 0.345\pi D_t^2$$

Then the inside surface area of the vessel up to the normal water level line is:

27) $$A_t = A_{sc} + A_h$$

Where,

A_t	=	inside surface area of vessel up to the normal water level line, ft^2
A_{sc}	=	inside surface area of cylinder for cooling blowoff water, ft^2
A_h	=	the inside surface area of the ellipsoidal head, ft^2
D_t	=	design diameter of blowoff vessel, ft
H_N	=	normal water level in blowoff vessel, ft
a	=	the major semi-axis, ft
c	=	the minor semi-axis, ft
e	=	head eccentricity, dimensionless
π	=	constant, 3.142

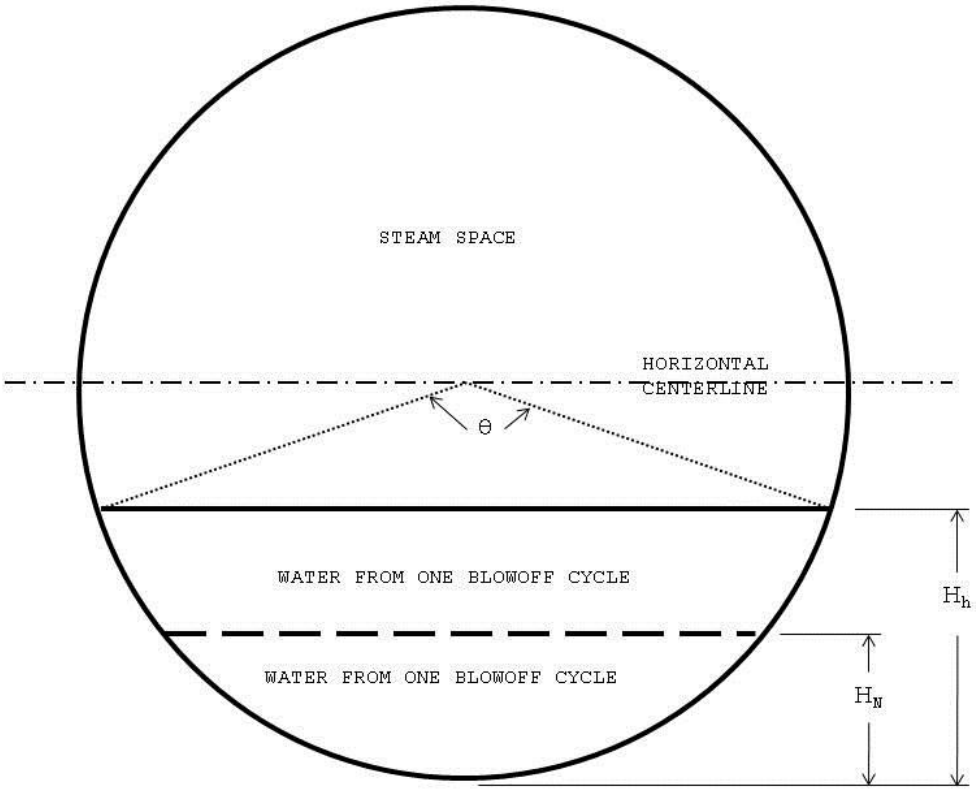
The actual temperature of the water should be measured before it is discharged to the sewer. Cooling water from an outside source may be added if the time required for the blowoff water to cool is excessive.

Sample calculations can be found in Appendix B.

Sizing Horizontal Blowoff Vessel (Figure 2)

The sizing of a horizontal blowoff vessel is similar to sizing a vertical vessel with space for steam and water from two blowoff cycles. As noted for sizing the vertical vessel, a steam velocity in the vessel of approximately 11 ft/sec is used for steam/water separation. The required cross-sectional area (A_R) of the space above the water is found from equation 13. The cross-sectional area of a horizontal vessel is shown below with the water in the vessel forming a circular segment.

28) $$A_R = \frac{m}{\rho_S V_S}$$



The area of the steam space (A_R) is the cross-sectional area of the vessel minus the cross-sectional area of the water in the vessel (area of a circular segment).

29) $$A_R = \pi \frac{D_t^2}{4} - \frac{D_t^2}{8}(0.0175\theta - \sin\theta)$$ where

30) $$D_t = 2\sqrt{\frac{A_R}{\pi - 0.5(0.0175\theta - \sin\theta)}}$$

Where,

A_R = required cross-sectional area of steam space in blowoff vessel, ft^2

D_t = design diameter of blowoff vessel, ft

θ = angle, degrees

The solution of equation 30 is an iterative process with the angle θ chosen by the designer. The designer should select a θ that yields a reasonable diameter, and then solve for the length of the cylindrical part of the vessel (L_t) and for the high water level (H_h). **Note**: at $\theta = 180°$ the diameter (D_t) is a maximum.

31) $$L_t \geq \frac{2V_D(1-F) - \pi\frac{D_t}{4}H_h^{\,2}\left(1-\frac{2H_h}{3D_t}\right)}{\frac{D_t^{\,2}}{4}\cos^{-1}\left(1-\frac{2H_h}{D_t}\right) - \left(\frac{D_t}{2}-H_h\right)\sqrt{D_tH_h - H_h^{\,2}}}$$ where

32) $$H_h = \frac{D_t}{2}\left(1-\cos\frac{\theta}{2}\right)$$

Where,

D_t = design diameter of blowoff vessel, ft

F = fraction of water that flashes to steam, dimensionless

H_h = distance from bottom of vessel ID to the high water level line, ft

L_t = length of vessel between tangent lines, ft

V_D = volume of water discharged from the steam drum during blowoff, ft^3

π = 3.142, constant

θ = angle, degrees; not to exceed 180°

The preceding process may be repeated if the diameter and length of the vessel are not acceptable.

The dimensions of the blowoff vessel are now defined. The vessel discharge connection is located at the normal water level as shown in Figure 2. Because of the complexity of the following equation, an iterative procedure is used to find the normal water level (H_N).

33) $$V_D(1-F)=\left[\frac{D_t^2}{4}\cos^{-1}\left(1-\frac{2H_N}{D_t}\right)-\left(\frac{D_t}{2}-H_N\right)\sqrt{D_tH_N-H_N^2}\right]L_t+\pi\frac{D_t}{4}H_N^2\left(1-\frac{2H_N}{3D_t}\right)$$

Where,

D_t = design diameter of blowoff vessel, ft

F = fraction of water that flashes to steam, dimensionless

H_N = normal water level, ft

L_t = length of vessel between tangent lines, ft

V_D = volume of water discharged from the steam drum during blowoff, ft^3

$\cos^{-1}$ is in radians

Time To Cool

As noted for the vertical vessel, the water below the normal water level in the horizontal vessel is discharged when the temperature reaches the specified value (typically 140°F). Calculate the time to cool one blowoff cycle volume of water per equation 22. The surface area of the horizontal vessel is determined by equation 37. For a horizontal vessel, the partial inside surface area (A_{sc}) of the cylinder up to the normal water line is:

34) $$A_{sc}=0.0175\frac{D_t}{2}\varphi L_t$$ where

35) $$\varphi=2\cos^{-1}\left(1-\frac{2H_N}{D_t}\right)$$

For two 2:1 ellipsoidal heads, the approximate surface area is:

36) $$A_h=0.694\pi D_tH_N$$

Where,

A_h = partial volume of both heads containing water up to the normal water level; ft^3

A_{sc} = inside surface area of cylinder up to the normal water level, ft^2

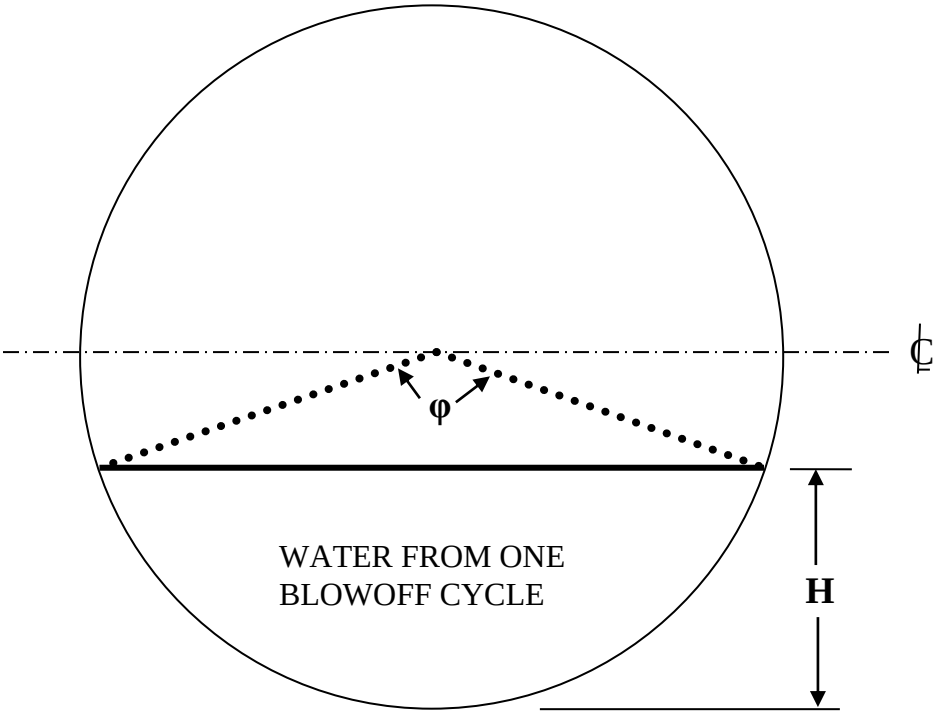
D_t = design diameter of blowoff vessel, ft

H_N = normal water level, ft

L_t = length of vessel between tangent lines, ft

φ = bottom angle defined by the normal water level, degrees

π = 3.142, constant



The total interior cooling surface area is:

37) $A_t = A_{sc} + A_h$

and the time to cool is determined by equations 19, 34, and 36.

The actual temperature of the water should be measured before it is discharged to the sewer. Cooling water from an outside source may be added if the time required for the blowoff water to cool is excessive.

Sample calculations may be found in Appendix B.

Note:

There is no single solution to the size of the blowoff vessel. The designer must evaluate each vessel design for applicability to the specific location and environment.

NOMENCLATURE

A_c = required cross-sectional area of blowoff vessel, ft^2

A_h = inside surface area of head for cooling blowoff water, ft^2

A_R = required cross-sectional area of steam space, ft^2

A_s = area of a segment of a circular cylinder, ft^2

A_{sc} = inside surface area of cylinder for cooling blowoff water, ft^2

A_t = inside surface area of vessel for cooling blowoff water, ft^2

A_v = cross-sectional area of the vent pipe, ft^2

BT = time required for blowoff, seconds

D_t = design diameter of blowoff vessel, ft

D_{tmin} = minimum inside diameter of blowoff vessel, ft

D_v = diameter of the vent pipe, ft

D_w = inside diameter of the boiler drum, ft

D_2 = distance from bottom head to the blowoff pipe, ft

F = fraction of water that flashes to steam, dimensionless

G = mass flux, lbm/hr-ft^2

H_h = high water level in blowoff vessel, ft

H_N = normal water level in blowoff vessel, ft

H_t = length of vertical blowoff vessel between tangent lines, ft

L = length of cylindrical part of boiler drum, ft

L_t = length of vessel between tangent lines, ft

L_v = equivalent length of the vent pipe, ft

M = total mass of water discharged from the boiler during blowoff, lbm

Q_1 = quantity of heat to be removed from the water, Btu

R = inside radius of the boiler drum, ft

Re = Reynolds Number, dimensionless

T_a = temperature of ambient air, °F

T_b = water temperature in vessel at end of blowdown, °F

T_d = water discharge temperature, °F

V_D = volume of water discharged from the cylindrical part of the steam drum during blowoff, ft^3

V_{fa} = volume of water in drum after blowdown, ft^3

V_{fb} = volume of water in drum before blowdown, ft^3

V_s = velocity of steam in blowoff vessel, ft/sec

V_{sv} = velocity of the steam in the vent pipe, ft/sec

a = length of ellipsoid major semi-axis, ft

NOMENCLATURE (cont.)

c = length of ellipsoid minor semi-axis, ft

e = eccentricity of an ellipsoid, dimensionless

f = friction factor, dimensionless

h_a = height of water in drum after blowoff, ft

h_b = height of water in drum before blowoff, ft

h_c = average heat transfer coefficient, Btu/hr-ft^2-°F

h_{fq} = latent heat of vaporization, Btu/lbm

H_h = normal water level in blowoff vessel, ft

H_N = high water level in blowoff vessel, ft

h_{1B} = enthalpy of water in the boiler, Btu/lbm

h_{1T} = enthalpy of water in the blowoff vessel, Btu/lbm

h_s = enthalpy of the water to be released to the sewer, Btu/lbm

h_t = enthalpy of the water in blowoff vessel, Btu/lbm

q_r = cooling rate, Btu/hr

m = mass flow rate of mixture, lbm/sec

m_s = mass flow rate of steam, lbm/sec

t = time required to cool the quantity of water from one discharge cycle, hrs

ΔH_w = change in boiler water level during blowoff, ft

ΔP_v = pressure drop across the vent pipe, psi

ΔT = temperature difference, ºF

ε/D_v = relative roughness of the vent pipe ID, dimensionless

θ = angle for sizing horizontal vessel, degrees

μ = dynamic viscosity of the steam in the vent, lbm/ft-hr

v_{sv} = specific volume of steam in vent, ft^3/lb

ρ_D = density of the water in the boiler at time of blowoff, lbm/ft^3

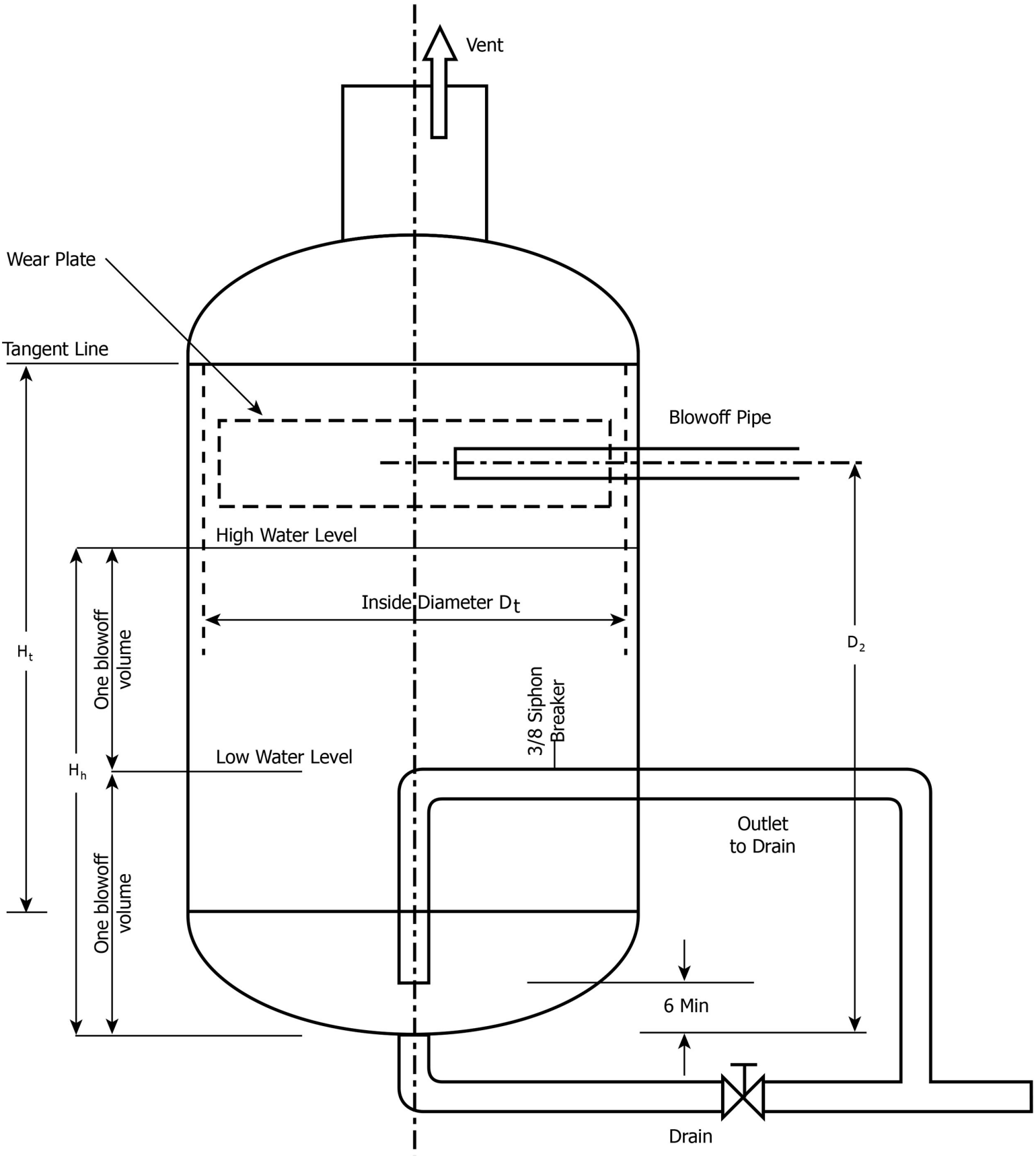
ρ_s = density of steam in blowoff vessel, lbm/ft^3

ρ_{sv} = density of the steam in the vent pipe, lbm/ft^3

ν_D = specific volume of water in the boiler at time of blowoff, ft^3/lbm

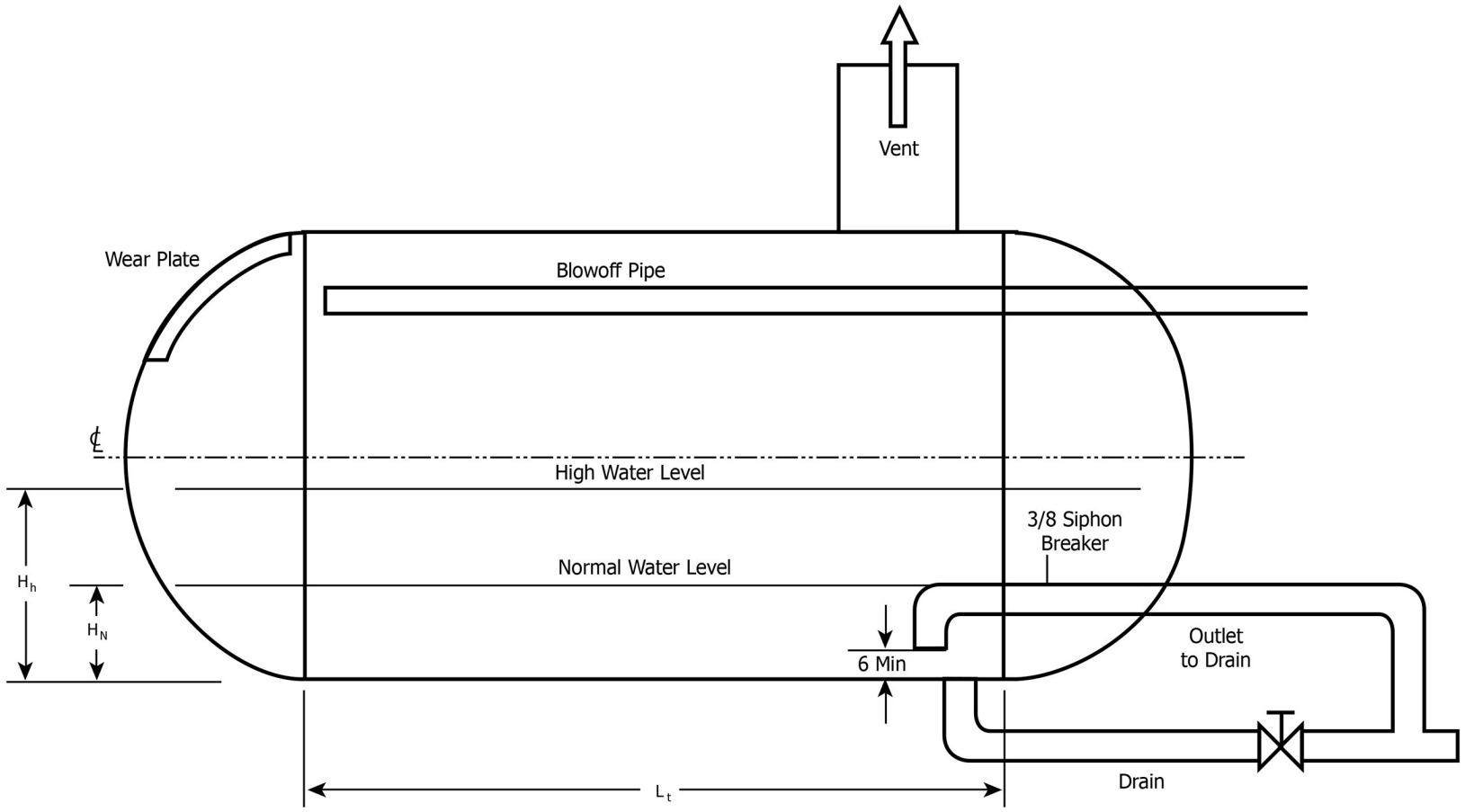
π = 3.142, constant

φ = angle to find normal water level in horizontal vessel, degrees



Vertical Blowoff Vessel

Figure 1



Horizontal Blowoff Vessel

Figure 2

Appendix A

Blowoff Piping Flow and Discharge Pressure Charts

The charts and equations contained in this appendix are based on the following paper. "The Flow of a Flashing Mixture of Water and Steam Through Pipes" by M.W. Benjamin and J. G. Miller, Trans ASME 64(7), 657-689 (Oct., 1942)

Chart Overview

Pipe Size Range:
Blowoff piping is limited in size to NPS 1 as a minimum size for all boilers other than Miniature Boilers (5 cubic feet in volume or less). Additionally, there is a maximum size limit of NPS 2-1/2 pipe size for all boilers. Charts are provided for all pipe sizes within this range.

Pipe sizes NPS 1/2 and NPS 3/4 are permitted on miniature boilers only.

Pipe Weight or Schedule:
Boilers having a design pressure over 100 psi shall be SCH 80 as a minimum. Charts are provided for SCH 80 (X-STR), SCH 160 and XX-STR pipe from NPS 1 to NPS 2-1/2 pipe sizes.

Due to the very small size of Miniature Boilers, 5 cubic feet or less, only one chart pair is provided for SCH 80 pipe in NPS 1/2 and NPS 3/4 pipe sizes.

Pipe Inside Diameter: Inside Diameter = Outside Diameter - (2 x Nominal thickness) These charts are based on pipe having inside diameters determined using nominal wall thickness as stated in the following table:

Nominal Pipe Size	Outside Diameter	EX. STR.	SCH 80	SCH 160	XX-STR.
NPS ½	0.840	0.147	0.147		
NPS ¾	1.050	0.154	0.154		
NPS 1	1.315	0.179	0.179	0.250	0.358
NPS 1¼	1.660	0.191	0.191	0.25	0.382
NPS 1½	1.900	0.200	0.200	0.281	0.400
NPS 2	2.375	0.218	0.218	0.344	0.436
NPS 2½	2.875	0.276	0.276	0.375	0.552

Notes: 1) All dimensions are given in inches.
2) The dimensional thicknesses noted for respective pipe sizes represent there nominal or average wall dimensions. The actual thicknesses may be as much as 12.5% over or under the nominal thicknesses because of mill tolerances.

Chart Design:
The charts provided, herein, are produced by The National Board of Boiler and Pressure Vessel Inspectors based on two-phase flow. The first set of charts provide an idealized discharge pressure at the blowoff pipe end entering the blowoff vessel, and are presented for information only. The second set of charts provide an idealized mass flow through the blowoff pipe. Their usage requires knowledge of boiler operating pressure, pipe size, wall thickness, and equivalent straight length of pipe.

TABLE OF CONTENTS

Charts
Discharge Pressure as a function of Equivalent Straight Pipe Length

Charts
Mass Flow as a Function of Equivalent Straight Pipe Length

NPS 1/2 SCH 80 Mass Flow Boiler pressures 10 psi to 100 psi
NPS 3/4 SCH 80 Mass Flow Boiler pressures 10 psi to 100 psi
NPS 1 SCH 80 Mass Flow Boiler pressures 30 psi to 300 psi
NPS 1 SCH 80 Mass Flow Boiler pressures 100 psi to 1000 psi
NPS 1 SCH 160 Mass Flow Boiler pressures 30 psi to 300 psi
NPS 1 SCH 160 Mass Flow Boiler pressures 150 psi to 1500 psi
NPS 1 XX-STR. Mass Flow Boiler pressures 30 psi to 300 psi
NPS 1 XX-STR. Mass Flow Boiler pressures 200 psi to 2000 psi
NPS 1-1/4 SCH 80 Mass Flow Boiler pressures 30 psi to 300 psi
NPS 1-1/4 SCH 80 Mass Flow Boiler pressures 100 psi to 1000 psi
NPS 1-1/4 SCH 160 Mass Flow Boiler pressures 30 psi to 300 psi
NPS 1-1/4 SCH 160 Mass Flow Boiler pressures 150 psi to 1500 psi
NPS 1-1/4 XX-STR. Mass Flow Boiler pressures 30 psi to 300 psi
NPS 1-1/4 XX-STR. Mass Flow Boiler pressures 200 psi to 2000 psi
NPS 1-1/2 SCH 80 Mass Flow Boiler pressures 30 psi to 300 psi
NPS 1-1/2 SCH 80 Mass Flow Boiler pressures 200 psi to 2000 psi
NPS 1-1/2 SCH 160 Mass Flow Boiler pressures 30 psi to 300 psi
NPS 1-1/2 SCH 160 Mass Flow Boiler pressures 200 psi to 2000 psi
NPS 1-1/2 XX-STR. Mass Flow Boiler pressures 30 psi to 300 psi
NPS 1-1/2 XX-STR. Mass Flow Boiler pressures 200 psi to 2000 psi
NPS 2 SCH 80 Mass Flow Boiler pressures 30 psi to 300 psi
NPS 2 SCH 80 Mass Flow Boiler pressures 300 psi to 3000 psi
NPS 2 SCH 160 Mass Flow Boiler pressures 30 psi to 300 psi
NPS 2 SCH 160 Mass Flow Boiler pressures 300 psi to 3000 psi
NPS 2 XX-STR. Mass Flow Boiler pressures 30 psi to 300 psi
NPS 2 XX-STR. Mass Flow Boiler pressures 300 psi to 3000 psi
NPS 2-1/2 SCH 80 Mass Flow Boiler pressures 30 psi to 300 psi
NPS 2-1/2 SCH 80 Mass Flow Boiler pressures 300 psi to 3000 psi
NPS 2-1/2 SCH 160 Mass Flow Boiler pressures 30 psi to 300 psi
NPS 2-1/2 SCH 160 Mass Flow Boiler pressures 300 psi to 3000 psi
NPS 2-1/2 XX-STR. Mass Flow Boiler pressures 30 psi to 300 psi
NPS 2-1/2 XX-STR. Mass Flow Boiler pressures 300 psi to 3000 psi

Polynomial Equations
Discharge Pressure as a Function of Equivalent Straight Pipe Length

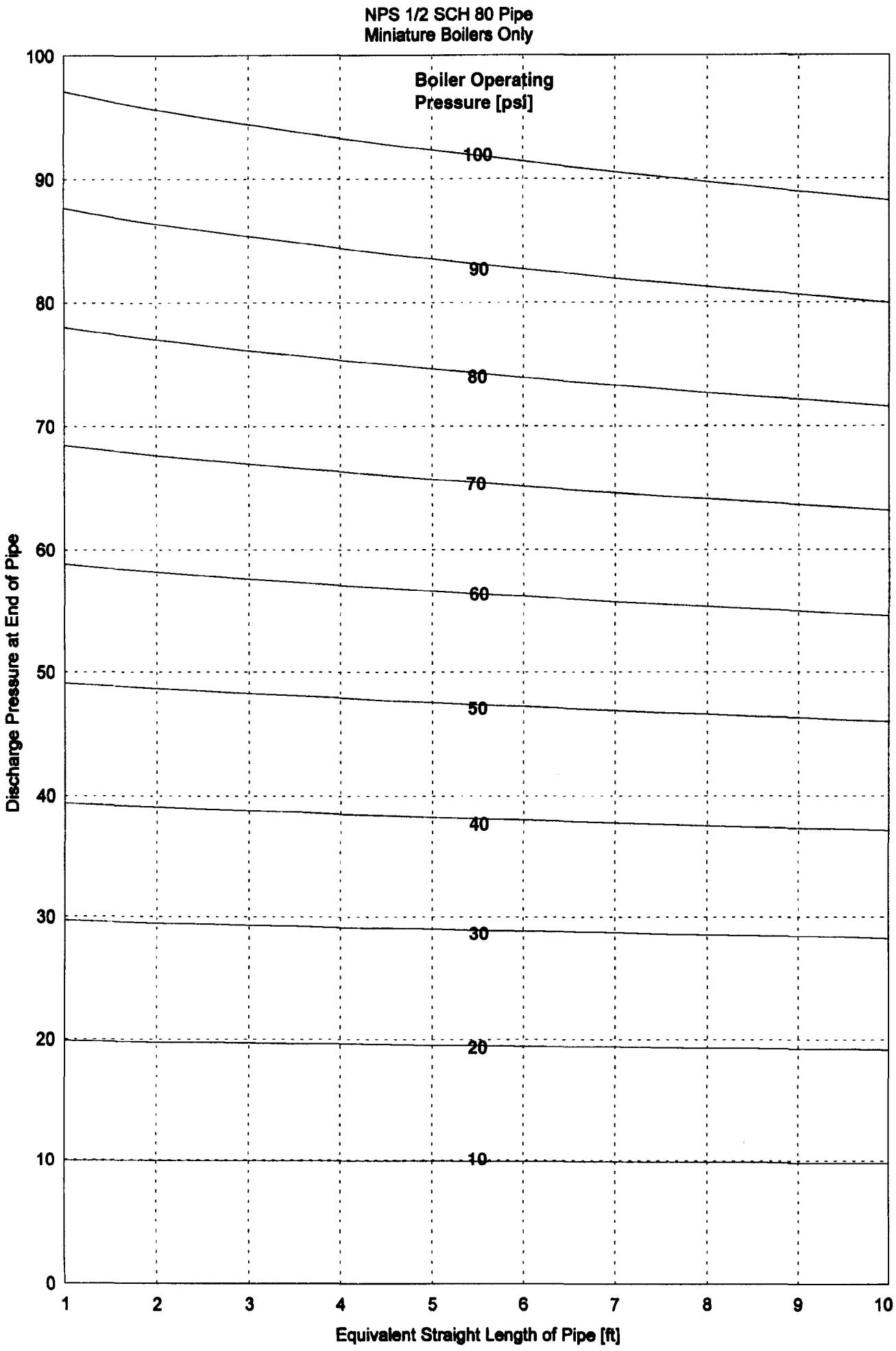
NPS 1/2 SCH 80 Discharge Pressure Boiler pressures 10 psi to 100 psi
NPS 3/4 SCH 80 Discharge Pressure Boiler pressures 10 psi to 100 psi
NPS 1 SCH 80 Discharge Pressure Boiler pressures 30 psi to 300 psi
NPS 1 SCH 80 Discharge Pressure Boiler pressures 100 psi to 1000 psi
NPS 1 SCH 160 Discharge Pressure Boiler pressures 30 psi to 300 psi
NPS 1 SCH 160 Discharge Pressure Boiler pressures 150 psi to 1500 psi
NPS 1 XX-STR. Discharge Pressure Boiler pressures 30 psi to 300 psi
NPS 1 XX-STR. Discharge Pressure Boiler pressures 200 psi to 2000 psi
NPS 1-1/4 SCH 80 Discharge Pressure Boiler pressures 30 psi to 300 psi
NPS 1-1/4 SCH 80 Discharge Pressure Boiler pressures 100 psi to 1000 psi
NPS 1-1/4 SCH 160 Discharge Pressure Boiler pressures 30 psi to 300 psi
NPS 1-1/4 SCH 160 Discharge Pressure Boiler pressures 150 psi to 1500 psi
NPS 1-1/4 XX-STR. Discharge Pressure Boiler pressures 30 psi to 300 psi
NPS 1-1/4 XX-STR. Discharge Pressure Boiler pressures 200 psi to 2000 psi
NPS 1-1/2 SCH 80 Discharge Pressure Boiler pressures 30 psi to 300 psi
NPS 1-1/2 SCH 80 Discharge Pressure Boiler pressures 200 psi to 2000 psi
NPS 1-1/2 SCH 160 Discharge Pressure Boiler pressures 30 psi to 300 psi
NPS 1-1/2 SCH 160 Discharge Pressure Boiler pressures 200 psi to 2000 psi
NPS 1-1/2 XX-STR. Discharge Pressure Boiler pressures 30 psi to 300 psi
NPS 1-1/2 XX-STR. Discharge Pressure Boiler pressures 200 psi to 2000 psi
NPS 2 SCH 80 Discharge Pressure Boiler pressures 30 psi to 300 psi
NPS 2 SCH 80 Discharge Pressure Boiler pressures 300 psi to 3000 psi
NPS 2 SCH 160 Discharge Pressure Boiler pressures 30 psi to 300 psi
NPS 2 SCH 160 Discharge Pressure Boiler pressures 300 psi to 3000 psi
NPS 2 XX-STR. Discharge Pressure Boiler pressures 30 psi to 300 psi
NPS 2 XX-STR. Discharge Pressure Boiler pressures 300 psi to 3000 psi
NPS 2-1/2 SCH 80 Discharge Pressure Boiler pressures 30 psi to 300 psi
NPS 2-1/2 SCH 80 Discharge Pressure Boiler pressures 300 psi to 3000 psi
NPS 2-1/2 SCH 160 Discharge Pressure Boiler pressures 30 psi to 300 psi
NPS 2-1/2 SCH 160 Discharge Pressure Boiler pressures 300 psi to 3000 psi
NPS 2-1/2 XX-STR. Discharge Pressure Boiler pressures 30 psi to 300 psi
NPS 2-1/2 XX-STR. Discharge Pressure Boiler pressures 300 psi to 3000 psi

Polynomial Equations
Mass Flow as a Function of Equivalent Straight Pipe Length

NPS 1/2 SCH 80 Mass Flow Boiler pressures 10 psi to 100 psi
NPS 3/4 SCH 80 Mass Flow Boiler pressures 10 psi to 100 psi
NPS 1 SCH 80 Mass Flow Boiler pressures 30 psi to 300 psi
NPS 1 SCH 80 Mass Flow Boiler pressures 100 psi to 1000 psi
NPS 1 SCH 160 Mass Flow Boiler pressures 30 psi to 300 psi
NPS 1 SCH 160 Mass Flow Boiler pressures 150 psi to 1500 psi
NPS 1 XX-STR. Mass Flow Boiler pressures 30 psi to 300 psi
NPS 1 XX-STR. Mass Flow Boiler pressures 200 psi to 2000 psi
NPS 1-1/4 SCH 80 Mass Flow Boiler pressures 30 psi to 300 psi
NPS 1-1/4 SCH 80 Mass Flow Boiler pressures 100 psi to 1000 psi
NPS 1-1/4 SCH 160 Mass Flow Boiler pressures 30 psi to 300 psi
NPS 1-1/4 SCH 160 Mass Flow Boiler pressures 150 psi to 1500 psi
NPS 1-1/4 XX-STR. Mass Flow Boiler pressures 30 psi to 300 psi
NPS 1-1/4 XX-STR. Mass Flow Boiler pressures 200 psi to 2000 psi
NPS 1-1/2 SCH 80 Mass Flow Boiler pressures 30 psi to 300 psi
NPS 1-1/2 SCH 80 Mass Flow Boiler pressures 200 psi to 2000 psi
NPS 1-1/2 SCH 160 Mass Flow Boiler pressures 30 psi to 300 psi
NPS 1-1/2 SCH 160 Mass Flow Boiler pressures 200 psi to 2000 psi
NPS 1-1/2 XX-STR. Mass Flow Boiler pressures 30 psi to 300 psi
NPS 1-1/2 XX-STR. Mass Flow Boiler pressures 200 psi to 2000 psi
NPS 2 SCH 80 Mass Flow Boiler pressures 30 psi to 300 psi
NPS 2 SCH 80 Mass Flow Boiler pressures 300 psi to 3000 psi
NPS 2 SCH 160 Mass Flow Boiler pressures 30 psi to 300 psi
NPS 2 SCH 160 Mass Flow Boiler pressures 300 psi to 3000 psi
NPS 2 XX-STR. Mass Flow Boiler pressures 30 psi to 300 psi
NPS 2 XX-STR. Mass Flow Boiler pressures 300 psi to 3000 psi
NPS 2-1/2 SCH 80 Mass Flow Boiler pressures 30 psi to 300 psi
NPS 2-1/2 SCH 80 Mass Flow Boiler pressures 300 psi to 3000 psi
NPS 2-1/2 SCH 160 Mass Flow Boiler pressures 30 psi to 300 psi
NPS 2-1/2 SCH 160 Mass Flow Boiler pressures 300 psi to 3000 psi
NPS 2-1/2 XX-STR. Mass Flow Boiler pressures 30 psi to 300 psi
NPS 2-1/2 XX-STR. Mass Flow Boiler pressures 300 psi to 3000 psi

CHARTS

Discharge Pressure as a Function of Equivalent Straight Pipe Length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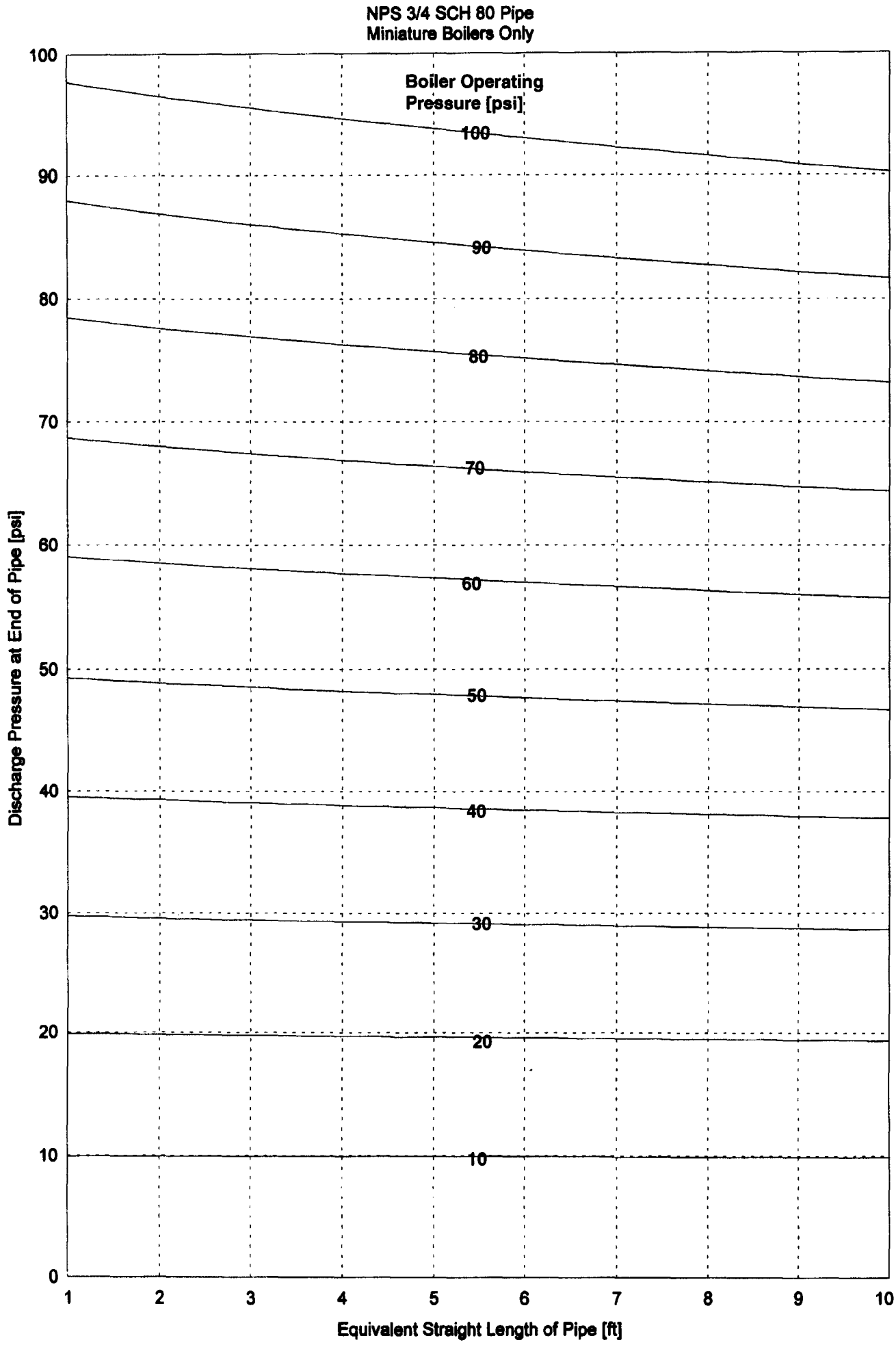
Miniature Boilers Only
Boiler Operating Pressure [psi]
100
90
80
70
60
50
40
30
20
10
Discharge Pressure at End of Pipe
0
1
2
3
4
5
6
7
8
9
10
Equivalent Straight Length of Pipe [ft]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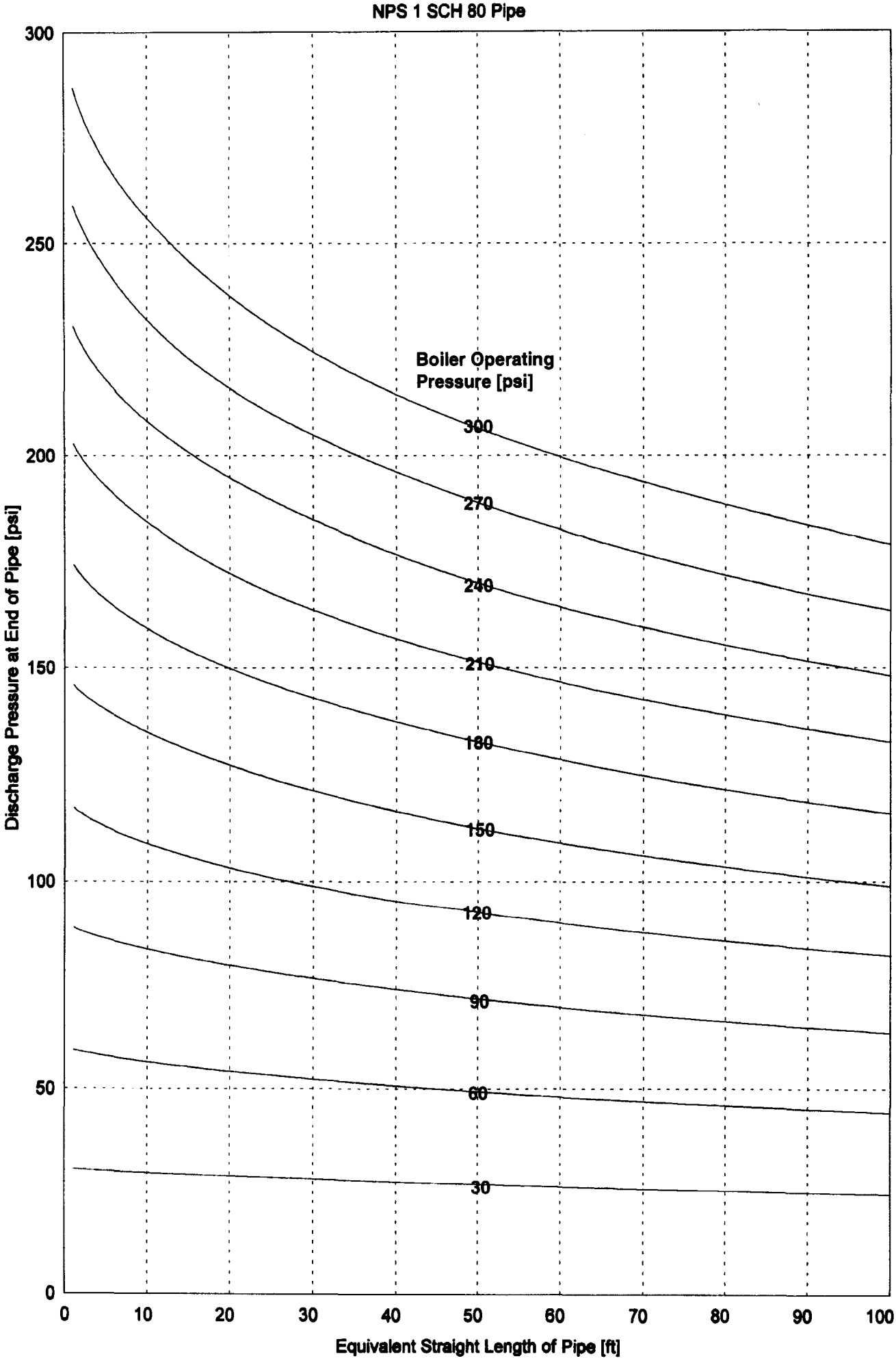
Miniature Boilers Only
Boiler Operating Pressure [psi]
100
90
80
70
60
50
40
30
20
10
Discharge Pressure at End of Pipe [psi]
0
1
2
3
4
5
6
7
8
9
10
Equivalent Straight Length of Pipe [ft]


NPS 1 SCH 80 Pipe
Discharge Pressure at End of Pipe [psi]
Equivalent Straight Length of Pipe [ft]
Boiler Operating Pressure [psi]
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270
240
210
180
150
120
90
60
30
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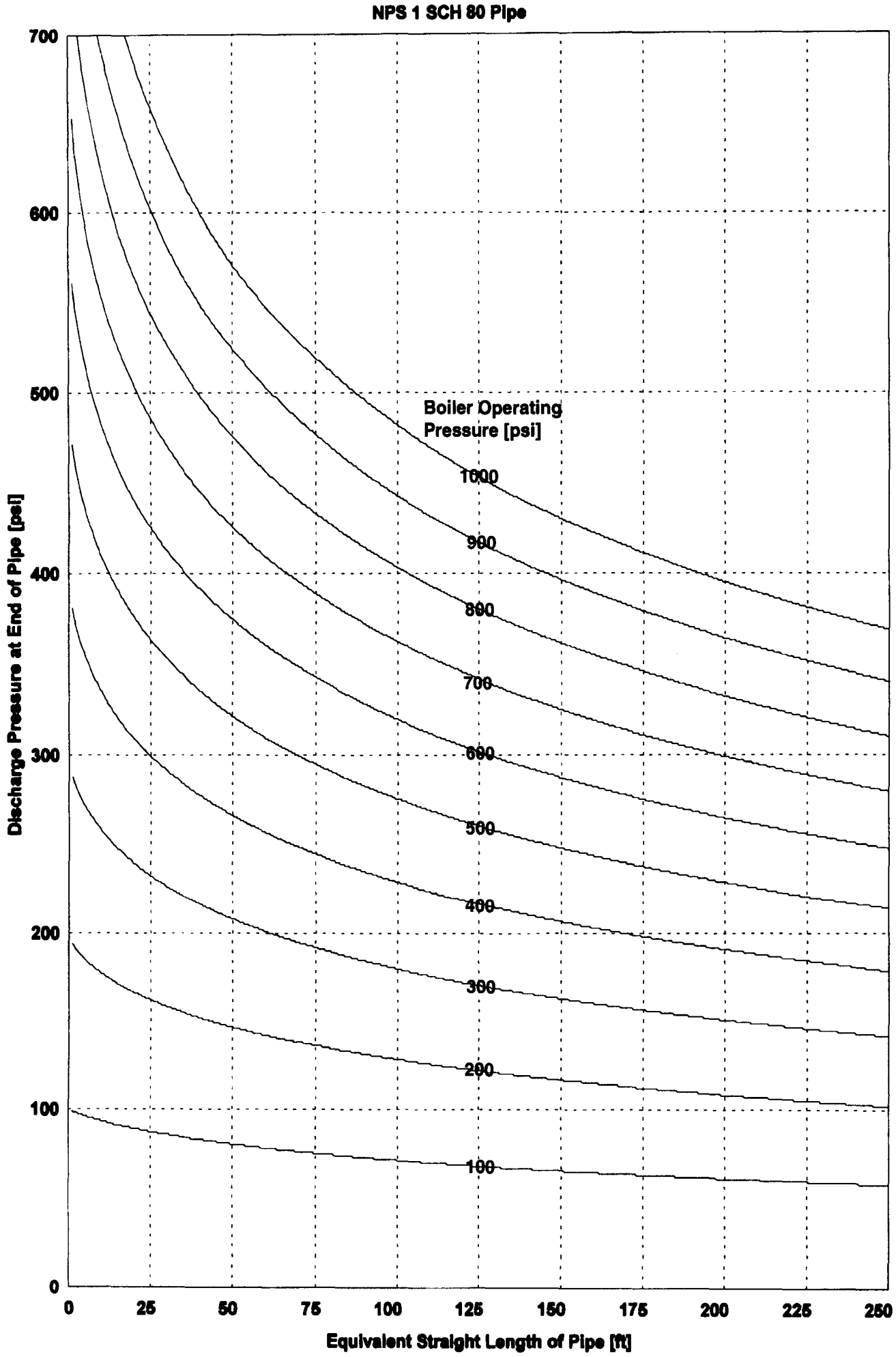
20
30
40
50
60
70
80
90
100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Discharge Pressure at End of Pipe [psi]
Equivalent Straight Length of Pipe [ft]
Boiler Operating Pressure [psi]
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900
800
700
600
500
400
300
200
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125
150
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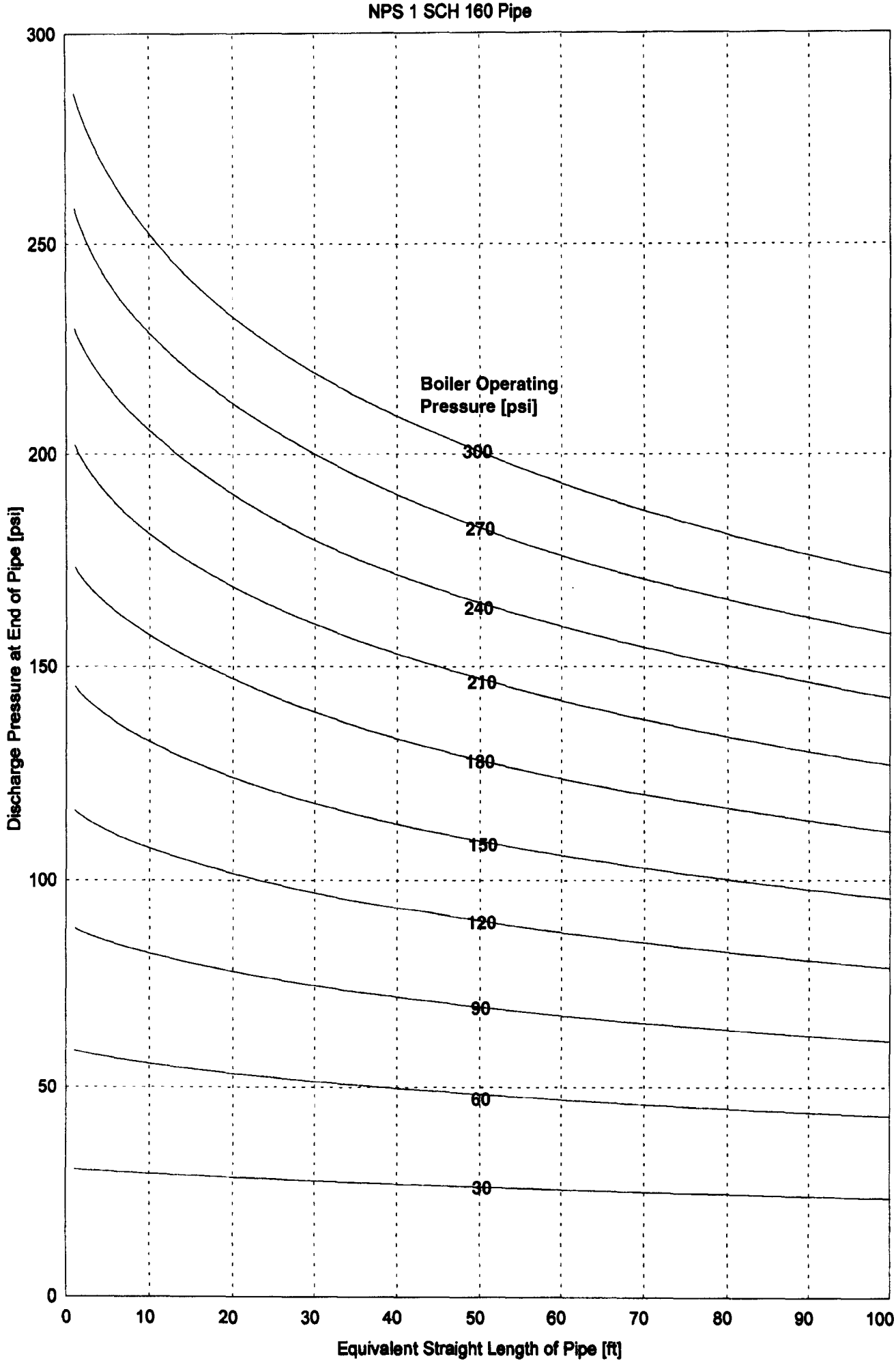
200
225
250
700
600
500
400
300
200
100
0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Equivalent Straight Length of Pipe [ft]
Boiler Operating Pressure [psi]
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270
240
210
180
150
120
90
60
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100
150
200
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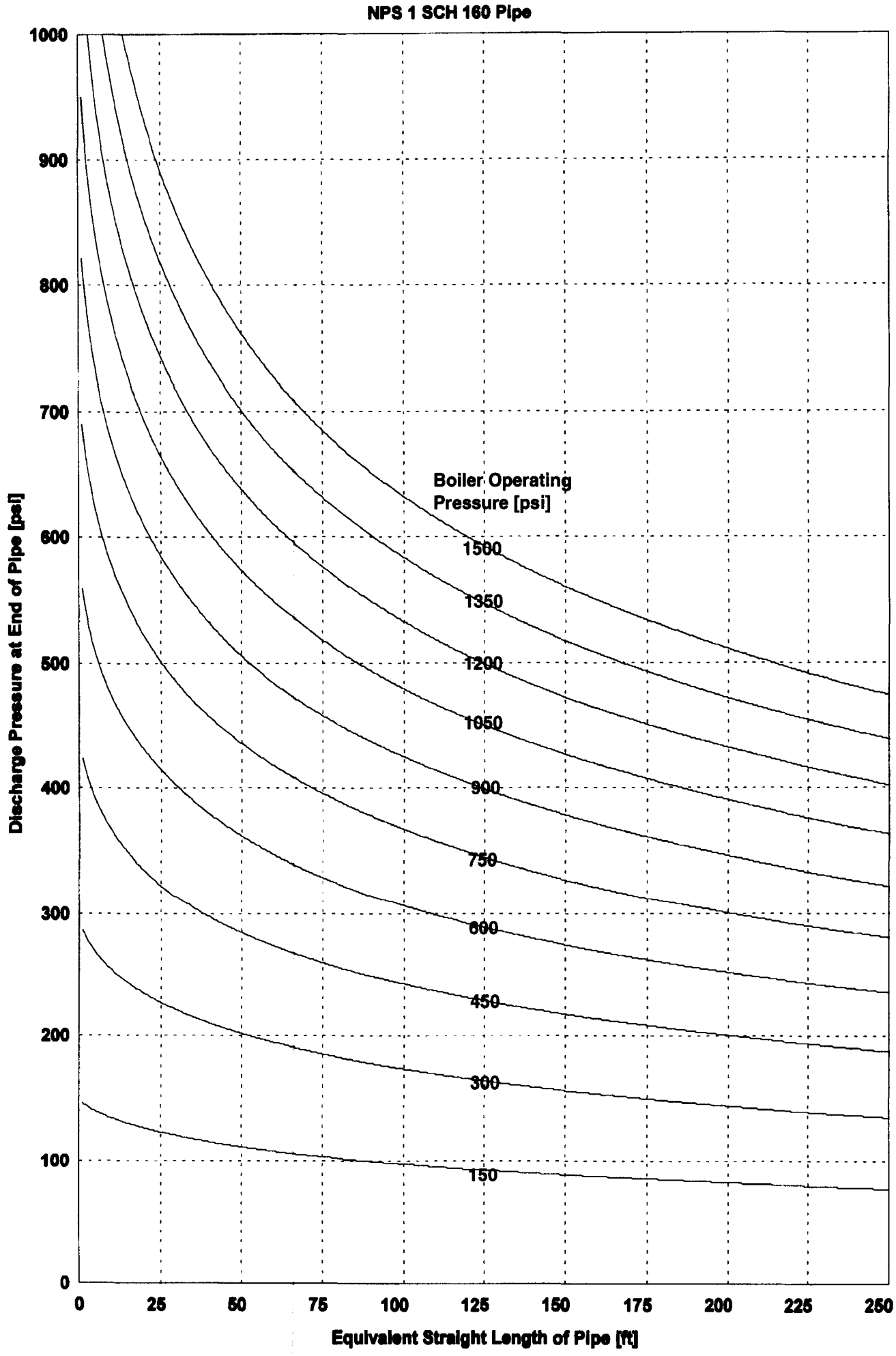
300
0
10
20
30
40
50
60
70
80
90
100


NPS 1 SCH 160 Pipe
Discharge Pressure at End of Pipe [psi]
Equivalent Straight Length of Pipe [ft]
Boiler Operating Pressure [psi]
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1050
900
750
600
450
300
150
0
100
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600
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900
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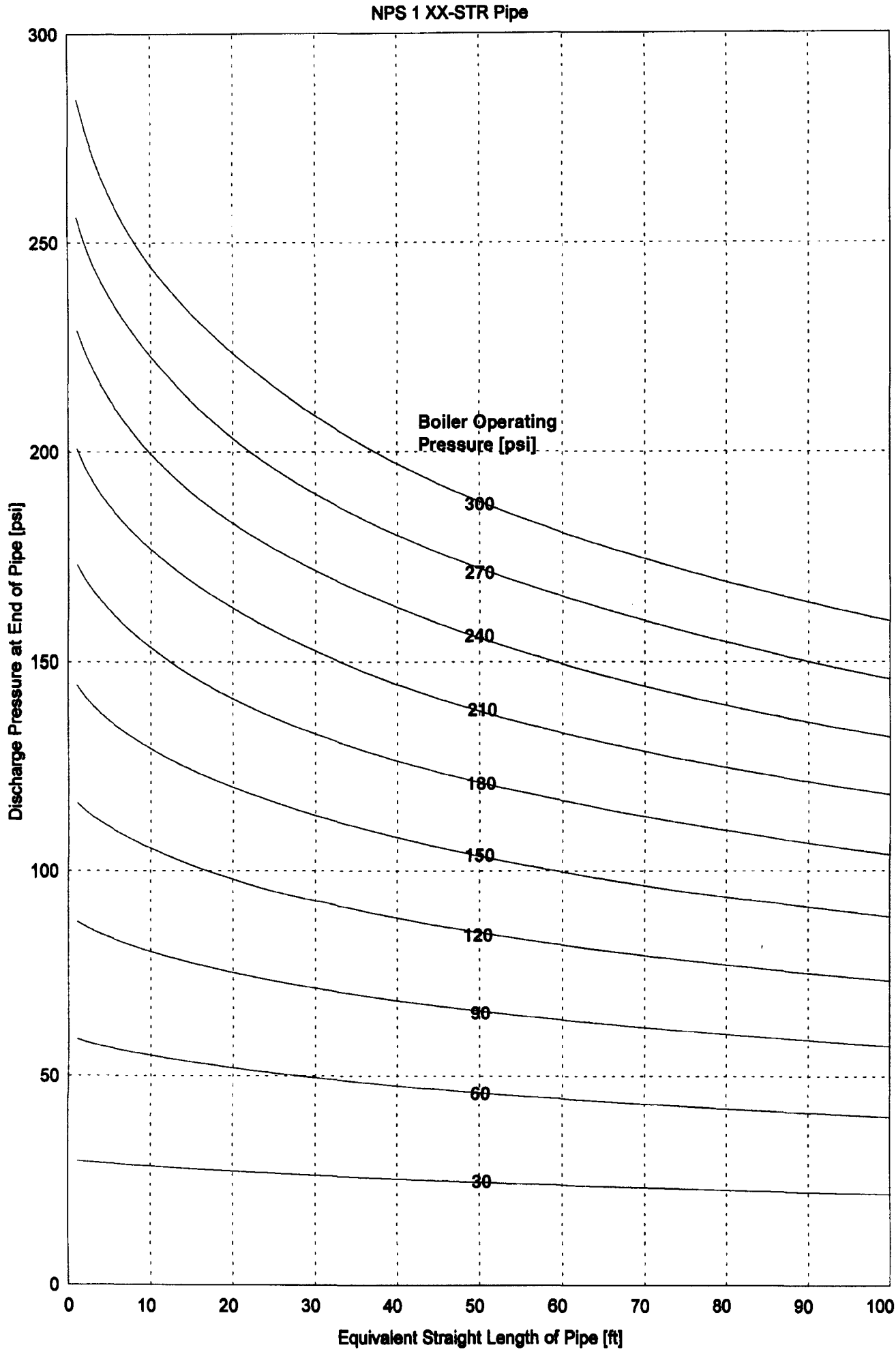
25
50
75
100
125
150
175
200
225
250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Discharge Pressure at End of Pipe [psi]
Equivalent Straight Length of Pipe [ft]
Boiler Operating Pressure [psi]
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120
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20
30
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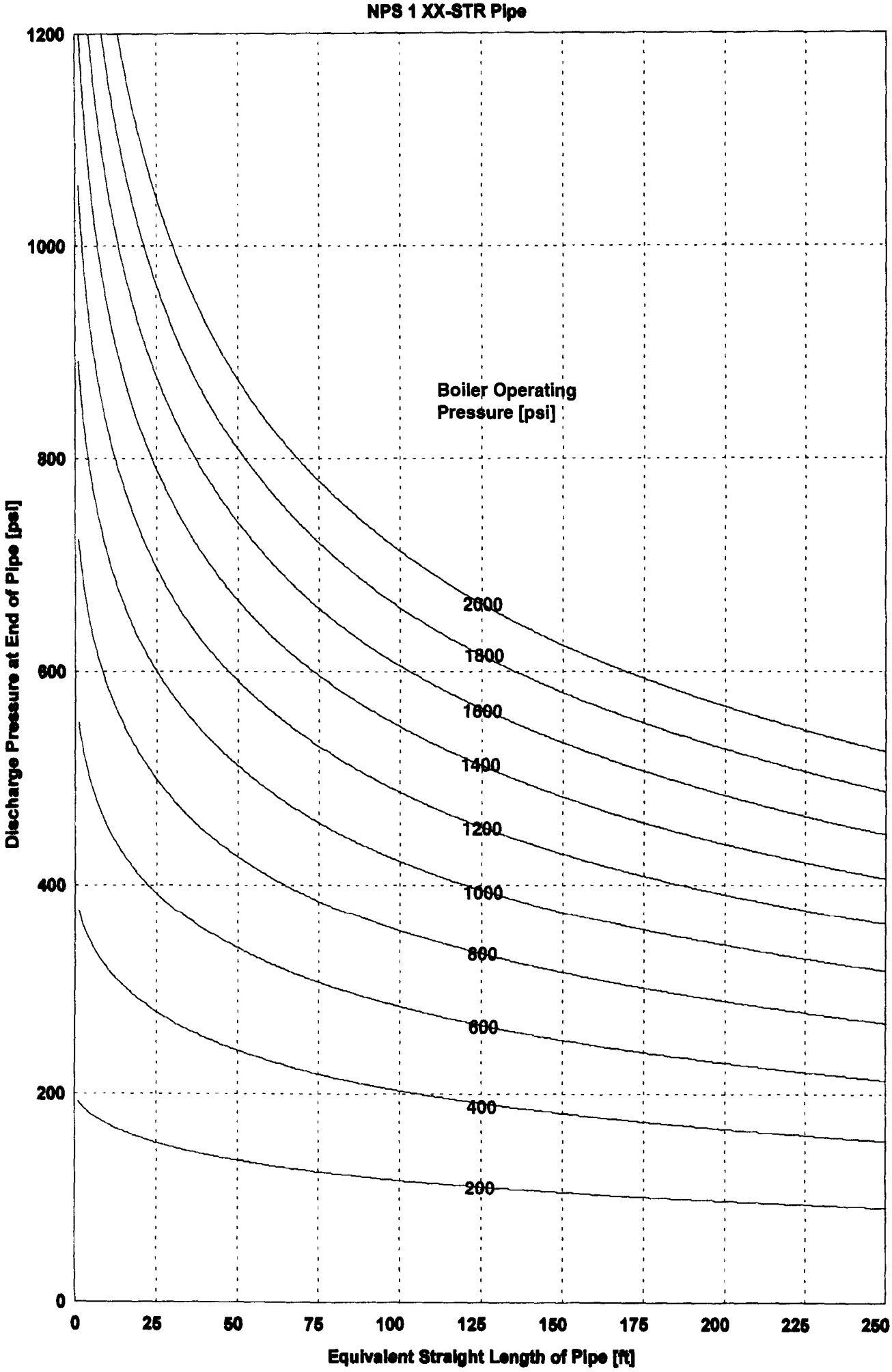
70
80
90
100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Discharge Pressure at End of Pipe [psi]
Equivalent Straight Length of Pipe [ft]
Boiler Operating Pressure [psi]
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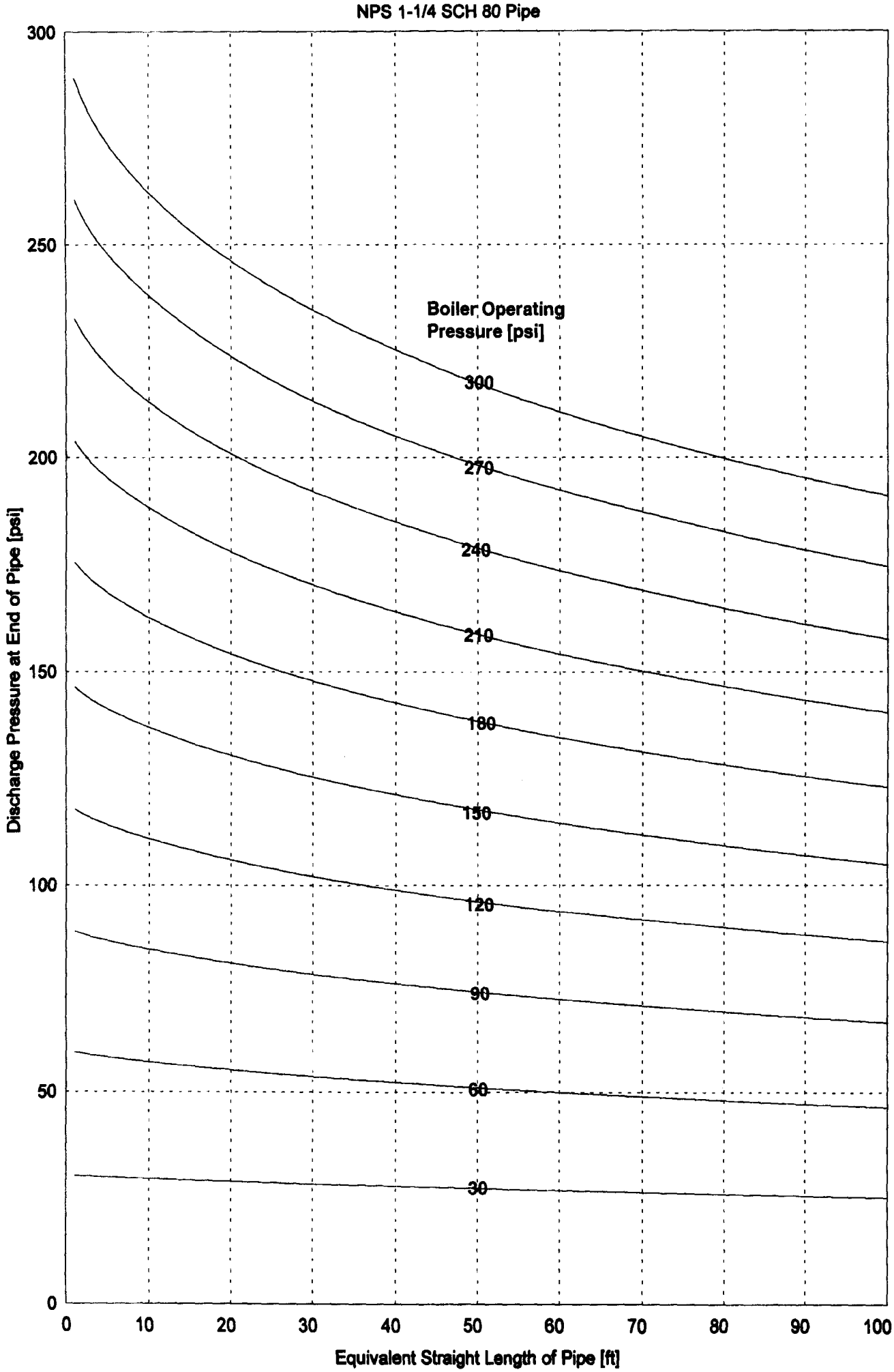
1800
1600
1400
1200
1000
800
600
400
200
0
25
50
75
100
125
150
175
200
225
250
1200
1000
800
600
400
200
0


NPS 1-1/4 SCH 80 Pipe
Boiler Operating Pressure [psi]
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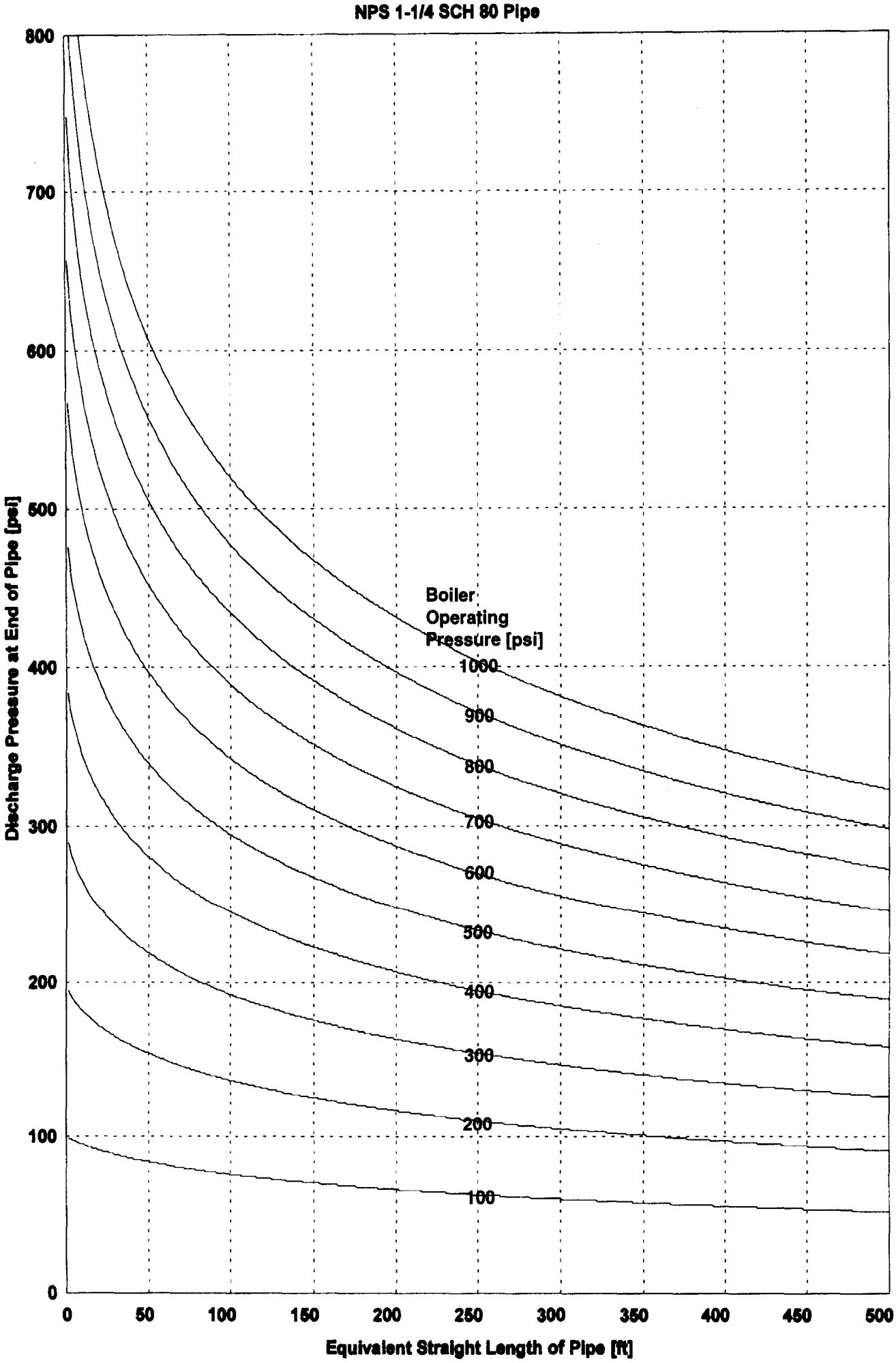
270
240
210
180
150
120
90
60
30
Discharge Pressure at End of Pipe [psi]
0
50
100
150
200
250
300
0
10
20
30
40
50
60
70
80
90
100
Equivalent Straight Length of Pipe [ft]


NPS 1-1/4 SCH 80 Pipe
Discharge Pressure at End of Pipe [psi]
Equivalent Straight Length of Pipe [ft]
Boiler Operating Pressure [psi]
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900
800
700
600
500
400
300
200
100
0
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200
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350
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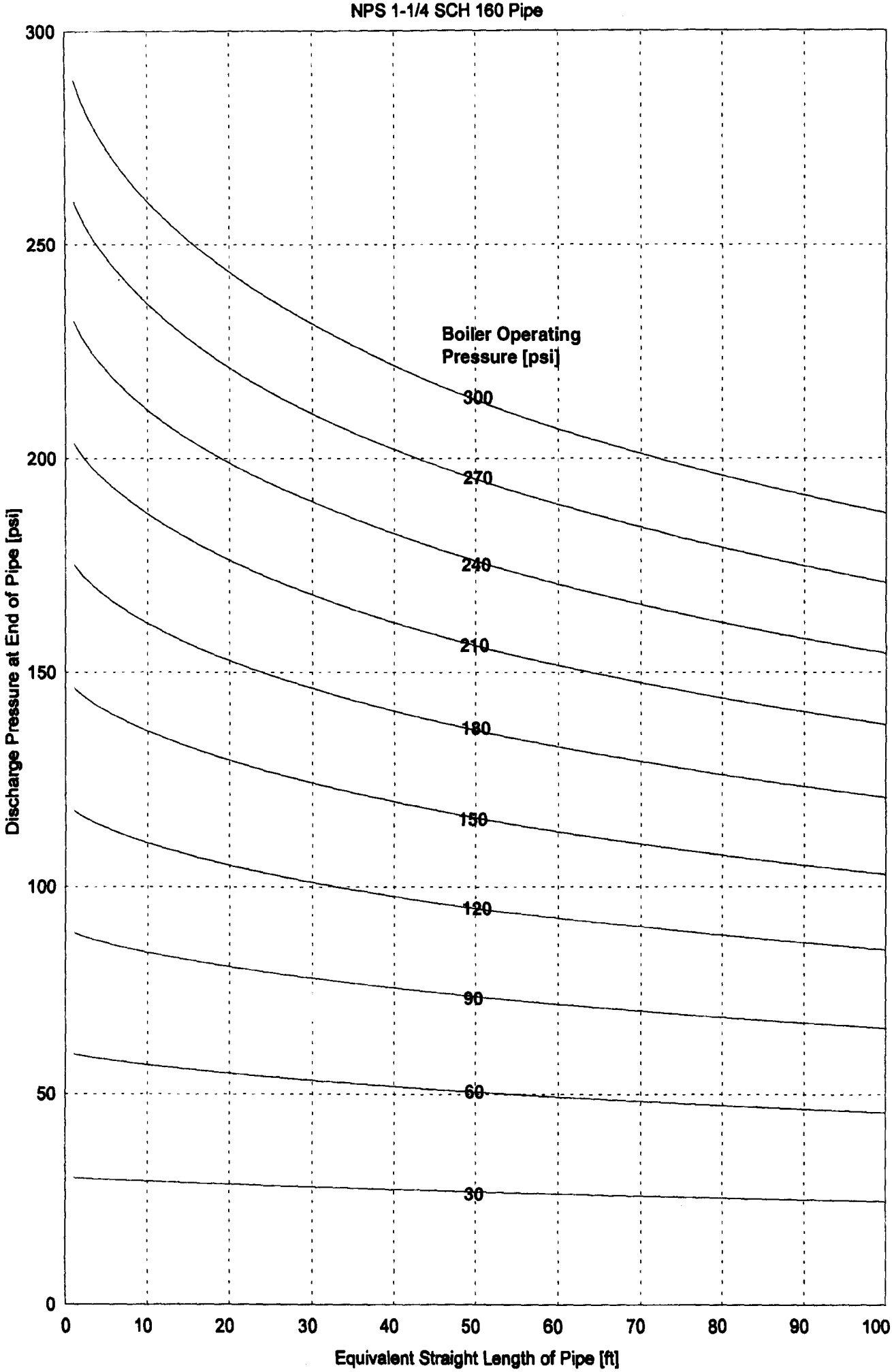
450
500
0
100
200
300
400
500
600
700
800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Discharge Pressure at End of Pipe [psi]
Equivalent Straight Length of Pipe [ft]
Boiler Operating Pressure [psi]
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180
150
120
90
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30
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150
200
250
300
0
10
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30
40
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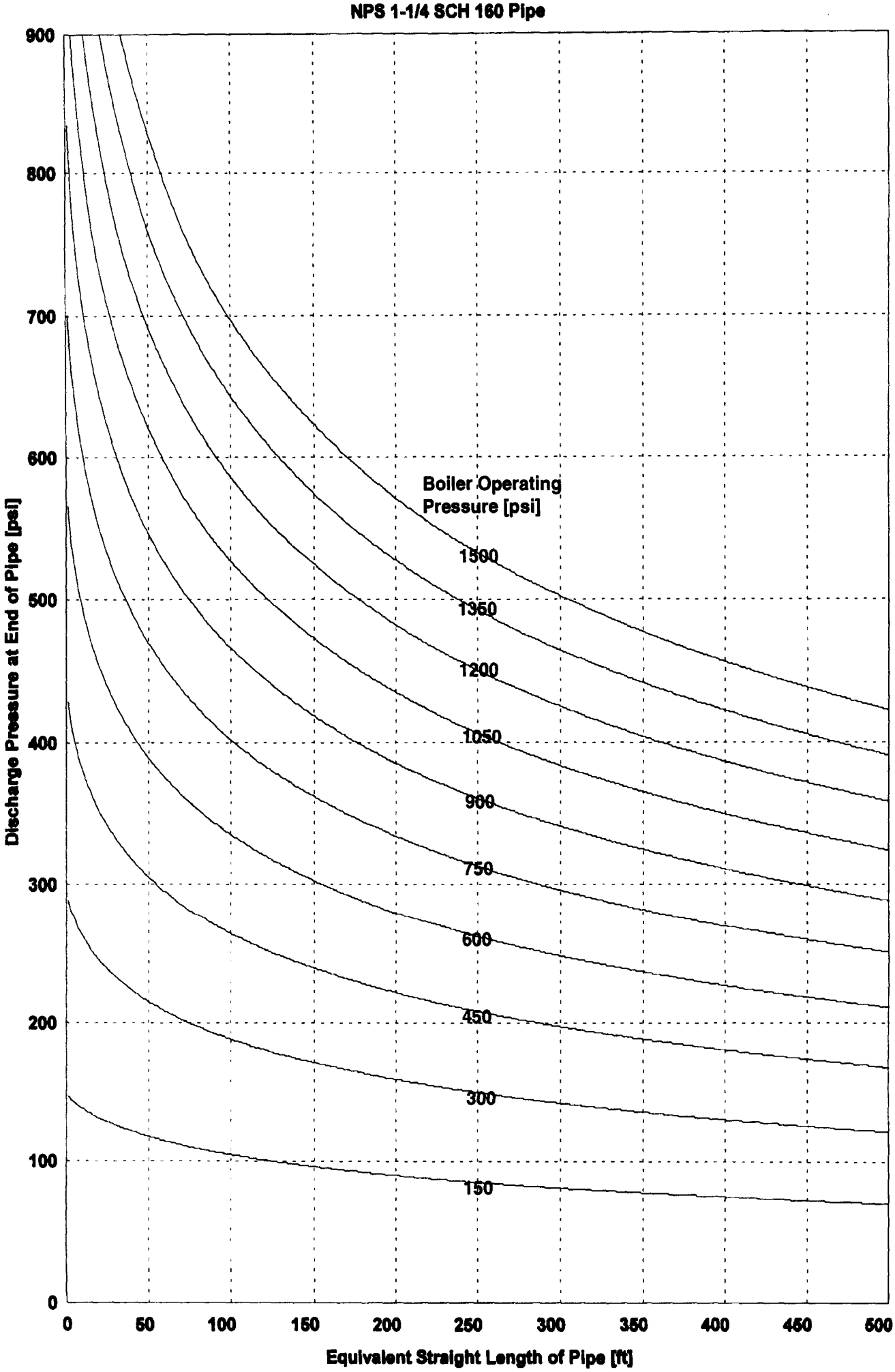
80
90
100


NPS 1-1/4 SCH 160 Pipe
Discharge Pressure at End of Pipe [psi]
Equivalent Straight Length of Pipe [ft]
Boiler Operating Pressure [psi]
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1350
1200
1050
900
750
600
450
300
150
0
100
200
300
400
500
600
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800
900
0
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100
150
200
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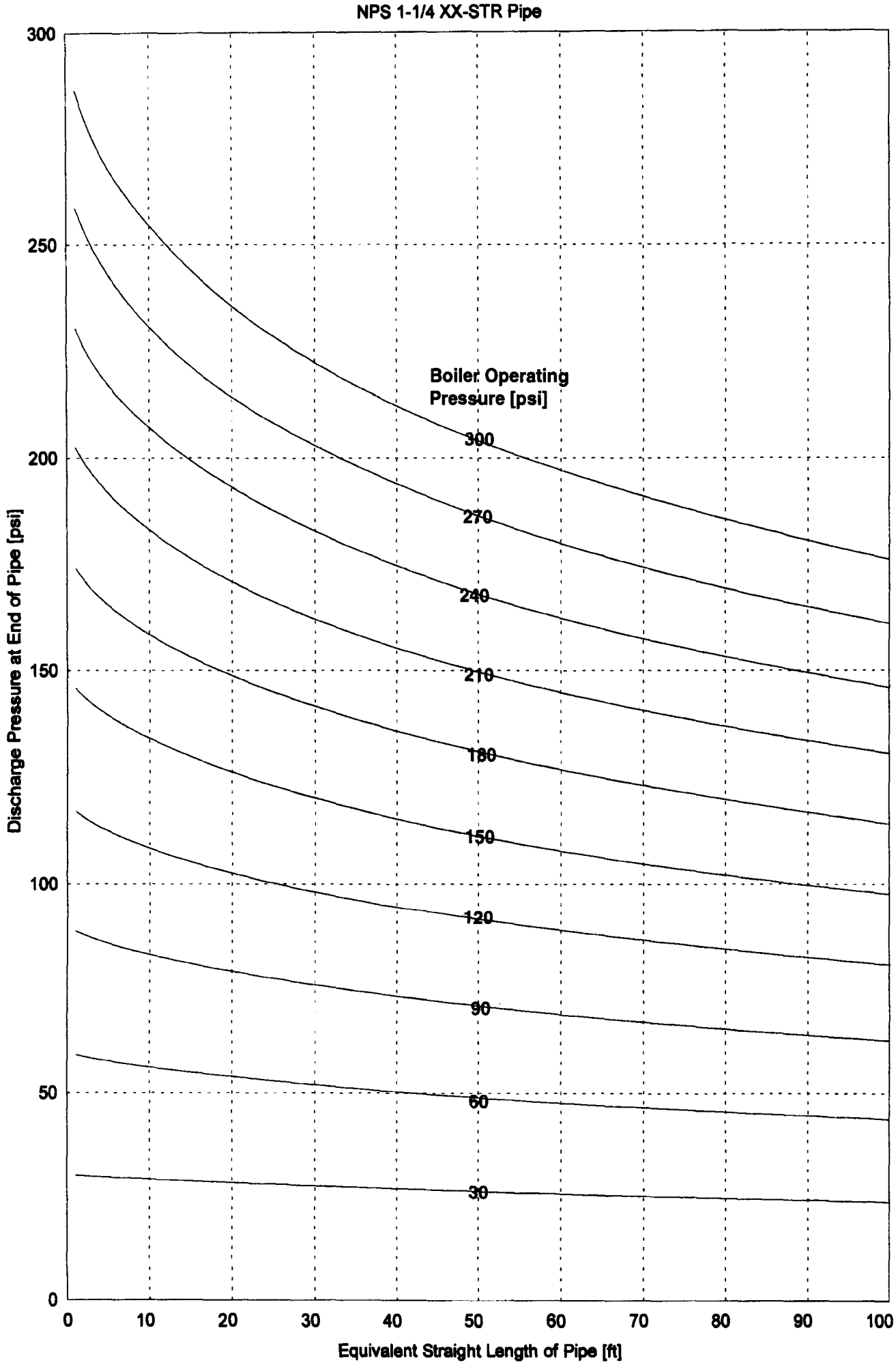
300
350
400
450
500


NPS 1-1/4 XX-STR Pipe
Discharge Pressure at End of Pipe [psi]
Equivalent Straight Length of Pipe [ft]
Boiler Operating Pressure [psi]
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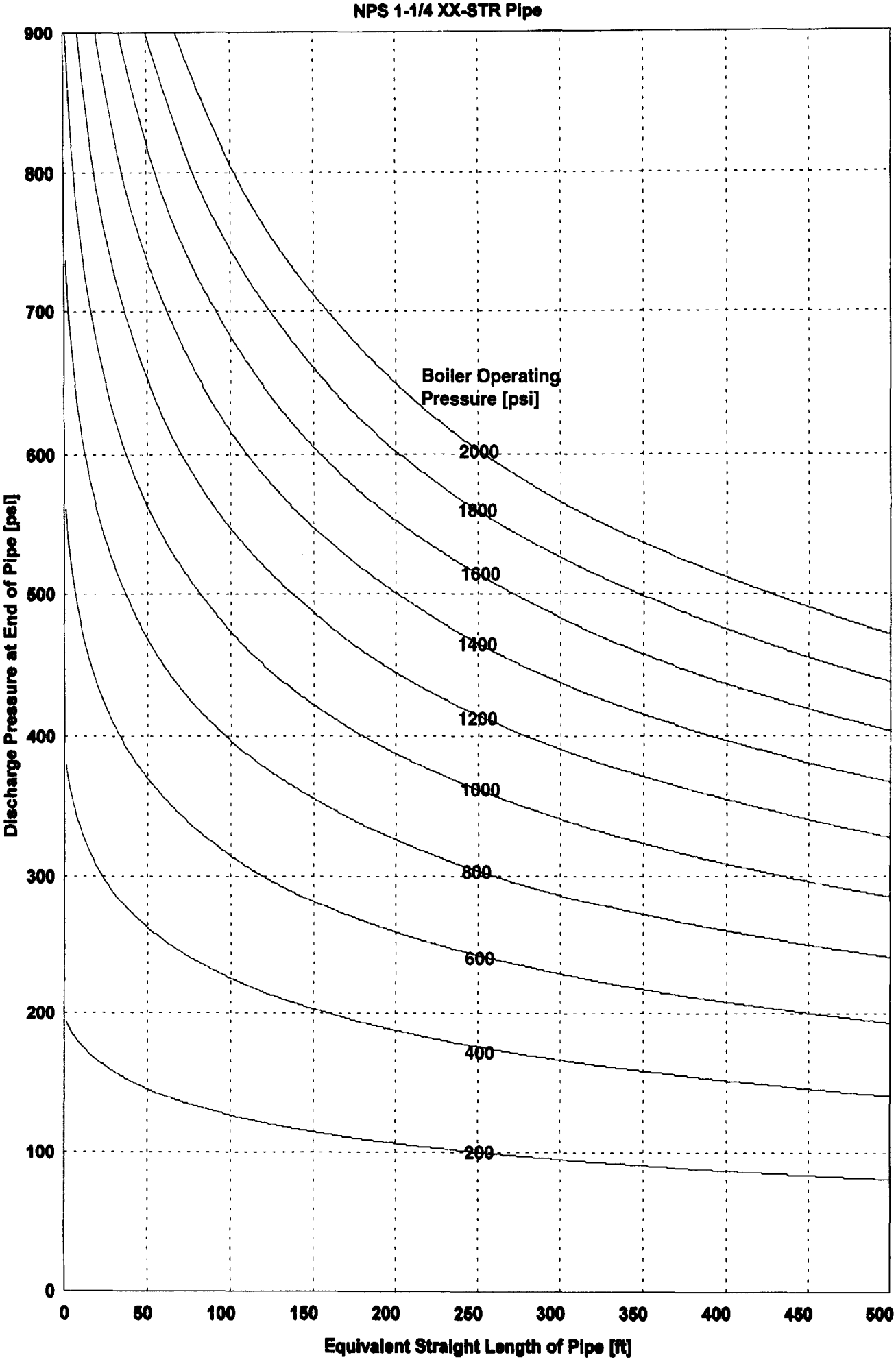
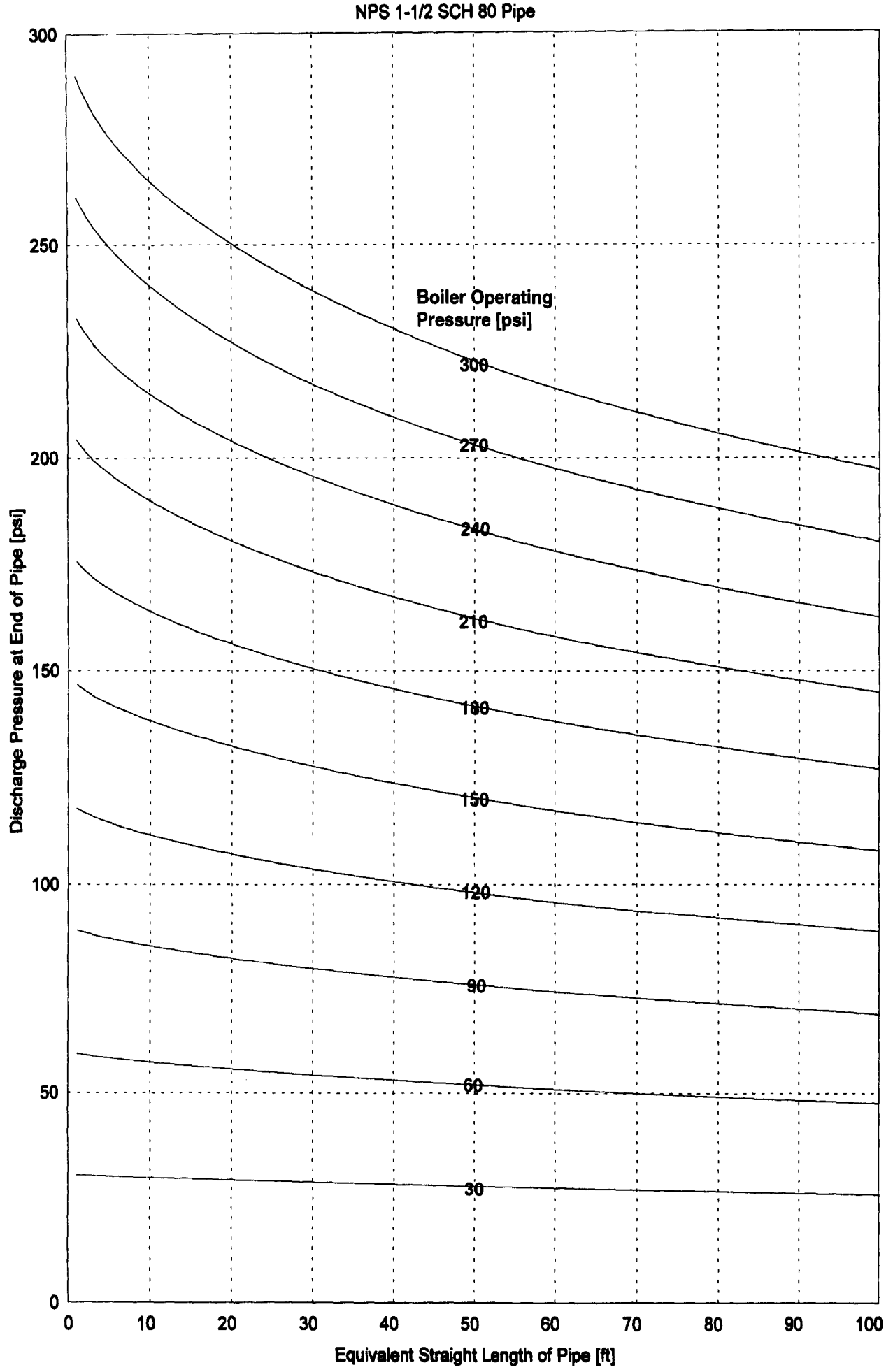
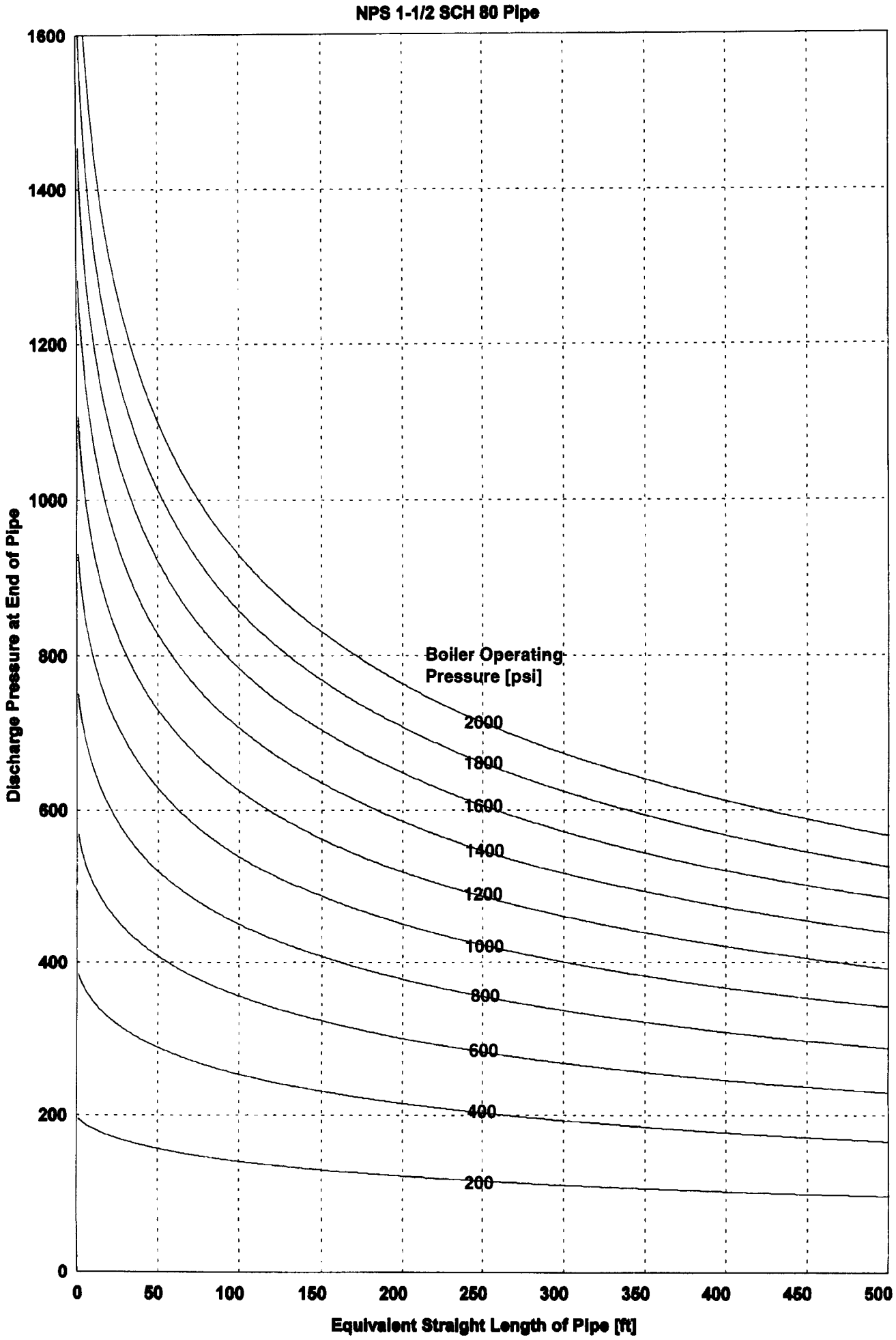
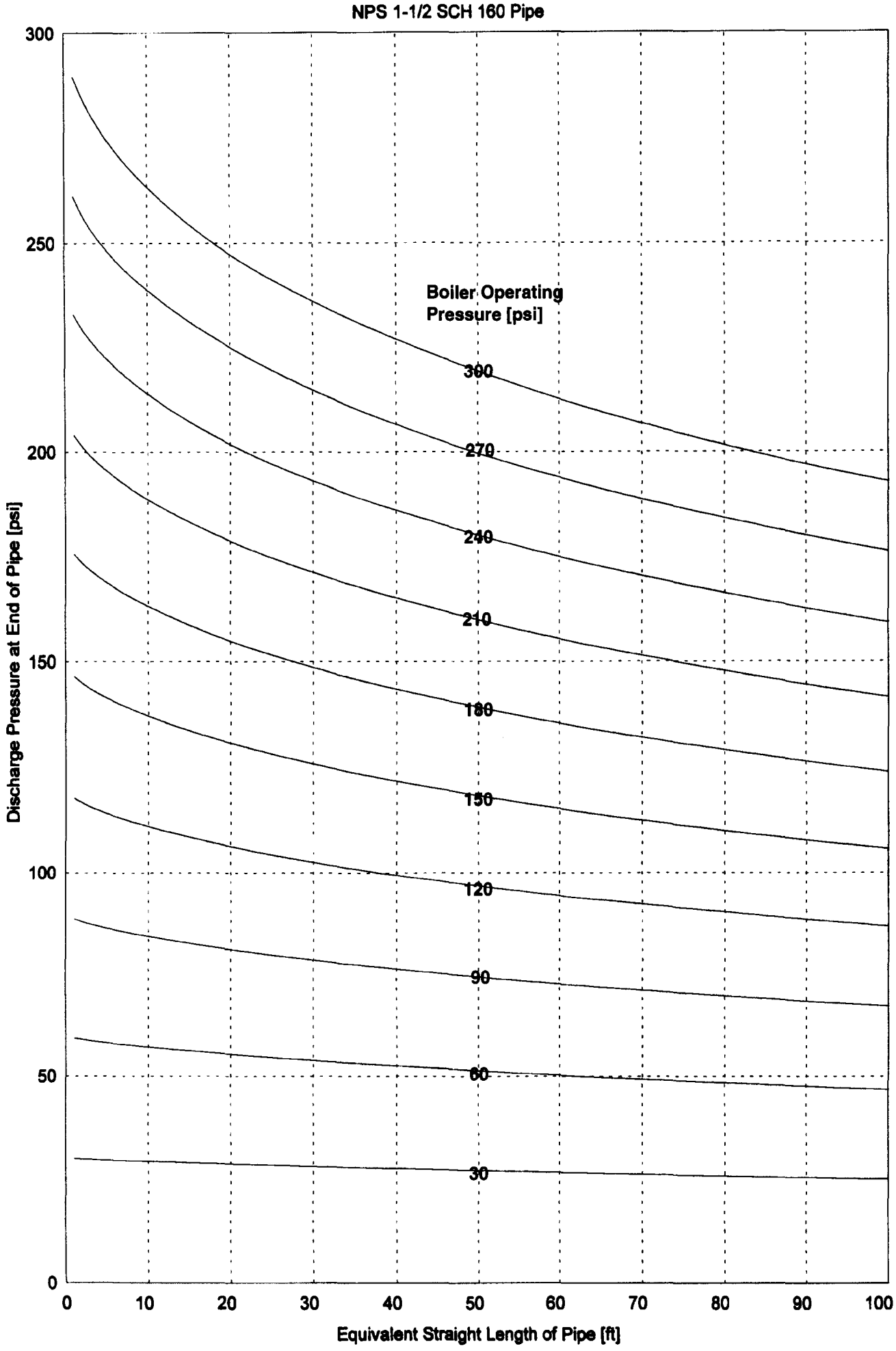
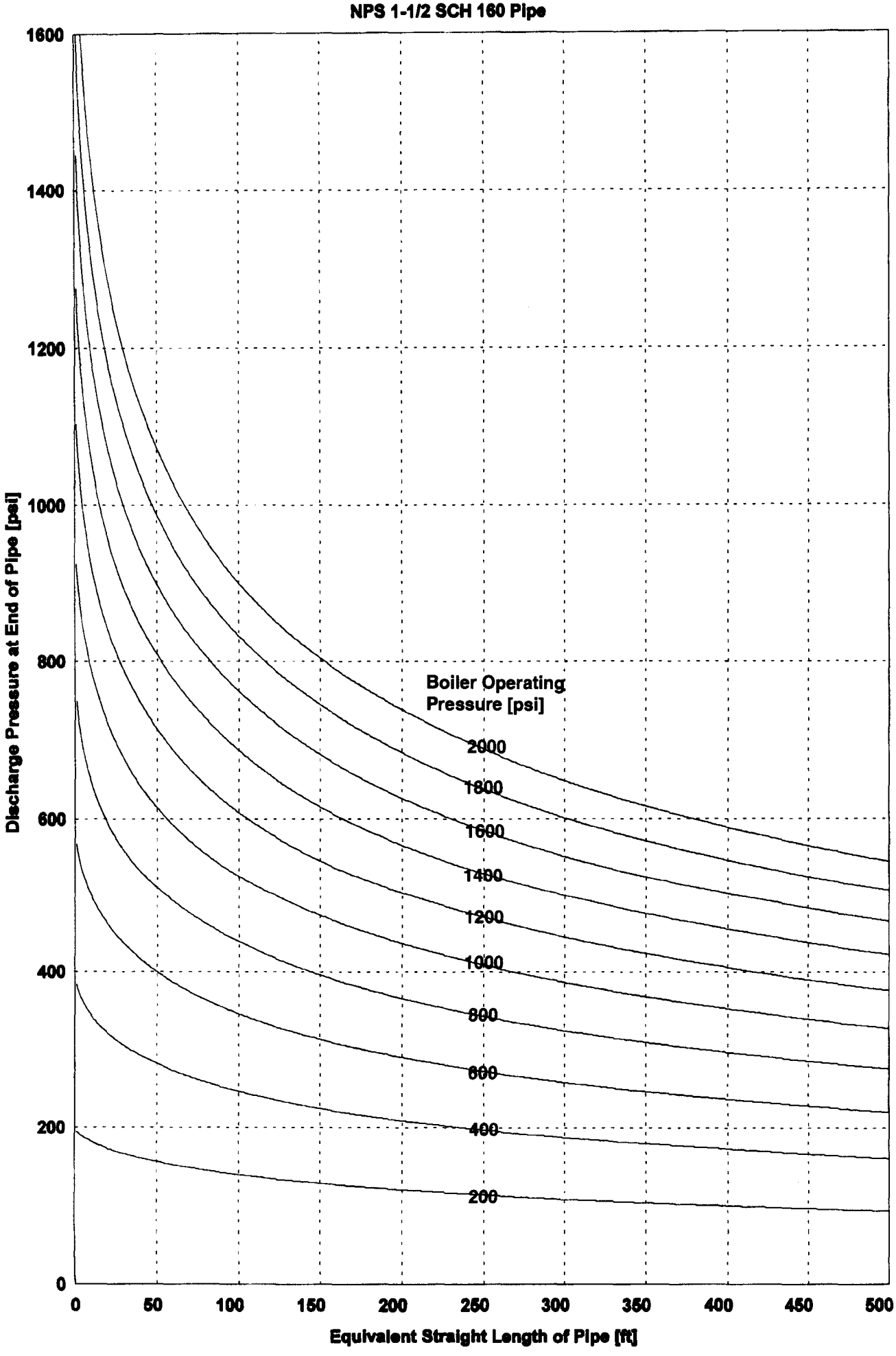
270
240
210
180
150
120
90
60
30
0
50
100
150
200
250
300
0
10
20
30
40
50
60
70
80
90
100

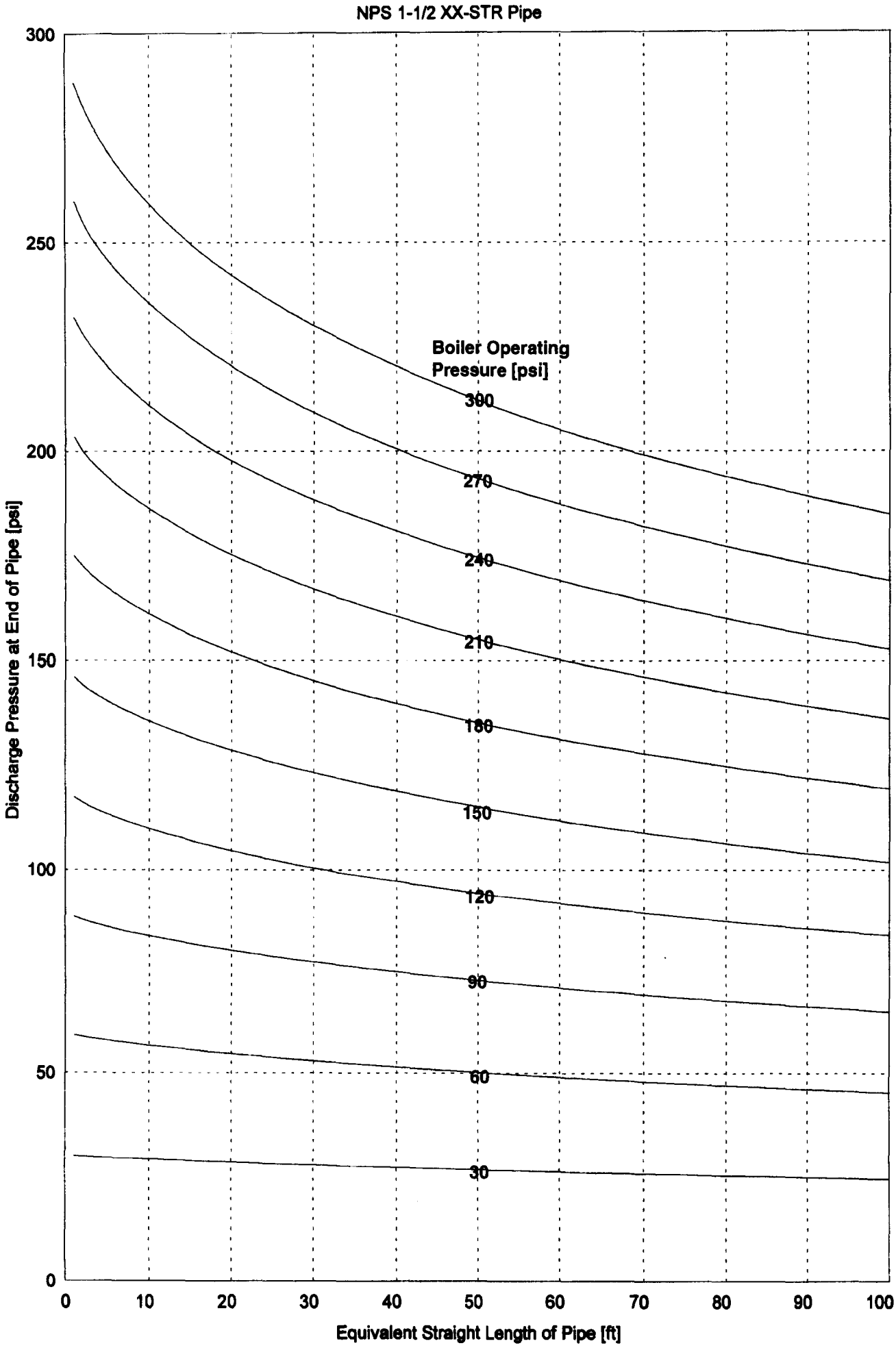

NPS 1-1/4 XX-STR Pipe
Discharge Pressure at End of Pipe [psi]
Equivalent Straight Length of Pipe [ft]
Boiler Operating Pressure [psi]
2000
1800
1600
1400
1200
1000
800
600
400
200
0
50
100
150
200
250
300
350
400
450
500
100
200
300
400
500
600
700
800
900

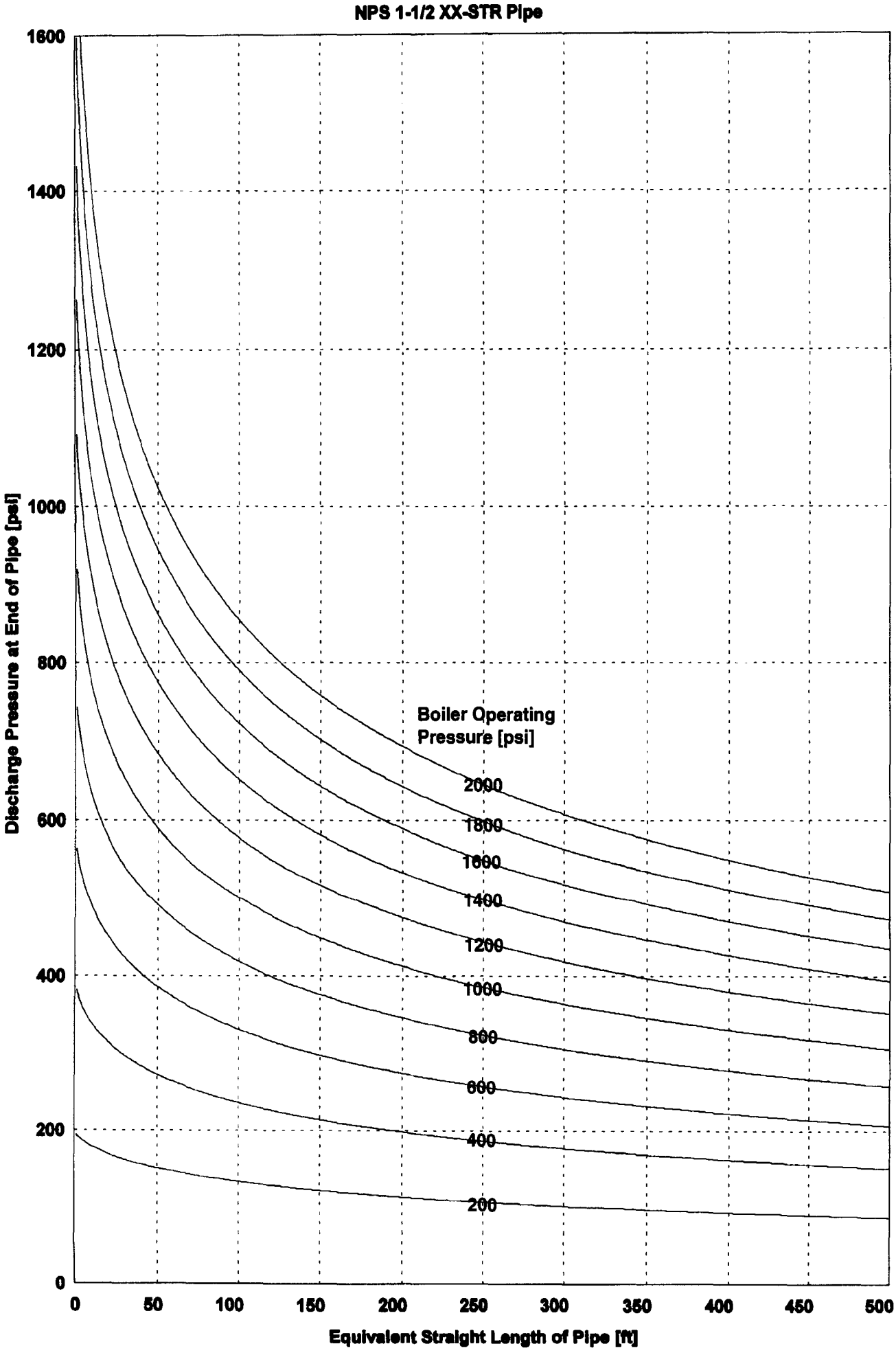

NPS 1-1/2 SCH 80 Pipe
Discharge Pressure at End of Pipe [psi]
Equivalent Straight Length of Pipe [ft]
Boiler Operating Pressure [psi]
300
270
240
210
180
150
120
90
60
30
0
50
100
150
200
250
300
0
10
20
30
40
50
60
70
80
90
100

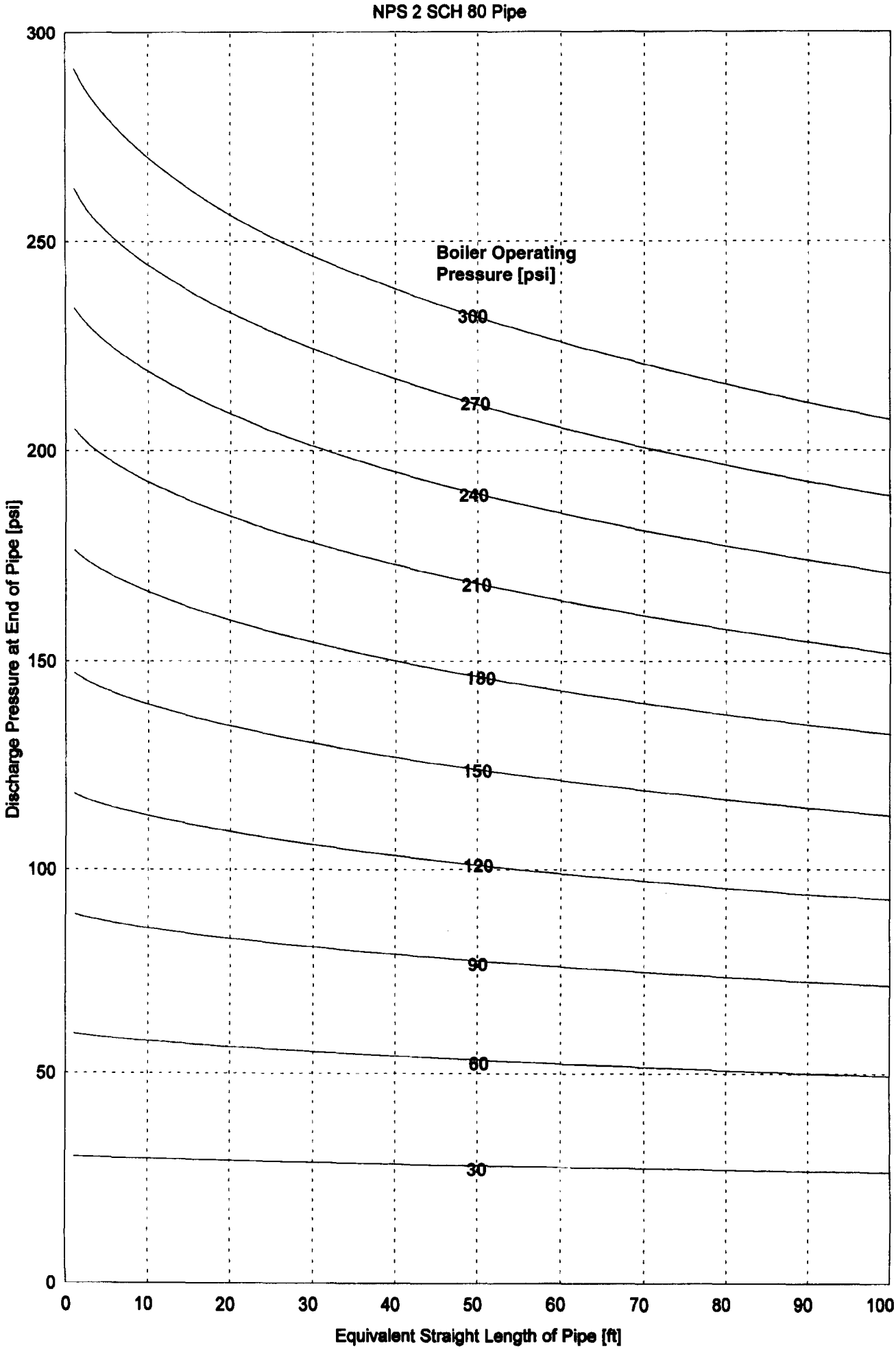

NPS 1-1/2 SCH 80 Pipe
Discharge Pressure at End of Pipe
Equivalent Straight Length of Pipe [ft]
Boiler Operating Pressure [psi]
2000
1800
1600
1400
1200
1000
800
600
400
200
0
50
100
150
200
250
300
350
400
450
500

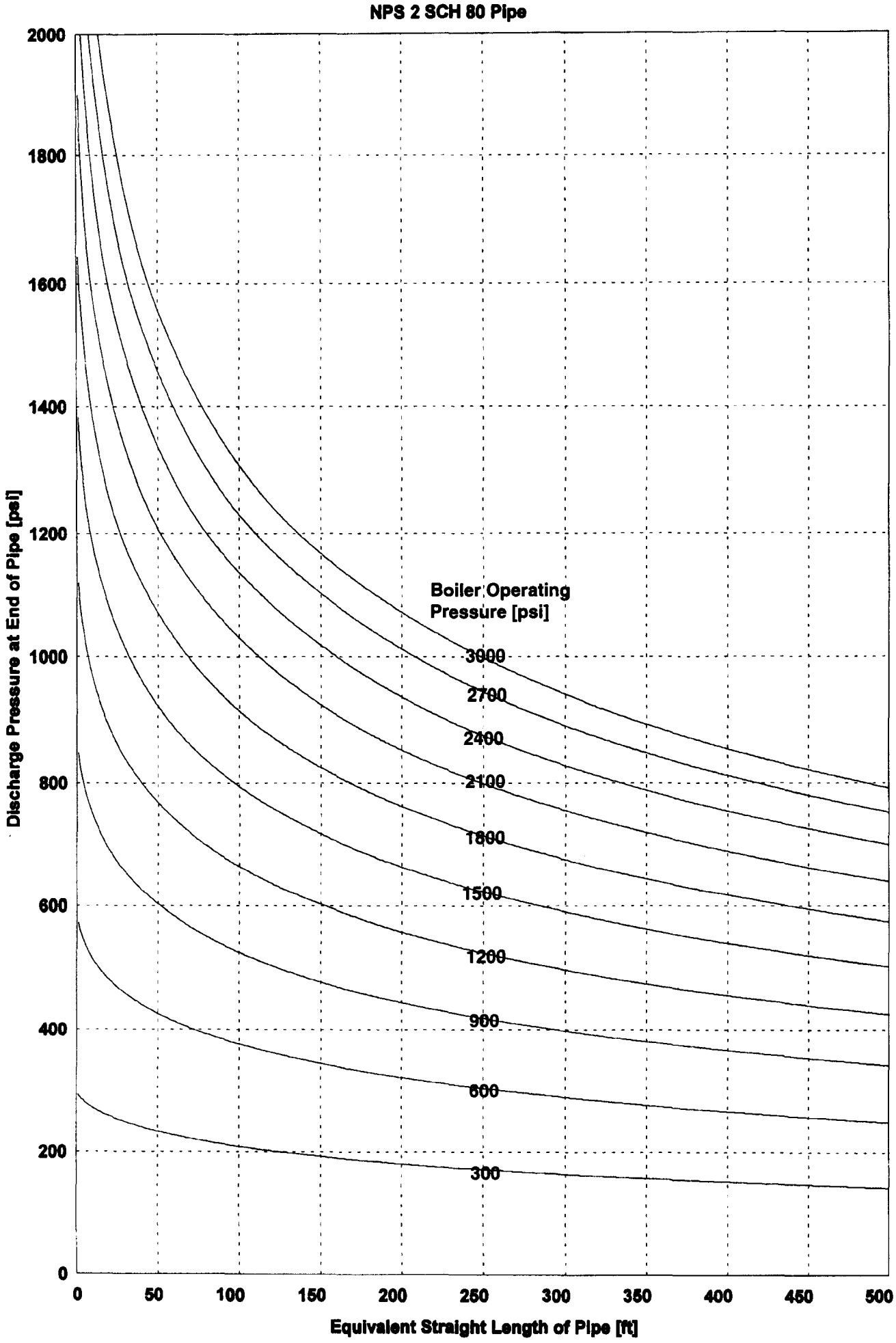

NPS 1-1/2 SCH 160 Pipe
Boiler Operating Pressure [psi]
300
270
240
210
180
150
120
90
60
30
Discharge Pressure at End of Pipe [psi]
0
50
100
150
200
250
300
0
10
20
30
40
50
60
70
80
90
100
Equivalent Straight Length of Pipe [ft]

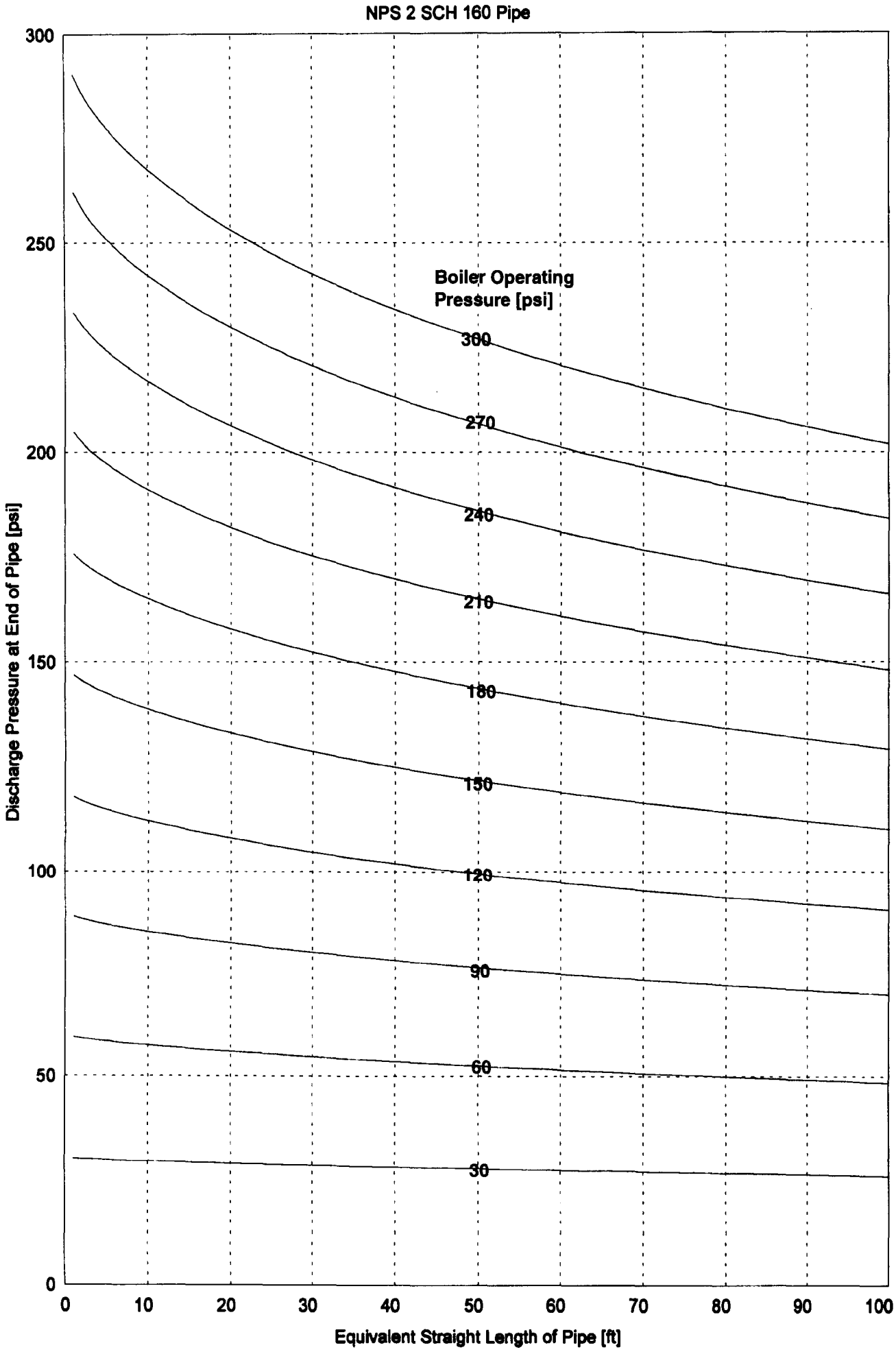

NPS 1-1/2 SCH 160 Pipe
Discharge Pressure at End of Pipe [psi]
Equivalent Straight Length of Pipe [ft]
Boiler Operating Pressure [psi]
2000
1800
1600
1400
1200
1000
800
600
400
200
0
50
100
150
200
250
300
350
400
450
500
1600
1400
1200
1000
800
600
400
200
0

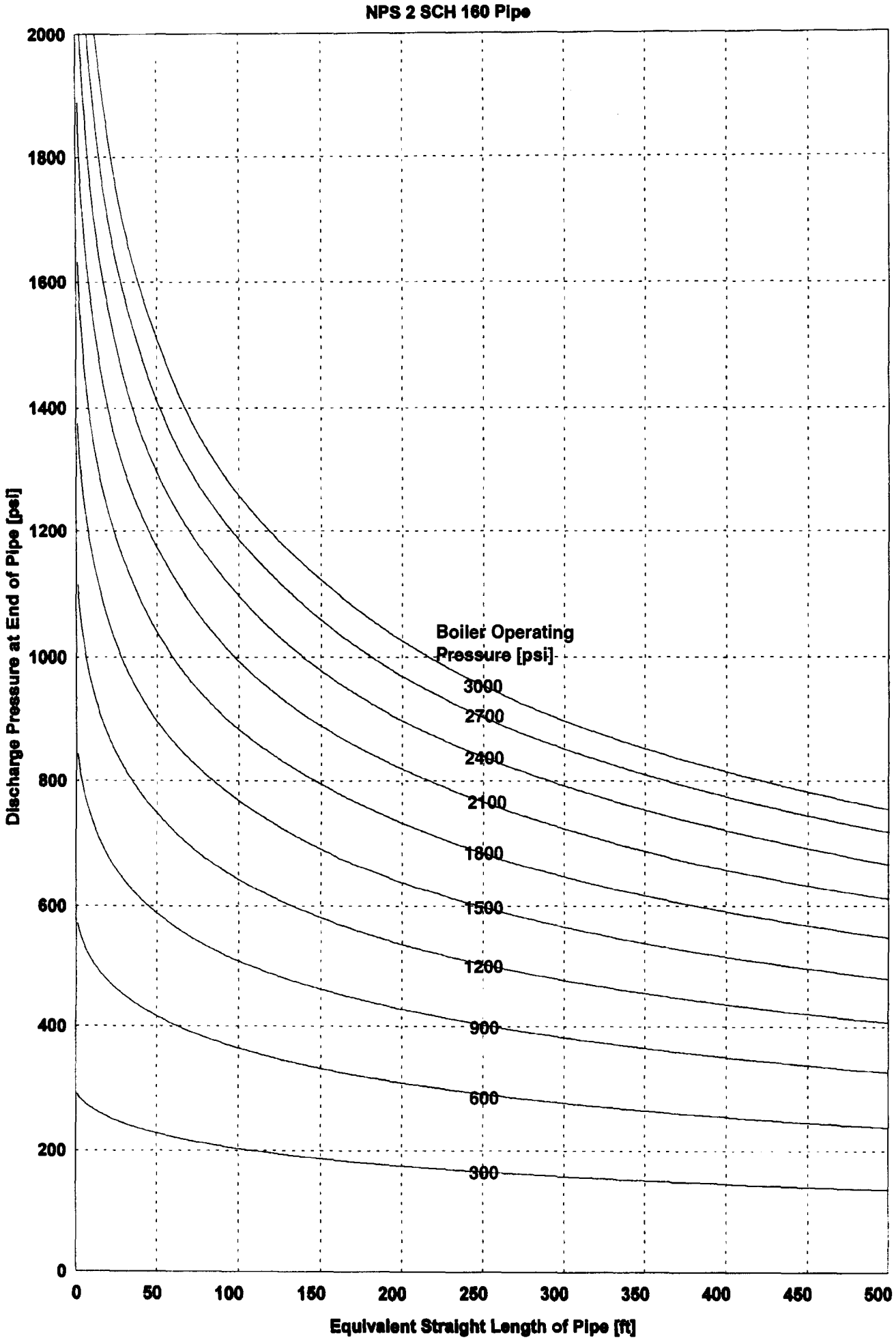

NPS 1-1/2 XX-STR Pipe
Discharge Pressure at End of Pipe [psi]
Equivalent Straight Length of Pipe [ft]
Boiler Operating Pressure [psi]
300
270
240
210
180
150
120
90
60
30
0
50
100
150
200
250
300
0
10
20
30
40
50
60
70
80
90
100

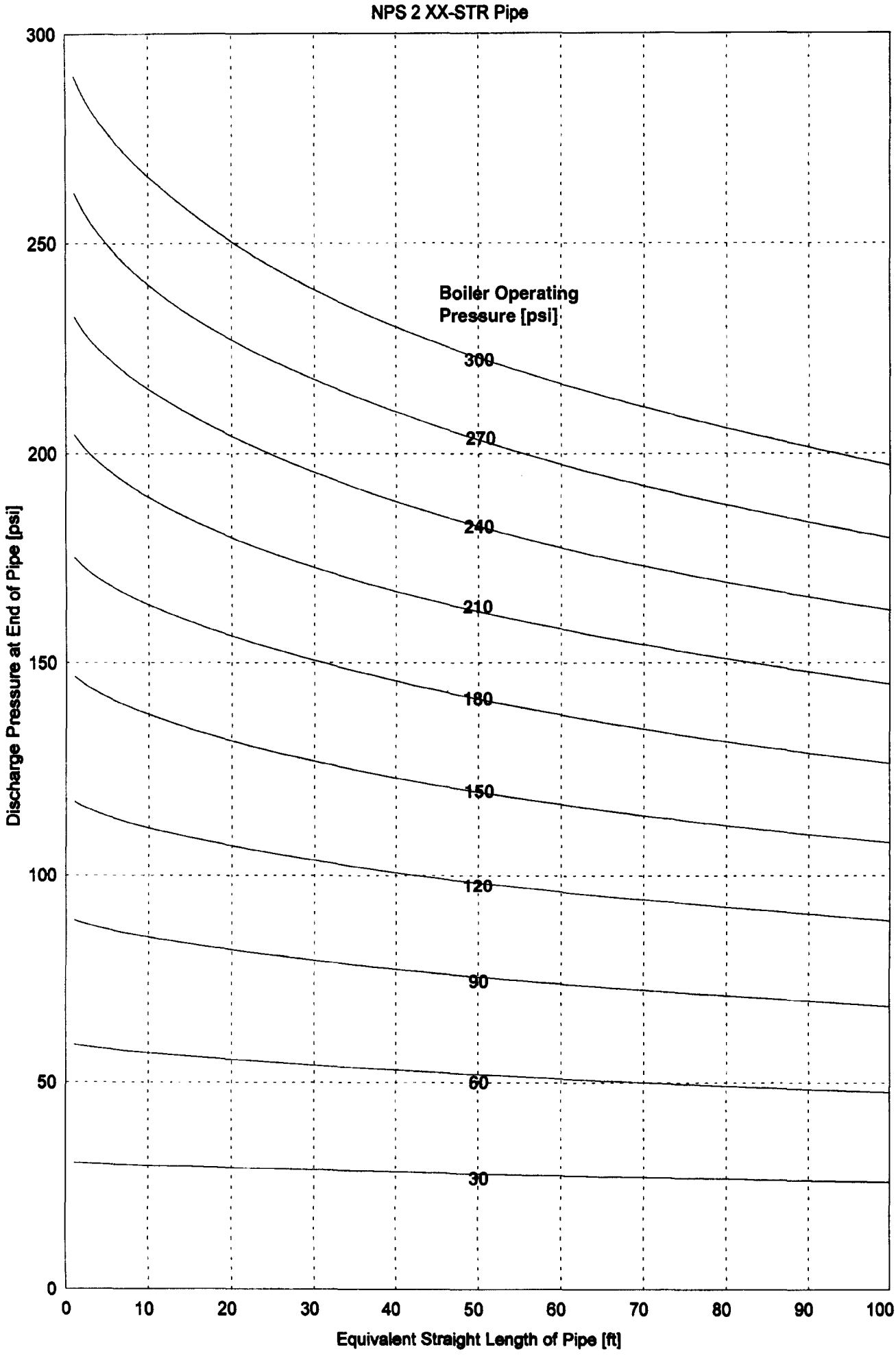

NPS 1-1/2 XX-STR Pipe
Discharge Pressure at End of Pipe [psi]
Equivalent Straight Length of Pipe [ft]
Boiler Operating Pressure [psi]
2000
1800
1600
1400
1200
1000
800
600
400
200
0
50
100
150
200
250
300
350
400
450
500
1600
1400
1200
1000
800
600
400
200
0

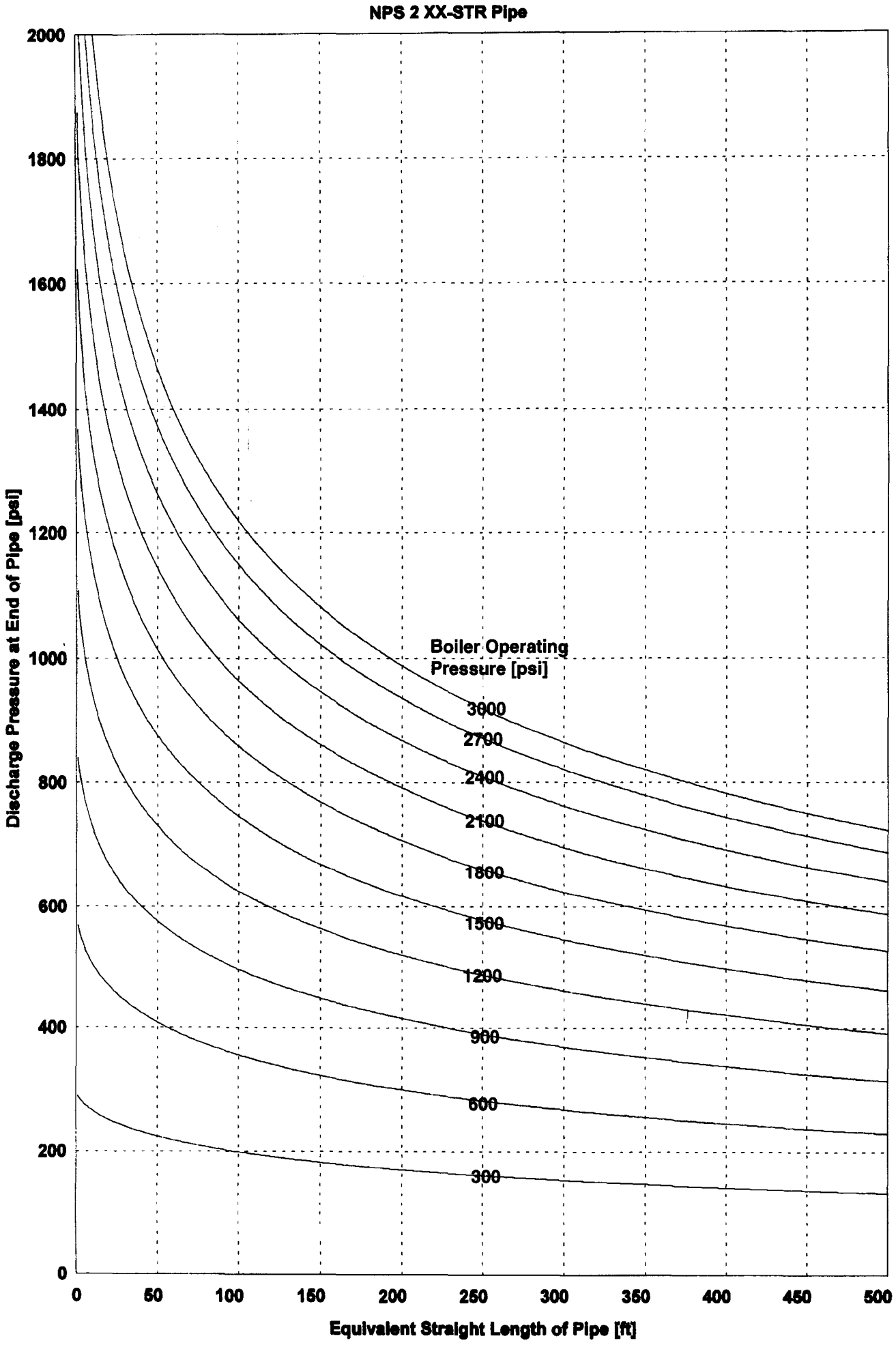

NPS 2 SCH 80 Pipe
Boiler Operating Pressure [psi]
300
270
240
210
180
150
120
90
60
30
Discharge Pressure at End of Pipe [psi]
0
50
100
150
200
250
300
0
10
20
30
40
50
60
70
80
90
100
Equivalent Straight Length of Pipe [ft]

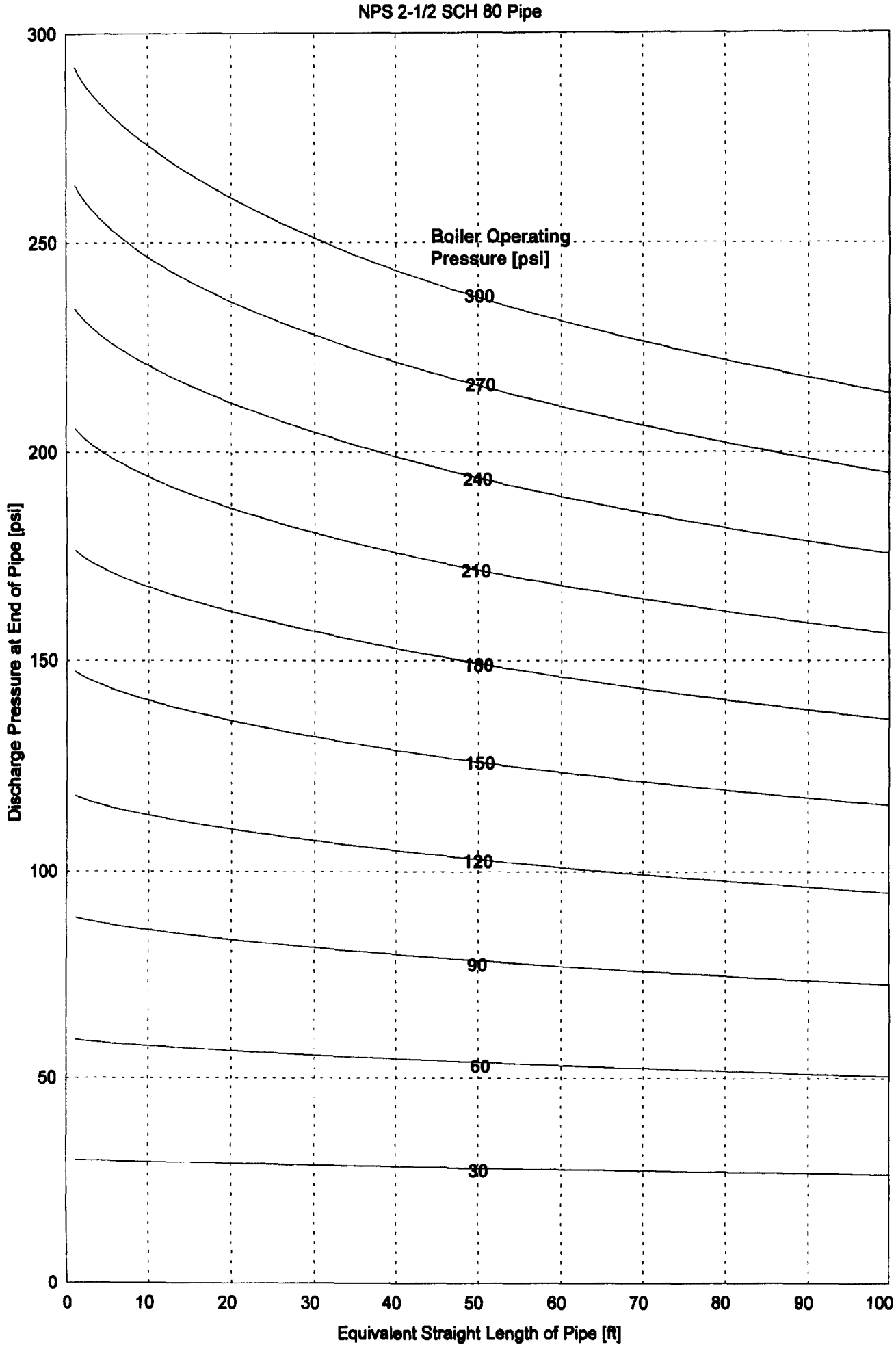

NPS 2 SCH 80 Pipe
Discharge Pressure at End of Pipe [psi]
Equivalent Straight Length of Pipe [ft]
Boiler Operating Pressure [psi]
3000
2700
2400
2100
1800
1500
1200
900
600
300
0
200
400
600
800
1000
1200
1400
1600
1800
2000
0
50
100
150
200
250
300
350
400
450
500

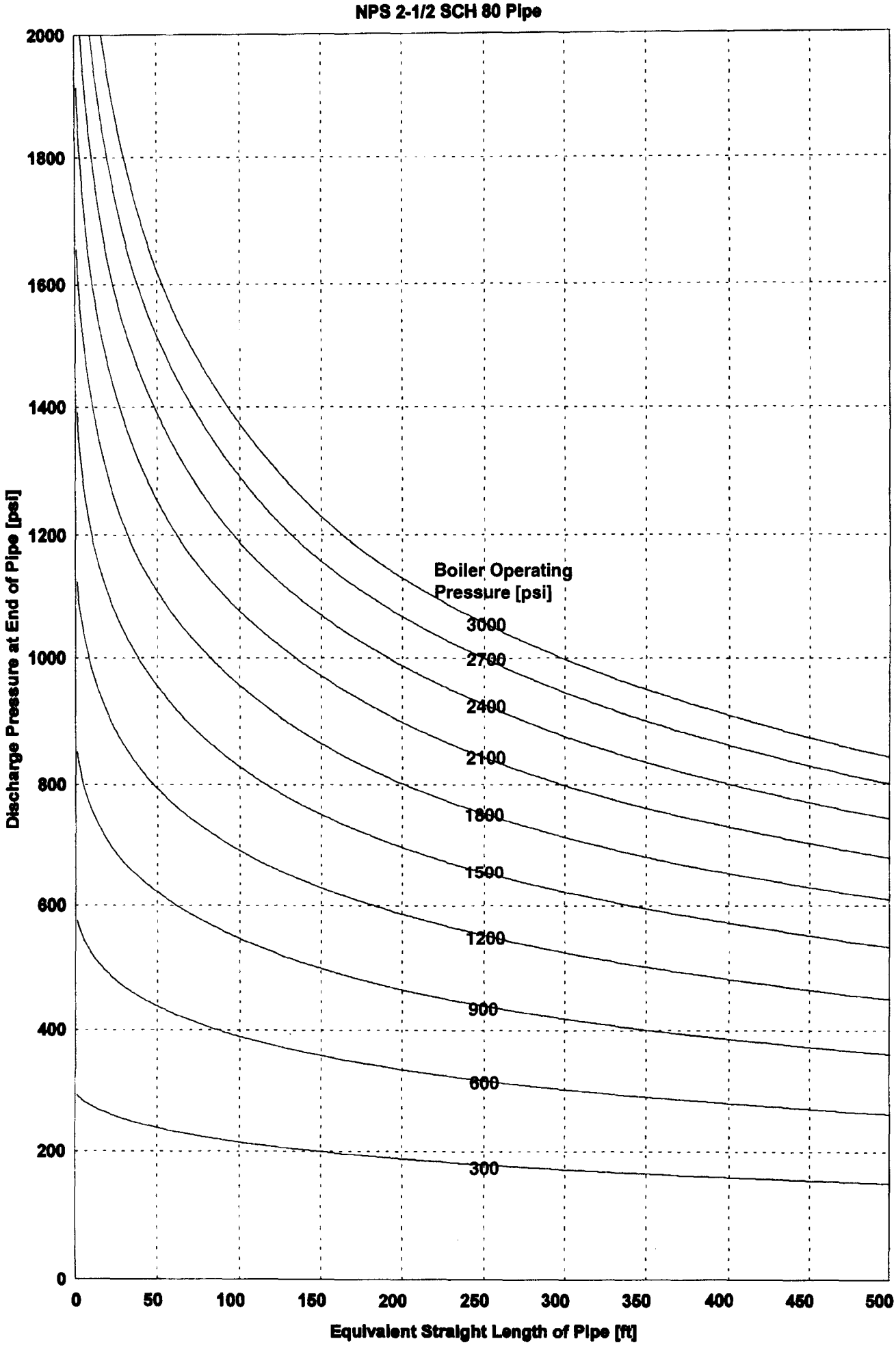

NPS 2 SCH 160 Pipe
Boiler Operating Pressure [psi]
300
270
240
210
180
150
120
90
60
30
Discharge Pressure at End of Pipe [psi]
0
50
100
150
200
250
300
0
10
20
30
40
50
60
70
80
90
100
Equivalent Straight Length of Pipe [ft]

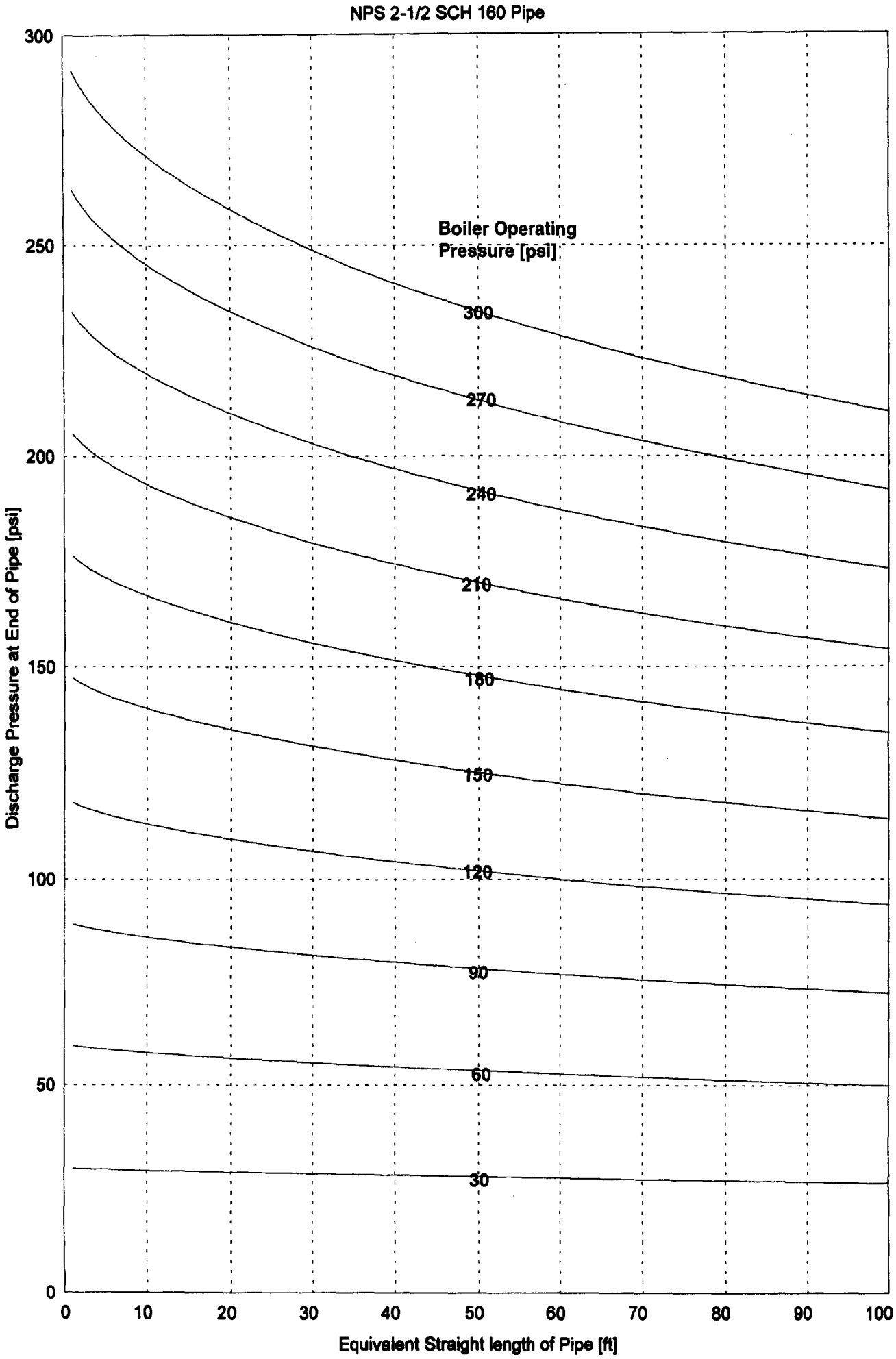

NPS 2 SCH 160 Pipe
Discharge Pressure at End of Pipe [psi]
Equivalent Straight Length of Pipe [ft]
Boiler Operating Pressure [psi]
3000
2700
2400
2100
1800
1500
1200
900
600
300
0
200
400
600
800
1000
1200
1400
1600
1800
2000
0
50
100
150
200
250
300
350
400
450
500

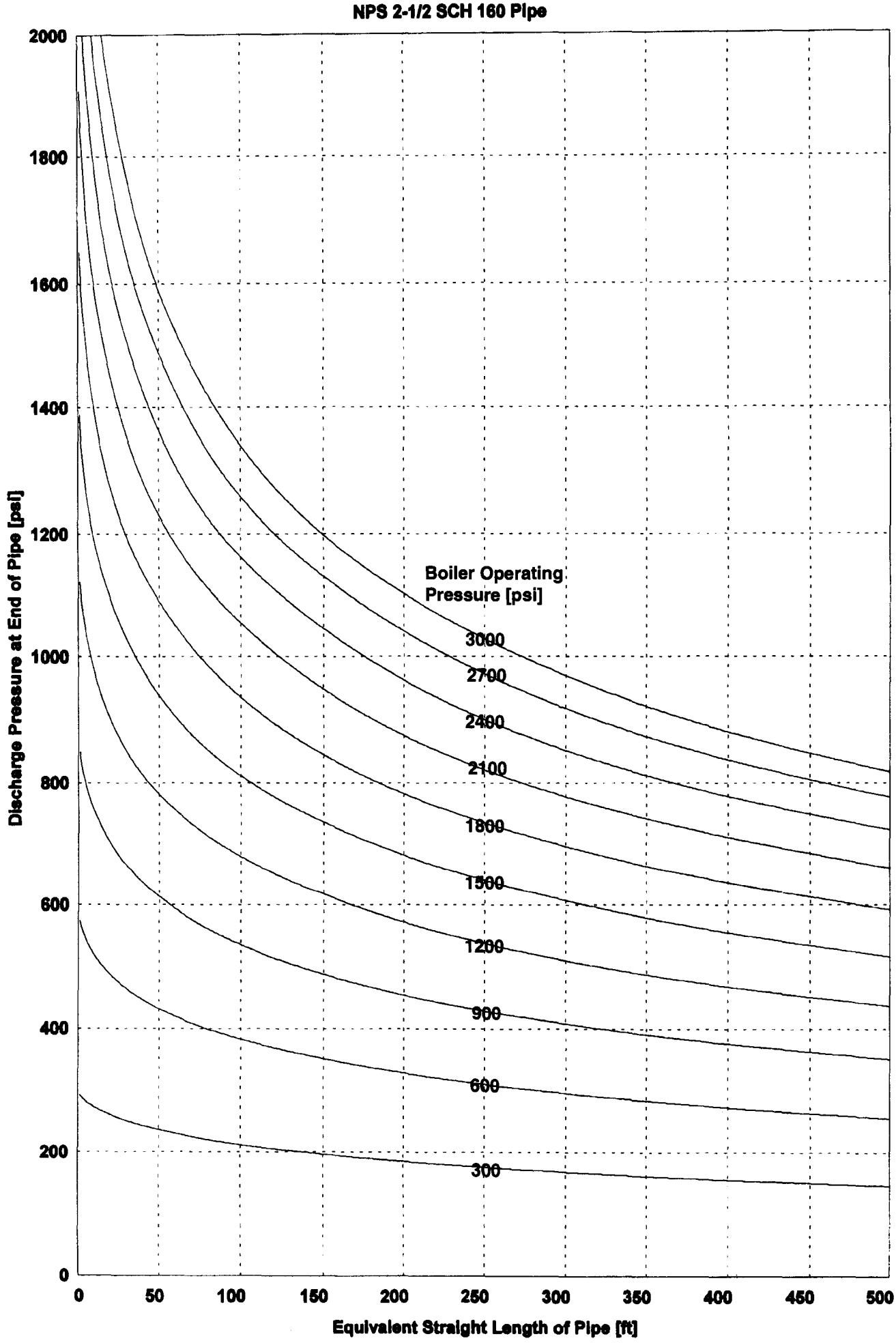

NPS 2 XX-STR Pipe
Discharge Pressure at End of Pipe [psi]
Equivalent Straight Length of Pipe [ft]
Boiler Operating Pressure [psi]
300
270
240
210
180
150
120
90
60
30
0
50
100
150
200
250
300
0
10
20
30
40
50
60
70
80
90
100

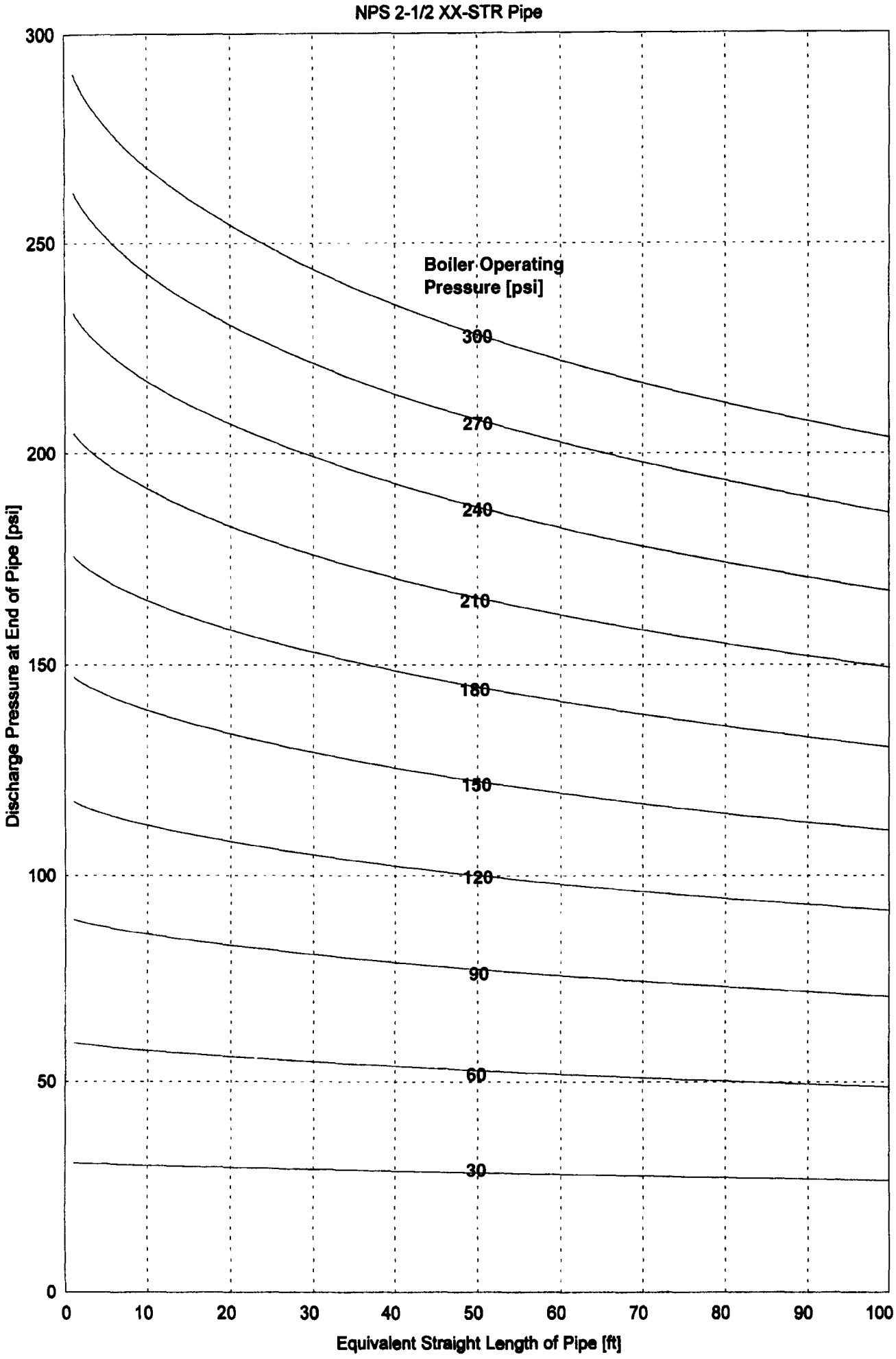

NPS 2 XX-STR Pipe
Discharge Pressure at End of Pipe [psi]
Equivalent Straight Length of Pipe [ft]
Boiler Operating Pressure [psi]
3000
2700
2400
2100
1800
1500
1200
900
600
300
0
200
400
600
800
1000
1200
1400
1600
1800
2000
0
50
100
150
200
250
300
350
400
450
500

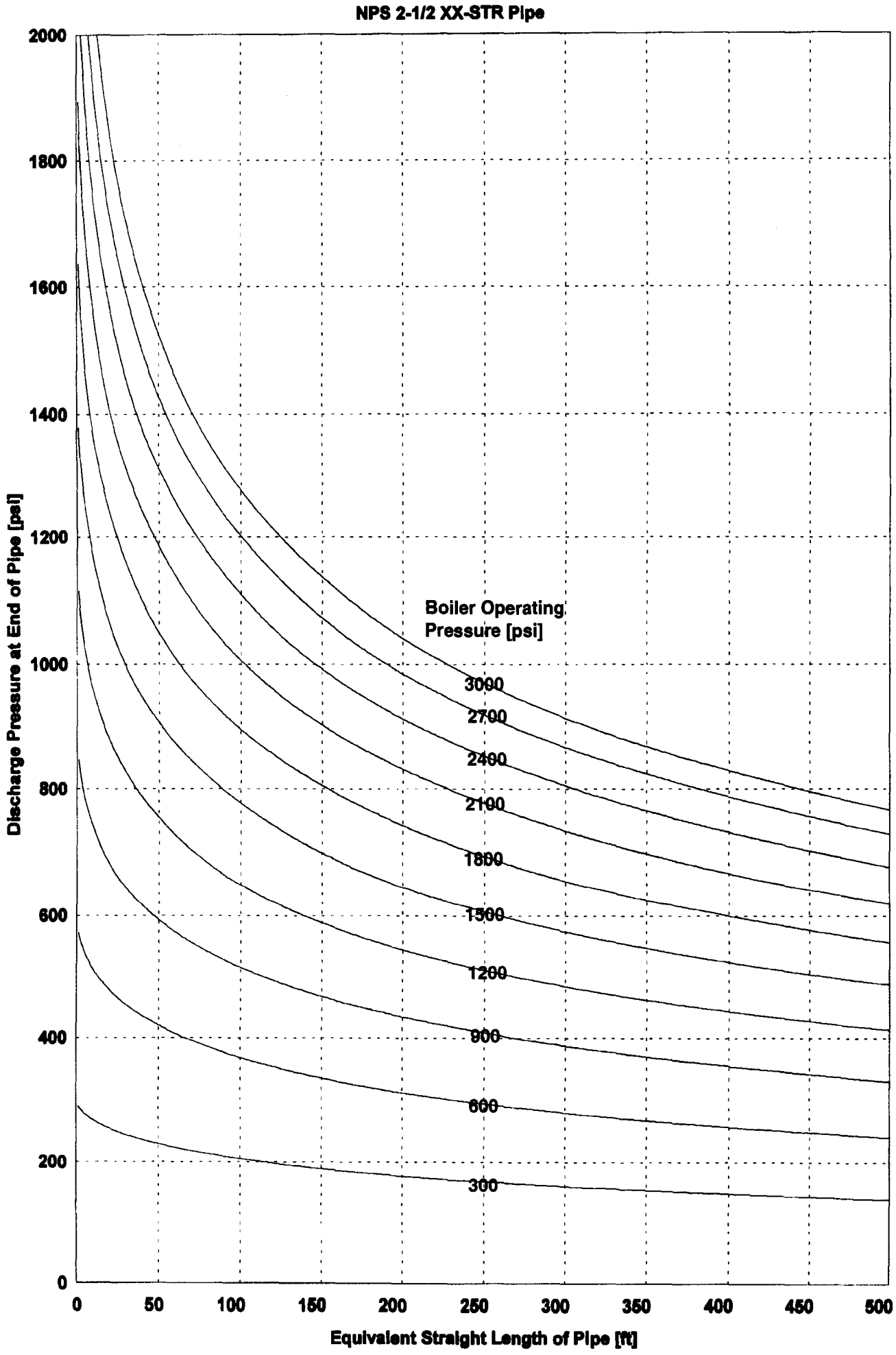

NPS 2-1/2 SCH 80 Pipe
Boiler Operating Pressure [psi]
300
270
240
210
180
150
120
90
60
30
Discharge Pressure at End of Pipe [psi]
0
50
100
150
200
250
300
0
10
20
30
40
50
60
70
80
90
100
Equivalent Straight Length of Pipe [ft]


NPS 2-1/2 SCH 80 Pipe
Discharge Pressure at End of Pipe [psi]
Equivalent Straight Length of Pipe [ft]
Boiler Operating Pressure [psi]
3000
2700
2400
2100
1800
1500
1200
900
600
300
0
200
400
600
800
1000
1200
1400
1600
1800
2000
0
50
100
150
200
250
300
350
400
450
500


NPS 2-1/2 SCH 160 Pipe
Boiler Operating Pressure [psi]
300
270
240
210
180
150
120
90
60
30
Discharge Pressure at End of Pipe [psi]
0
50
100
150
200
250
300
0
10
20
30
40
50
60
70
80
90
100
Equivalent Straight length of Pipe [ft]

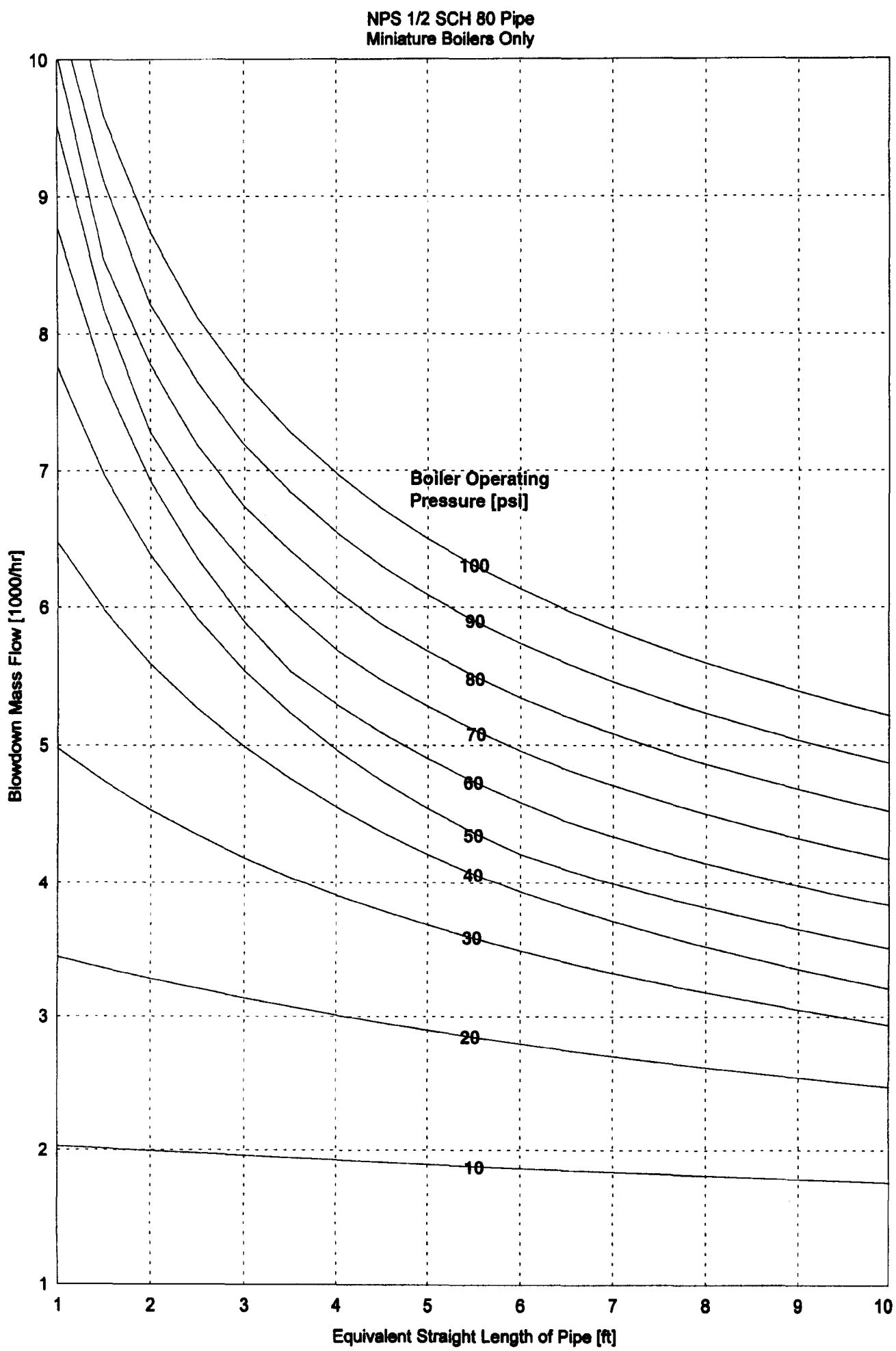

NPS 2-1/2 SCH 160 Pipe
Discharge Pressure at End of Pipe [psi]
Equivalent Straight Length of Pipe [ft]
Boiler Operating Pressure [psi]
3000
2700
2400
2100
1800
1500
1200
900
600
300
0
200
400
600
800
1000
1200
1400
1600
1800
2000
0
50
100
150
200
250
300
350
400
450
500

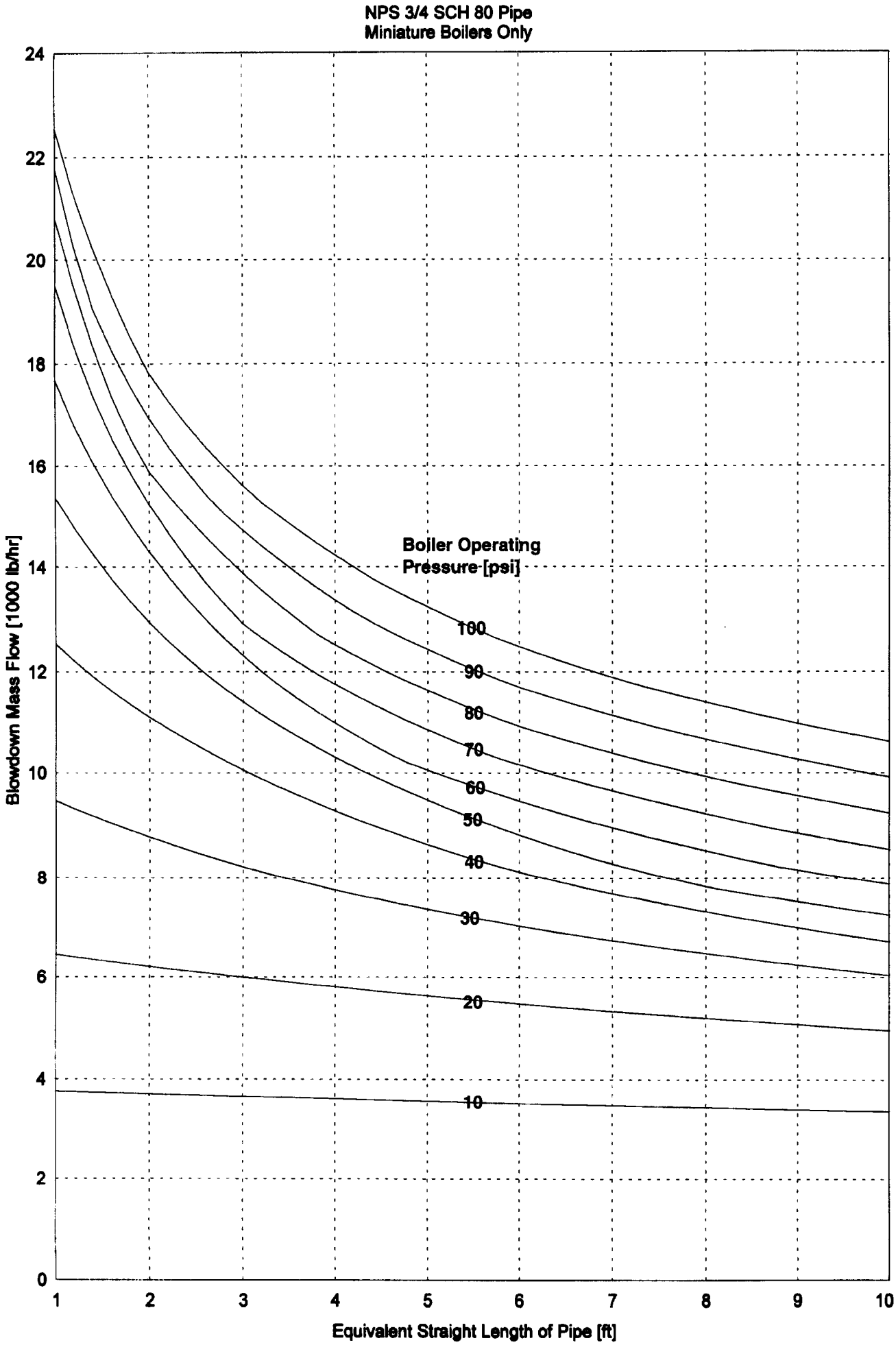

NPS 2-1/2 XX-STR Pipe
Boiler Operating Pressure [psi]
300
270
240
210
180
150
120
90
60
30
Discharge Pressure at End of Pipe [psi]
0
50
100
150
200
250
300
0
10
20
30
40
50
60
70
80
90
100
Equivalent Straight Length of Pipe [ft]

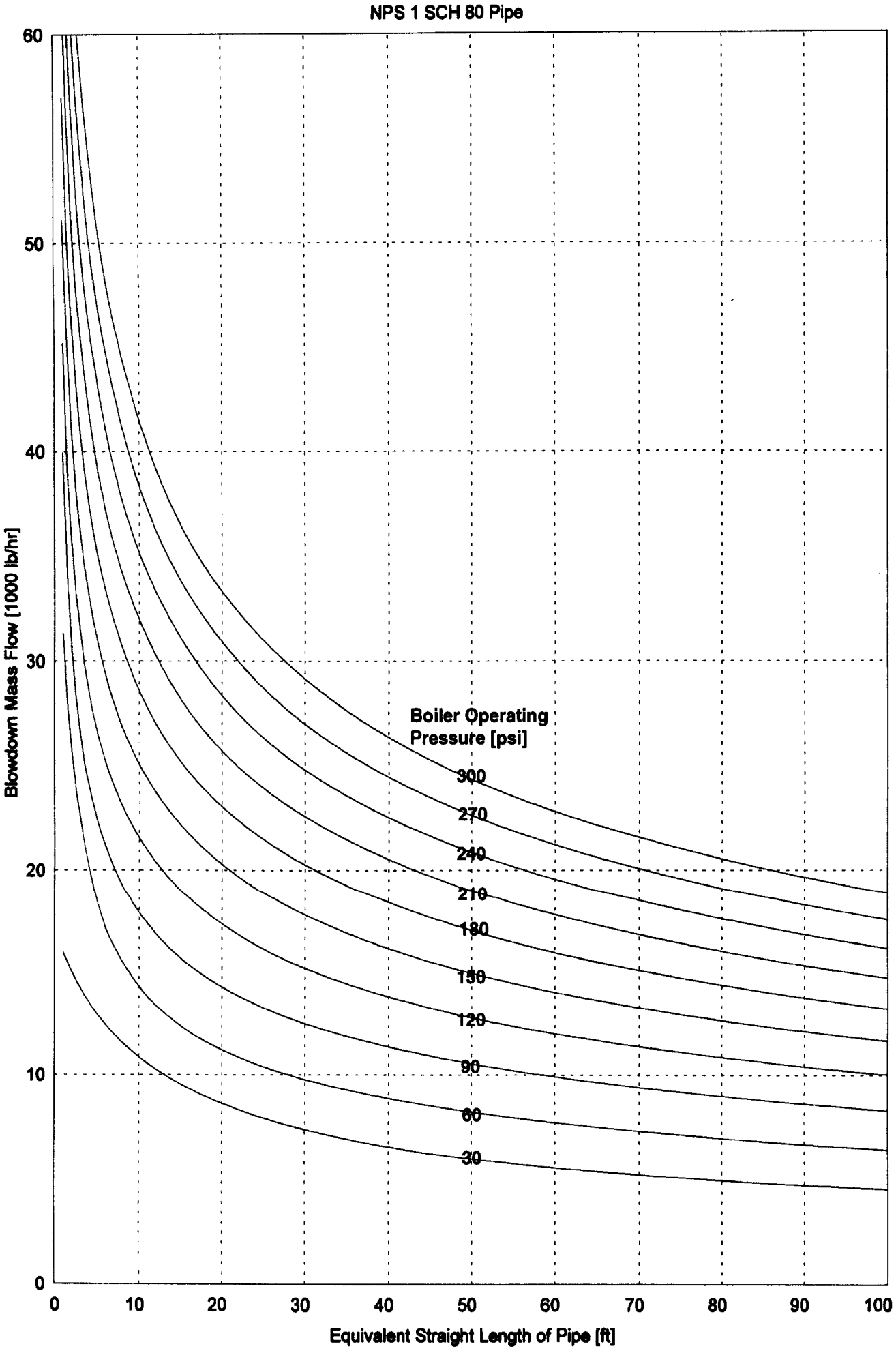

NPS 2-1/2 XX-STR Pipe
Discharge Pressure at End of Pipe [psi]
Equivalent Straight Length of Pipe [ft]
Boiler Operating Pressure [psi]
3000
2700
2400
2100
1800
1500
1200
900
600
300
0
200
400
600
800
1000
1200
1400
1600
1800
2000
0
50
100
150
200
250
300
350
400
450
500

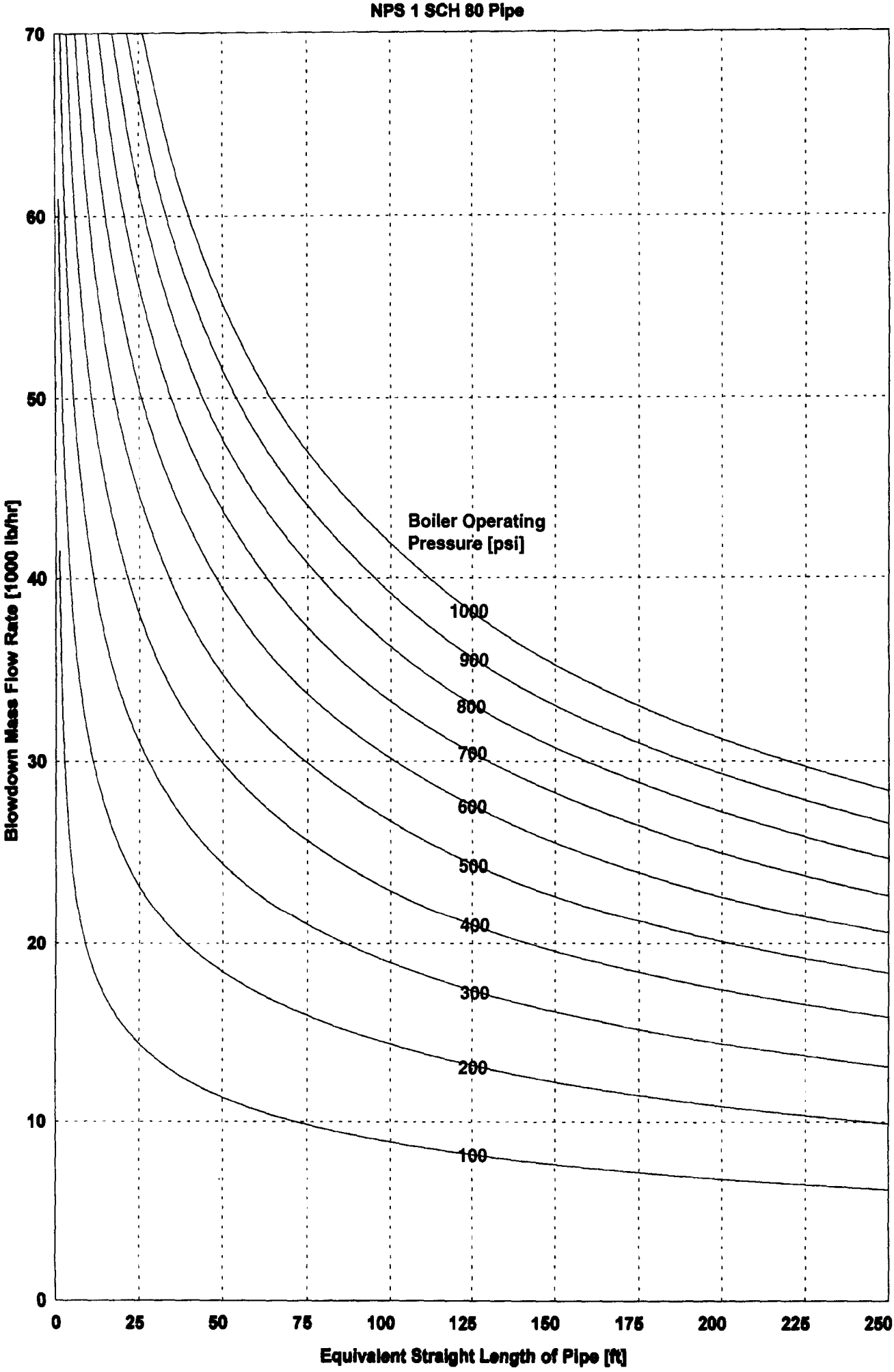
CHARTS

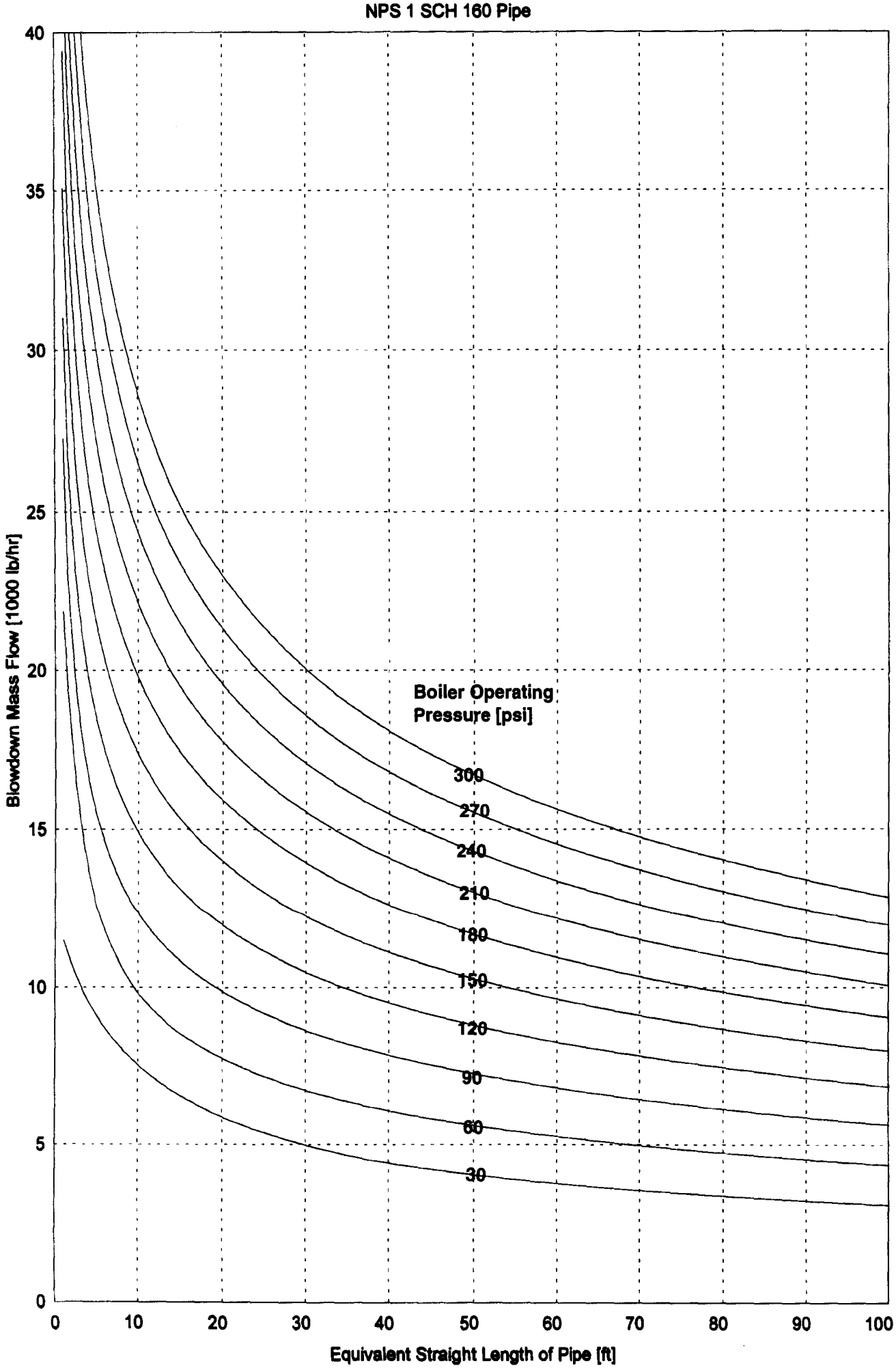
Mass Flow as a Function of Equivalent Straight Pipe Length

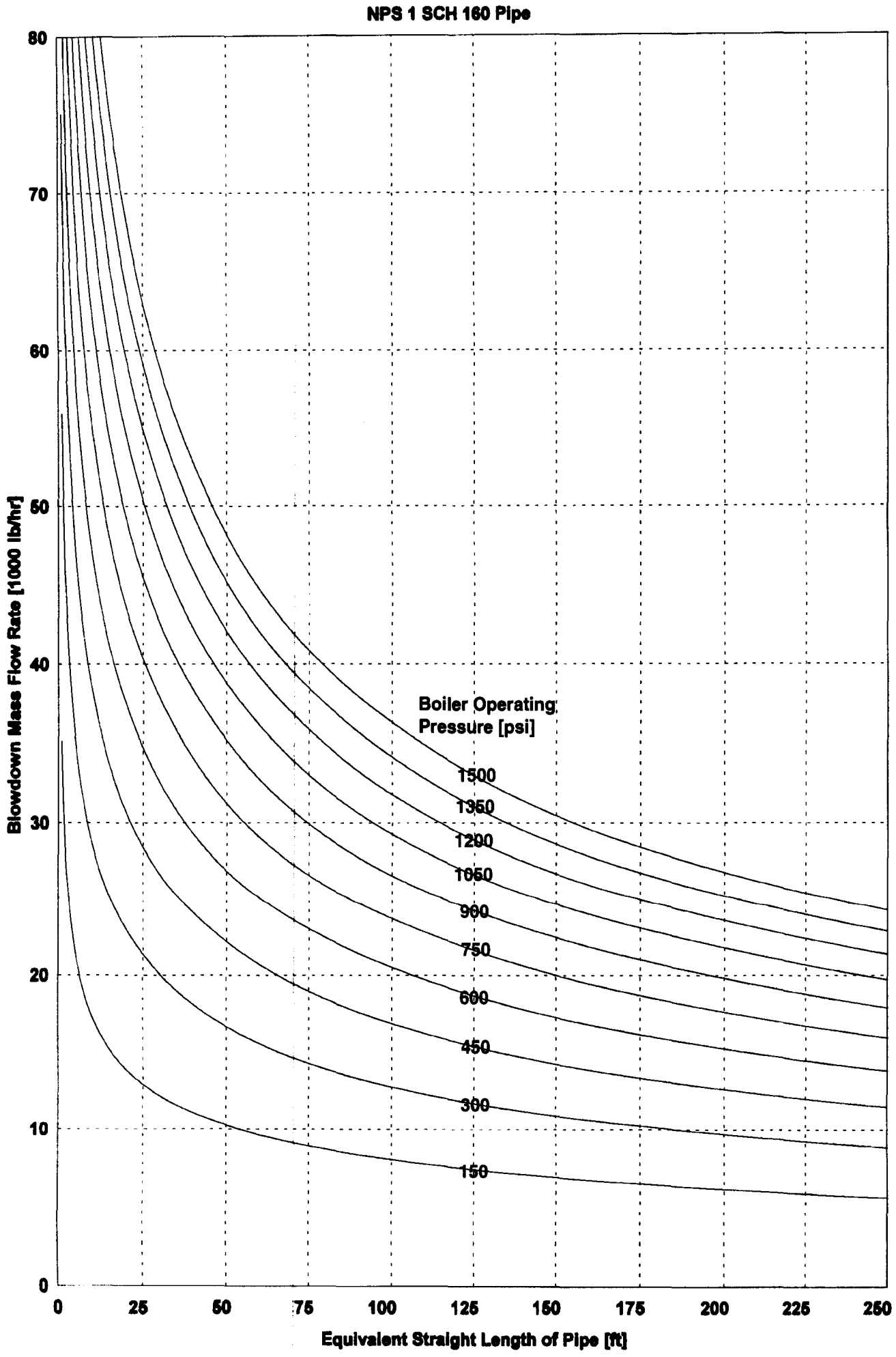

NPS 1/2 SCH 80 Pipe
Miniature Boilers Only
Blowdown Mass Flow [1000/hr]
Equivalent Straight Length of Pipe [ft]
Boiler Operating Pressure [psi]
100
90
80
70
60
50
40
30
20
10
1
2
3
4
5
6
7
8
9
10

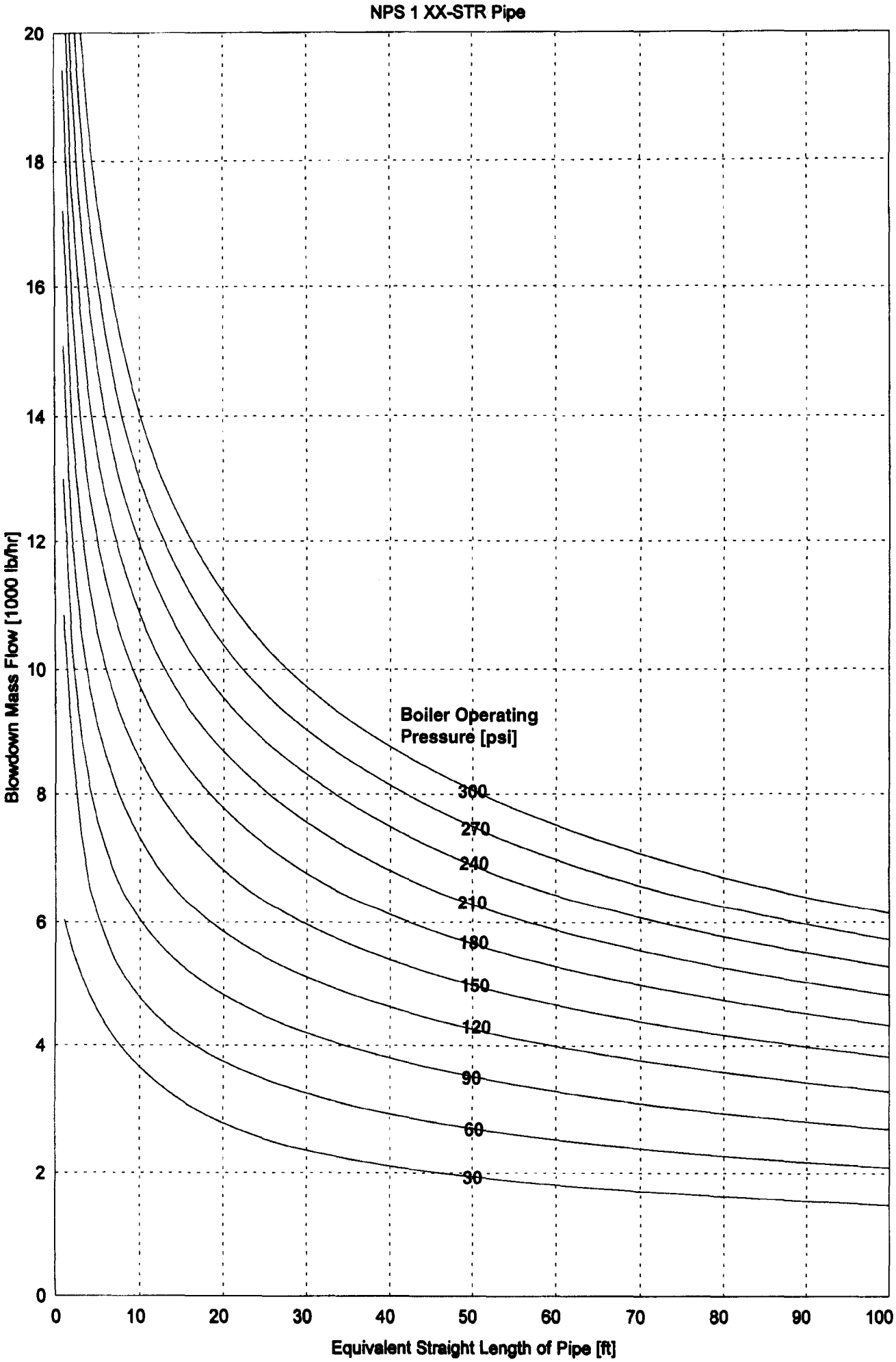

NPS 3/4 SCH 80 Pipe
Miniature Boilers Only
Blowdown Mass Flow [1000 lb/hr]
Equivalent Straight Length of Pipe [ft]
Boiler Operating Pressure [psi]
100
90
80
70
60
50
40
30
20
10
0
2
4
6
8
10
12
14
16
18
20
22
24
1
2
3
4
5
6
7
8
9
10

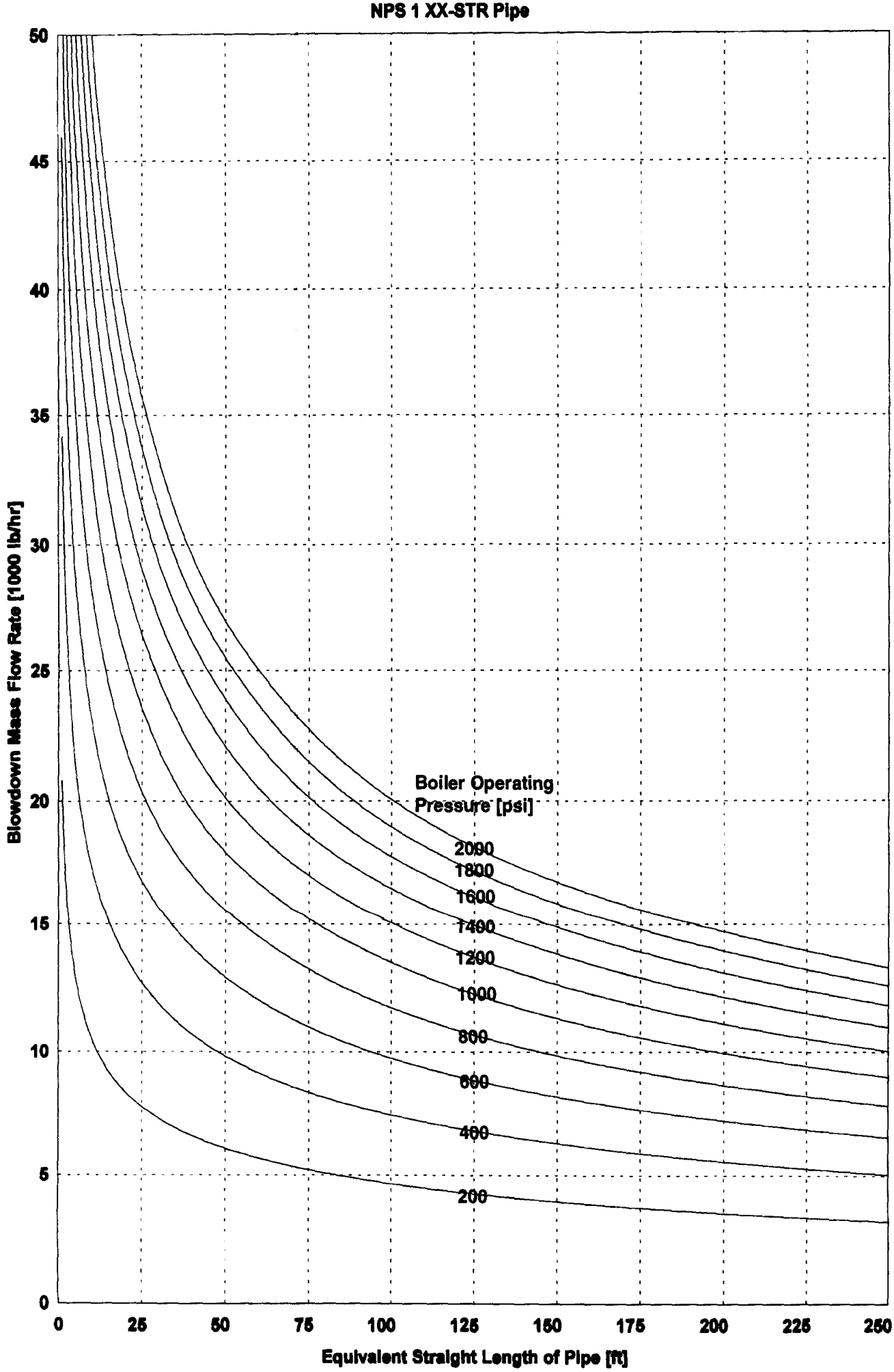

NPS 1 SCH 80 Pipe
Blowdown Mass Flow [1000 lb/hr]
Equivalent Straight Length of Pipe [ft]
Boiler Operating Pressure [psi]
300
270
240
210
180
150
120
90
60
30
0
10
20
30
40
50
60
70
80
90
100

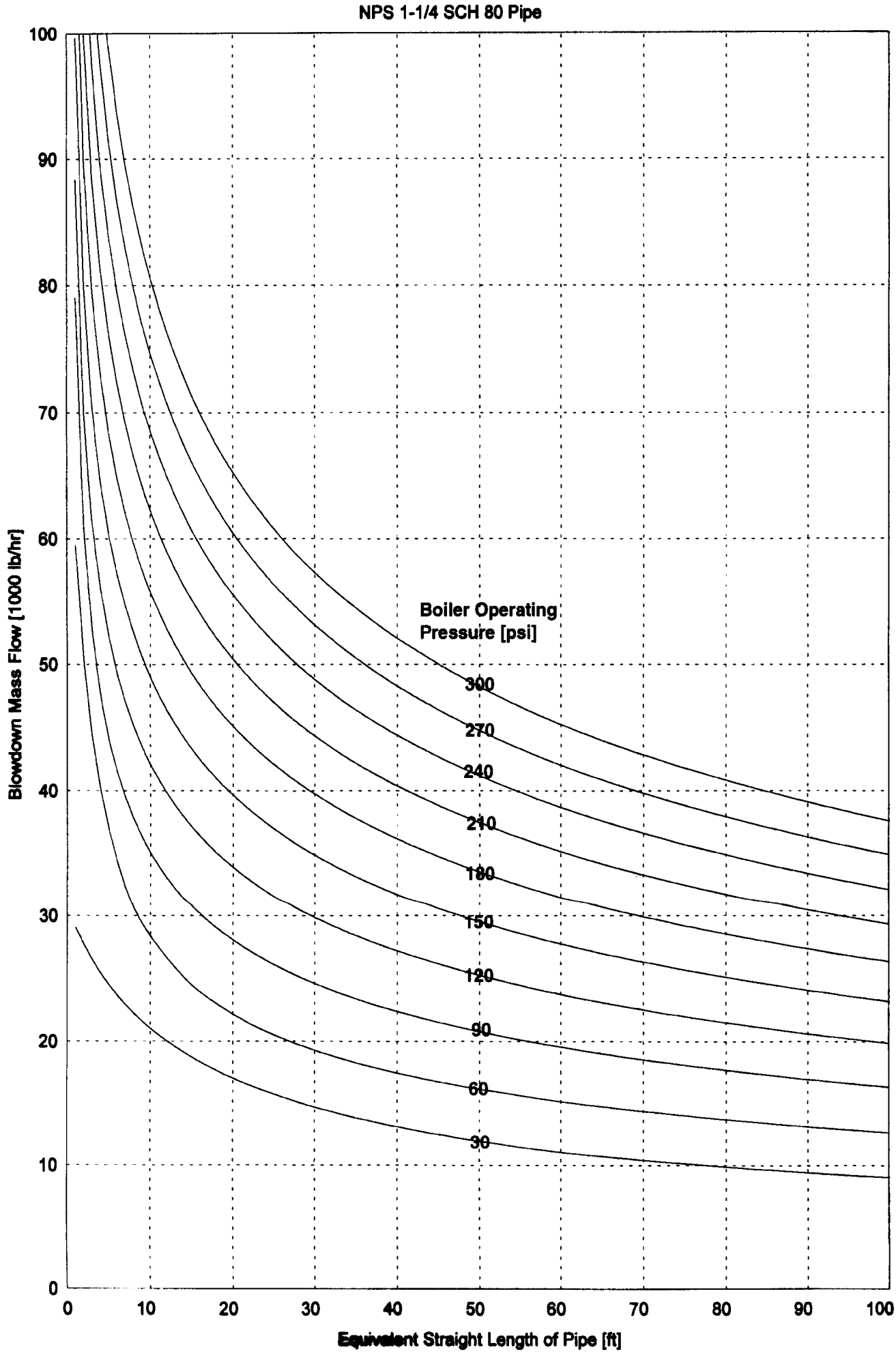

NPS 1 SCH 80 Pipe
Blowdown Mass Flow Rate [1000 lb/hr]
Equivalent Straight Length of Pipe [ft]
Boiler Operating Pressure [psi]
1000
900
800
700
600
500
400
300
200
100
0
10
20
30
40
50
60
70
0
25
50
75
100
125
150
175
200
225
250

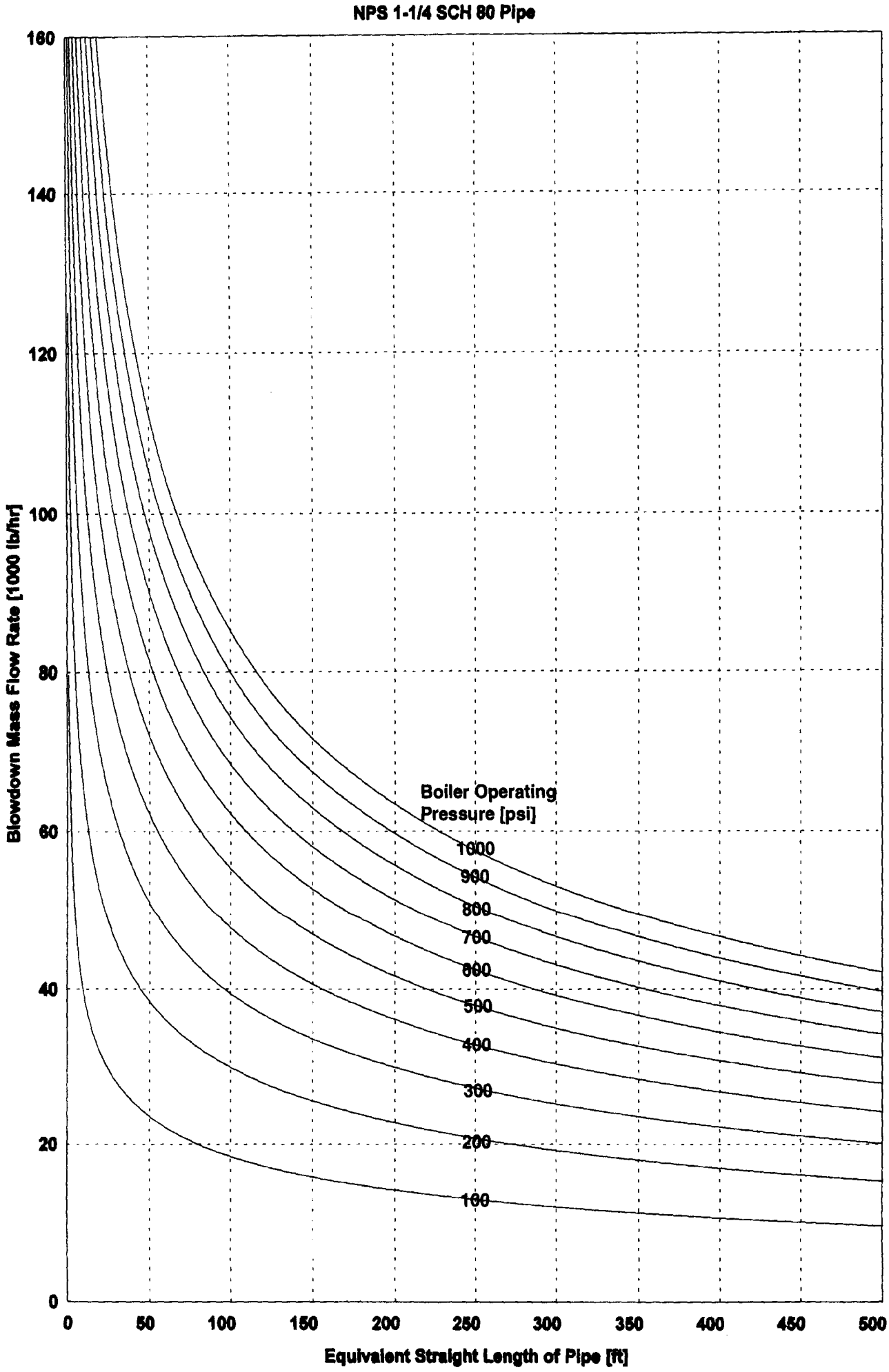

NPS 1 SCH 160 Pipe
Blowdown Mass Flow [1000 lb/hr]
Equivalent Straight Length of Pipe [ft]
Boiler Operating Pressure [psi]
300
270
240
210
180
150
120
90
60
30
0
5
10
15
20
25
30
35
40
0
10
20
30
40
50
60
70
80
90
100

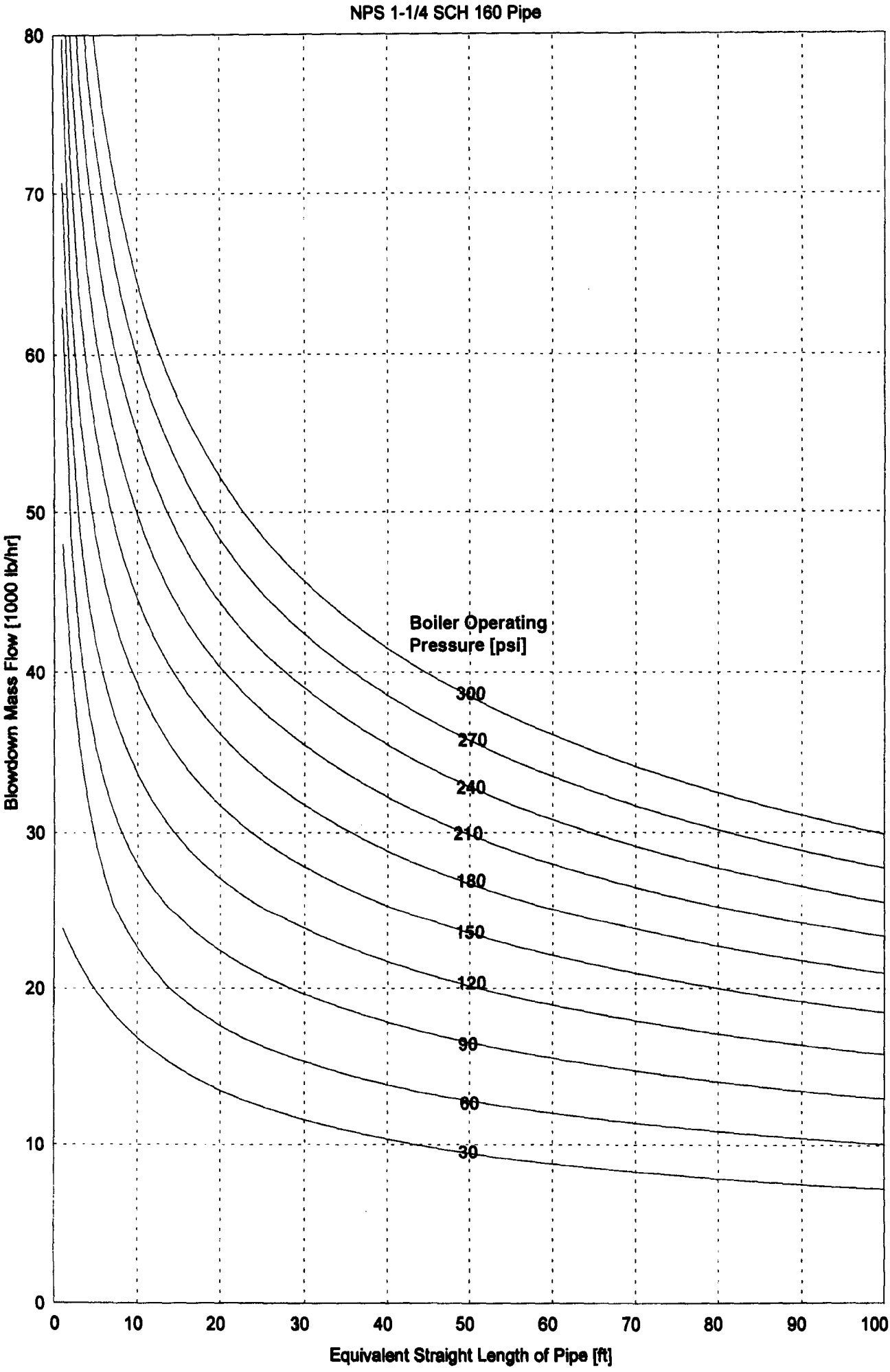

NPS 1 SCH 160 Pipe
Blowdown Mass Flow Rate [1000 lb/hr]
Equivalent Straight Length of Pipe [ft]
Boiler Operating Pressure [psi]
1500
1350
1200
1050
900
750
600
450
300
150
0
10
20
30
40
50
60
70
80
0
25
50
75
100
125
150
175
200
225
250

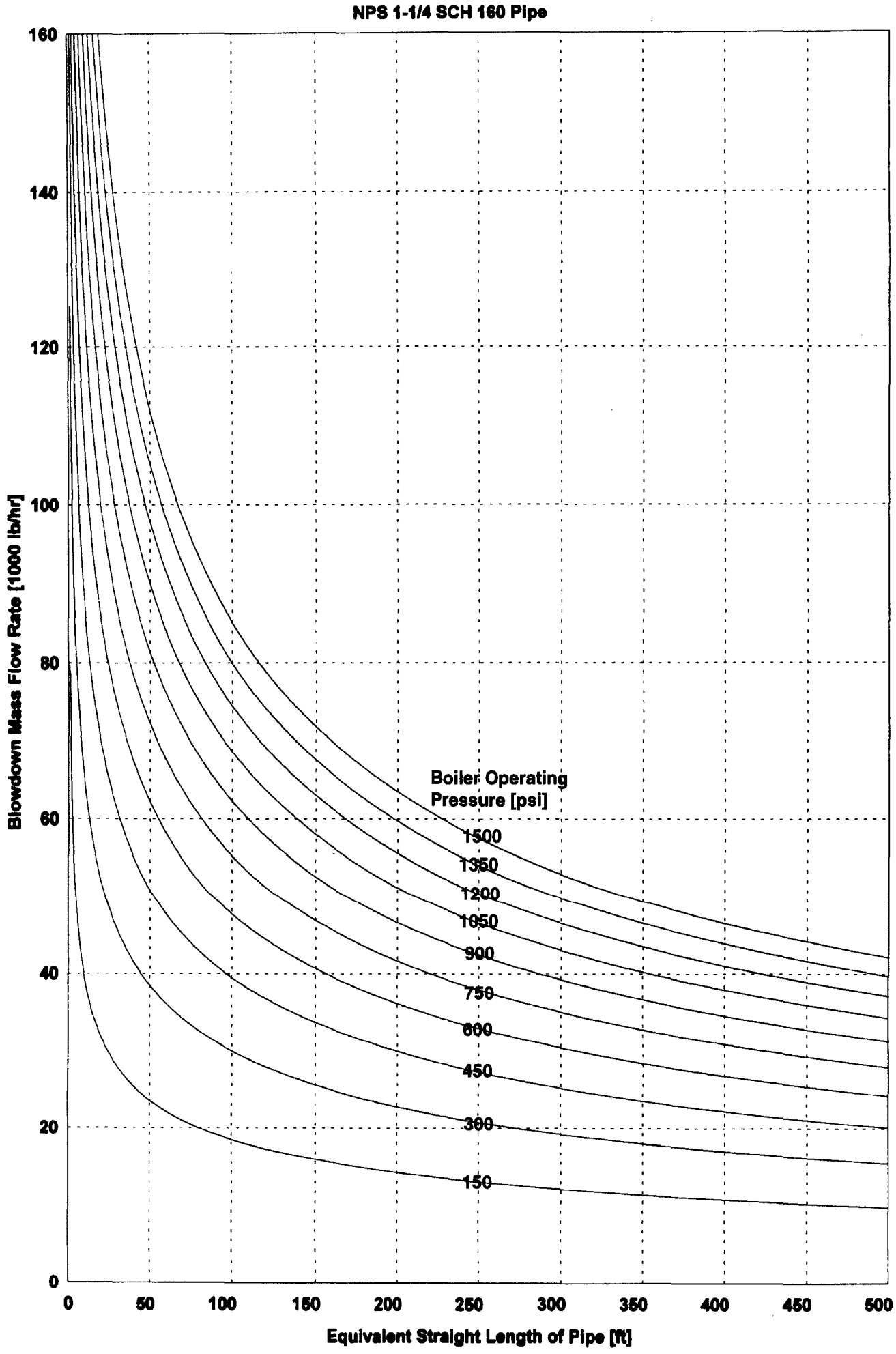

NPS 1 XX-STR Pipe
Blowdown Mass Flow [1000 lb/hr]
Equivalent Straight Length of Pipe [ft]
Boiler Operating Pressure [psi]
300
270
240
210
180
150
120
90
60
30
0
2
4
6
8
10
12
14
16
18
20
0
10
20
30
40
50
60
70
80
90
100

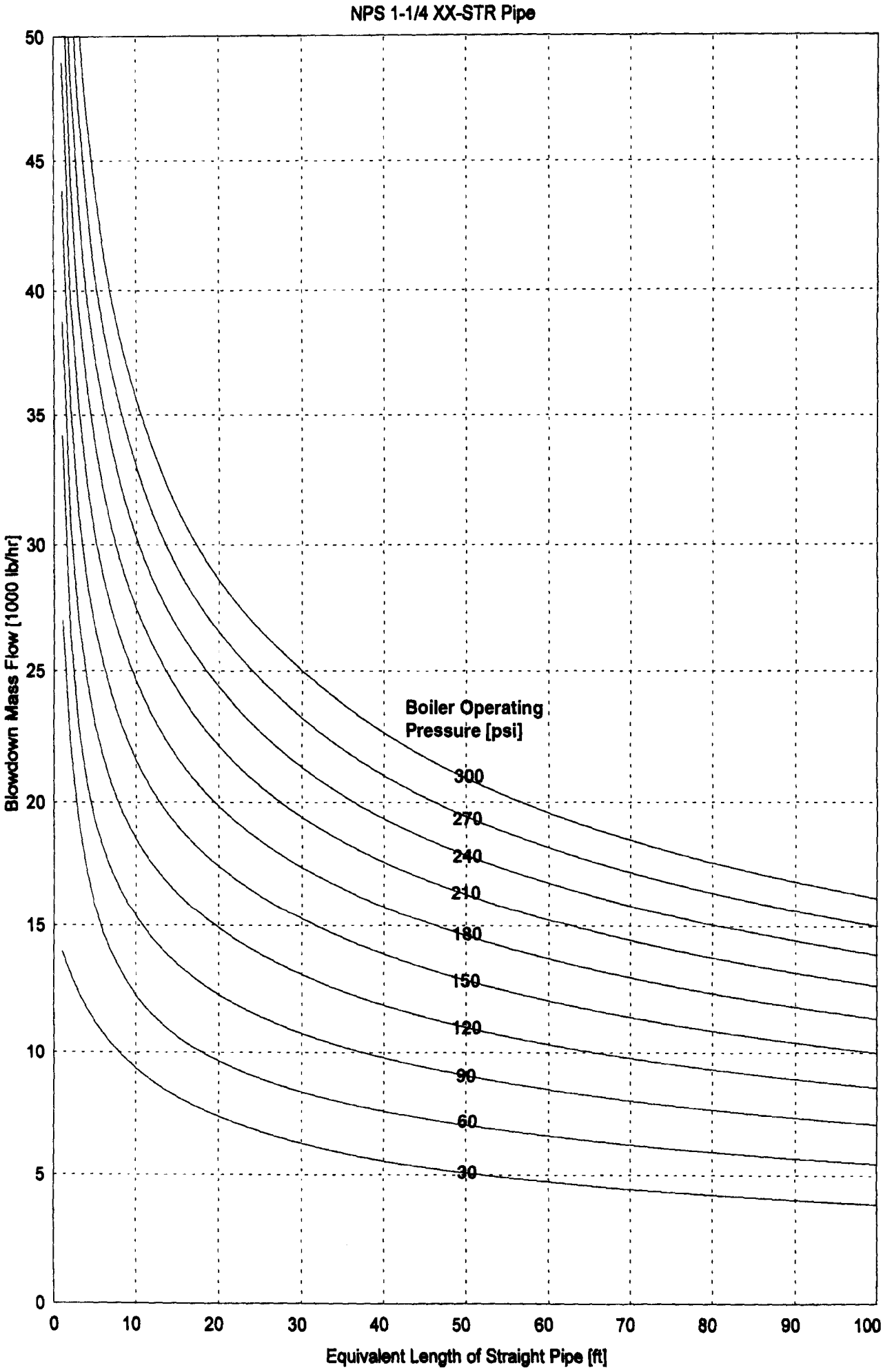

NPS 1 XX-STR Pipe
Blowdown Mass Flow Rate [1000 lb/hr]
Equivalent Straight Length of Pipe [ft]
Boiler Operating Pressure [psi]
2000
1800
1600
1400
1200
1000
800
600
400
200
0
5
10
15
20
25
30
35
40
45
50
0
25
50
75
100
125
150
175
200
225
250

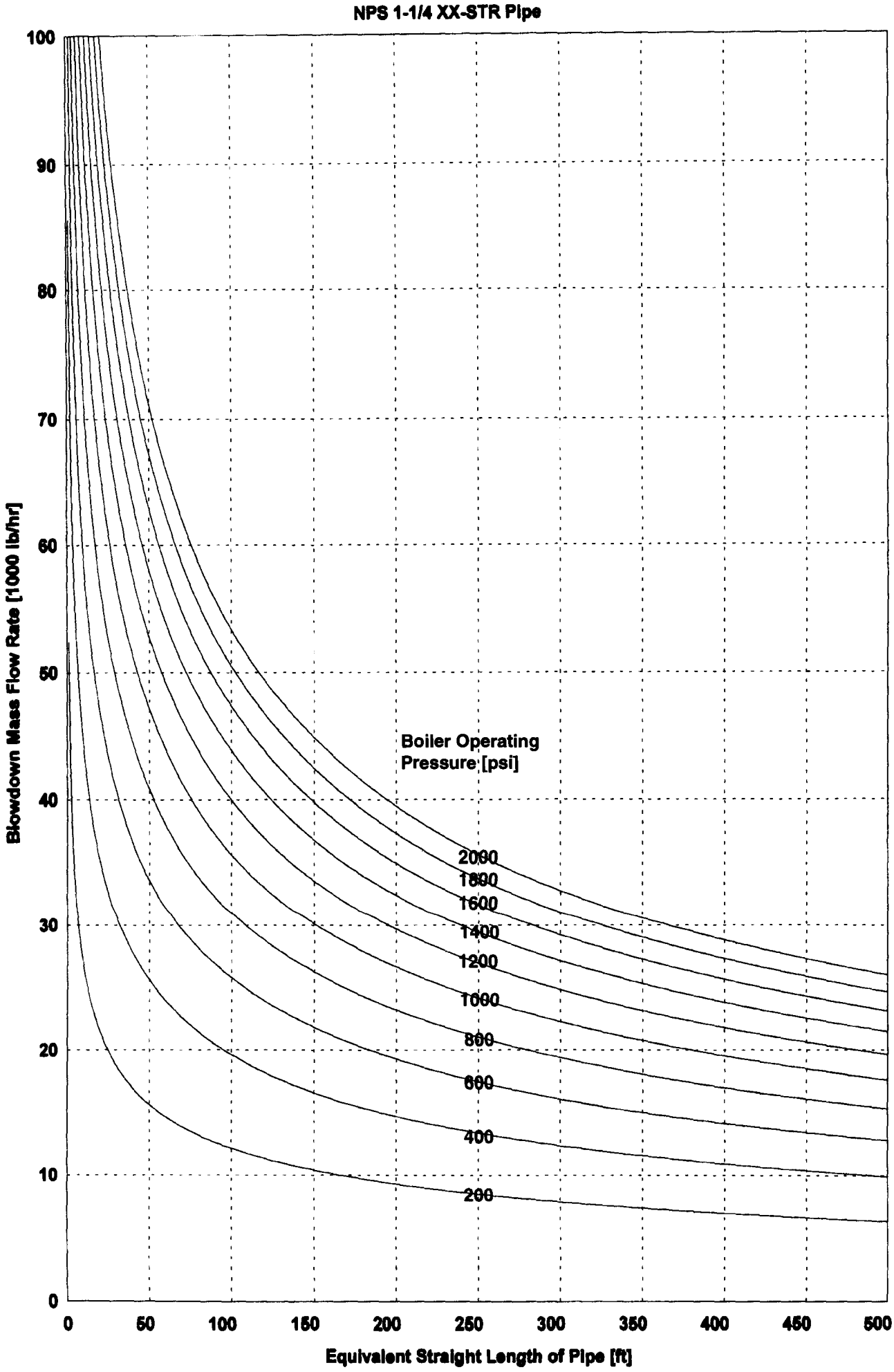

NPS 1-1/4 SCH 80 Pipe
Blowdown Mass Flow [1000 lb/hr]
Equivalent Straight Length of Pipe [ft]
Boiler Operating Pressure [psi]
300
270
240
210
180
150
120
90
60
30
0
10
20
30
40
50
60
70
80
90
100

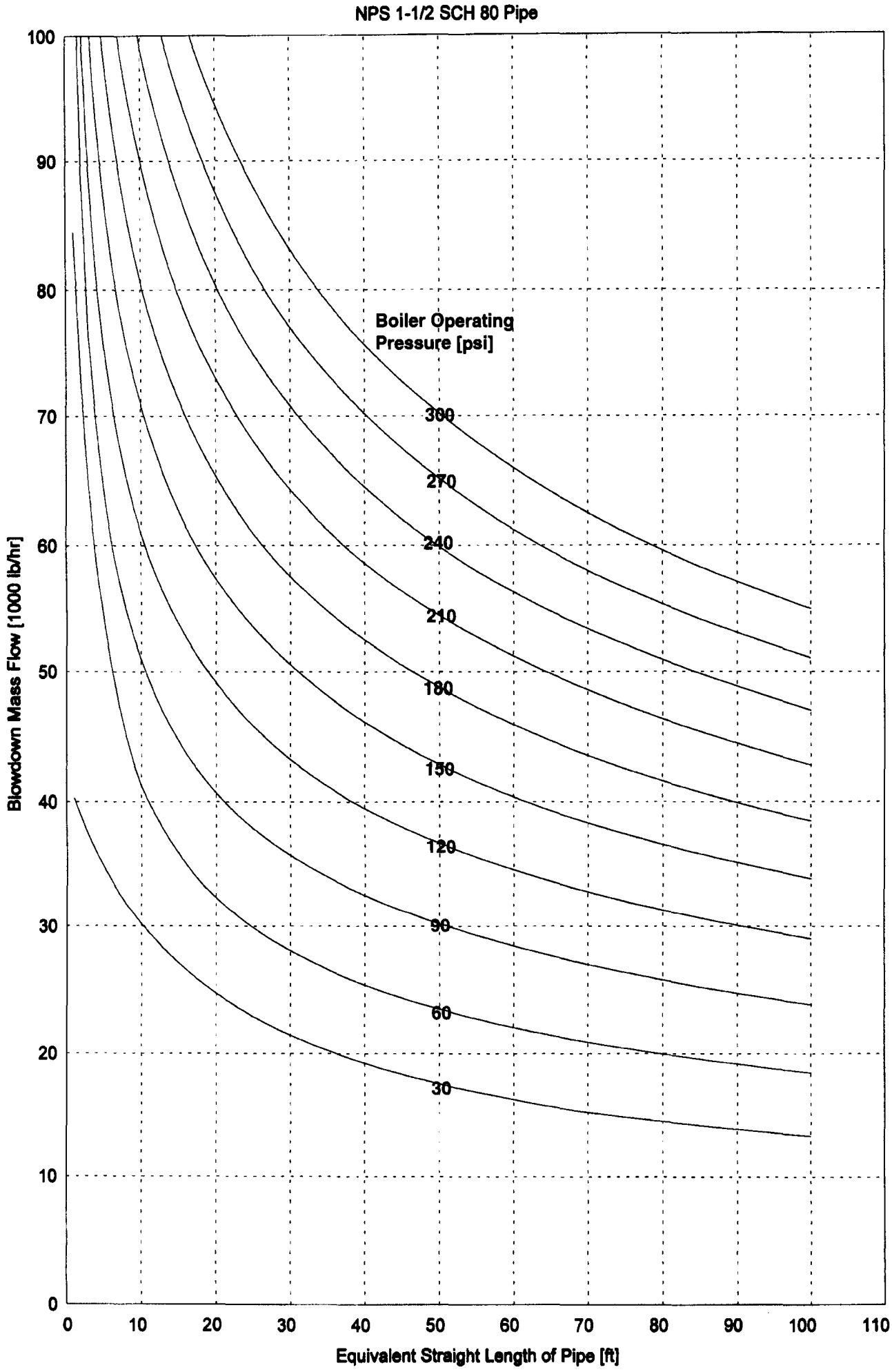

NPS 1-1/4 SCH 80 Pipe
Blowdown Mass Flow Rate [1000 lb/hr]
160
140
120
100
80
60
40
20
0
0
50
100
150
200
250
300
350
400
450
500
Equivalent Straight Length of Pipe [ft]
Boiler Operating Pressure [psi]
1000
900
800
700
600
500
400
300
200
100

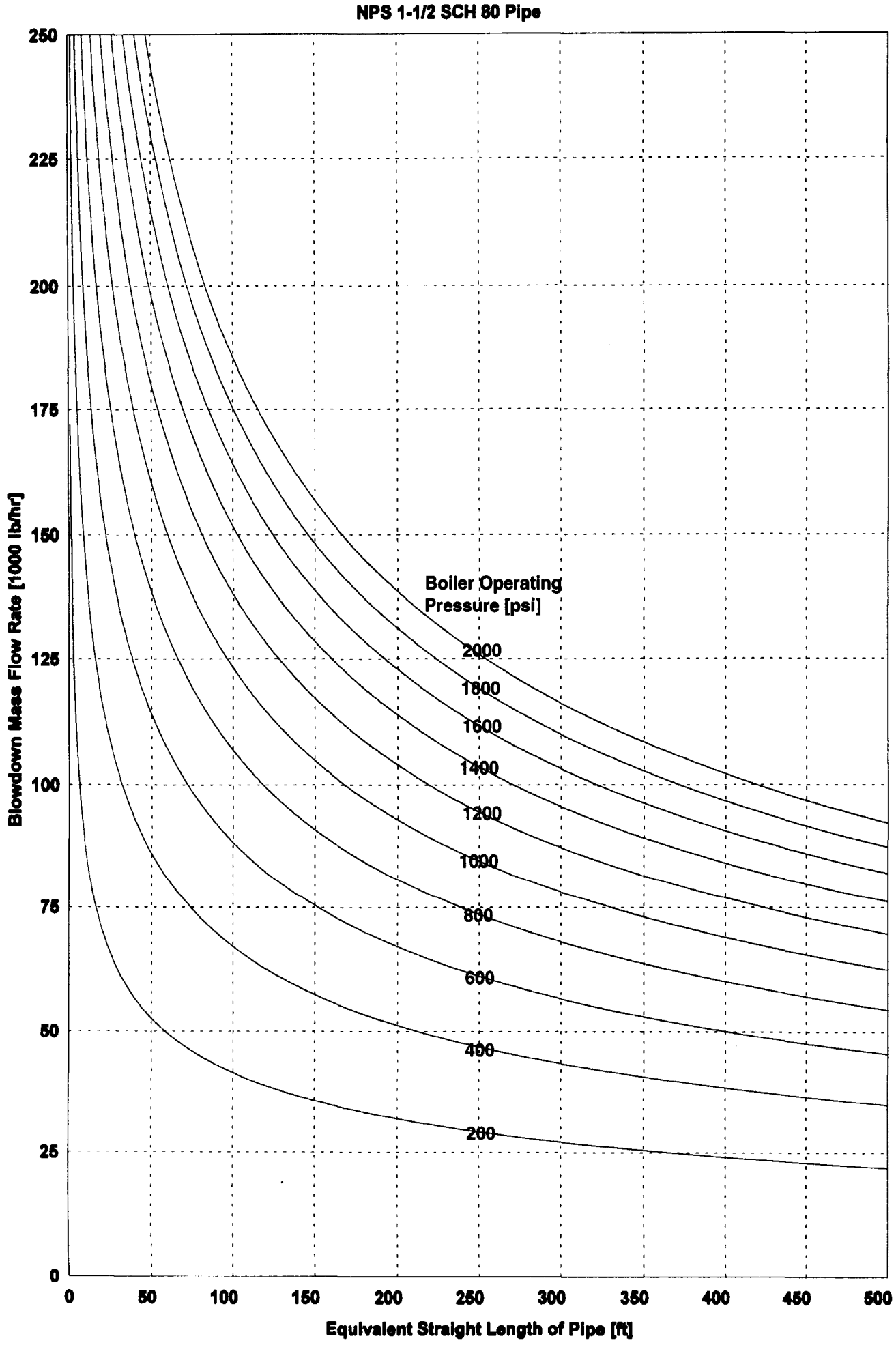

NPS 1-1/4 SCH 160 Pipe
Blowdown Mass Flow [1000 lb/hr]
Equivalent Straight Length of Pipe [ft]
Boiler Operating Pressure [psi]
300
270
240
210
180
150
120
90
60
30
0
10
20
30
40
50
60
70
80
90
100

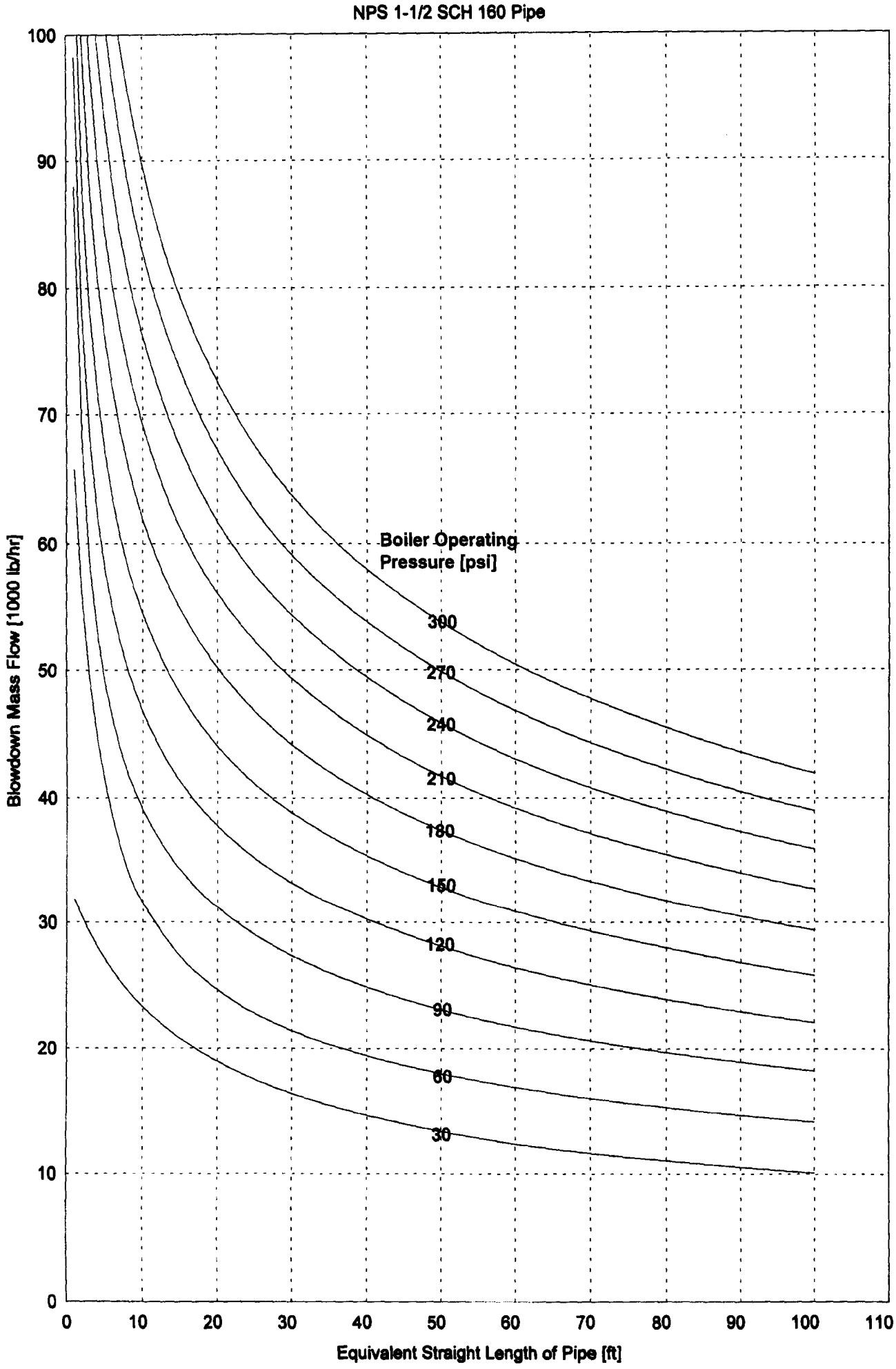

NPS 1-1/4 SCH 160 Pipe
Blowdown Mass Flow Rate [1000 lb/hr]
Equivalent Straight Length of Pipe [ft]
Boiler Operating Pressure [psi]
1500
1350
1200
1050
900
750
600
450
300
150
0
20
40
60
80
100
120
140
160
0
50
100
150
200
250
300
350
400
450
500

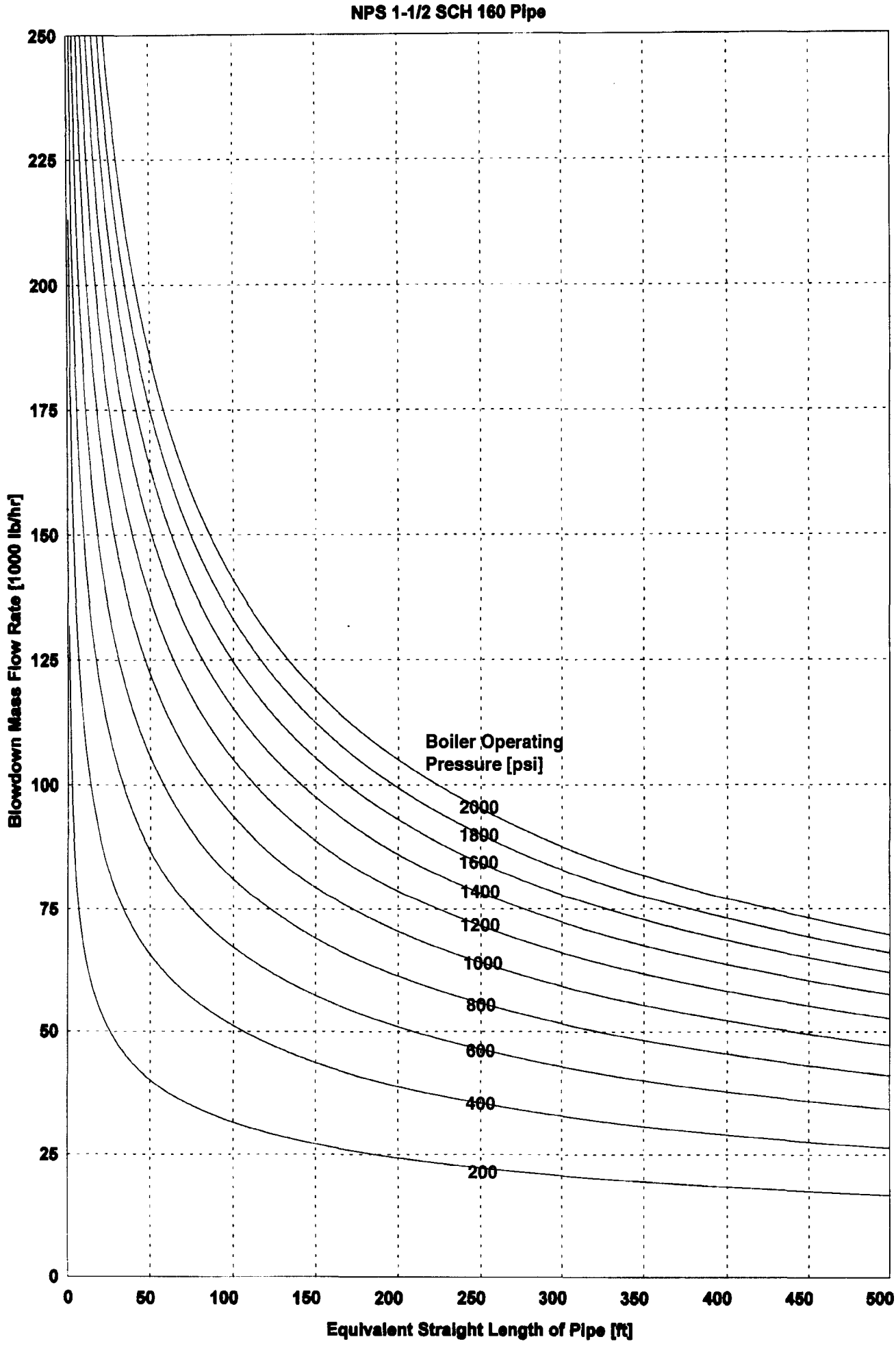

NPS 1-1/4 XX-STR Pipe
Blowdown Mass Flow [1000 lb/hr]
Equivalent Length of Straight Pipe [ft]
Boiler Operating Pressure [psi]
300
270
240
210
180
150
120
90
60
30
0
5
10
15
20
25
30
35
40
45
50
0
10
20
30
40
50
60
70
80
90
100

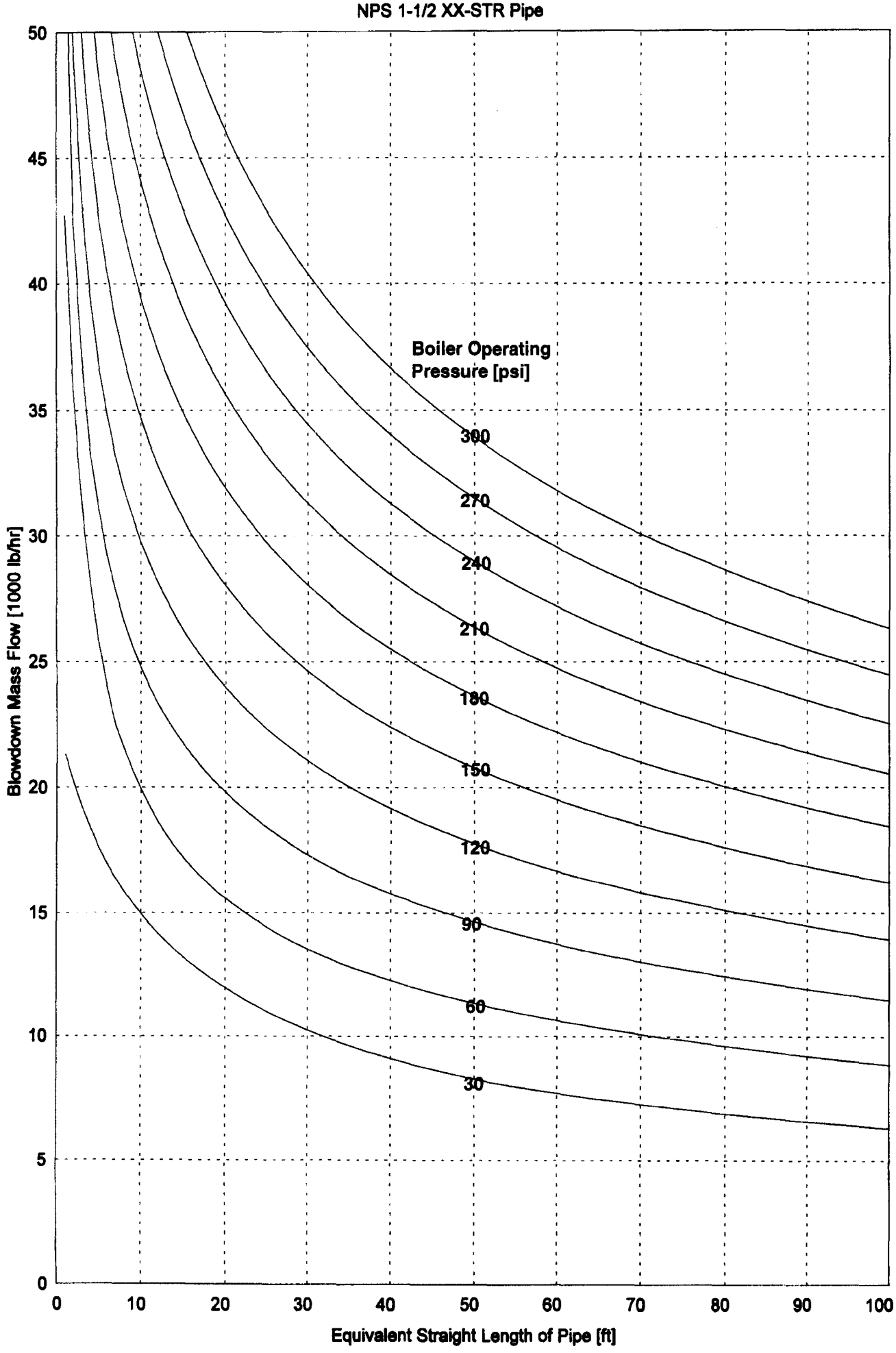

NPS 1-1/4 XX-STR Pipe
Blowdown Mass Flow Rate [1000 lb/hr]
Equivalent Straight Length of Pipe [ft]
Boiler Operating Pressure [psi]
2000
1800
1600
1400
1200
1000
800
600
400
200
0
10
20
30
40
50
60
70
80
90
100
0
50
100
150
200
250
300
350
400
450
500

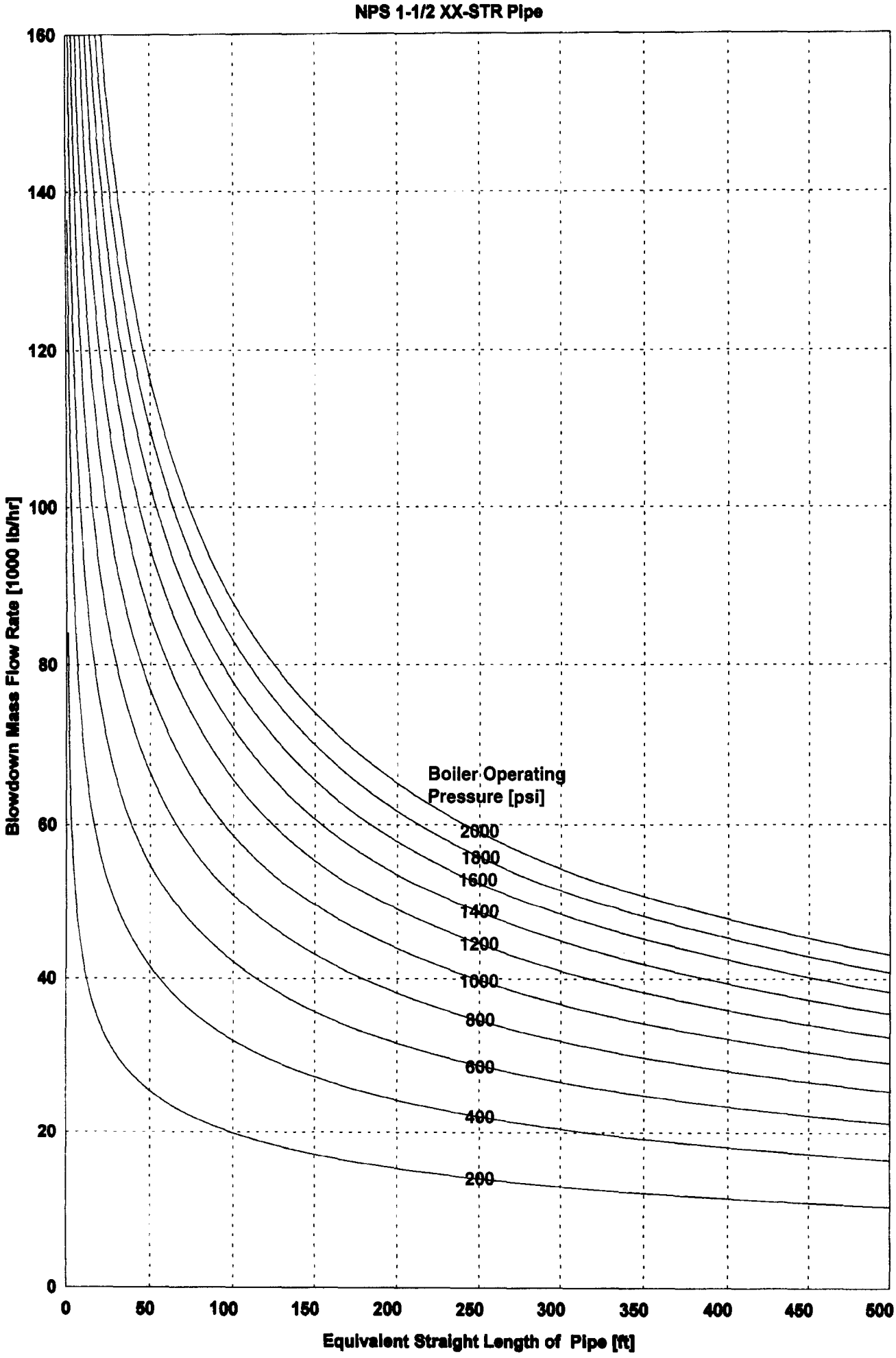

NPS 1-1/2 SCH 80 Pipe
Blowdown Mass Flow [1000 lb/hr]
Equivalent Straight Length of Pipe [ft]
Boiler Operating Pressure [psi]
300
270
240
210
180
150
120
90
60
30
0
10
20
30
40
50
60
70
80
90
100
110

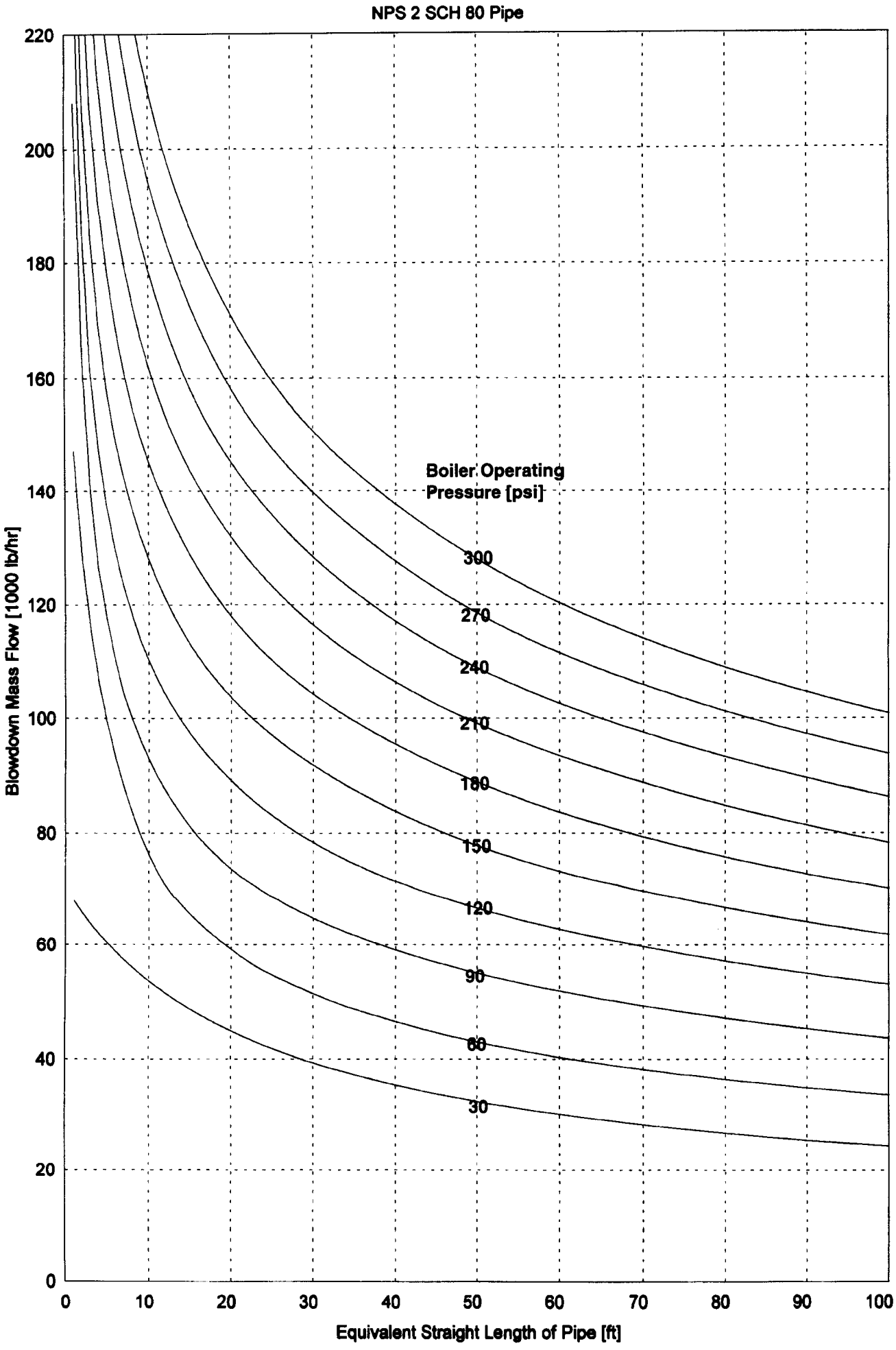

NPS 1-1/2 SCH 80 Pipe
Blowdown Mass Flow Rate [1000 lb/hr]
250
225
200
175
150
125
100
75
50
25
0
Boiler Operating Pressure [psi]
2000
1800
1600
1400
1200
1000
800
600
400
200
0
50
100
150
200
250
300
350
400
450
500
Equivalent Straight Length of Pipe [ft]

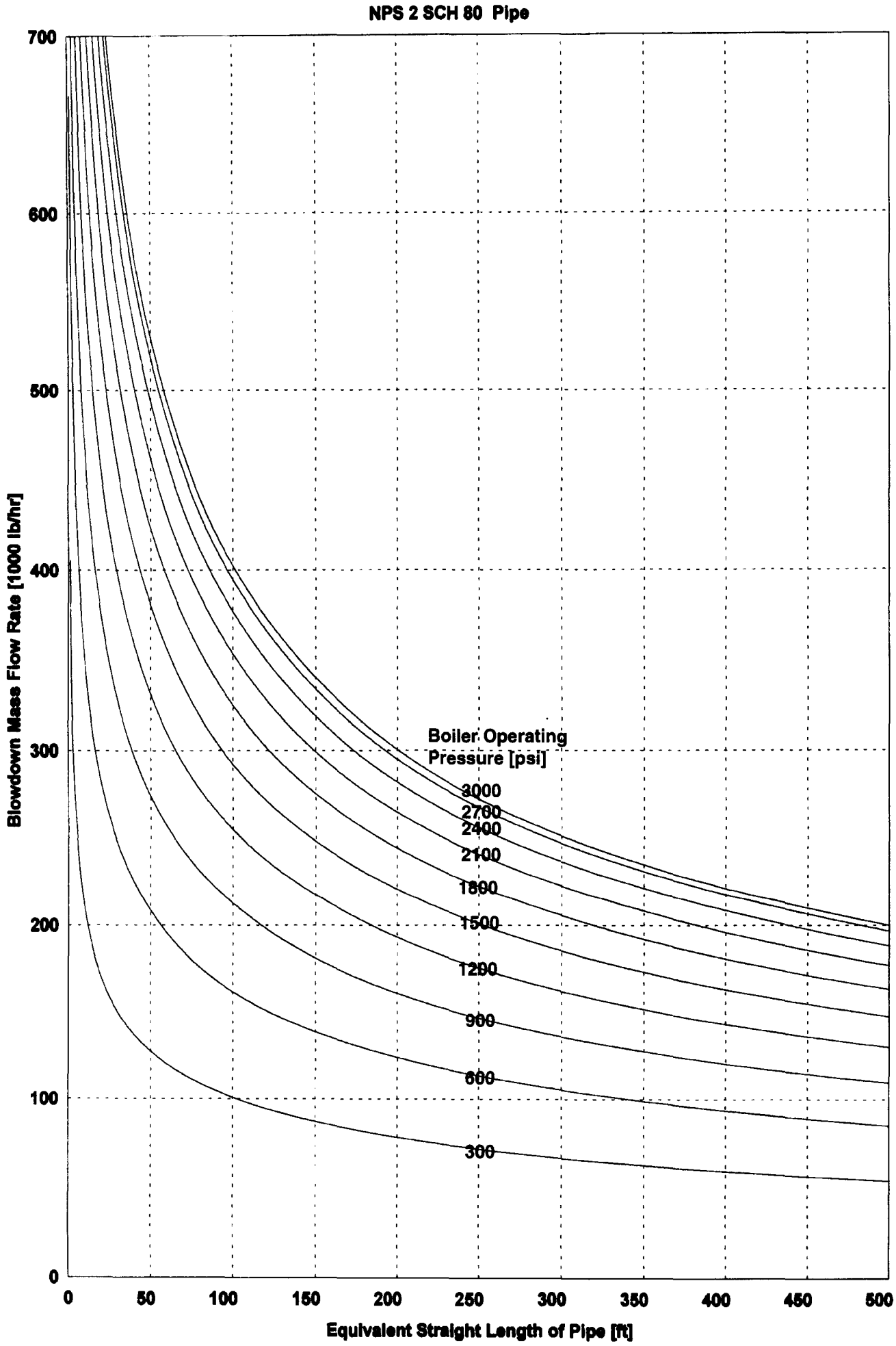

NPS 1-1/2 SCH 160 Pipe
Blowdown Mass Flow [1000 lb/hr]
Equivalent Straight Length of Pipe [ft]
Boiler Operating Pressure [psi]
300
270
240
210
180
150
120
90
60
30
0
10
20
30
40
50
60
70
80
90
100
110

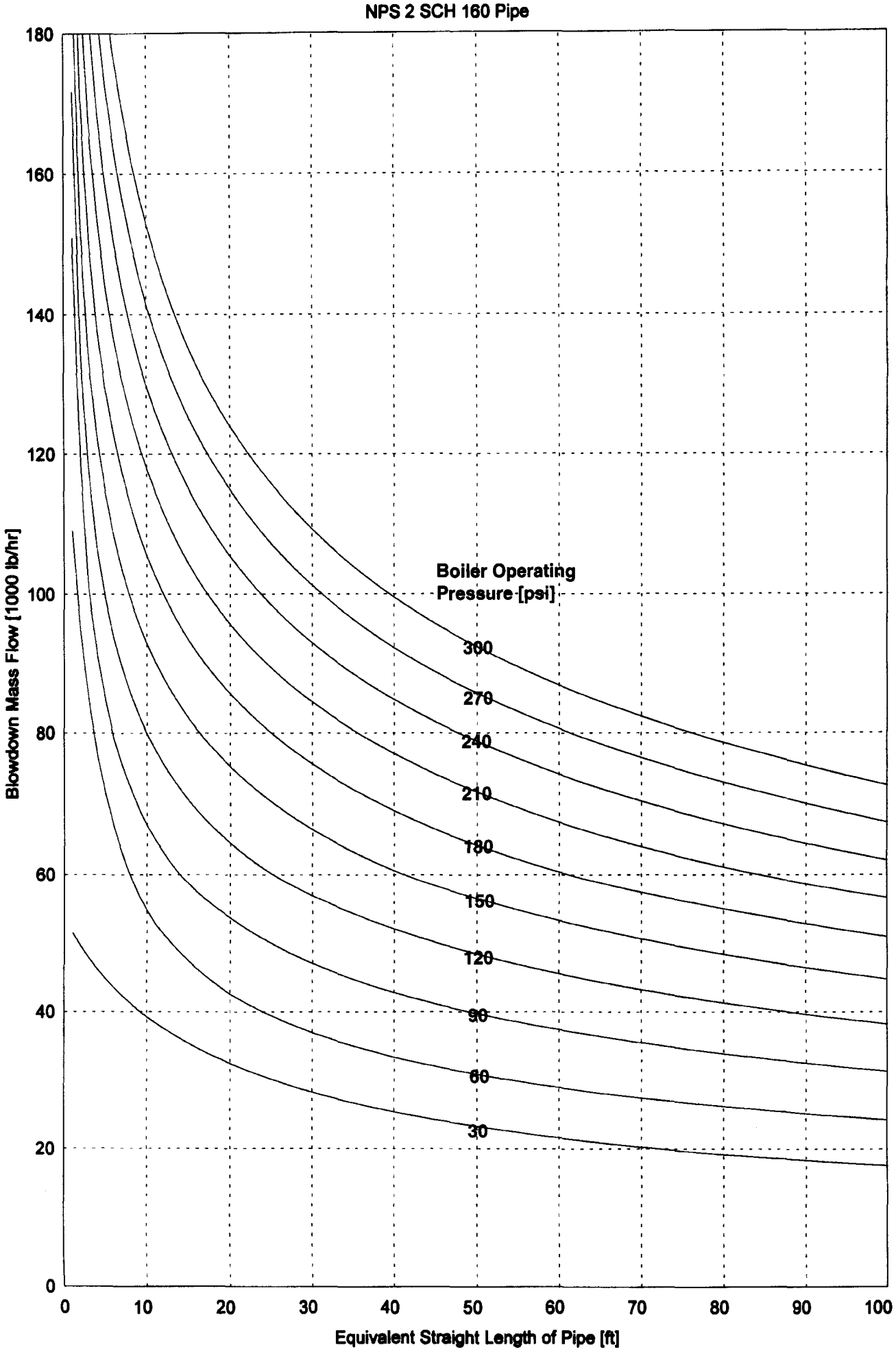

NPS 1-1/2 SCH 160 Pipe
Blowdown Mass Flow Rate [1000 lb/hr]
250
225
200
175
150
125
100
75
50
25
0
0
50
100
150
200
250
300
350
400
450
500
Equivalent Straight Length of Pipe [ft]
Boiler Operating Pressure [psi]
2000
1800
1600
1400
1200
1000
800
600
400
200

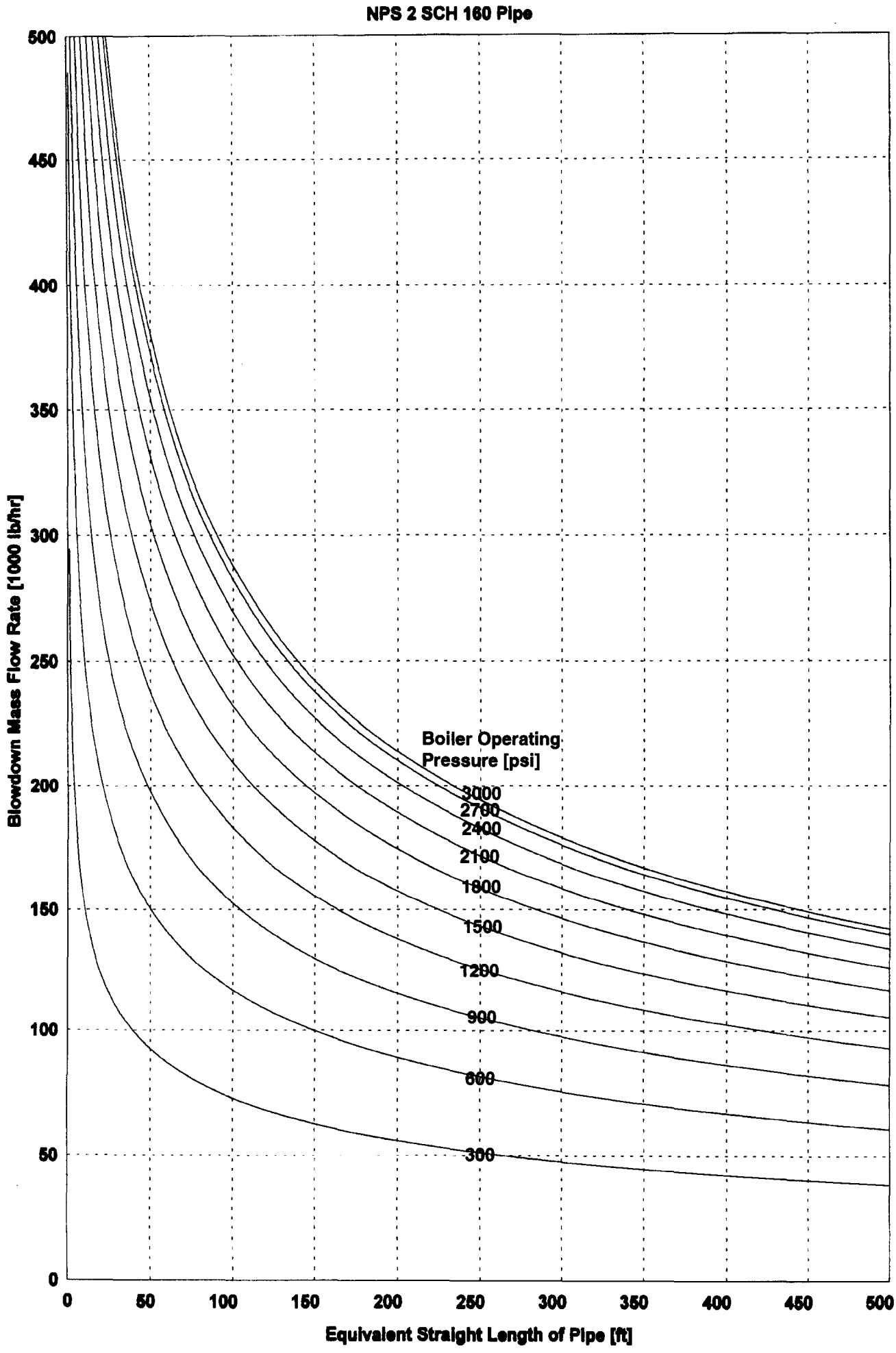

NPS 1-1/2 XX-STR Pipe
Blowdown Mass Flow [1000 lb/hr]
Equivalent Straight Length of Pipe [ft]
Boiler Operating Pressure [psi]
300
270
240
210
180
150
120
90
60
30
0
5
10
15
20
25
30
35
40
45
50
0
10
20
30
40
50
60
70
80
90
100

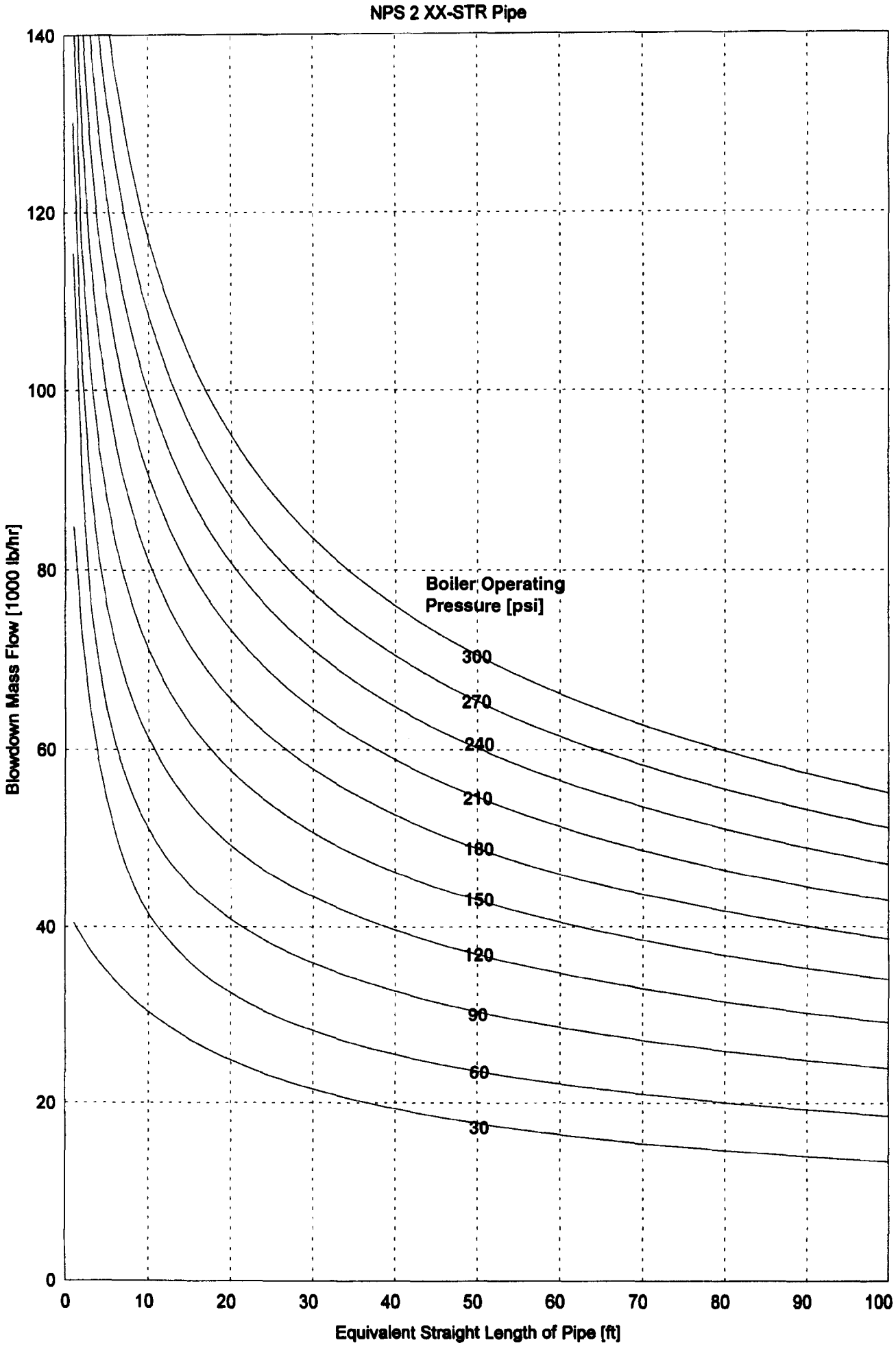

NPS 1-1/2 XX-STR Pipe
Blowdown Mass Flow Rate [1000 lb/hr]
160
140
120
100
80
60
40
20
0
0
50
100
150
200
250
300
350
400
450
500
Equivalent Straight Length of Pipe [ft]
Boiler Operating Pressure [psi]
2000
1800
1600
1400
1200
1000
800
600
400
200

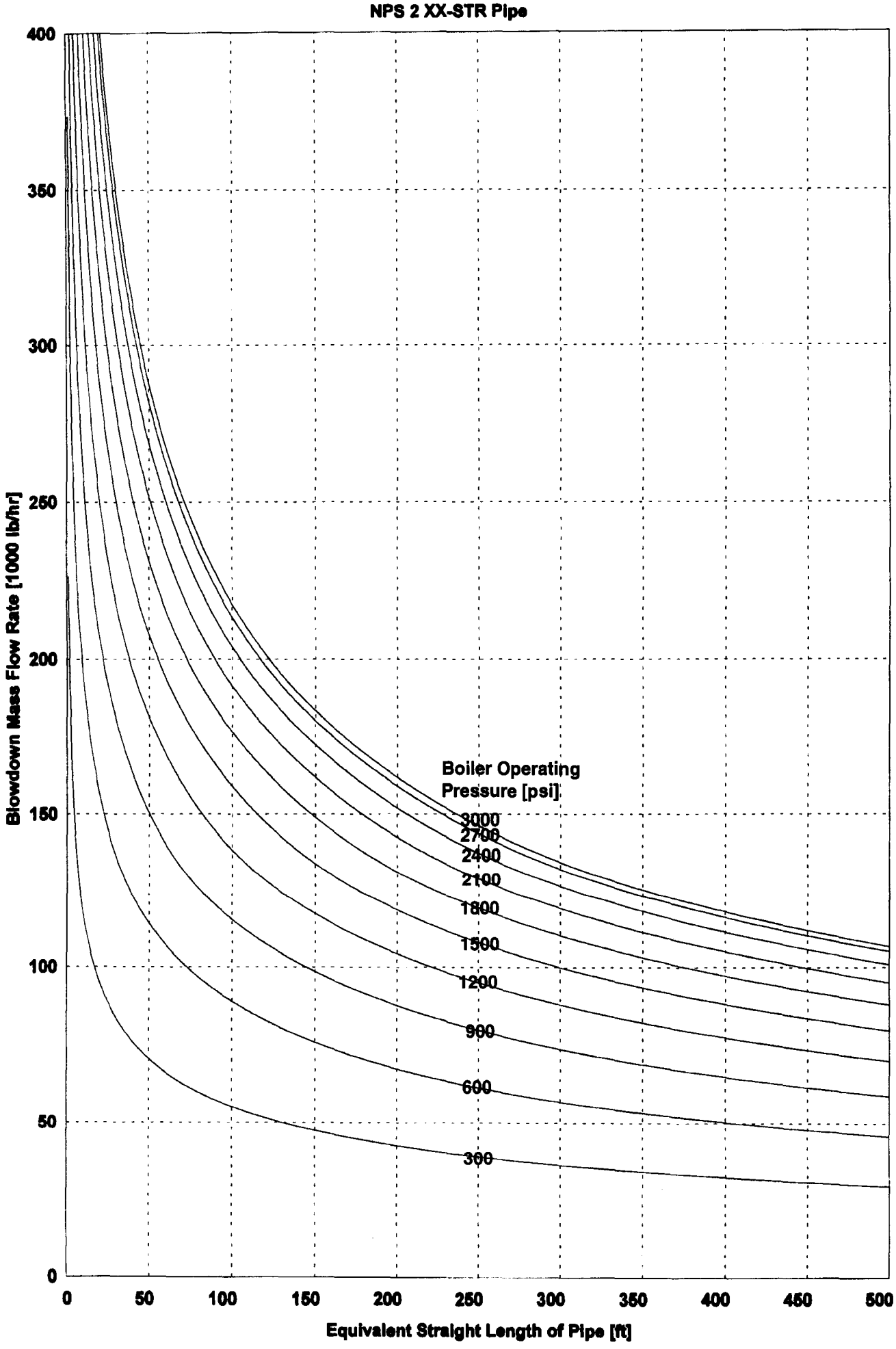

NPS 2 SCH 80 Pipe
Blowdown Mass Flow [1000 lb/hr]
Equivalent Straight Length of Pipe [ft]
Boiler Operating Pressure [psi]
300
270
240
210
180
150
120
90
60
30
0
20
40
60
80
100
120
140
160
180
200
220
0
10
20
30
40
50
60
70
80
90
100

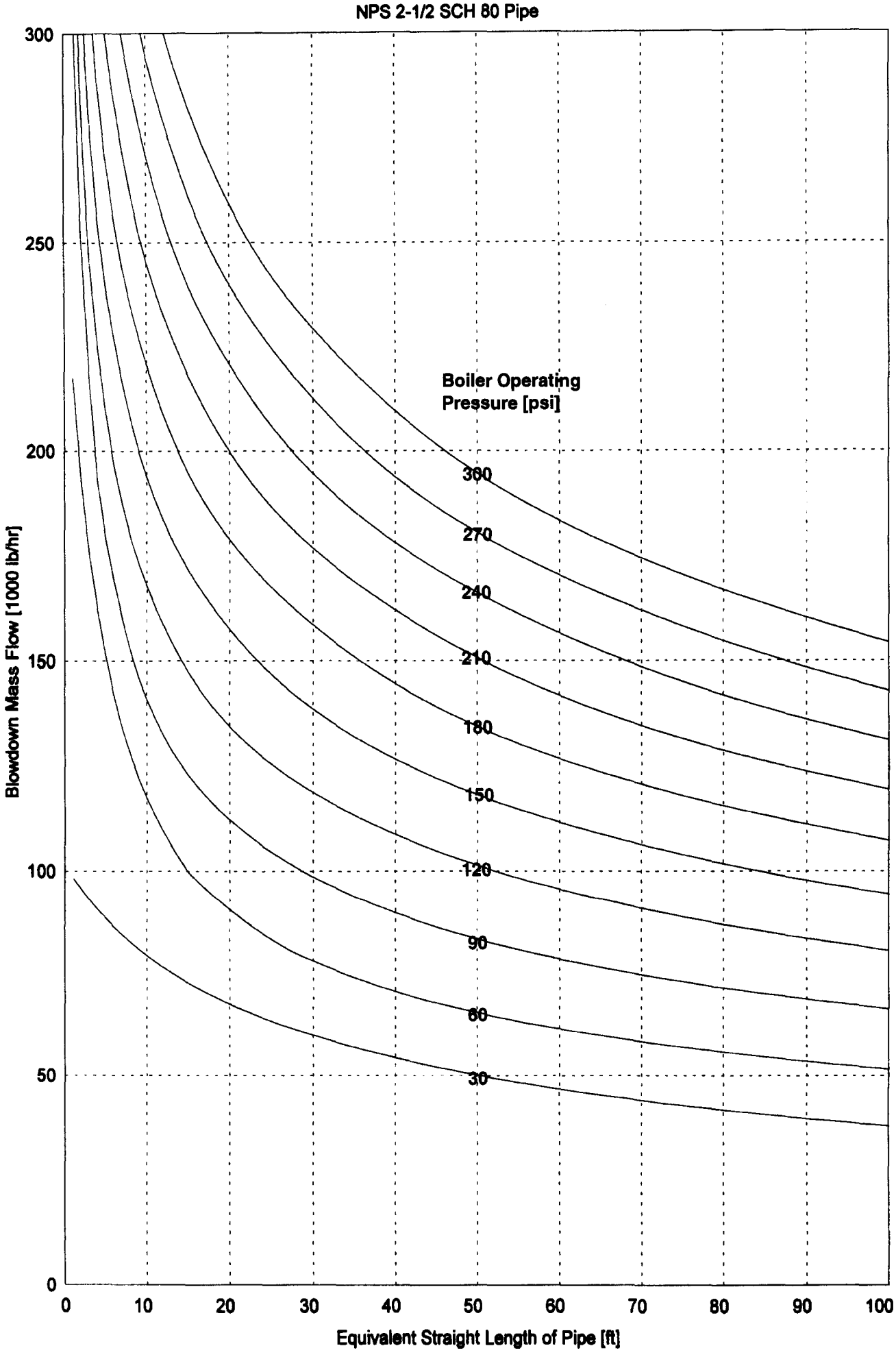

NPS 2 SCH 80 Pipe
Blowdown Mass Flow Rate [1000 lb/hr]
Equivalent Straight Length of Pipe [ft]
Boiler Operating Pressure [psi]
3000
2700
2400
2100
1800
1500
1200
900
600
300
0
100
200
300
400
500
600
700
0
50
100
150
200
250
300
350
400
450
500

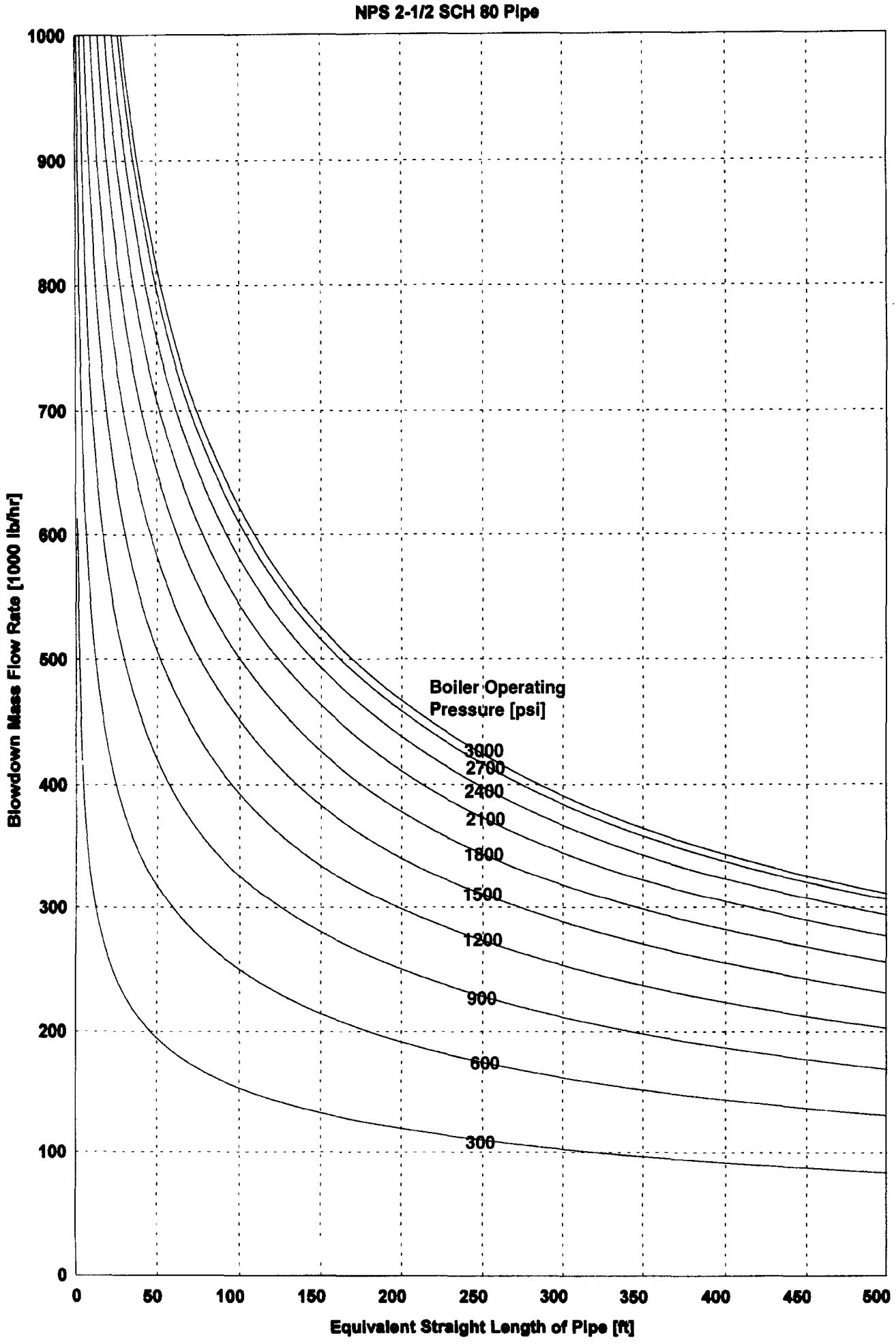

NPS 2 SCH 160 Pipe
Blowdown Mass Flow [1000 lb/hr]
Equivalent Straight Length of Pipe [ft]
Boiler Operating Pressure [psi]
300
270
240
210
180
150
120
90
60
30
0
20
40
60
80
100
120
140
160
180
0
10
20
30
40
50
60
70
80
90
100

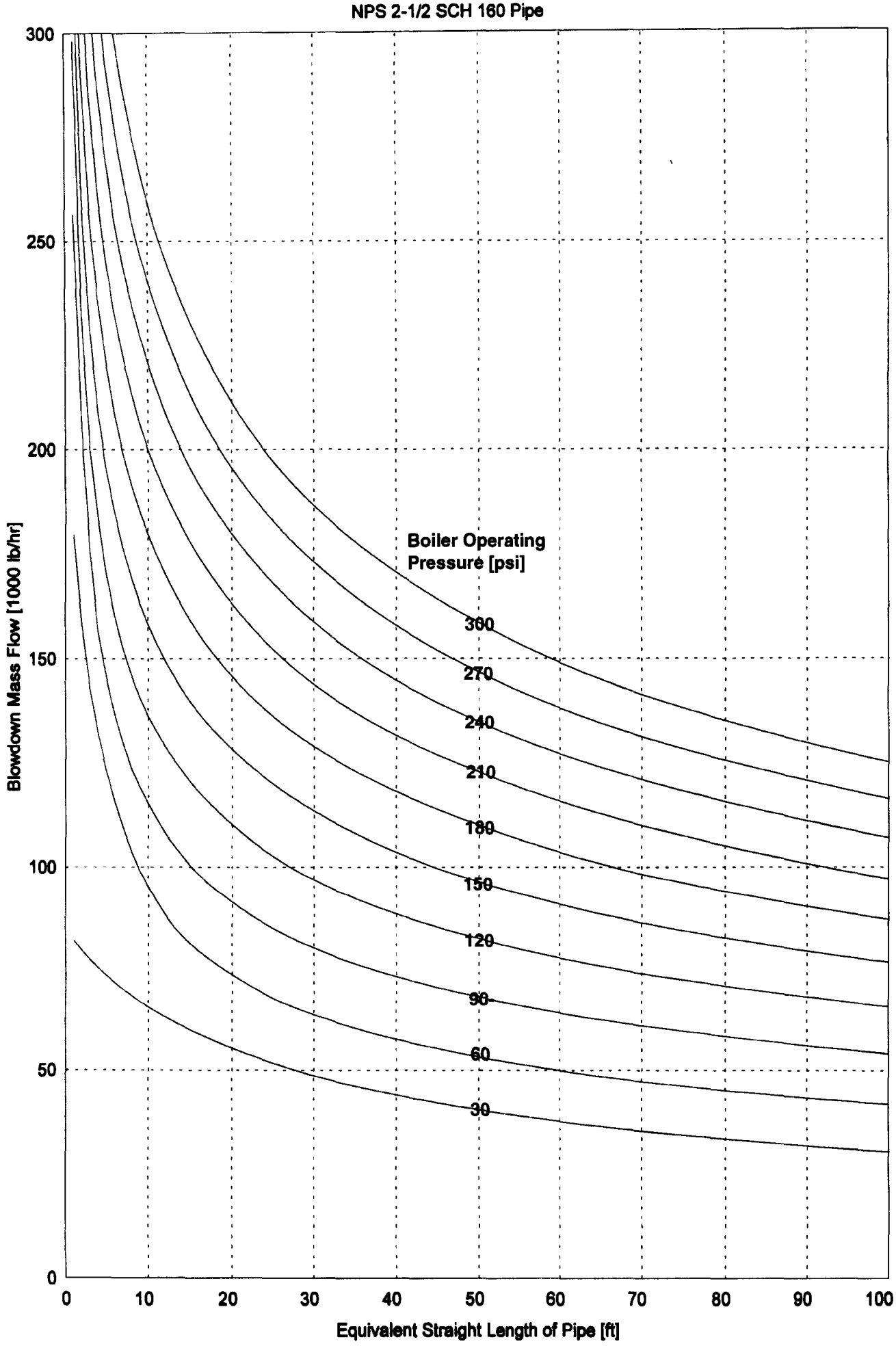

NPS 2 SCH 160 Pipe
Blowdown Mass Flow Rate [1000 lb/hr]
Equivalent Straight Length of Pipe [ft]
Boiler Operating Pressure [psi]
3000
2700
2400
2100
1800
1500
1200
900
600
300
0
50
100
150
200
250
300
350
400
450
500

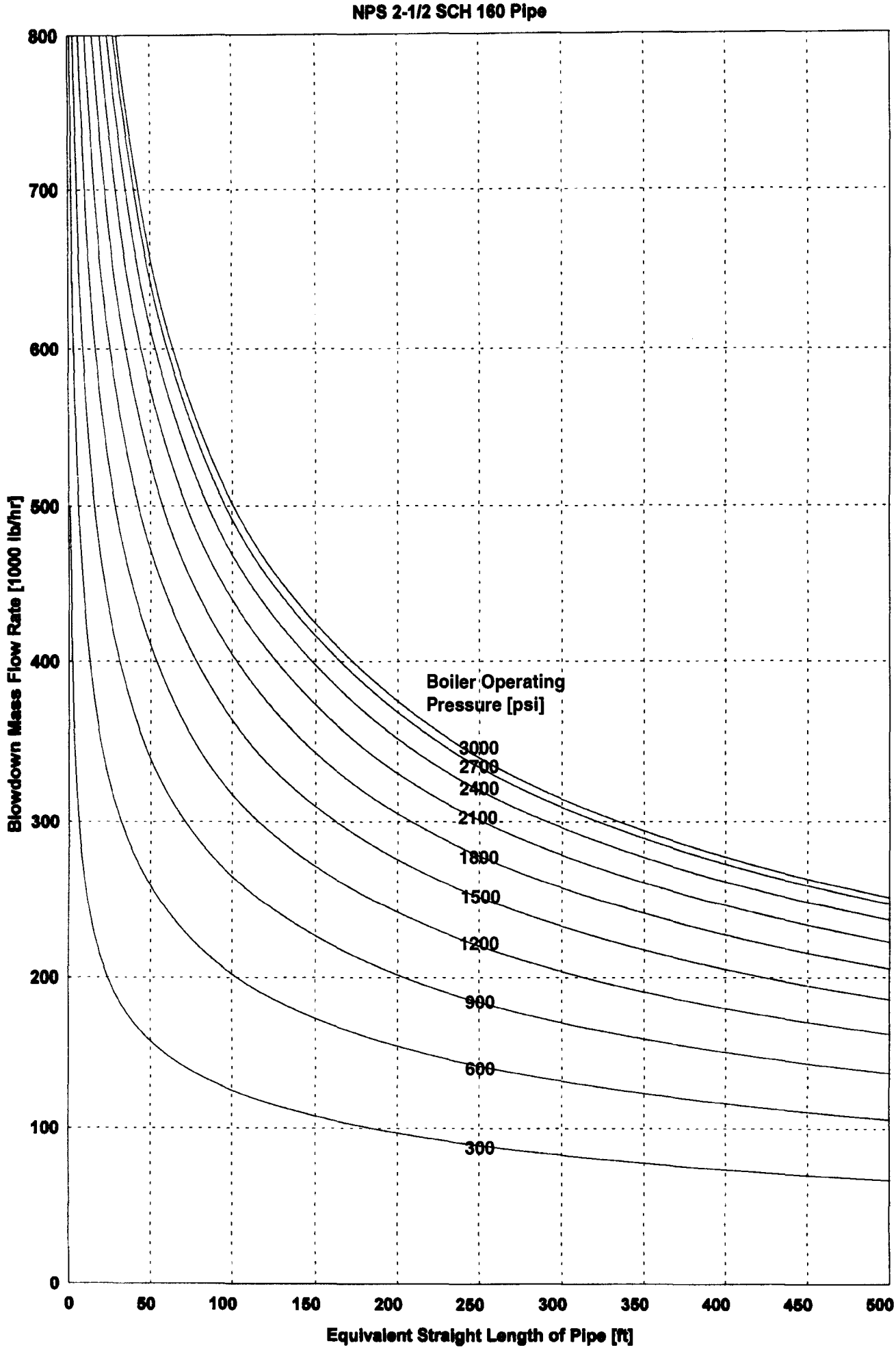

NPS 2 XX-STR Pipe
Blowdown Mass Flow [1000 lb/hr]
Equivalent Straight Length of Pipe [ft]
Boiler Operating Pressure [psi]
300
270
240
210
180
150
120
90
60
30
0
20
40
60
80
100
120
140
0
10
20
30
40
50
60
70
80
90
100

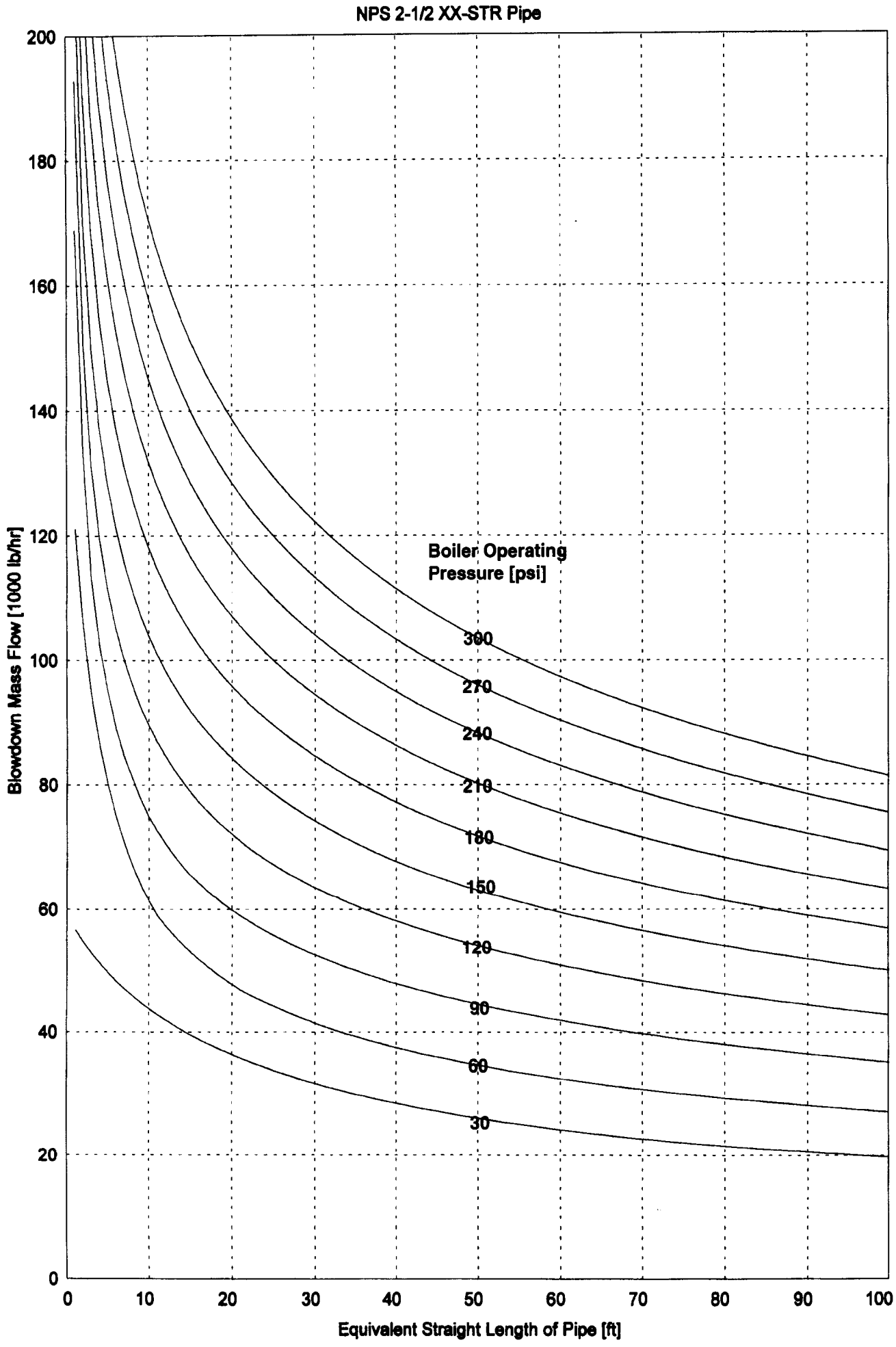

NPS 2 XX-STR Pipe
Blowdown Mass Flow Rate [1000 lb/hr]
Equivalent Straight Length of Pipe [ft]
Boiler Operating Pressure [psi]
3000
2700
2400
2100
1800
1500
1200
900
600
300
0
50
100
150
200
250
300
350
400
450
500

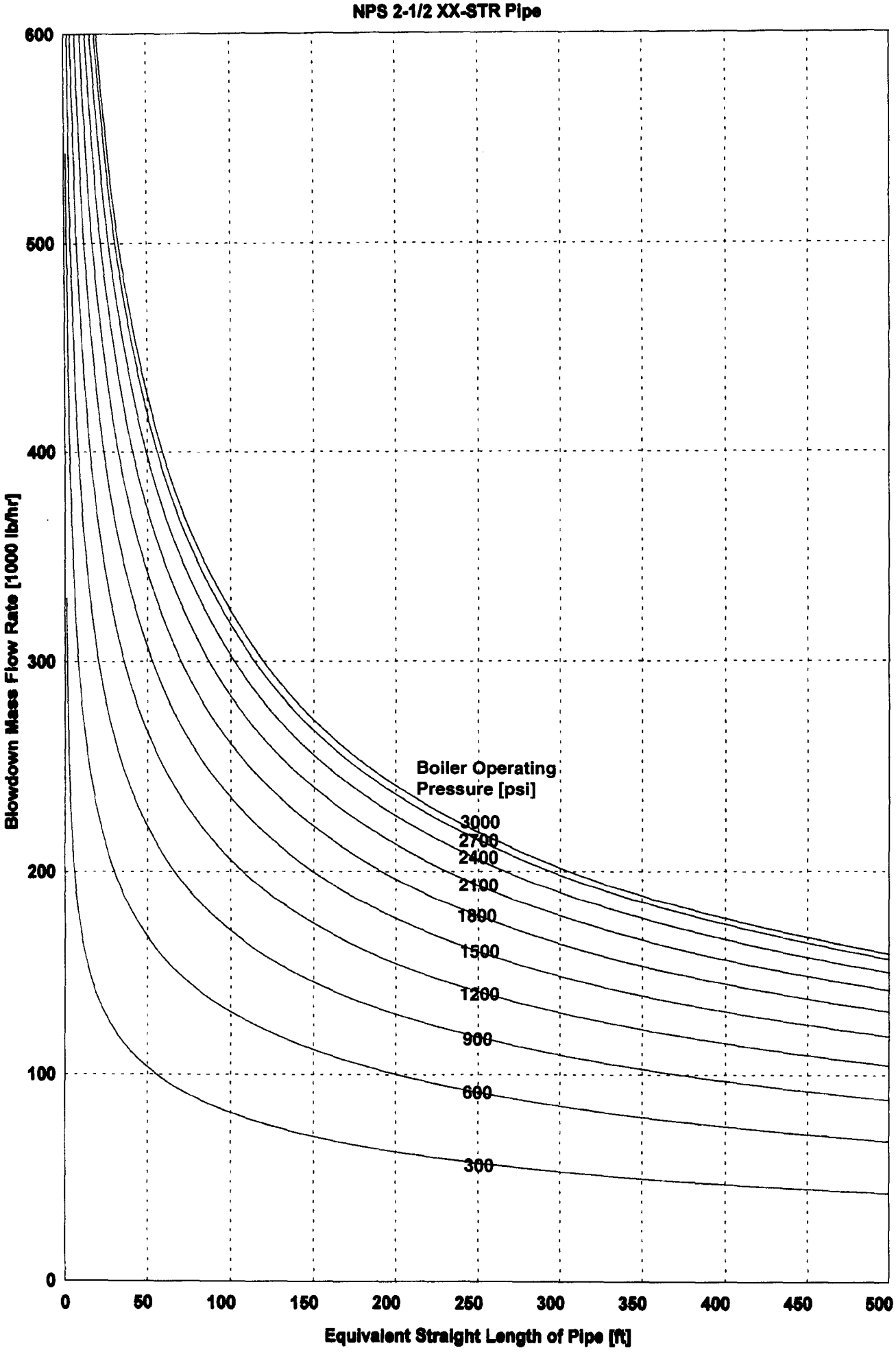

NPS 2-1/2 SCH 80 Pipe
Blowdown Mass Flow [1000 lb/hr]
Equivalent Straight Length of Pipe [ft]
Boiler Operating Pressure [psi]
300
270
240
210
180
150
120
90
60
30
0
50
100
150
200
250
300
0
10
20
30
40
50
60
70
80
90
100


NPS 2-1/2 SCH 80 Pipe
Blowdown Mass Flow Rate [1000 lb/hr]
Equivalent Straight Length of Pipe [ft]
Boiler Operating Pressure [psi]
3000
2700
2400
2100
1800
1500
1200
900
600
300
0
100
200
300
400
500
600
700
800
900
1000
0
50
100
150
200
250
300
350
400
450
500


NPS 2-1/2 SCH 160 Pipe
Blowdown Mass Flow [1000 lb/hr]
Equivalent Straight Length of Pipe [ft]
Boiler Operating Pressure [psi]
300
270
240
210
180
150
120
90
60
30
0
50
100
150
200
250
0
10
20
30
40
50
60
70
80
90
100


NPS 2-1/2 SCH 160 Pipe
Blowdown Mass Flow Rate [1000 lb/hr]
Equivalent Straight Length of Pipe [ft]
Boiler Operating Pressure [psi]
3000
2700
2400
2100
1800
1500
1200
900
600
300
0
100
200
300
400
500
600
700
800
0
50
100
150
200
250
300
350
400
450
500


NPS 2-1/2 XX-STR Pipe
Blowdown Mass Flow [1000 lb/hr]
Equivalent Straight Length of Pipe [ft]
Boiler Operating Pressure [psi]
300
270
240
210
180
150
120
90
60
30
0
20
40
60
80
100
120
140
160
180
200
0
10
20
30
40
50
60
70
80
90
100


NPS 2-1/2 XX-STR Pipe
Blowdown Mass Flow Rate [1000 lb/hr]
600
500
400
300
200
100
0
0
50
100
150
200
250
300
350
400
450
500
Equivalent Straight Length of Pipe [ft]
Boiler Operating Pressure [psi]
3000
2700
2400
2100
1800
1500
1200
900
600
300

POLYNOMIAL EQUATIONS

Discharge Pressure as a Function of Equivalent Straight Pipe Length

Polynomial equation for discharge pressure for selected boiler operating pressures.

$$Dp = b0 + b1 \cdot L + b2 \cdot L^2 + b3 \cdot L^3 + b4 \cdot L^4$$

NPS 1/2 SCH 80 PIPE – [10 psi to 100 psi]

Dp denotes discharge pressure at end of pipe [psi]
L denotes equivalent straight length of pipe [ft.]

	10 psi	20 psi	30 psi	40 psi	50 psi
b0	9.89869809590036	19.9814698940173	29.9324354617475	39.76341934158961	49.6029049178809
b1	0.0539052686264631	-0.115351281274515	-0.244393107567746	-0.370580486335473	-0.494918171481244
b2	-0.017700903054501	0.0122539935033767	0.0151444898475143	0.027152313723401	0.0183803690586138
b3	0.00199901641593568	-0.00163797552957052	-0.000841114043097596	-0.00272086154352591	-0.000504132029589913
b4	-0.0000837722134689834	0.0000783293860281673	0.0000115955889366796	0.000116665822714445	2.3664463655838E-7

	60 psi	70 psi	80 psi	90 psi	100 psi
b0	59.5510864793438	69.3406395568253	79.1976673659681	89.0266156283802	98.8979526307388
b1	-0.763907258393438	-0.966554017593957	-1.27122783908044	-1.55499193462734	-1.93527830345656
b2	0.0489590609665259	0.0644499394385098	0.109720893230949	0.130800490573165	0.187689277796699
b3	-0.00282632618384937	-0.00421117079723408	-0.00916146178574231	-0.00974013688761017	-0.0151880127323646
b4	0.0000620009037021465	0.000124948386128147	0.000330829249795616	0.000310951097458164	0.000505473016710057

Polynomial equation for discharge pressure for selected boiler operating pressures.

$$Dp = b0 + b1 \cdot L + b2 \cdot L^2 + b3 \cdot L^3 + b4 \cdot L^4 + b5 \cdot L^5 + b6 \cdot L^6$$

NPS 3/4 SCH 80 PIPE – [10 psi to 100 psi]

Dp denotes discharge pressure at end of pipe [psi]
L denotes equivalent straight length of pipe [ft.]

	10 psi	20 psi	30 psi	40 psi	50 psi
b0	9.78984941757783	19.8490946785375	30.0986978430139	39.9553877954057	49.6772548363996
b1	0.294608109985244	0.146265739522095	-0.45124358053343	-0.572673844528301	-0.33846798399399
b2	-0.205131148727729	-0.143275273325338	0.153511621216845	0.203090802442695	-0.0551799249993151
b3	0.066682712183838	0.046059132855564	-0.0368932721679263	-0.0592450184452883	0.0251768352629908
b4	-0.0108393029881077	-0.00749936531985803	0.00484813759637314	0.00927554973225345	-0.00410678277248678
b5	0.000848143197940599	0.00060089367116909	-0.000329391749462366	-0.000724287128734968	0.000303363622747465
b6	-0.1111254432389461968	-0.0000187808764132726	0.000009067845848124	0.0000221696264873616	-0.0000084636841148004

	60 psi	70 psi	80 psi	90 psi	100 psi
b0	59.5494858787374	69.6546897489053	79.5218348530841	89.449475068361	99.1613911079796
b1	-0.542044300480093	-1.12150026102663	-1.36468676479005	-1.72227567649221	-1.78953170403102
b2	-0.0104644880341723	0.231292192638944	0.276857579166277	0.365635608632502	0.286512965757433
b3	0.0147657051186141	-0.0491290652885782	-0.0598039782754479	-0.077516266296831	-0.0509894433721672
b4	-0.00276964106182034	0.00628849952411819	0.00788663354625475	0.00986606358537078	0.00595844999561967
b5	0.000217752166145778	-0.000428477189513728	-0.00055132717498233	-0.000664250270298034	-0.000391477120157615
b6	-0.00000627687131345668	0.0000119476982199579	0.0000156175150434978	0.0000182073609552893	0.0000108868228228597

Polynomial equation for discharge pressure for selected boiler operating pressures.

$$Dp = b0 + b1 \cdot L + b2 \cdot L^2 + b3 \cdot L^3 + b4 \cdot L^4 + b5 \cdot L^5 + b6 \cdot L^6$$

NPS 1 SCH 80 PIPE – [30 psi to 300 psi]

Dp denotes discharge pressure at end of pipe [psi]
L denotes equivalent straight length of pipe [ft.]

	30 psi	60 psi	90 psi	120 psi	150 psi
b0	29.8539454677502	59.45587397262614	88.78163384111637	117.9458132001336	146.9176190106654
b1	-0.1085853158890622	-0.383199622137422	-0.7320969137060103	-1.159376532150142	-1.638330613577178
b2	0.00148989464850354	0.008886321684905022	0.01849372266213301	0.03233779553220406	0.04886504281143499
b3	-0.00003108892318305836	-0.000205425710128466	-0.0004074189414919446	-0.000738094194741954	-0.001144291061533446
b4	0.000000432382926991 0598	0.00000291389954948 7502	0.00000543554651009 9929	0.00001004372546522846	0.00001576631381304531
b5	-3.126232262495467E-9	-2.14592287425473E-8	-3.806494620172818E-8	-7.141958122807722E-8	-0.000000112827229611 7043
b6	8.961913917877781E-12	6.290771484476498E-11	1.07352949592326E-10	2.040668256230759E-10	3.232091000948262E-10

	180 psi	210 psi	240 psi	270 psi	300 psi
b0	175.7196684700696	204.4189521057421	232.9376036089634	261.3418407322143	289.6376303537258
b1	-2.14940492476833	-2.711424314900803	-3.309923805433877	-3.923688032386862	-4.58547305408302
b2	0.06608382884017787	0.08594441533960666	0.1088695439291937	0.1308575660910014	0.1571881290973913
b3	-0.001551819651967718	-0.002020787200718749	-0.002612778401082307	-0.003125037221851162	-0.003813555200397849
b4	0.0000214016385634903	0.00002769720808027879	0.00003632511454936894	4.308802963752801E-5	0.00005319089340067211
b5	-0.000000153573446016 6985	-0.000000197330731939739	-0.000000261503069717467	-3.078566352777977E-7	-0.000000383310241060266
b6	4.417499593857032E-10	5.639907313896093E-10	7.530552638990175E-10	8.81247863535915E-10	1.10390241133095E-9

Polynomial equation for discharge pressure for selected boiler operating pressures.

$$Dp = b0 + b1 \cdot L + b2 \cdot L^2 + b3 \cdot L^3 + b4 \cdot L^4 + b5 \cdot L^5 + b6 \cdot L^6$$

NPS 1 SCH 80 PIPE – [100 psi to 1000 psi]

Dp denotes discharge pressure at end of pipe [psi]
L denotes equivalent straight length of pipe [ft.]

	100 psi	200 psi	300 psi	400 psi	500 psi
b0	98.89608924786083	193.1144660642947	285.1379889391826	375.2271800624419	463.50548833231597
b1	-0.6103739141847783	-1.738844979704741	-3.064172321975483	-4.48941268848513	-6.0000144095371523
b2	0.007251060438208972	0.02553677212482501	0.04914368077637317	0.0749237115036702	0.1035206573855721
b3	-0.0000646939535217869	-0.0002502887976141805	-0.0005034523006518838	-0.000777397300070464	-0.001091440724597878
b4	3.429593749776812E-7	1.395806859569468E-6	2.88438031551575E-6	4.473541988849203E-6	6.341934824035416E-6
b5	-9.526778138606108E-10	-4.015047544137589E-9	-8.450218594814782E-9	-1.312657750108513E-8	-1.873712882672527E-8
b6	1.06473404353835E-12	4.617152903061497E-12	9.845328024675101E-12	1.530257730325264E-11	2.195918240959939E-11

	600 psi	700 psi	800 psi	900 psi	1000 psi
b0	550.4591933037584	636.0125104255294	720.6759308793527	803.817249335857	886.0842806075824
b1	-7.543011201835498	-9.131082491622587	-10.80580008618296	-12.42807664611082	-14.12958343725828
b2	0.1322074410061275	0.1624995774478843	0.195630577812544	0.2263423126008061	0.2683315351203467
b3	-0.001398289257619117	-0.001728602105467851	0.0020986112390972178	-0.002427141101857095	-0.002808912852671872
b4	8.125739623847732E-6	1.007142521213833E-5	1.229244687347716E-5	1.4148943875876605E-5	1.649378166473073E-5
b5	-2.39962100041777E-8	-2.977712507127186E-8	-3.648529525876639E-8	-4.202010632037014E-8	-4.901928069133776E-8
b6	2.811298038591E-11	3.490077431653163E-11	4.28383277016616E-11	4.928961951269379E-11	5.7672613047120702E-11

Polynomial equation for discharge pressure for selected boiler operating pressures.

$$Dp = b0 + b1 \cdot L + b2 \cdot L^2 + b3 \cdot L^3 + b4 \cdot L^4 + b5 \cdot L^5 + b6 \cdot L^6$$

NPS 1 SCH 160 PIPE – [30 psi to 300 psi]

Dp denotes discharge pressure at end of pipe [psi]
L denotes equivalent straight length of pipe [ft.]

	30 psi	60 psi	90 psi	120 psi	150 psi
b0	29.85215393103639	59.37969811002646	88.68942760870377	117.7760837153989	146.6527406708576
b1	-0.1262034983065858	-0.4226554319749453	-0.8209837248054301	-1.292060190440824	-1.812547571376171
b2	0.001906703139346686	0.009356469071890788	0.02129205687448499	0.03690167716365852	0.05504675959164827
b3	-4.261367119415468E-5	-0.0002031556311733964	-0.0004708143811452264	-0.0008431327094088974	-0.001290118774355356 6
b4	6.434309487439416E-7	2.778521982937937E-6	6.302502769306001E-6	1.14584865066147E-5	1.781486011076442E-5
b5	-5.028459021435762E-9	-2.005531673670407E-8	-4.427719055591835E-8	-8.131838394151294E-8	-1.280019573014559E-7
b6	1.547132533425145E-11	5.814427896590747E-11	1.25166065344645E-10	2.31726461467335E-10	3.684558813080652E-10

	180 psi	210 psi	240 psi	270 psi	300 psi
b0	175.3412868010484	203.9069119739303	232.2958094812861	260.5771673809955	288.6707676911628
b1	-2.375387487348943	-2.98592966683766	-3.627872983527887	-4.305273969266134	-5.002139947472823
b2	0.07473883200844933	0.09696286504422898	0.1214930959555453	0.1472718845359891	0.1747021125097669
b3	-0.001760449411949034	-0.002293365063867112	-0.002918886244068231	-0.003546273174959892	-0.004253145635279856
b4	2.429680007780194E-5	3.150866564637726E-5	4.055609152541045E-5	4.910185825509003E-5	5.944483958229831E-5
b5	-1.744500732560175E-7	-2.24711845801253E-7	-2.917827889728877E-7	-3.516262269175894E-7	-4.295562369244921E-7
b6	5.019249150674908E-10	6.423343352450295E-10	8.396303955327745E-10	1.00760287028282E-9	1.241467426519799E-9

Polynomial equation for discharge pressure for selected boiler operating pressures.

$$Dp = b0 + b1 \cdot L + b2 \cdot L^2 + b3 \cdot L^3 + b4 \cdot L^4 + b5 \cdot L^5 + b6 \cdot L^6$$

NPS 1 SCH 160 PIPE – [150 psi to 1500 psi]

Dp denotes discharge pressure at end of pipe [psi]
L denotes equivalent straight length of pipe [ft.]

	150 psi	300 psi	450 psi	600 psi	750 psi
b0	146.0626461513118	283.6210585329057	416.3445345260713	545.680669997731	671.6449753649305
b1	-1.274320339912056	-3.317932441198618	-5.5766251348623052	-7.995482956362492	-10.4737793234411
b2	0.01810024643698655	0.05449694803339118	0.09625773242505194	0.1423016060963631	0.1902097335539186
b3	-0.000173982212614984	-0.0005623991561473248	-0.001011322904742934	-0.001510943679607062	-0.002036144591495314
b4	9.579218097163718E-7	3.233182485153147E-6	5.856658983460016E-6	8.787895171525426E-6	0.00001189369131613794
b5	-2.72842675816111E-9	-9.496576824257619E-9	-1.725603854519645E-8	-2.594634702148359E-8	-3.520855734044611E-8
b6	3.111368978132345E-12	1.109190875982857E-11	2.018102578268286E-11	3.037949519902564E-11	4.12486386376128E-11

	900 psi	1050 psi	1200 psi	1350 psi	1500 psi
b0	795.6280565960286	916.5408705242686	1035.506768864016	1152.391021040262	1267.477849495202
b1	-13.11333850401511	-15.71861182549257	-18.37827985931974	-21.10189241194582	-23.83729928832392
b2	0.2431490361802817	0.294981579019976	0.3480624308396725	0.4040601247527722	0.4595454097763341
b3	-0.002627732646482393	-0.00320330579225115	-0.003788867016388119	-0.004422768364791384	-0.005038477801405956
b4	0.00001543274585251645	1.886485576542225E-5	2.232029501107349E-5	2.614990511739853E-5	2.979367199623015E-5
b5	-4.584451166184668E-8	-5.615301461786325E-8	-6.640270991763529E-8	-7.801400201735709E-8	-8.884188129579262E-8
b6	5.389643916902593E-11	6.612907658339192E-11	7.81269680843654E-11	9.200159322183354E-11	1.046937562579487E-10

Polynomial equation for discharge pressure for selected boiler operating pressures.

$$Dp = b0 + b1 \cdot L + b2 \cdot L^2 + b3 \cdot L^3 + b4 \cdot L^4 + b5 \cdot L^5 + b6 \cdot L^6 + b7 \cdot L^7 + b8 \cdot L^8$$

NPS 1 XX-STR PIPE – [30 psi to 300 psi]

Dp denotes discharge pressure at end of pipe [psi]
L denotes equivalent straight length of pipe [ft.]

	30 psi	60 psi	90 psi	120 psi	150 psi
b0	29.8743757825984	59.40546006642314	88.76983495031081	117.9068830117052	146.8990852691831
b1	-0.1791712916039307	-0.596252787243885	-1.169747921665695	-1.846878085757797	-2.62553390353374
b2	0.004544109188391995	0.02132749793184147	0.04876275379178646	0.08453567456069278	0.1295486633220977
b3	-0.000181808558680321	-0.0008284320530531324	-0.001901295778270732	-0.003382651522396968	-0.005334816429210941
b4	5.305499912409691E-6	2.219221055580768E-5	4.965272620103279E-5	8.913748355297035E-5	0.0001423186643913869
b5	-9.671816425273727E-8	-3.699787508931415E-7	-8.100005000142715E-7	-1.461375709801533E-6	-2.343355251812092E-6
b6	1.045173107166273E-9	3.663147229931509E-9	7.909410984754799E-9	1.432220527632351E-8	2.294833622993625E-8
b7	-6.107884008901399E-12	-1.96848536818498E-11	-4.220462564796251E-11	-7.665611120027933E-11	-1.222929009684099E-10
b8	1.482509267185766E-14	4.415681004049178E-14	9.449996050728495E-14	1.720993584643447E-13	2.726523954604886E-13

	180 psi	210 psi	240 psi	270 psi	300 psi
b0	175.7254204193667	204.3375054604938	232.9194056628128	261.2586863824603	289.5280687801112
b1	-3.473409382678278	-4.344583769519074	-5.329902076966175	-6.296819459057516	-7.368602510344169
b2	0.1804424560286307	0.2293030330553093	0.2932274249776717	0.349705293435949	0.4229609481224991
b3	-0.007599267444457729	-0.009558798749711085	-0.01249402300300378	-0.01478154241171338	-0.01829413691564479
b4	0.0002059850967331113	0.0002556472984399729	0.0003388115184151265	0.0003968830266741804	0.0005007526788763332
b5	-3.439478807482147E-6	-4.222140767982039E-6	-5.645323898684609E-6	-6.560631823603194E-6	-8.414069382304741E-6
b6	3.41167623766967E-8	4.156440931911578E-8	5.5860192397576587E-8	6.457084002919417E-8	8.39445041899324E-8
b7	-1.83995739904211E-10	-2.231530639797444E-10	-3.001713587844446E-10	-3.4641967917103E-10	-4.553698286703695E-10
b8	4.149445548068065E-13	5.0218936932323E-13	6.767887368056852E-13	7.7882856167548E-13	1.032939985888771E-12

Polynomial equation for discharge pressure for selected boiler operating pressures.

$$Dp = b0 + b1 \cdot L + b2 \cdot L^2 + b3 \cdot L^3 + b4 \cdot L^4 + b5 \cdot L^5 + b6 \cdot L^6 + b7 \cdot L^7 + b8 \cdot L^8 + b9 \cdot L^9 + b10 \cdot L^{10}$$

NPS 1 XX-STR PIPE – [200 psi to 2000 psi]

Dp denotes discharge pressure at end of pipe [psi]
L denotes equivalent straight length of pipe [ft.]

	200 psi	400 psi	600 psi	800 psi	1000 psi
b0	194.5948735911871	379.073891536775	558.000045583645	731.5660874649195	901.6040776063182
b1	-3.307388865899265	-8.687262018519608	-15.04108346851081	-21.6896165193865	-28.79590986417997
b2	0.1151099542791498	0.3383139036984791	0.630046077409482	0.9370661500538429	1.275530477231423
b3	-0.003080549121571944	-0.009298549536122901	-0.01799338398360964	-0.0270543537938287	-0.0371634061178214
b4	5.443873369573664E-5	0.0001643169556822 3971	0.0003262331909309592	0.0004929166787352283	0.0006796891061778276
b5	-6.284440269978801E-7	-1.880933744161973E-6	-3.805738190212155E-6	-5.766424721405835E-6	-7.963307030346522E-6
b6	4.752789486475939E-9	1.407580858592942E-8	2.889108412185622E-8	4.386712171865831E-8	6.059574959576797E-8
b7	-2.329620162935687E-11	-6.828719054918069E-11	-1.416948490238428E-10	-2.155527767364098E-10	-2.976144246271986E-10
b8	7.117818078199238E-14	2.067318914194734E-13	4.324968910167552E-13	6.591947606353506E-13	9.093027677797123E-13
b9	-1.230721009151442E-16	-3.546475381409425E-16	-7.464944100840794E-16	-1.140051574945945E-15	-1.570657495488058E-15
b10	9.191005068763192E-20	2.631053907572144E-19	5.563000938043611E-19	8.51358303144961E-19	1.171241329635363E-18

	1200 psi	1400 psi	1600 psi	1800 psi	2000 psi
b0	1067.716668723431	1203.460886556334	1390.77916977719	1547.383180273738	1701.587520892491
b1	-36.10041105374252	-43.48919626915243	-51.30642928828687	-59.07639990674046	-67.17831235439142
b2	1.628796977613893	1.981895589970848	2.37244130378683	2.757066461194187	3.171168106667848
b3	-0.04783710121961611	-0.052645100503482	-0.07019928609646296	-0.08182361157783671	-0.09463632553896027
b4	0.0008795701936057345	0.001069726389024153	0.001293485248155082	0.001509583771807162	0.001751843734838758
b5	-1.035176030809971E-5	-1.256258704929957E-5	-1.522274212165676E-5	-1.777920458434405E-5	-2.067730018018904E-5
b6	7.9104199000762E-8	9.578301963739855E-8	1.162061953918145E-7	1.358045688848738E-7	1.5816063987509E-7
b7	-3.901015933860812E-10	-4.71362949285245E-10	-5.72199197083599E-10	-6.691110114427441E-10	-7.799016313860524E-10
b8	1.196549077211999E-12	1.443116836922657E-12	1.752048036465891E-12	2.050124068468253E-12	2.390550822523812E-12
b9	-2.074543756157807E-15	-2.498056070873405E-15	-3.032190019032761E-15	-3.550519245912842E-15	-4.140480177820959E-15
b10	1.55244525355023E-18	1.866880881942011E-18	2.265056645187787E-18	2.654168458657416E-18	3.094769381962645E-18

Polynomial equation for discharge pressure for selected boiler operating pressures.

$$Dp = b0 + b1 \cdot L + b2 \cdot L^2 + b3 \cdot L^3 + b4 \cdot L^4 + b5 \cdot L^5 + b6 \cdot L^6$$

NPS 1-1/4 SCH 80 PIPE – [30 psi to 300 psi]

Dp denotes discharge pressure at end of pipe [psi]
L denotes equivalent straight length of pipe [ft.]

	30 psi	60 psi	90 psi	120 psi	150 psi
b0	29.89600404209104	59.527421132282235	88.98218141723997	118.2853516522761	147.4189485628328
b1	-0.0899469364877909	-0.3105491238434146	-0.6110141776871645	-0.97214110741559	-1.375824846937447
b2	0.00148528661391413	0.007130369610762843	0.01591719456544923	0.0271269936058703	0.04012101559489196
b3	-3.460139565966609E-5	-0.0001680357150154514	-0.0003766855559203028	-0.000638022436268256	-0.0009408078886804439
b4	4.879205985410913E-6	2.391441112773098E-6	5.347972722829975E-6	8.894964347155392E-6	1.295587166409106E-5
b5	-3.493101349101327E-9	-1.756202335314245E-8	-3.947120552344509E-8	-6.44396136996286E-8	-9.261224702714126E-8
b6	9.870666638016669E-12	9.870666638016669E-12	1.163816733127363E-10	1.867747469189168E-10	2.651828698239228E-10

	180 psi	210 psi	240 psi	270 psi	300 psi
b0	176.4543499806105	205.722997828486	234.18980989994	262.8190715278827	291.4290273300476
b1	-1.832759381565634	-2.319104767263021	-2.856247544367195	-3.39017627140203	-3.978263837356392
b2	0.05635818475483942	0.0731253330538393	0.09353461263322344	0.1126122208775039	0.1352359784446697
b3	-0.001354502851053904	-0.001755953467631302	-0.002275700028293214	-0.002745643216164507	-0.003315460645032685
b4	1.899304178180232E-5	2.453188835652463E-5	3.1917261755426797E-5	3.86226803286277E-5	4.659899909811978E-5
b5	-1.377555975599191E-7	-1.77444630872373E-7	-2.308328441433879E-7	-2.806453419240156E-7	-3.373494640704328E-7
b6	3.9902933477954E-10	5.130537548950835E-10	6.661902535297929E-10	8.14509358595874E-10	9.7422737220026E-10

Polynomial equation for discharge pressure for selected boiler operating pressures.

$$Dp = b0 + b1 \cdot L + b2 \cdot L^2 + b3 \cdot L^3 + b4 \cdot L^4 + b5 \cdot L^5 + b6 \cdot L^6 + b7 \cdot L^7 + b8 \cdot L^8 + b9 \cdot L^9 + b10 \cdot L^{10}$$

NPS 1-1/4 SCH 80 PIPE – [100 psi to 1000 psi]

Dp denotes discharge pressure at end of pipe [psi]
L denotes equivalent straight length of pipe [ft.]

	100 psi	200 psi	300 psi	400 psi	500 psi
b0	99.16141759548906	195.2653403010722	289.1116868619249	382.0294570936673	472.9201623433307
b1	-0.51519171279016	-1.641002541815202	-2.94079466361323	-4.47888207715781	-6.051836051407713
b2	0.006923783367455074	0.0246032896937837	0.05658000555689117	0.09181933723397234	0.128301091381014
b3	-8.660857492917695E-5	-0.000406750198063514	-0.0007901368904056282	-0.001310814353412147	-0.001858477666962487
b4	7.65276282618167E-7	3.683964622432893E-6	7.121455004693253E-6	1.189726738766315E-5	1.700649150308911E-5
b5	-4.524724809925677E-9	-2.168416532621119E-8	-4.153532416000724E-8	-6.945357473882498E-8	-9.978155982317965E-8
b6	1.76977995184476E-11	8.332751128894982E-11	1.580690809370275E-10	2.638366089206512E-10	3.802246044853472E-10
b7	-4.50460716406044E-14	-2.070510397555056E-13	-3.892359203428648E-13	-6.476626254262224E-13	-9.35065776299988E-13
b8	7.156742957109737E-17	3.201752758411991E-16	5.97091562727647E-16	9.898235689117476E-16	1.430394127021286E-15
b9	-6.434562995959918E-20	-2.798582864178202E-19	-5.182660444606538E-19	-8.557239704376742E-19	-1.237018479828454E-18
b10	2.496764936263995E-23	1.055587829470238E-22	1.942970251907545E-22	3.1950114580439E-22	4.61936046789315E-22

	600 psi	700 psi	800 psi	900 psi	1000 psi
b0	562.91561392878	652.1212856694609	740.1835445390791	826.9157339310199	913.229808706522
b1	-7.725835474234628	-9.501872384902686	-11.29835285554784	-13.12656321077929	-15.0358681321275
b2	0.1681541354516085	0.2112042891455021	0.2538894750660443	0.2993532079949552	0.3461839739476665
b3	-0.002468884810578154	-0.003123066956537443	-0.003754721220205091	-0.004465916668403095	-0.005170018125208673
b4	2.282532257682223E-5	2.895001909867358E-5	3.471096175525256E-5	4.15771360394122E-5	4.806040825241887E-5
b5	-1.35109244344673E-7	-1.715426917653468E-7	-2.04959754821566E-7	-2.470251956632143E-7	-2.848638677202973E-7
b6	5.188566889499787E-10	6.590655757191987 8E-10	7.845911677935902E-10	9.508732340258169E-10	1.09359292709785E-9
b7	-1.284761102515238E-12	-1.632285179743138E-12	-1.936311485917085E-12	-2.358385651613885E-12	-2.70507769380649E-12
b8	1.977227671969023E-15	2.512319167273958E-15	2.970349684248766E-15	3.633963252359706E-15	4.157534057116882E-15
b9	-1.719062637676499E-18	-2.184335460948698E-18	-2.574606326394458E-18	-3.162336835930543E-18	-3.609490059764985E-18
b10	6.448448875236961E-22	8.193259552492855E-22	9.629736193300042E-22	1.186988307861686E-21	1.351992761265942E-21

Polynomial equation for discharge pressure for selected boiler operating pressures.

$$Dp = b0 + b1 \cdot L + b2 \cdot L^2 + b3 \cdot L^3 + b4 \cdot L^4 + b5 \cdot L^5 + b6 \cdot L^6$$

NPS 1-1/4 SCH 160 PIPE – [30 psi to 300 psi]

Dp denotes discharge pressure at end of pipe [psi]
L denotes equivalent straight length of pipe [ft.]

	30 psi	60 psi	90 psi	120 psi	150 psi
b0	29.8899070718651	59.5020165820039	88.9140954376943	118.183187195051	147.318076229491
b1	-0.0956909233477678	-0.330717666604292	-0.645741891549692	-1.0288865004206	-1.46834288488756
b2	0.00141337885838675	0.00736569533493298	0.0164158444584984	0.0284897599970235	0.0433656768530672
b3	-0.0000308017094169396	-0.000166693634299877	-0.000375620602976091	-0.000659835121253297	-0.00101752197263512
b4	4.39729025648386E-7	2.31313728186873E-6	5.19041412686673E-6	9.09827570608471E-6	0.0000140046846253999
b5	-3.30447330673448E-9	-1.67383859948045E-8	-3.7458360533099E-8	-6.54134568154952E-8	-1.00006753316833E-7
b6	9.97839714108712E-12	4.84687445959399E-11	1.08340159561703E-10	1.88623771981537E-10	2.85914569136751E-10

	180 psi	210 psi	240 psi	270 psi	300 psi
b0	176.251328723718	205.08739284107	233.870371071289	262.411803955346	290.966809666134
b1	-1.93711567586809	-2.44411865541309	-3.01760748709436	-3.56840502801991	-4.19822788865394
b2	0.059488694030042	0.0771447613512814	0.0994436698933092	0.118651252663614	0.14406287394394
b3	-0.00141439259606362	-0.00184112883460072	-0.00241405015519275	-0.00287020221589103	-0.00353685193277852
b4	0.0000196487991966945	0.0000256057772356567	0.0000337878714040816	0.0000400854707071019	0.0000497707457997414
b5	-1.41412920608009E-7	-1.84694399579797E-7	-2.43999458641309E-7	-2.89648648408881E-7	-0.00000036088347364659
b6	4.068904830231957E-10	5.33217431034917E-10	7.03379325460923E-10	8.37146529527602E-10	1.04410726650355E-9

Polynomial equation for discharge pressure for selected boiler operating pressures.

$$Dp = b0 + b1 \cdot L + b2 \cdot L^2 + b3 \cdot L^3 + b4 \cdot L^4 + b5 \cdot L^5 + b6 \cdot L^6 + b7 \cdot L^7 + b8 \cdot L^8 + b9 \cdot L^9 + b10 \cdot L^{10}$$

NPS 1-1/4 SCH 160 PIPE – [150 psi to 1500 psi]

Dp denotes discharge pressure at end of pipe [psi]
L denotes equivalent straight length of pipe [ft.]

	150 psi	300 psi	450 psi	600 psi	750 psi
b0	147.19652488684	288.4525680688545	426.5179215676114	561.2103681581244	693.3160064179748
b1	-1.090907619571431	-3.096254951750497	-5.520042817027744	-8.095428614611462	-10.80488200236035
b2	0.01777117828152491	0.06038993122946774	0.1172502110183474	0.1785507225106766	0.2440979914993776
b3	-2.345736462663517E-4	-8.445755455231266E-4	-1.704797425068938E-3	-2.629501626729007E-3	-3.625941370068928E-3
b4	2.078388033515436E-6	7.584210458057398E-6	1.567678164049351E-5	2.429926607534746E-5	3.367155837010675E-5
b5	-1.208193284342743E-8	-4.394609334863714E-8	-9.245403960688731E-8	-1.435526724999989E-7	-1.996941639193014E-7
b6	4.605234211564517E-11	1.658919757615976E-10	3.540225541802277E-10	5.498065529241576E-10	7.675767573987638E-10
b7	-1.137566918958395E-13	-4.048967708130436E-13	-8.744027403399966E-13	-1.357260794364288E-12	-1.901460318231593E-12
b8	1.750932604381045E-16	6.15508804725287E-16	1.342507389945526E-15	2.082077517930849E-15	2.92683610298537E-15
b9	-1.524530864568009E-19	-5.294912572525553E-19	-1.164481588162109E-18	-1.804245260850646E-18	-2.544671245695295E-18
b10	5.730964557203717E-23	1.967962615382112E-22	4.357704069146207E-22	6.745490510838653E-22	9.543984174624885E-22

	900 psi	1050 psi	1200 psi	1350 psi	1500 psi
b0	823.3804338879138	951.4083814031779	1077.431232653082	1201.938225885302	1324.331164567918
b1	-13.62113561284238	-16.57909653910076	-19.58237999139082	-22.67922599295878	-25.79741635907181
b2	0.3122282267231057	0.3870919557722664	0.4633263129978779	0.5424165924885188	0.6227288433533886
b3	-0.0046445294485775	-5.806581401070867E-3	-6.990914524992186E-3	-8.210963129957423E-3	-9.463433119256601E-3
b4	4.305068144247008E-5	5.407396136089672E-5	6.535428442066666E-5	7.681594769460929E-5	8.875278480921484E-5
b5	-2.546747802071937E-7	-3.207536673113131E-7	-3.888850398470096E-7	-4.56917266720305E-7	-5.289645485225975E-7
b6	9.765409165887593E-10	1.23176166223826E-9	1.497550962736815E-9	1.757963964176437E-9	2.03867892035736E-9
b7	-2.414057095163246E-12	-3.047100115525818E-12	-3.713952991539889E-12	-4.354889936906856E-12	-5.058114935680767E-12
b8	3.70946815307236E-15	4.683088461162601E-15	5.720992442578447E-15	6.70032816143048E-15	7.793114279724134E-15
b9	-3.220680213321378E-18	-4.065443739377188E-18	-4.976645428956932E-18	-5.82179808149248E-18	-6.779665155763448E-18
b10	1.206637649982E-21	1.522615907694842E-21	1.867296159045644E-21	2.182042078397114E-21	2.543808374226819E-21

Polynomial equation for discharge pressure for selected boiler operating pressures.

$$Dp = b0 + b1 \cdot L + b2 \cdot L^2 + b3 \cdot L^3 + b4 \cdot L^4 + b5 \cdot L^5 + b6 \cdot L^6$$

NPS 1-1/4 XX-STR PIPE – [30 psi to 300 psi]

Dp denotes discharge pressure at end of pipe [psi]
L denotes equivalent straight length of pipe [ft.]

	30 psi	60 psi	90 psi	120 psi	150 psi
b0	29.87675008900412	59.41364609526203	88.76753107697981	117.9326965080057	146.9016920658673
b1	-0.1201913396211941	-0.3962032215709303	-0.773922303471275	-1.222931615769975	-1.727834967360033
b2	0.001986855668043773	0.008854233898921281	0.02011273240507856	0.03492782312447245	0.05280061559597007
b3	-4.637512415979174E-5	-0.0001967379717626907	-0.0004500214351607323	-0.0008068421646706297	-0.001252188930812822
b4	6.886996002565263E-7	2.720647645356025E-6	6.071913328856348E-6	1.107670879085775E-5	1.741801651955222E-5
b5	-5.202301045940909E-9	-1.967821010573845E-8	-4.289372293570361E-8	-7.93117567325167E-8	-1.256683287298564E-7
b6	1.537823942047604E-11	5.685628260988562E-11	1.21793143658508E-10	2.278111369190896E-10	3.626053514632743E-10

	180 psi	210 psi	240 psi	270 psi	300 psi
b0	175.7139644072643	204.3836743968721	232.9255706831818	261.3245540499244	289.586466770955
b1	-2.271616355062612	-2.858366205543637	-3.488905677442012	-4.139428631988967	-4.830691279377744
b2	0.07166162777892904	0.9293994353590762	0.117529312007532	0.1417816715181613	0.1700324335296098
b3	-0.001697903430829195	-0.002211623553444456	-0.002851380738097304	-0.003430576292925851	-0.004185350490481902
b4	2.346385609455474E-5	3.050123152211524E-5	3.988646664938851E-5	0.0000476331428230362	5.893658093096037E-5
b5	-1.68127667682703E-7	-2.179731997880604E-7	-2.882677940183957E-7	-3.415609872568618E-7	-4.27692634405158E-7
b6	4.81872650068767E-10	6.237066644657852E-10	8.322909654609523E-10	9.792149624303492E-10	1.238361400504687E-9

Polynomial equation for discharge pressure for selected boiler operating pressures.

$$Dp = b0 + b1 \cdot L + b2 \cdot L^2 + b3 \cdot L^3 + b4 \cdot L^4 + b5 \cdot L^5 + b6 \cdot L^6 + b7 \cdot L^7 + b8 \cdot L^8 + b9 \cdot L^9 + b10 \cdot L^{10}$$

NPS 1-1/4 XX-STR PIPE – [200 psi to 2000 psi]

Dp denotes discharge pressure at end of pipe [psi]
L denotes equivalent straight length of pipe [ft.]

	200 psi	400 psi	600 psi	800 psi	1000 psi
b0	193.9102882732917	377.6908173498991	554.7136752517671	727.6457738347799	895.6367730317414
b1	-2.023296227639676	-5.31339603143137	-8.934601276647783	-12.92018033731681	-16.9806711480166
b2	0.03840219363517766	0.114723614105834	0.2008608456911059	0.300853317839447	0.4031119327974518
b3	-0.0005322611160544957	-0.001675526615985167	-0.00296433224198517	-0.004506902765984971	-0.006078186762154098
b4	4.773911041070007E-6	1.543960879545671E-5	5.737960583147111E-5	4.197100797799435E-5	5.675533067718621E-5
b5	-2.772452341367135E-8	-9.118407098919186E-8	-1.616735779409879E-7	-2.491360196515881E-7	-3.373083092547827E-7
b6	1.05054118207776E-10	3.496009471866047E-10	6.192608479999333E-10	9.577154814859832E-10	1.297446454541067E-9
b7	-2.57500945237907E-13	-8.64647279046438E-13	-1.52974071841123E-12	-2.37193475708755E-12	-3.21437787718451E-12
b8	3.930520825455258E-16	1.329605369566351E-15	2.349377424263852E-15	3.649722821640494E-15	4.947038821685906E-15
b9	-3.39345201707745E-19	-1.15541421415142E-18	-2.0389575695461E-18	-3.17193545208996E-18	-4.30018549063826E-18
b10	1.264970826996868E-22	4.333022845249221E-22	7.636374221974072E-22	1.18920257879712E-21	1.612504468423122E-21

	1200 psi	1400 psi	1600 psi	1800 psi	2000 psi
b0	1060.576474107891	1221.748529554784	1379.718873037338	1534.960512729108	1687.102092300117
b1	-21.27829107947963	-25.59470397882312	-30.00092946951536	-34.55939055661386	-39.12585642995648
b2	0.5150260386835298	0.627245067046276	0.7419848500671562	0.8650742220369563	0.9861211151052772
b3	-0.007827870195062965	-0.009584115733779004	-0.01135679735508692	-0.01332316436465989	-0.01520947263508661
b4	0.0000733858077974127	9.015794308171588E-5	0.000106780059227231 5	0.000125789721208607 1	0.000143604258358976 6
b5	-4.371157189260363E-7	-5.384365989618868E-7	-6.369288601068031E-7	-7.526532022866947E-7	-8.589533493912077E-7
b6	1.683516387069703E-9	2.078201401782093E-9	2.454934333527267E-9	2.90804188871088E-9	3.317501898879732E-9
b7	-4.17395748604427E-12	-5.16152354599723E-12	-6.08902632519347E-12	-7.22692765205586E-12	-8.24205773479007E-12
b8	6.426503266786887E-15	7.958182302950954E-15	9.37693425734947E-15	1.114678758748592E-14	1.271029421317603E-14
b9	-5.58730935697303E-18	-6.92658100970625E-18	-8.15292071766451E-18	-9.70416820491365E-18	-1.1064776270378E-17
b10	2.095283265055197E-21	2.599687829328275E-21	3.057254631209089E-21	3.642783096757408E-21	4.153804266243485E-21

Polynomial equation for discharge pressure for selected boiler operating pressures.

$$Dp = b0 + b1 \cdot L + b2 \cdot L^2 + b3 \cdot L^3 + b4 \cdot L^4 + b5 \cdot L^5 + b6 \cdot L^6 + b7 \cdot L^7 + b8 \cdot L^8$$

NPS 1-1/2 SCH 80 PIPE – [30 psi to 300 psi]

Dp denotes discharge pressure at end of pipe [psi]
L denotes equivalent straight length of pipe [ft.]

	30 psi	60 psi	90 psi	120 psi	150 psi
b0	29.9302743138104	59.62622691404646	89.20351030110469	118.7183198793981	148.0456576077535
b1	-0.9662380377713863	-0.3151766724523102	-0.627089100461774	-1.032269974375221	-1.471798347632762
b2	0.003792783349543405	0.01191554792991976	0.025973938413926679	0.04707311670356455	0.06909881180000634
b3	-0.0001789818430558929	-0.0005029329930819308	-0.001091538066897274	-0.002020871076079114	-0.002940863381533686
b4	5.007804712081908E-6	1.392519217289535E-5	2.966026464816925E-5	5.578457392153089E-5	0.0000805065700723763
b5	-8.208211865422808E-8	-2.388258522247964E-7	-4.916625274088028E-7	-9.429851744116098E-7	-1.351806203249514E-6
b6	7.785567391221342E-10	2.444416485499351E-9	4.80213746315647E-9	9.443550112502037E-9	7.34530822251996E-8
b7	-3.95702255081858E-12	-1.36324009148743E-11	-2.53285570211079E-11	-5.13677640254187E-11	-7.2708089662829E-11
b8	8.339634799048576E-15	3.179295697428815E-14	5.552127960378474E-14	1.167903003228099E-13	1.642099052985778E-13

	180 psi	210 psi	240 psi	270 psi	300 psi
b0	177.2739776272162	206.499492456963	235.6139342557731	264.6125118838393	293.4976086281824
b1	-1.954848291486964	-2.517914999102947	-3.117730865820562	-3.744157893612255	-4.385125453450638
b2	0.09326421816935844	0.125005893727708	0.1596683023513409	0.1957601688667503	0.230553812828364
b3	-0.003916894581926679	-0.005311000460328886	-0.006853585848282314	-0.008420463863655041	-0.009825400441908097
b4	0.0001057294885061011	0.0001443553738018967	0.0001878691945854986	0.0002300754243188061	0.00026099695477429
b5	-1.755257599248025E-6	-2.408535976714973E-6	-3.162962726618467E-6	-3.850509397082708E-6	-4.425046117054324E-6
b6	1.732707954746089E-8	2.385560799256146E-8	3.162034737063152E-8	3.82131066349393968E-8	4.37338339050615E-8
b7	-9.3173648980878E-11	-1.28506300229287E-10	-1.718961916916941 82E-10	-2.06122917055264E-10	-2.35344108900039E-10
b8	2.099104340330688E-13	2.895998305906857E-13	3.90778477836375E-13	4.649587123064591E-13	5.3032677887345E-13

Polynomial equation for discharge pressure for selected boiler operating pressures.

$$Dp = b0 + b1 \cdot L + b2 \cdot L^2 + b3 \cdot L^3 + b4 \cdot L^4 + b5 \cdot L^5 + b6 \cdot L^6 + b7 \cdot L^7 + b8 \cdot L^8 + b9 \cdot L^9 + b10 \cdot L^{10}$$

NPS 1-1/2 SCH 80 PIPE – [200 psi to 2000 psi]

Dp denotes discharge pressure at end of pipe [psi]
L denotes equivalent straight length of pipe [ft.]

	200 psi	400 psi	600 psi	800 psi	1000 psi
b0	196.0340236232225	383.5290466692038	566.0519558102935	744.5889832052291	920.0815367249983
b1	-1.516234628527679	-4.126972962196613	-7.192141038414892	-10.53585149529764	-14.15145056976761
b2	0.02676971500618677	0.08312430868574572	0.1533166225377222	0.2320537234783863	0.3207207814758057
b3	-0.00036424996302623	-0.00118615923874293	-0.00222631009340946	-0.00340535975486447	-0.00476235907833919
b4	3.2333393172209E-6	1.0805064594724E-5	0.0000203897327269	3.1356131335191E-5	4.4121251576095E-5
b5	-1.8593977137485E-8	-6.3363160301541E-8	-1.1964305537485E-7	-1.8474521368724E-7	-2.6085901021749E-7
b6	6.9724310993069E-11	2.4173910696517E-10	4.5576302483756E-10	7.0641418506376E-10	9.9941539624471E-10
b7	-1.690412425963E-13	-5.955884274655E-13	-1.120202813181E-12	-1.742618458838E-12	-2.46802708783E-12
b8	2.5516806991157E-16	9.1283006246386E-16	1.712368080341E-15	2.6732911476346E-15	3.788013899683E-15
b9	-2.178813990699E-19	-7.907624419829E-19	-1.479643016264E-18	-2.317911781808E-18	-3.28494497077E-18
b10	8.0348913340815E-23	2.9562282479195E-22	5.5191606026193E-22	8.6744209151476E-22	1.2292589369097E-21

	1200 psi	1400 psi	1600 psi	1800 psi	2000 psi
b0	1092.348945812523	1261.900295467436	1428.154797563672	1592.477439237684	1753.412444253921
b1	-17.9419731145174	-21.88111244909457	-25.84444766795474	-30.07773138293298	-34.22287460004515
b2	0.4155436168732073	0.5160608449855356	0.6154141862810473	0.7267780422539869	0.832008491624707
b3	-0.00622539372552496	-0.00779964804461647	-0.00931454365149045	-0.0110729470813183	-0.0126813490626968
b4	5.7959882253554E-5	7.3053826503134E-5	8.7183141553961E-5	0.00010404022913071	0.0001190580746441
b5	-3.4379272949671E-7	-4.3534513394382E-7	-5.1889542103085E-7	-6.2081491320208E-7	-7.0973111006925E-7
b6	1.32028122458979E-9	1.67814430463269E-9	1.99759587188838E-9	2.39434640576723E-9	2.73485965702017E-9
b7	-3.266358683159E-12	-4.164291603994E-12	-4.951175740283E-12	-5.942570097656E-12	-6.782918794151E-12
b8	5.0206550589229E-15	6.4164320299861E-15	7.6213630475757E-15	9.1565515333482E-15	1.0446039296414E-14
b9	-4.359132542483E-18	-5.581769897865E-18	-6.624733702399E-18	-7.964971984057E-18	-9.083598542947E-18
b10	1.6328924072797E-21	2.0940431752767E-21	2.4838059390341E-21	2.9878555423698E-21	3.4068474017919E-21

Polynomial equation for discharge pressure for selected boiler operating pressures.

$$Dp = b0 + b1 \cdot L + b2 \cdot L^2 + b3 \cdot L^3 + b4 \cdot L^4 + b5 \cdot L^5 + b6 \cdot L^6$$

NPS 1-1/2 SCH 160 PIPE – [30 psi to 300 psi]

Dp denotes discharge pressure at end of pipe [psi]
L denotes equivalent straight length of pipe [ft.]

	30 psi	60 psi	90 psi	120 psi	150 psi
b0	29.88562657699905	59.51259294971629	89.03366769281429	118.3426609414991	147.4948856245841
b1	-0.08657485017755867	-0.2959207989319554	-0.5974745467218319	-0.9475064615277199	-1.336883213212
b2	0.001574625550093149	0.00636695653701068	0.01572390885245245	0.02661780138727435	0.03879803188420272
b3	-0.00004182859146430679	-0.0001548956783112358	-0.0003743199693411156	-0.0006330300472612315	-0.000908524700620382
b4	6.550902071999372E-7	2.182227730519767E-6	5.30704931274435E-6	8.903457499188699E-6	0.00001249275741183266
b5	-5.127537788053965E-9	-1.585685360230324E-8	-3.893700554610087E-8	-6.4916243019633E-8	-8.918896396576356E-8
b6	1.567876749770691E-11	4.581985768498608E-11	1.138057370982513E-10	1.889932331544763E-10	2.551342029745438E-10

	180 psi	210 psi	240 psi	270 psi	300 psi
b0	176.5486529748824	205.4754211349714	234.3034138747412	263.00797414667	291.6013261027841
b1	-1.786523467438607	-2.254242405444338	-2.774082738577361	-3.305622825730026	-3.871054363363867
b2	0.05488801108802095	0.0706830952370739	0.09018882014883695	0.1094773743051529	0.1307411637229555
b3	-0.001319697361383028	-0.001696049449743127	-0.002189995872586312	-0.002672352302663913	-0.003198677842938287
b4	0.00001848014498375087	0.00002368310843347649	0.00003068450982727052	0.00003763838563298012	0.00004490411450043376
b5	-1.337416498284821E-7	-1.711567372047938E-7	-2.217831437525752E-7	-2.736879681754271E-7	-3.248377748871577E-7
b6	3.894360180341836E-10	4.942592671126631E-10	6.398531726218407E-10	7.944150346729816E-10	9.377164498693874E-10

Polynomial equation for discharge pressure for selected boiler operating pressures.

$$Dp = b0 + b1 \cdot L + b2 \cdot L^2 + b3 \cdot L^3 + b4 \cdot L^4 + b5 \cdot L^5 + b6 \cdot L^6 + b7 \cdot L^7 + b8 \cdot L^8 + b9 \cdot L^9 + b10 \cdot L^{10}$$

NPS 1-1/2 SCH 160 PIPE – [200 psi to 2000 psi]

Dp denotes discharge pressure at end of pipe [psi]
L denotes equivalent straight length of pipe [ft.]

	200 psi	400 psi	600 psi	800 psi	1000 psi
b0	195.2413021066822	382.6260303505324	563.9005037415102	741.2329032185822	914.8390459762811
b1	-1.590921192296025	-4.393417680025441	-7.566761137793849	-11.05055775317388	-14.73931489611804
b2	0.02837717649813318	0.09017427480196961	0.1635923436534366	0.246714431516558	0.3373583781577122
b3	-3.905481238129562E-4	-0.00129467818436465	-2.393779612961117E-3	-3.639544386863919E-3	-5.0277655264143093E-3
b4	3.519752675145835E-6	1.181806273727992E-5	2.207102223675335E-5	3.359797177111685E-5	4.669691971651301E-5
b5	-2.058203884502679E-8	-6.93935649145548E-8	-1.30317674486333E-7	-1.981830464088506E-7	2.766857223613048E-7
b6	7.849367629004746E-11	2.645521060693784E-10	4.99266342126496E-10	7.580235902239884E-10	1.062140675115935E-9
b7	-1.934526541010273E-13	-6.518697247723733E-13	-1.233445079168285E-12	-1.86945176865318E-12	-2.627620578357888E-12
b8	2.966328325394644E-16	9.995169904617872E-16	1.894119285530004E-15	2.86609400491135E-15	4.039482975143701E-15
b9	-2.570796573976825E-19	-8.665733680641896E-19	-1.643349132695581E-18	-2.482984179811623E-18	-3.508113353282718E-18
b10	9.61459307766916E-23	3.243629877766713E-22	6.151887194407874E-22	9.28030302009304689E-22	1.314487285806773E-21

	1200 psi	1400 psi	1600 psi	1800 psi	2000 psi
b0	1085.951245433867	1253.453580274791	1418.465076247632	1580.946817694128	1739.962207541108
b1	-18.66752599147793	-22.63510096137955	-26.79500318493644	-31.08337392232333	-35.33928870177859
b2	0.4365988600882712	0.5365969656440429	0.6437369726975941	0.7566100520434194	0.8663877390893621
b3	-6.563944274864847E-3	-8.106645608877966E-3	-9.765680744412496E-3	-0.01155147253784253	-0.01324332760656062
b4	6.124063551305785E-5	7.584173981965772E-5	9.145721138818979E-5	1.086525293652857E-4	1.245031203695877E-4
b5	-3.638118482558087E-7	-4.515127916432583E-7	-5.44309581215936E-7	-6.488766731561244E-7	-7.427066964251923E-7
b6	1.398787756161968E-9	1.73934269651118E-9	2.094844721782003E-9	2.50452684156108E-9	2.862830982010552E-9
b7	-3.463513188810516E-12	-4.314803981663914E-12	-5.190304223233326E-12	-6.220850228903571E-12	-7.100800235777627E-12
b8	5.326693767975353E-15	6.64809125237254E-15	7.986378150032059E-15	9.592807967225733E-15	1.093452939473817E-14
b9	-4.626288471283235E-18	-5.784288668263106E-18	-6.939474882477788E-18	-8.350955401136425E-18	-9.506402477762008E-18
b10	1.733132111777146E-21	2.170723448269635E-21	2.600959360260341E-21	3.13506033793605E-21	3.564436505706198E-21

Polynomial equation for discharge pressure for selected boiler operating pressures.

$$Dp = b0 + b1 \cdot L + b2 \cdot L^2 + b3 \cdot L^3 + b4 \cdot L^4 + b5 \cdot L^5 + b6 \cdot L^6$$

NPS 1-1/2 XX-STR PIPE – [30 psi to 300 psi]

Dp denotes discharge pressure at end of pipe [psi]
L denotes equivalent straight length of pipe [ft.]

	30 psi	60 psi	90 psi	120 psi	150 psi
b0	29.89256016136391	59.49818147267267254	88.90082109772007	118.1017490976608	147.2324377368294
b1	-0.1010141147867887	-0.3476469669469977	-0.6730102799172882	-1.059723054698012	-1.519344072730505
b2	1.601869576746951E-3	8.139516026021743E-3	0.01721375954177543	0.292920731435208	0.04534406269837745
b3	-3.703836103058019E-5	-1.931194589031866E-4	-3.903351738283301E-4	-6.758127518853305E-4	-1.070721326739872E-3
b4	5.426496256769724E-7	2.778653853280874E-6	5.33439804188709E-6	9.311733925429488E-6	1.481509770621919E-5
b5	-4.075016840096627E-9	-2.061993782532019E-8	-3.811392774014579E-8	-6.704457980757777E-8	-1.062307339207924E-7
b6	1.207790593066734E-11	6.071020595724411E-11	1.09340226431574E-10	1.938471346480409E-10	3.046503916937298E-10

	180 psi	210 psi	240 psi	270 psi	300 psi
b0	176.1592021664603	204.97574324288	233.7087044259332	262.1850865848769	290.6935483553824
b1	-2.006267239025144	-2.53244098629379	-3.114896972609035	-3.672062125413998	-4.316427915645387
b2	0.06234346511722803	0.08065313398650878	0.103510009174303	0.1222528492703169	0.1484535323807034
b3	-1.492600932523429E-3	-1.925683568579241E-3	-2.525239891055307E-3	-2.943824048602552E-3	-3.637081838654791E-3
b4	2.086591141063939E-5	2.674612231600147E-5	3.552715402400462E-5	4.090779019791995E-5	5.107769501905667E-5
b5	-1.510394450078021E-7	-1.926023949841411E-7	-2.578976527492215E-7	-2.94213762858028E-7	-3.697194047302557E-7
b6	4.36831607930592E-10	5.551686014918001E-10	7.471586229234425E-10	8.468050308157372E-10	1.068010581040604E-9

Polynomial equation for discharge pressure for selected boiler operating pressures.

$$Dp = b0 + b1 \cdot L + b2 \cdot L^2 + b3 \cdot L^3 + b4 \cdot L^4 + b5 \cdot L^5 + b6 \cdot L^6 + b7 \cdot L^7 + b8 \cdot L^8 + b9 \cdot L^9 + b10 \cdot L^{10}$$

NPS 1-1/2 XX-STR PIPE – [200 psi to 2000 psi]

Dp denotes discharge pressure at end of pipe [psi]
L denotes equivalent straight length of pipe [ft.]

	200 psi	400 psi	600 psi	800 psi	1000 psi
b0	194.7688720776364	379.925160274595	559.7455668012574	735.0203136463464	906.1994013046175
b1	-1.781221232062338	-4.772170046342997	-8.244087883576144	-11.97066682291735	-15.87796080498824
b2	0.03212852639932193	0.09921586439854445	0.1825054503157401	0.2733228153466299	0.3714400030828661
b3	-4.370774345554429E-4	-1.424627100588025E-3	-2.692410023338042E-3	-4.068776795416312E-3	-5.585138405117501E-3
b4	3.897757925111658E-6	1.298645452114708E-5	2.492658763673258E-5	3.776919994843684E-5	5.213500971426184E-5
b5	-2.264206967100048E-8	-7.607230610136128E-8	-1.47565967831684E-7	-2.236808231978284E-7	-3.099093755065679E-7
b6	8.607068447918629E-11	2.897409215806619E-10	5.664274235102668E-10	8.581732576465771E-10	1.192269162421525E-9
b7	-2.119619334650763E-13	-7.126596751378964E-13	-1.401392438032537E-12	-2.121527210287995E-12	-2.953797277412654E-12
b8	3.253203351105886E-16	1.090766751158806E-15	2.154366871644617E-15	3.25875057177033E-15	4.544983262342022E-15
b9	-2.825455351268924E-19	-9.440404695471557E-19	-1.87061100388131E-18	-2.827459712513365E-18	-3.948982366357902E-18
b10	1.059863297540679E-22	3.52779670785389E-22	7.006328626367445E-22	1.058396543141342E-21	1.47989058119187E-21

	1200 psi	1400 psi	1600 psi	1800 psi	2000 psi
b0	1074.077395841777	1238.604727963567	1400.187320182055	1559.070935129166	1715.34754114598
b1	-19.91876169681607	-24.07892329171099	-28.35291266694364	-32.74582002088214	-37.27909711634305
b2	0.4731742474728043	0.5798307852245869	0.6910097964135127	0.8067688283659866	0.9287539933721919
b3	-7.146752415784099E-3	-8.798234373925667E-3	-0.01053567563553354	-0.01235029300264662	-0.01429282373861888
b4	6.6830809875292568E-5	8.242030098824625E-5	9.896330489694074E-5	1.162156047367985E-4	1.349392837938259E-4
b5	-3.977002000723636E-7	-4.907404071820846E-7	-5.903479887868181E-7	-6.938531543175021E-7	-8.075403970452142E-7
b6	1.531517351754247E-9	1.889677345504613E-9	2.276522204242589E-9	2.676822615962974E-9	3.120953884864034E-9
b7	-3.798248304328736E-12	-4.684658034979061E-12	-5.650153071132638E-12	-6.645417525626978E-12	-7.758566107297956E-12
b8	5.851083463226947E-15	7.212572844748846E-15	8.706925983516671E-15	1.024287942705377E-14	1.197107451790883E-14
b9	-5.090188789390162E-18	-6.27075552909936E-18	-7.575212547489008E-18	-8.913649956706095E-18	-1.042570684684412E-17
b10	1.910101921259368E-21	2.351646202208485E-21	2.842276374231091E-21	3.345427859848643E-21	3.915140732875773E-21

Polynomial equation for discharge pressure for selected boiler operating pressures.

$$Dp = b0 + b1 \cdot L + b2 \cdot L^2 + b3 \cdot L^3 + b4 \cdot L^4 + b5 \cdot L^5 + b6 \cdot L^6$$

NPS 2 SCH 80 PIPE – [30 psi to 300 psi]

Dp denotes discharge pressure at end of pipe [psi]
L denotes equivalent straight length of pipe [ft.]

	30 psi	60 psi	90 psi	120 psi	150 psi
b0	29.90281949125291	59.62969517611172	89.17482538937112	118.6060242281119	147.9152326194996
b1	-0.06428549444967459	-0.2340064532345906	-0.4659064339439026	-0.7410890921355906	-1.060932170548653
b2	0.001111227725122072	0.005427776566386804	0.01237949491342038	0.02038239924013472	0.03055420598982731
b3	-0.0000266937070788939	-0.0001273511837023015	-0.0003038206499315304	0.0004880869449350806	-0.0007332809575096008
b4	3.75311931312636E-7	1.765972057170827E-6	4.363742905323691E-6	6.853313916890018E-6	0.00001027046935651307
b5	-2.689652160781547E-9	-1.269445212020182E-8	-3.217558742430626E-8	-4.966379615731122E-8	-7.421656968672372E-8
b6	7.661328568199069E-12	3.66351392309985E-11	9.423541935729264E-11	1.435207814102232E-10	2.137925069578479E-10

	180 psi	210 psi	240 psi	270 psi	300 psi
b0	177.149347223112	206.2597539968156	235.2909997262555	264.2479224275044	293.0798520560468
b1	-1.42453015654294	-1.809601884334648	-2.226064660210009	-2.677348424071148	-3.139032972839331
b2	0.04272893571874126	0.05573740634203324	0.07000282640883306	0.08650055410809479	0.1025637281348573
b3	-0.001029025424460757	-0.001352627540689132	0.001697238084408137	-0.002116743113965758	-0.002495999582124686
b4	0.0000143781559021077 4	0.0000190310777669868 5	0.0000238117546259768	0.0000298321173728620 9	0.0000349118058936655 6
b5	-1.036569752329367E-7	-1.381128537376325E-7	-1.725311401647588E-7	-2.16564122219021E-7	-2.517556173260397E-7
b6	2.983643087131727E-10	3.99852535577410E-10	4.993792960625794	6.268966636768489E-10	7.249252521224465E-10

Polynomial equation for discharge pressure for selected boiler operating pressures.

$$Dp = b0 + b1 \cdot L + b2 \cdot L^2 + b3 \cdot L^3 + b4 \cdot L^4 + b5 \cdot L^5 + b6 \cdot L^6 + b7 \cdot L^7 + b8 \cdot L^8 + b9 \cdot L^9 + b10 \cdot L^{10}$$

NPS 2 SCH 80 PIPE – [300 psi to 3000 psi]

Dp denotes discharge pressure at end of pipe [psi]
L denotes equivalent straight length of pipe [ft.]

	300 psi	600 psi	900 psi	1200 psi	1500 psi
b0	291.3967751025353	570.4727880174964	841.2366116551459	1105.530224813208	1363.636893626988
b1	-2.346336487780506	-6.394459183561679	-11.10263032057914	-16.33799652269459	-21.86474357973262
b2	0.04341321506463064	0.1333097609105313	0.2425115995968241	0.3707567600004388	0.5076123892220085
b3	-6.092930804264843E-4	-0.00193763348816165	-3.557603178135858E-3	-5.529931092148883E-3	-7.627504278135943E-3
b4	5.551809083833712E-6	1.786793315419627E-5	3.277036155788612E-5	5.146495860291579E-5	7.120470700943093E-5
b5	-3.271994436835E-8	-1.057643963086227E-7	-1.931036308111258E-7	-3.056012205258707E-7	-4.234129728829153E-7
b6	1.256171592369878E-10	4.066175349953941E-10	7.382352691351401E-10	1.175627791389457E-9	1.629879294771592E-9
b7	-3.11501306317315E-13	-1.00849704253998E-12	-1.820320139681478E-12	-2.914180166041692E-12	-4.041147981969284E-12
b8	4.80450915335628E-16	1.554944415168575E-15	2.790815949683263E-15	4.488284935613704E-15	6.224089295769108E-15
b9	-4.187371625030526E-19	-1.354461033936363E-18	-2.418134460960094E-18	-3.904451162598821E-18	-5.413872023054964E-18
b10	1.57453673568039E-22	5.089882419391762E-22	9.042798410145029E-22	1.465230470074031E-21	2.031305612152536E-21

	1800 psi	2100 psi	2400 psi	2700 psi	3000 psi
b0	1616.674939777046	1863.378379311025	2104.66166587162	2339.747899007559	2564.844101407051
b1	-27.76091761761092459	-33.79889330847228	-40.18835059588017	-46.95635065694828	-54.52985484134466
b2	0.657400908406682	0.8116914113226544	0.9786003547228938	1.156777713478795	1.362487761491882
b3	-9.942950385192707E-3	-0.01233767748571607	-0.01495602448433204	-0.01773267252898821	-0.02099320412558967
b4	9.303716032007279E-5	1.157477562765494E-4	1.407547947377484E-4	1.669635795682448E-4	1.982005497762556E-4
b5	-5.535580817150779E-7	-6.898770181919633E-7	-8.408206217013066E-7	-9.968376303807782E-7	-1.185555870657017E-6
b6	2.130264047406658E-9	2.658225117058256E-9	3.24571134222082E-9	3.844197481821126E-9	5.578937683945395E-9
b7	-5.277999539845382E-12	-6.592445796156496E-12	-8.061759333622509E-12	-9.5373462625831E-12	-1.137546668040322E-11
b8	8.121342568307315E-15	1.015153203194024E-14	1.243054811107336E-14	1.468845149144013E-14	1.754074485871345E-14
b9	-7.05666281550888E-18	-8.825991531131159E-18	-1.081990156247374E-17	-1.27706962098184E-17	-1.526769315393951E-17
b10	2.644762159867578E-21	3.309517067590708E-21	4.061253565905203E-21	4.788405639428017E-21	5.730539049682289E-21

Polynomial equation for discharge pressure for selected boiler operating pressures.

$$Dp = b0 + b1 \cdot L + b2 \cdot L^2 + b3 \cdot L^3 + b4 \cdot L^4 + b5 \cdot L^5 + b6 \cdot L^6$$

NPS 2 SCH 160 PIPE – [30 psi to 300 psi]

Dp denotes discharge pressure at end of pipe [psi]
L denotes equivalent straight length of pipe [ft.]

	30 psi	60 psi	90 psi	120 psi	150 psi
b0	29.92168412222472	59.41364609526203	89.12177044279268	118.5018974627417	147.77242796351
b1	-0.07697092451674589	-0.2577064636094011	-0.5101618302559861	-0.8110061229015976	-1.158661699649697
b2	1.584416464558893E-3	5.994362759170086E-3	0.01343058212798789	0.02242847535276498	0.03354581293890098
b3	-4.029703207943865E-5	-1.411321689183417E-4	-3.250493411863944E-4	-5.357905380154809E-4	-0.00080259074458451
b4	5.796398588452417E-7	1.959088148240661E-6	4.639309350114501E-6	1.107670879085775E-5	1.126091177113149E-5
b5	-5.202301045940909E-9	-1.397689376124481E-8	-3.413192227014328E-8	-5.470214583141505E-8	-8.183126552856654E-8
b6	1.537823942047604E-11	3.972800410406906E-11	9.998472794099568E-11	1.585029128490116E-10	2.376838685232182E-10

	180 psi	210 psi	240 psi	270 psi	300 psi
b0	176.9168577379669	205.9940761491063	234.932744512334	263.8126339480144	292.5999111926218
b1	-1.544537539957802	-1.965398872998376	-2.410008917583092	-2.894016783744564	-3.40537883029071
b2	0.04647869503985835	0.06079270925212085	0.07597817780872271	0.09388492322252123	0.1128951658925252
b3	-1.117899820509084E-3	-1.465508904329529E-3	-1.824107324880354E-3	-2.284050666645633E-3	-2.756014383536767E-3
b4	1.564775394363346E-5	2.050979549539288E-5	2.532973955112697E-5	3.204300969247852E-5	3.860889812762213E-5
b5	-1.13058565191697E-7	-1.482391101045896E-7	-1.817235796575908E-7	-2.318705659800255E-7	-2.786224165844771E-7
b6	3.259169033165931E-10	4.277612898903351E-10	5.211460684817968E-10	6.696726560812257E-10	8.02384112104541E-10

Polynomial equation for discharge pressure for selected boiler operating pressures.

$$Dp = b0 + b1 \cdot L + b2 \cdot L^2 + b3 \cdot L^3 + b4 \cdot L^4 + b5 \cdot L^5 + b6 \cdot L^6 + b7 \cdot L^7 + b8 \cdot L^8 + b9 \cdot L^9 + b10 \cdot L^{10}$$

NPS 2 SCH 160 PIPE – [300 psi to 3000 psi]

Dp denotes discharge pressure at end of pipe [psi]
L denotes equivalent straight length of pipe [ft.]

	300 psi	600 psi	900 psi	1200 psi	1500 psi
b0	290.8154917976353	568.3468469563052	836.8761027922928	1098.738341804445	1354.032206690461
b1	-2.548650726742113	-6.829778746553981	-11.79578890641606	-17.20393934634918	-22.94691539494662
b2	0.04788764893005555	0.1439025694856795	0.2625440375692438	0.3945763603910918	0.5386342648822506
b3	-6.691452988495159E-4	-2.083891256434932E-3	-3.887689256260284E-3	-0.00589545838680887	-8.112171897920673E-3
b4	6.048619188330954E-6	1.90761858251087E-5	3.604349648598335E-5	5.483771322599011E-5	7.571635615758048E-5
b5	-3.536383049084608E-8	-1.11992292734974E-7	-2.134428013911519E-7	-3.251936795213603E-7	-4.497284314427256E-7
b6	1.347928003689368E-10	4.270961407625868E-10	8.191809596759904E-10	1.248957474158O5E-9	1.728465397749661E-9
b7	-3.321491499122885E-13	-1.051346166458717E-12	-2.026254297834591E-12	-3.09068466730053E-12	-4.278113382992571E-12
b8	5.094782672408697E-16	1.609993681902541E-15	3.114480651529967E-15	4.752216558282623E-15	6.577267866045201E-15
b9	-4.419008017877105E-19	-1.393898532564435E-18	-2.704262013608657E-18	-4.127555408899038E-18	-5.710968172508934E-18
b10	1.65466727444454E-22	5.209895475381982E-22	1.013058133512239E-21	1.546696797218474E-21	2.13911457052904E-21

	1800 psi	2100 psi	2400 psi	2700 psi	3000 psi
b0	1603.885138036609	1847.421937853098	2085.048238889337	2316.718677067161	2537.245542184115
b1	-28.99171709936571	-35.25108540909506	-41.71792214533799	-48.74870836514864	-56.38296963982436
b2	0.6928947566768217	0.8555934756942902	1.024058463318405	1.214428013190904	1.421156717800215
b3	-0.010501060245365	-0.01305104579889947	-0.0156792325713006	-0.01871372673722239	-0.02195587936779516
b4	9.829965437740293E-5	1.226670161317494E-4	1.476283507673754E-4	1.768456091623646E-4	2.074939867343054E-4
b5	-5.848077531252604E-7	-7.320751331663496E-7	-8.819362803869853E-7	-1.058957675780718E-6	-1.241467638979421E-6
b6	2.249828877819452E-9	2.82389848781286E-9	3.404238545208129E-9	4.093972133087629E-9	4.794286956521657E-9
b7	-5.572038621398182E-12	-7.010094358059368E-12	-8.454895459313492E-12	-1.017888127157378E-11	-1.190643724497381E-11
b8	8.570170039933688E-15	1.08040623188723E-14	1.303606753506846E-14	1.570564208950339E-14	1.835124747787749E-14
b9	-7.443577613581264E-18	-9.400646925899766E-18	-1.134681351672516E-17	-1.367708322900306E-17	-1.596526074506753E-17
b10	2.788715486606512E-21	3.527430663320743E-21	4.259150133167004E-21	5.135416855686047E-21	5.98937875917258E-21

Polynomial equation for discharge pressure for selected boiler operating pressures.

$$Dp = b0 + b1 \cdot L + b2 \cdot L^2 + b3 \cdot L^3 + b4 \cdot L^4 + b5 \cdot L^5 + b6 \cdot L^6$$

NPS 2 XX-STR PIPE – [30 psi to 300 psi]

Dp denotes discharge pressure at end of pipe [psi]
L denotes equivalent straight length of pipe [ft.]

	30 psi	60 psi	90 psi	120 psi	150 psi
b0	29.90225716862249	59.55684967470545	89.0458337190033	118.428343839086	147.6165233861567
b1	-0.07991958216452637	-0.2780593685394043	-0.5430049774592307	-0.8763100070201573	-1.239798252770421
b2	1.414802418474579E-3	6.539194485181224E-3	0.0138418672842508	0.02438466809235637	0.03575776333127928
b3	-3.441042683870323E-5	-1.57599129051184E-4	-3.247067979654745E-4	-5.792375337303114E-4	-8.450330542228602E-4
b4	4.898966829759784E-7	2.256336081152449E-6	4.530277305085133E-6	8.091130464481306E-6	1.173621469616438E-5
b5	-3.51258641265363E-9	-1.660742903471053E-8	-3.265035334788841E-8	-5.831573014390646E-8	-8.456847839978386E-8
b6	9.911202250969627E-12	4.861015246262522E-11	9.366906928109067E-11	1.673113199032536E-10	2.439264469511782E-10

	180 psi	210 psi	240 psi	270 psi	300 psi
b0	176.7765050431607	205.7209872989523	234.649479871789	263.4136083833942	292.1436032341743
b1	-1.667590205064174	-2.095592283532585	-2.59120657688333	-3.086235275972308	-3.637112047165421
b2	0.05096973100762522	0.06472778286282092	0.08314465272267528	0.1005345283467464	0.1220230395940621
b3	-1.229955969382961E-3	-1.547267535986957E-3	-0.00200853363657686	-2.431595861561063E-3	-0.00298851395157847
b4	1.726331579250742E-5	2.153043150800018E-5	2.799552879328591E-5	3.391064179311453E-5	4.196349787306721E-5
b5	-1.251321551828057E-7	-1.549953584779756E-7	-2.013115073994357E-7	-2.440429885451096E-7	-3.033620725952852E-7
b6	3.620906120400414E-10	4.458102420695806E-10	5.780371260523403E-10	7.011980205913031E-10	8.746686584432659E-10

Polynomial equation for discharge pressure for selected boiler operating pressures.

$$Dp = b0 + b1 \cdot L + b2 \cdot L^2 + b3 \cdot L^3 + b4 \cdot L^4 + b5 \cdot L^5 + b6 \cdot L^6 + b7 \cdot L^7 + b8 \cdot L^8 + b9 \cdot L^9 + b10 \cdot L^{10}$$

NPS 2 XX-STR PIPE – [300 psi to 3000 psi]

Dp denotes discharge pressure at end of pipe [psi]
L denotes equivalent straight length of pipe [ft.]

	300 psi	600 psi	900 psi	1200 psi	1500 psi
b0	290.3524015621823	565.9909292453751	833.2049116578698	1092.419177934587	1345.555076438159
b1	-2.712436947868954	-12.37681134980155	-11.79578890641606	-17.91416463249917	-23.83429905142484
b2	0.05131009019603174	0.1519861848853459	0.2786726475851463	0.4145774694183078	0.5644449688794175
b3	-7.141048538497678E-4	-2.203392194470488E-3	-4.138157157924547E-3	-6.209203521155577E-3	-8.52617475873609E-3
b4	6.427835516687147E-6	2.018578368285068E-5	3.840955755246206E-5	5.781174021097476E-5	7.971017693079243E-5
b5	-3.745887950761799E-8	-1.186169075443013E-7	-2.274745231041523E-7	-3.42983777424961E-7	-4.739580063830227E-7
b6	1.42444896471836E-10	4.527884511061565E-10	8.72747030877936E-10	1.317500413678582E-9	1.822898684390726E-9
b7	-3.504316664103267E-13	-1.115535997720347E-12	-2.157471437625629E-12	-3.260224140046104E-12	-4.5113913612498524E-12
b8	5.369031640456759E-16	1.709497531518809E-15	3.313593664041453E-15	5.012141313847021E-15	6.941615365141639E-15
b9	-4.652874864049732E-19	-1.480881741395784E-18	-2.874536713823099E-18	-4.35230471692463E-18	-6.028051631575949E-18
b10	1.74096881640184E-22	5.537448267024342E-22	1.075770662141264E-21	1.63046391150736E-21	2.257932086016433E-21

	1800 psi	2100 psi	2400 psi	2700 psi	3000 psi
b0	1592.511993115902	1833.409066248298	2068.112409537315	2295.99762524724	2513.064492215395
b1	-30.01585413999957	-36.3738953873755	-43.00071457423232	-50.06414444963444	-57.86946311733392
b2	0.7240302625986406	0.8884943318406969	1.062902901169765	1.254147318911294	1.469870024356047
b3	-0.01101718264269136	-0.01357080950973375	-0.01629727467389544	-0.01934359576753176	-0.02278042150725794
b4	1.034197971795011E-4	1.275904844585798E-4	1.534403666226822E-4	1.828021455473785E-4	2.15725730320524E-4
b5	-6.16661580969892E-7	-7.614942161781293E-7	-9.16089774394999E-7	-1.094468946229764E-6	-1.29277441781157E-6
b6	2.376887789859275E-9	2.937408197339245E-9	3.532948110318311E-9	4.230735983894914E-9	4.999046123486442E-9
b7	-5.896197070624664 1E-12	-7.292205003853782E-12	-8.765719155294736E-12	-1.051830074597483E-11	-1.2428898190946E-11
b8	9.080880862017345E-15	1.124002936676647E-14	1.350099811201322E-14	1.622950801973207E-14	1.91746931133692E-14
b9	-7.895895915433519E-18	-9.781603986991972E-18	-1.173899062183662E-17	-1.413423722244842E-17	-1.6694887423068E-17
b10	2.960834805651356E-21	3.671187489387077E-21	4.401774112312868E-21	5.307658206081542E-21	6.2672016704934E-21

Polynomial equation for discharge pressure for selected boiler operating pressures.

$$Dp = b0 + b1 \cdot L + b2 \cdot L^2 + b3 \cdot L^3 + b4 \cdot L^4 + b5 \cdot L^5 + b6 \cdot L^6$$

NPS 2-1/2 SCH 80 PIPE – [30 psi to 300 psi]

Dp denotes discharge pressure at end of pipe [psi]
L denotes equivalent straight length of pipe [ft.]

	30 psi	60 psi	90 psi	120 psi	150 psi
b0	29.94081198904529	59.67941892421874	89.25258746080908	118.72304707489	148.1253177224488
b1	-0.06314998093223649	-0.2134532048347869	-0.4142691332456171	-0.6601065290838494	-0.9511367782327925
b2	1.523905713248823E-3	5.426893622230404E-3	0.01094731903453145	0.01813300871404568	0.02734834391273501
b3	-4.176161877228812E-5	-1.35139139289991E-4	-2.651721330693586E-4	-4.371342655174229E-4	-6.619271813629945E-4
b4	6.328375105292053E-7	1.940005839671755E-6	3.723073405746519E-6	6.150401232952229E-6	9.338138406210706E-6
b5	-4.815986517147642E-9	-1.428058334580951E-8	-2.679571479493926E-8	-4.458134227055638E-8	-6.799909507517354E-8
b6	1.444920997237812E-11	4.189791870905907E-11	7.670501221384792E-11	1.28784432205814E-10	1.976299825898934E-10

	180 psi	210 psi	240 psi	270 psi	300 psi
b0	177.3816411853664	206.5711881140056	235.7313595316033	264.7182875933697	293.6963070624748
b1	-1.272081437907845	-1.6217366823713	-2.011022160909219	-2.407904698452763	-2.836155294270127
b2	0.03783769046184838	0.04950135861629629	0.06312062175202302	0.07700124186227404	0.09198596160502877
b3	-9.170296860022169E-4	-1.205482966641625E-3	-1.544146482612752E-3	-1.890509196464062E-3	-2.254602873619632E-3
b4	1.288480627523977E-5	1.699098115102802E-5	2.181811366535017E-5	2.671856199670849E-5	3.179656026207638E-5
b5	-9.332800014586222E-8	-1.233797859994291E-7	-1.589377412014906E-7	-1.943603916511949E-7	-2.311680728348807E-7
b6	2.697284379496939E-10	3.57220742124178E-10	4.618686526978408E-10	5.635573097124143E-10	6.707698581913742E-10

Polynomial equation for discharge pressure for selected boiler operating pressures.

$$Dp = b0 + b1 \cdot L + b2 \cdot L^2 + b3 \cdot L^3 + b4 \cdot L^4 + b5 \cdot L^5 + b6 \cdot L^6 + b7 \cdot L^7 + b8 \cdot L^8 + b9 \cdot L^9 + b10 \cdot L^{10}$$

NPS 2-1/2 SCH 80 PIPE – [300 psi to 3000 psi]

Dp denotes discharge pressure at end of pipe [psi]
L denotes equivalent straight length of pipe [ft.]

	300 psi	600 psi	900 psi	1200 psi	1500 psi
b0	292.539302341018	573.527948046275	846.773881796897	1114.07745399636	1375.56015340293
b1	-2.13496722335058	-5.91284325073348	-10.3168589808944	-15.2806024274468	-20.5569003178663
b2	0.0388368277179646	0.12194668135565	0.222160500284268	0.342483046587135	0.471615630704697
b3	-0.000542836088000417	-0.00176811525092801	-0.00325069822710627	-0.00509639376580046	-0.00706702270778833
b4	0.00000492425546417336	0.0000162431918799859	0.000029951041832055	0.0000473901790118028	0.0000658944674771774
b5	-2.88558713580999E-8	-9.56411971601748E-8	-0.000000176741294323753	-0.000000281166474905989	-0.000000391484397596197
b6	1.10059957518475E-10	3.65433507514568E-10	6.77029772188726E-10	1.08041862593381E-9	1.50559213232693E-9
b7	-2.7104200965902E-13	-9.00380312478885E-13	-1.67316044413635E-12	-2.67445772730543E-12	-3.72921922710229E-12
b8	4.15137177785528E-16	1.37893994064866E-15	2.57114738150416E-15	4.11252786371428E-15	5.73730960391413E-15
b9	-3.59334104856412E-19	-1.19320885441649E-18	-2.23286334965783E-18	-3.57141920310399E-18	-4.98455069733644E-18
b10	1.3421981371498E-22	4.45528155391107E-22	8.36801999078932E-22	1.33785638447817E-21	1.8679090411708E-21

	1800 psi	2100 psi	2400 psi	2700 psi	3000 psi
b0	1631.90830633277	1882.65616877377	2128.53204953551	2368.63147279626	2599.12053677446
b1	-26.1596240233613	-31.9431070672144	-38.1366316032542	-44.7533811807088	-52.1578759051606
b2	0.611850400946807	0.756695243902946	0.91710472924561	1.09055403220653	1.2897836860081
b3	-0.0092281719623273	-0.0114494254489424	-0.0139547515036344	-0.0166696869395592	-0.0198175011073282
b4	0.0000863094648486138	0.000107191954863777	0.000130982140669382	0.00015682074233543	0.000186914895785666
b5	-0.00000513729114962135	0.00000638230574072844	-0.00000780784052620848	-0.00000936213416118592	-0.00000111761107647621
b6	1.97844953208486E-9	2.4580666014078E-9	3.00833651216582E-9	3.6115718020823E-9	4.31577444599068E-9
b7	-4.90611564755547E-12	-7.01009435805936 8E-12	-7.45951570115269E-12	-8.96509378553554E-12	-1.0720590187592E-11
b8	7.55584042004154E-15	9.38602995002992E-15	1.14841857416959E-14	1.38164030171253E-14	1.65293296190122E-14
b9	-6.57094075157179E-18	-8.16159687775888E-18	-9.98213366064688E-18	-1.20213708991067E-17	-1.43856606313261E-17
b10	2.46470267634659E-21	3.06098991294704E-21	3.74204436902796E-21	4.51088906884308E-21	5.39870786902862E-21

Polynomial equation for discharge pressure for selected boiler operating pressures.

$$Dp = b0 + b1 \cdot L + b2 \cdot L^2 + b3 \cdot L^3 + b4 \cdot L^4 + b5 \cdot L^5 + b6 \cdot L^6$$

NPS 2-1/2 SCH 160 PIPE – [30 psi to 300 psi]

Dp denotes discharge pressure at end of pipe [psi]
L denotes equivalent straight length of pipe [ft.]

	30 psi	60 psi	90 psi	120 psi	150 psi
b0	29.959119493959	59.6326143029051	89.2047427889561	118.655578374823	148.016369930727
b1	-0.0706780357892791	-0.218561224370749	-0.437257553620149	-0.696599333291967	-1.0026570422477
b2	0.0018232618790224	0.0051056875213153	0.0115437065078029	0.0190822670779127	0.0287240421517595
b3	-5.10858358571407E-5	-0.000121125807155638	-0.000280783022198384	-0.000458799599512377	-0.000687349604380107
b4	7.8594434439981E-7	1.6882630768873E-6	3.9773862946502E-6	6.4619693962166E-6	9.5747916909721E-6
b5	-6.03109385618029E-9	-1.21569055951559E-8	-2.89349890025332E-8	-4.69437540307947E-8	-6.87470310641922E-8
b6	1.811665956169E-11	3.504560864752E-11	8.381439988634E-11	1.359398435218E-10	1.967456436122E-10

	180 psi	210 psi	240 psi	270 psi	300 psi
b0	177.250836708332	206.416209032057	235.49449137415	264.512641914721	293.420852878208
b1	-1.33489663476841	-1.71006443415633	-2.10995668778638	-2.54446213105522	-2.98734243227854
b2	0.032318529723296	0.0523143192888342	0.0661056788025836	0.0821068803341927	0.0974106551736615
b3	-0.000936030353797239	-0.00126995112983844	-0.00160697083101753	-0.00201791518406042	-0.00237955368599817
b4	1.2987737948794E-5	1.7868467381658E-5	2.2593443848884E-5	2.8528910435486E-5	3.3394719146583E-5
b5	-9.30627933772129E-8	-1.29640783151011E-7	-1.639937074852238E-7	-2.07575442197491E-7	-2.41512206854535E-7
b6	2.663555700002E-10	3.751800191585E-10	4.754542078049E-10	6.019729712757E-10	6.972054890698E-10

Polynomial equation for discharge pressure for selected boiler operating pressures.

$$Dp = b0 + b1 \cdot L + b2 \cdot L^2 + b3 \cdot L^3 + b4 \cdot L^4 + b5 \cdot L^5 + b6 \cdot L^6 + b7 \cdot L^7 + b8 \cdot L^8 + b9 \cdot L^9 + b10 \cdot L^{10}$$

NPS 2-1/2 SCH 160 PIPE – [300 psi to 3000 psi]

Dp denotes discharge pressure at end of pipe [psi]
L denotes equivalent straight length of pipe [ft.]

	300 psi	600 psi	900 psi	1200 psi	1500 psi
b0	292.09815520854	572.12806848715	844.00138390693	1110.0779049399	1369.9767369033
b1	-2.2378656631307	-6.13854680995409	-10.6936726296141	-15.806549882246	-21.2277948555312
b2	0.04092739896549	0.12667652910393	023215155068122	0.35677432253953	0.49064187834103
b3	-0.000571373380135	-0.001731027675441	-0.003407548406383	-0.005322350991061	-0.007374410713357
b4	5.1801899422E-6	1.6797684721E-5	3.1446452402E-5	4.9593601103E-5	6.8914004846E-5
b5	-3.03665475469E-8	-9.89212731521E-8	-1.85685381943E-7	-2.94888681304E-7	-4.10234301545E-7
b6	1.159218524E-10	3.783965178E-10	7.112943782E-10	1.1358278376E-9	1.5806051009E-9
b7	-2.8576666897E-13	-9.3388966162E-13	-1.7571395282E-12	-2.818497092E-12	-3.9217873574E-12
b8	4.381054103E-16	1.4330232E-15	2.698498294E-15	4.344641664E-15	6.043368232E-15
b9	-3.7951340559E-19	-1.2424710693E-18	-2.3417102593E-18	-3.7820303131E-18	-5.2584354208E-18
b10	1.418412315E-22	4.648130413E-22	8.76900603E-22	1.42000729E-21	1.97337173E-21

	1800 psi	2100 psi	2400 psi	2700 psi	3000 psi
b0	1624.4547187777	1873.3312574216	2117.2277446231	2354.5997270657	2583.2312536983
b1	-26.9183780645375	-32.8441765840652	-39.202016218391	-45.853930796857	-53.4138533769763
b2	0.63261386100054	0.78277589319226	0.9500122438265	1.1238810701677	1.3286967581621
b3	-0.009544964310617	-0.011863889614923	-0.014505532731133	-0.017209460000769	-0.020455142937115
b4	8.9237938434E-5	0.00011114446641	0.00013647510632	0.00016201133863	0.00019311893484
b5	-5.3090151407E-7	-6.619353011E-7	-8.1508113189E-7	-9.67452257177E-7	-1.15547280347E-6
b6	2.0437212891E-9	2.5499632087E-9	3.1455817652E-9	3.7322437027E-9	4.4643999759E-9
b7	-5.0663808575E-12	-6.3239213946E-12	-7.80108058954E-12	-9.2640123565E-12	-1.1095297597E-11
b8	7.801065612E-15	9.739868762E-15	1.203974813E-14	1.42753315E-14	1.711534119E-14
b9	-6.7834877839E-18	-8.4708175199E-18	-1.0476205107E-17	-1.2418894239E-17	-1.4902847913E-17
b10	2.544376703E-21	3.177660958E-21	3.930902575E-21	4.659377241E-21	5.595493991E-21

Polynomial equation for discharge pressure for selected boiler operating pressures.

$$Dp = b0 + b1 \cdot L + b2 \cdot L^2 + b3 \cdot L^3 + b4 \cdot L^4 + b5 \cdot L^5 + b6 \cdot L^6$$

NPS 2-1/2 XX-STR PIPE – [30 psi to 300 psi]

Dp denotes discharge pressure at end of pipe [psi]
L denotes equivalent straight length of pipe [ft.]

	30 psi	60 psi	90 psi	120 psi	150 psi
b0	29.9285677172642	59.59194268605	89.1178394999569	118.545182249751	147.816440542622
b1	-0.0735259258930926	-0.246005542084734	-0.486713747240711	-0.790094934228131	-1.12412667680391
b2	0.00147702950843444	0.00558962992595064	0.0123810426353603	0.0221058659323457	0.0326704668290836
b3	-0.0000381236781267589	-0.000129250387747181	-0.000292309385382147	-0.000534317961501995	-0.000790056247170198
b4	0.00000056665366292027	0.00000176389996101258	0.00000408526811950745	0.00000756686078024305	0.0000111983357534512
b5	-4.25691575326003E-9	-1.23808901038118E-8	-2.94821979834638E-8	-5.52626917589888E-8	-8.20919499569189E-8
b6	1.2608962011066E-11	3.46388898928274E-11	8.48108403953647E-11	1.60838370002823E-10	2.40179340127604E-10

	180 psi	210 psi	240 psi	270 psi	300 psi
b0	177.017190380492	206.076959862731	235.065627054242	263.928088388469	292.775623706235
b1	-1.50211470676441	-1.90667473106753	-2.34554062890142	-2.80908603507674	-3.31020957640451
b2	0.0450196006073407	0.058816039207131	0.0739367942755942	0.0907300166006245	0.109200007163998
b3	-0.00107889283242681	-0.00142300724058175	-0.00178272340675609	-0.00220918514281392	-0.00266439703117443
b4	0.0000150375578434	0.0000200032764146787	0.0000248640921173708	0.0000310315797659814	0.000037331928931279
b5	-0.000000108255744347286	-1.45209151621835E-7	-0.000000179113981130841	-0.000000224787763776467	-0.000000269536162754402
b6	3.11255861546786E-10	4.20719679631852E-10	5.15556751031131E-10	6.49740490084928E-10	7.76739963341111E-10

Polynomial equation for discharge pressure for selected boiler operating pressures.

$$Dp = b0 + b1 \cdot L + b2 \cdot L^2 + b3 \cdot L^3 + b4 \cdot L^4 + b5 \cdot L^5 + b6 \cdot L^6 + b7 \cdot L^7 + b8 \cdot L^8 + b9 \cdot L^9 + b10 \cdot L^{10}$$

NPS 2-1/2 XX-STR PIPE – [300 psi to 3000 psi]

Dp denotes discharge pressure at end of pipe [psi]
L denotes equivalent straight length of pipe [ft.]

	300 psi	600 psi	900 psi	1200 psi	1500 psi
b0	291.464571207535	569.441672576487	838.722963730663	1101.12637559161	1357.53774161452
b1	- 2.52618129318174	- 6.70412745165635	- 11.5781816214642	- 16.9019805218788	- 22.5772997620648
b2	0.0480376507584185	0.141156350615478	0.256378670088451	.386223881335576	0.528017320598068
b3	- 0.000677448215091057	- 0.00204952782025629	- 0.00378804386835708	- 0.00576490894144125	- 0.00794593146982884
b4	0.0000061578748477902	0.0000188210823531649	0.0000350683110553916	0.0000536009010093583	0.0000741660596066848
b5	- 3.61303321040212E-8	- 0.00000110856698966806	- 0.00000020741517110367	- 0.00000031779112098504	- 0.00000044068092558888
b6	1.38059873737485E-10	4.24142073735859E-10	7.95152745912119E-10	1.22038764100938E-9	1.69460900936718E-9
b7	- 3.40880192706497E-13	- 1.04737725542451E-12	- 1.96469389964202E-12	- 3.01981797969994E-12	- 4.19697662965224E-12
b8	5.23797040401104E-16	1.60877048012873E-15	3.01666820483174E-15	4.6431672292269E-15	6.45692465587726E-15
b9	- 4.55088220608231E-19	- 1.39683342955882E-18	- 2.61661029944362E-18	- 4.03286300822908E-18	- 5.61041159039289E-18
b10	1.70691637878533E-22	5.23496443040075E-22	9.79215868003271E-22	1.5112446885701E-21	2.10293588636893E-21

	1800 psi	2100 psi	2400 psi	2700 psi	3000 psi
b0	1608.12847911069	1853.22491262656	2091.87260196084	2324.87522046739	2546.18185793626
b1	- 28.5392941711861	- 34.7339270524567	- 41.1500827210096	- 48.1026698943344	- 55.6423330276598
b2	0.679986357271251	0.839480261172961	1.00637151343021	1.19305154867543	1.39743691460091
b3	-0 .010302209691259	- 0.0127848925053192	- 0.0153865308009356	- 0.0183433713603948	- 0.0215672408501766
b4	.000096465879654312	0.00012005133326841	0.000144747398537586	0.000173068317182706	0.000203766902386747
b5	- 0.000000574155370639535	-0.000000715904207741199	- 0.000000864153918017	- 0.000010349737463567 5	- 0.000012192448249838 7
b6	2.20994013985802E-9	2.75946326095301E-9	3.33371733644095E-9	3.99664348220073E-9	4.70960831854822E-9
b7	- 5.47600921507141E-12	- 6.84508089130048E-12	- 8.27551169413155E-12	- 9.92659806337073E-12	- 1.170025081838E-11
b8	8.42668444454243E-15	1.05420175241575E-14	1.27533351931646E-14	1.53018680519116E-14	1.80410197793482E-14
b9	- 7.32253401212458E-18	- 9.16605288011839E-18	- 1.10955373137667E-17	- 1.33138090729341E-17	- 1.57025959472831E-17
b10	2.74466538251883E-21	3.4370085299297E-21	4.16291750899457E-21	4.99495793871008E-21	5.8936815236407E-21

POLYNOMIAL EQUATIONS

Mass Flow as a Function of Equivalent Straight Pipe Length

NPS 1/2 SCH 80 Pipe (10 psi – 100 psi) - Polynomial equation for blowdown mass flow [1000 lb/hr]

$$Mf=b0+b1\cdot L+b2\cdot L^2+b3\cdot L^3+b4\cdot L^4+b5\cdot L^5+b6\cdot L^6$$

Where: Mf denotes mass flow [1000 lb/hr] and L denotes equivalent straight length of pipe [ft]

	10 psi	20 psi	30 psi	40 psi	50 psi
b0	2.06772737217409	3.63322677134229	5.57994719395943	7.85812286600274	10.3169903051383
b1	- 0.0396200980206415	- 0.207560901979541	- 0.704936346451531	- 1.7406911728611	- 3.45601416856104
b2	0.00113796787883246	0.0173455390603934	0.116133548601686	0.420250947169031	1.11143033045417
b3	- 0.0000360071383082912	- 0.00145179695476381	- 0.0159286268509128	- 0.0725588678902393	- 0.23618380564959
b4	0.00000113219090256358	0.0000992955991585648	0.00149828710296029	0.00782123852799492	0.0297416009277054
b5	- 2.97082360945496E-8	- 0.0000044541486888773	- 0.0000818328163167747	- 0.000464492610381423	- 0.0019793899012697
b6	4.41466682609547E-10	9.25388028340622E-8	0.00000192333483034006	0.000011526366310057	0.0000533121468149106

	60 psi	70 psi	80 psi	90 psi	100 psi
b0	12.1723681717914	14.5263301700674	15.4606783879573	15.094031048659	16.3552054446088
b1	- 4.51073638892415	- 7.26048670058405	- 8.03890730902184	- 6.66317834828178	- 7.72979382251225
b2	1.31142449261974	2.78795434444344	3.2513082599019	2.44353209581959	3.01445443588416
b3	- 0.225309694418046	- 0.615759012227952	- 0.74970566292446	- 0.525307756577836	- 0.679875953577164
b4	0.022246306450724	0.0764521445445282	0.0963335746530843	0.0640448796775731	0.0860441958437626
b5	- 0.00116650215314468	- 0.00495639996071925	- 0.00641802875400817	- 0.00409766841080396	- 0.00567002771853507
b6	0.0000251162376264774	0.000130340949160528	0.000172500114362145	0.000106683385292656	0.000151157137021519

NPS 3/4 SCH 80 Pipe (10 psi – 100 psi) - Polynomial equation for blowdown mass flow [1000 lb/hr]

$$Mf=b0+b1\cdot L+b2\cdot L^2+b3\cdot L^3+b4\cdot L^4+b5\cdot L^5+b6\cdot L^6$$

Where: Mf denotes mass flow [1000 lb/hr] and L denotes equivalent straight length of pipe [ft]

	10 psi	20 psi	30 psi	40 psi	50 psi
b0	3.81870295204624	6.71023626296829	10.3184472001827	14.6323793326106	19.214163109953
b1	- 0.0538437308393181	- 0.282622883285227	- 0.978926519700468	- 2.5532879380323	- 4.91497094535402
b2	0.00113856020426594	0.0176635055316081	0.128196155123158	.528410995132345	1.22095692423077
b3	- 0.0000266580370013445	- 0.00115584149228615	- 0.0150554736915547	- 0.08334881387823	- 0.200449981423552
b4	0.000000635905471663597	0.0000661800567923702	0.00128678797696824	0.00852135942261515	0.0195016235511725
b5	- 1.34342653318068E-8	- 0.0000264888156092489	- 0.0000663106101681677	- 0.00049021960947418	- 0.00100799536980056
b6	1.73286165967035E-10	5.13271265574051E-8	0.0000150359493710772	0.0000119290015488748	0.0000213262771988851

	60 psi	70 psi	80 psi	90 psi	100 psi
b0	23.6107215862885	27.9902449246686	32.0346257030983	32.528439905549	32.4604263824369
b1	- 7.91534310854913	- 11.6784922583165	- 16.474400283048	- 15.8851461917636	- 14.1173386695913
b2	2.36651526939298	3.82346105872341	6.51470998245443	6.21705786044571	5.1436894113064
b3	- 0.46934194012072	- 0.737237458426203	- 1.47411816713776	- 1.40510798715618	- 1.10230100865527
b4	0.0575422913115752	0.0816253286021072	0.186755182839623	0.178356429618082	0.134314938630928
b5	- 0.00387325076704145	- 0.00480568540094402	- 0.0123176713755904	- 0.0117979889519011	- 0.00860519104927763
b6	0.00010804006408801	0.000116553046444976	0.000328848710340626	0.000315924941808896	0.000224657465659804

NPS 1 SCH 80 Pipe (30 psi – 300 psi) - Polynomial equation for blowdown mass flow [1000 lb/hr]

$$Mf=b0+b1\cdot L+b2\cdot L^{2}+b3\cdot L^{3}+b4\cdot L^{4}+b5\cdot L^{5}+b6\cdot L^{6}+b7\cdot L^{7}+b8\cdot L^{8}+b9\cdot L^{9}+b10\cdot L^{10}+b11\cdot L^{11}+b12\cdot L^{12}$$

Where: Mf denotes mass flow [1000 lb/hr] and L denotes equivalent straight length of pipe [ft]

	30 psi	60 psi	90 psi	120 psi	150 psi
b0	17.1057449242791	37.126676719961	47.1245841793622	52.8018245555545	59.3761674054903
b1	-1.19276440385358	-7.31491670195654	-10.6037491378727	-11.0083879589029	-11.8482291111831
b2	0.101301887606077	1.08775846072215	1.76607443714483	1.79971060019289	1.9148435717471
b3	-0.00689552506449807	-0.0974337101699043	-0.171356703508032	-0.17319329649289	-0.183360741334839
b4	0.000338870100236803	0.00552432566811023	0.0103188667912476	0.0103784908566297	0.0109557791211869
b5	-0.0000116675745935842	-0.000207270680519427	-0.00040661326968594	-0.000407550036728535	-0.000429337689721869
b6	2.78837782514762E-7	5.29539671514895E-6	1.08410140757736E-5	1.08363235982799E-5	1.13970606334369E-5
b7	-4.58662231629036E-9	-9.33633384447111E-8	-1.98811733323674E-7	-1.9826028316958E-7	-2.08225810238182E-7
b8	5.1045561195299E-11	1.13400784806845E-9	2.50870047852923E-9	2.49639003033357E-9	2.61846169150062E-9
b9	-3.7096322401217E-13	-9.30087011191071E-12	-2.1384302885129E-11	-2.12356884127073E-11	-2.22460085796176E-11
b10	1.6393925351827E-15	4.9096471927996E-14	1.1752952608769E-13	1.1647365967516E-13	1.2185997868974E-13
b11	-3.77993623404075E-18	-1.50233458494687E-16	-3.75658170049275E-16	-3.7149769284389E-16	-3.8816402058271E-16
b12	2.9700965539465E-21	2.0195621347625E-19	5.3004984652846E-19	5.2300923434715E-19	5.4570272356402E-19

	180 psi	210 psi	240 psi	270 psi	300 psi
b0	66.0146156815934	72.9242579524579	79.7178983966909	86.4319370846035	93.0675671645651
b1	-12.742097762396	-13.8607506202769	-14.9667640741572	-16.0840784427385	-17.2220872724948
b2	2.03687932291759	2.2066252464158	2.37250208244353	2.54066400705302	2.71369957295335
b3	-0.194022238894195	-0.20991102927611	-0.225261831151645	-0.240884817514387	-0.256962272321414
b4	0.0115548955688165	0.0124946474979557	0.0133933381806473	0.0143080386700569	0.0152541936804186
b5	-0.000451743036826336	-0.00048838238189561	-0.000523096140074164	-0.000558500899104801	-0.000595132597641434
b6	0.000011968983637235	1.29389439477965E-5	1.38499670280291E-5	1.47810290561554E-5	1.57441333063668E-5
b7	-2.18313258864454E-7	-2.36008390434754E-7	-2.52489673235356E-7	-2.69367896504235E-7	-2.86818788762572E-7
b8	2.74112707456982E-9	2.96347791554932E-9	3.16886318626561E-9	3.37962964542755E-9	3.59741639851967E-9
b9	-2.32538302222583E-11	-2.51423223220507E-11	-2.6872029891193E-11	-2.86508412359783E-11	-3.04876324306819E-11
b10	1.2719204831813E-13	1.3753699654179E-13	1.4692888921531E-13	1.566091101548E-13	1.6659717152813E-13
b11	-4.04526323151521E-16	-4.3748618444617E-16	-4.67129151732719E-16	-4.97756045889603E-16	-5.29330042355454E-16
b12	5.6777574132936E-19	6.1413210207868E-19	6.5539834734917E-19	6.9814753869197E-19	7.4217706764074E-19

NPS 1 SCH 80 Pipe (100 psi – 1000 psi) - Polynomial equation for blowdown mass flow [1000 lb/hr]

$$Mf=b0+b1\cdot L+b2\cdot L^{2}+b3\cdot L^{3}+b4\cdot L^{4}+b5\cdot L^{5}+b6\cdot L^{6}+b7\cdot L^{7}+b8\cdot L^{8}+b9\cdot L^{9}+b10\cdot L^{10}+b11\cdot L^{11}+b12\cdot L^{12}$$

Where: Mf denotes mass flow [1000 lb/hr] and L denotes equivalent straight length of pipe [ft]

	100 psi	200 psi	300 psi	400 psi	500 psi
b0	38.2139041165342	57.611210592554	76.6510524670024	94.5877636664198	111.460585721539
b1	-3.35921645288375	-4.61772307411579	-6.05077976139326	-7.4623716398059	-8.82194008213401
b2	0.1948657725274	0.260930869149417	0.339333201272842	0.417307033783517	0.492741674106192
b3	-0.00581284316381947	-0.00772511014154985	-0.0100218637698991	-0.0123130396248874	-0.0145321202007753
b4	0.000086739225391961 6	0.000115785174570589	0.000150388478224358	0.000184900008748529	0.000218304823909778
b5	-3.82445874519839E-7	-5.44724957141198E-7	-7.20702052308673E-7	-8.94134597471116E-7	-0.00000106068395068131
b6	-7.86295418161245E-9	-9.6083005929429E-9	-1.21345488943986E-8	-1.47116700119635E-8	-1.72398706469709E-8
b7	1.56001236420916E-10	1.96939288932564E-10	2.51377720430632E-10	3.06430121358274E-10	3.60140930651451E-10
b8	-1.34184169855973E-12	-1.70548382070799E-12	-2.18157279679196E-12	-2.66226663433093E-12	-3.1307273579265E-12
b9	6.68673695084625E-15	8.52057713999862E-15	1.09077355826922E-14	1.33166774535461E-14	1.56633014648949E-14
b10	-1.98979674041882E-17	-2.5384929732765E-17	-3.2508558151625E-17	-3.96955993320719E-17	-4.66952315047054E-17
b11	3.29119341502065E-20	4.2012704012163E-20	5.38121063852613E-20	6.5715427847489E-20	7.73070004268476E-20
b12	-2.33440901626494E-23	-2.98085355652985E-23	-3.81838377186938E-23	-4.66326025487529E-23	-5.48595245987077E-23

	600 psi	700 psi	800 psi	900 psi	1000 psi
b0	127.455447860555	142.685082303618	157.253220595614	171.22460394823	184.648382345756
b1	-10.1326674333863	-11.3980797346853	-12.622236518926	-13.8072201156611	-14.9552282393097
b2	0.565653064025623	0.636232357404775	0.704620281118621	0.770914274919698	0.835229268403915
b3	-0.0166781849444762	-0.0187576404226963	-0.0207729188223336	-0.0227273278530234	-0.0246241659183455
b4	0.000250600777299343	0.000281906561617635	0.000312229138895341	0.000341641355066733	0.000370185572200808
b5	-0.00000122109217199	-0.000001376497552129	-0.0000015263588715099	-0.00000167175079263085	-0.00000181257732478232
b6	-1.96998253891838E-8	-2.20887146418531E-8	-2.44185864753817E-8	-2.66782214882365E-8	-2.88789585410245E-8
b7	4.1226659405150E-10	4.6286454966567E-10	5.12069360762426E-10	5.59794797700734E-10	6.06217386987701E-10
b8	-3.5812778881838E-12	-4.02619940693368E-12	-4.45487280909019E-12	-4.87065716162022E-12	-5.27501264770406E-12
b9	1.7939046163823E-14	2.01480774808841E-14	2.22945330136581E-14	2.43764096140048E-14	2.6400993261433E-14
b10	-5.34828064050097E-17	-6.00715569345795E-17	-6.64730188665052E-17	-7.26817228610418E-17	-7.87196500639748E-17
b11	8.8546847065735E-20	9.94576754891952E-20	1.10057860929472E-19	1.20338570022221E-19	1.3033680751129E-19
b12	-6.28365981493664E-23	-7.05802904146443E-23	-7.81033651490378E-23	-8.53994996543666E-23	-9.24954257280586E-23

NPS 1 SCH 160 Pipe (30 psi – 300 psi) - Polynomial equation for blowdown mass flow [1000 lb/hr]

$$Mf=b0+b1\cdot L+b2\cdot L^2+b3\cdot L^3+b4\cdot L^4+b5\cdot L^5+b6\cdot L^6+b7\cdot L^7+b8\cdot L^8+b9\cdot L^9+b10\cdot L^{10}$$

Where: Mf denotes mass flow [1000 lb/hr] and L denotes equivalent straight length of pipe [ft]

	30 psi	60 psi	90 psi	120 psi	150 psi
b0	12.3111593694982	25.2058697442323	30.5828956060215	34.7817120003378	39.2250321973068
b1	-0.924345782271788	-4.6099848133375	-5.74621239666654	-6.1257661381869	-6.60130109775578
b2	0.0736436847047768	0.600663028978947	0.784282067043749	0.823485294160167	0.8753671401865
b3	-0.0041871049973066	-0.0451352817549898	-0.0608555820869672	-0.0635120849903468	-0.067110562967593
b4	0.000159167099303555	0.00206681157015628	0.00284912553528061	0.00296390827977099	0.00312141885615202
b5	-0.00000402785107481494	-0.0000601780514175676	-0.0000842896918239781	-0.0000875093626415286	-0.0000919651286085002
b6	6.79501700572445E-8	0.00000113628695122798	0.00000161067040929151	0.00000166989999161433	0.00000175237150433679
b7	-7.54490375585418E-10	-1.38516852279422E-8	-1.98165849881131E-8	-2.05248146745756E-8	-2.15156097600735E-8
b8	5.29267203784894E-12	1.05115110733525E-10	1.51487015613075E-10	1.56782137913763E-10	1.64217932858949E-10
b9	-2.12563007835437E-14	-4.51311073849082E-13	-6.54294404538395E-13	-6.76761531077565E-13	-7.08410395338794E-13
b10	3.72412090148714E-17	8.37098349025227E-16	1.21959352056745E-15	1.26086587720091E-15	1.319159350921E-15

	180 psi	210 psi	240 psi	270 psi	300 psi
b0	43.9799212360095	48.6461083973388	53.2804114106486	57.8551733350784	62.3587812659092
b1	-7.25018365841687	-7.89638634569999	-8.56402497906654	-9.232120583618	-9.92036272010811
b2	0.955849902828024	1.03546772129657	1.11882140155179	1.20347595623972	1.28977284994529
b3	-0.0731221590355393	-0.0790304067360867	-0.0852588452387738 7	-0.09158907508814	-0.0980815450851861
b4	0.00339742004598064	0.00366734191839585	0.00395305889563043	0.00424355660908107	0.00454259882181394
b5	-0.000100035451756568	-0.000107899379366843	-0.000116246004041732	-0.000124733980799032	-0.000133492735087293
b6	0.0000019053952685 3815	0.0000020541013467 5115	0.0000022122273706 2432	0.0000023730665357 5421	0.0000025393048904213
b7	-2.33879892631587E-8	-2.52037736925323E-8	-2.71371390279528E-8	-2.91041302571634E-8	-3.11394340837773E-8
b8	1.78472664577468E-10	1.92274198961431E-10	2.06983944493655E-10	2.21952902093524E-10	2.37454273410077E-10
b9	-7.69783224118592E-13	-8.29128280286261E-13	-8.92426601765895E-13	-9.56853898002218E-13	-1.0236131257661E-12
b10	1.43326736720812E-15	1.54348961380903E-15	1.66112515692028E-15	1.7808816323953E-15	1.90503057278579E-15

NPS 1 SCH 160 Pipe (150 psi – 1500 psi) - Polynomial equation for blowdown mass flow [1000 lb/hr]

$$Mf=b0+b1\cdot L+b2\cdot L^{2}+b3\cdot L^{3}+b4\cdot L^{4}+b5\cdot L^{5}+b6\cdot L^{6}+b7\cdot L^{7}+b8\cdot L^{8}+b9\cdot L^{9}+b10\cdot L^{10}+b11\cdot L^{11}+b12\cdot L^{12}$$

Where: Mf denotes mass flow [1000 lb/hr] and L denotes equivalent straight length of pipe [ft]

	150 psi	300 psi	450 psi	600 psi	750 psi
b0	32.9413444216929	53.1426039259873	71.5484255843745	88.4173601548634	104.066641205179
b1	-2.70095916101694	-4.21245910854383	-5.68735943047867	-7.08093963763341	-8.39988737865606
b2	0.153527187552339	0.235978146289963	0.317629116021141	0.395204669598932	0.468887852269731
b3	-0.00455321316334802	-0.00696654806580888	-0.00936701415010138	-0.0116506693872123	-0.0138221454408017
b4	0.0000681722309546191	0.000104556935337058	0.000140712516005607	0.00175080446477554	0.000207765547229565
b5	-0.000000315965981209584	-0.000000502428414261076	-0.000000683783992456573	-0.000000854491044441668	-0.000001016444443874071
b6	-5.78065917812115E-9	-8.40052202962229E-9	-1.11094619156678E-8	-1.37271457801721E-8	-1.62286307553806E-8
b7	1.17526448790585E-10	1.74307101434539E-10	2.32098398328449E-10	2.87567681019789E-10	3.40485373143841E-10
b8	-1.01608136689555E-12	-1.51320400445438E-12	-2.0176810520497E-12	-2.50123242973378E-12	-2.96240958571084E-12
b9	5.07316570039963E-15	7.56681476756454E-15	1.00946912203497E-14	1.25164394320953E-14	1.48259432719837E-14
b10	-1.51098856290459E-17	-2.25527047925951E-17	-3.00942190173736E-17	-3.73172771524703E-17	-4.4205396267733E-17
b11	3.73328852719242E-20	4.2012704012163E-20	4.98229555099237E-20	6.17839586226404E-20	7.31902938194818E-20
b12	-2.64908635738887E-23	-2.98085355652985E-23	-3.53559486800625E-23	-4.38448478695554E-23	-5.19401388429599E-23

	900 psi	1050 psi	1200 psi	1350 psi	1500 psi
b0	118.722079213851	132.516499271852	145.587503886474	157.976123843081	169.732289637975
b1	-9.65433555265519	-10.8498909594842	-11.9974223379827	-13.0951501410244	-14.1461974159324
b2	0.539143609894886	0.606239238413351	0.670800780781424	0.732640422240027	0.791932154780304
b3	-0.0158939295287409	-0.0178735099630432	-0.0197797905615324	-0.0216064534329306	-0.0233581694562542
b4	0.000238947135723724	0.000268733704994214	0.000297418870356679	0.000324917152988395	0.000351270735117505
b5	-0.0000117055362552944	-0.0000131728724184021	-0.0000145830897949405	-0.0000159374523329625	-0.0000172289536901323
b6	-1.86256287764158E-8	-2.09276870130184E-8	-2.31527456374123E-8	-2.52804468623331E-8	-2.73351123063631E-8
b7	3.91105947776907E-10	4.39616593704474E-10	4.86440624520184E-10	5.31268818321162E-10	5.74418528263097E-10
b8	-3.40342390051148E-12	-3.82587092143313E-12	-4.23352097094684E-12	-4.62390772649166E-12	-4.99941204724951E-12
b9	1.70342230948004E-14	1.91491714889743E-14	2.11898255751639E-14	2.31443374208952E-14	2.50237675091532E-14
b10	-5.07913020935725E-17	-5.70983388797221E-17	-6.31834858627946E-17	-6.90122803608022E-17	-7.46162207747327E-17
b11	8.4095963816959E-20	9.45393873825332E-20	1.0461504848464E-19	1.14266865047915E-19	1.2354535705932E-19
b12	-5.96800441433681E-23	-6.70916999502918E-23	-7.42421794038609E-23	-8.10922046120856E-23	-8.767678955791E-23

NPS 1 XX-STR Pipe (30 psi – 300 psi) - Polynomial equation for blowdown mass flow [1000 lb/hr]

$$Mf=b0+b1\cdot L+b2\cdot L^{2}+b3\cdot L^{3}+b4\cdot L^{4}+b5\cdot L^{5}+b6\cdot L^{6}+b7\cdot L^{7}+b8\cdot L^{8}+b9\cdot L^{9}+b10\cdot L^{10}+b11\cdot L^{11}+b12\cdot L^{12}$$

Where: Mf denotes mass flow [1000 lb/hr] and L denotes equivalent straight length of pipe [ft]

	30 psi	60 psi	90 psi	120 psi	150 psi
b0	6.63834062357961	13.2202742579114	15.675472780834	17.9674929089856	20.4187280782079
b1	-0 .667961612870331	- 3.00770812047841	- 3.48847288178702	- 3.77841682257977	- 4.14984089687936
b2	0.0703099216196107	0.487098973215521	0.576961850545737	0.617542720984342	.672095418593012
b3	- 0.00525560519764638	- 0.0458810244487951	-0.0553362861203566	-0 .0589946258601092	-0.0639753001645856
b4	0.000263510517693636	0.00267837929698416	0.00327682581540129	0.00348721040518762	0.0037742553513329
b5	- 0.00000889141014792382	-0.000102053252275246	- 0.000126353477080011	-0.000134334534458139	- 0.000145204664626155
b6	0.00000204275175836693	0.00000262146117119451	0.00000328046751768514	0.0000034855527193796	0.00000376389301090621
b7	- 3.20681467190501E-9	- 4.6097785653858E-8	- 5.82776399138814E-8	- 6.18947423075487E-8	- 6.67814014210252E-8
b8	3.40104343944002E-11	5.54399132411384E-10	7.08190571874338E-10	7.51900346828494E-10	8.10630303286718E-10
b9	- 2.35579169522848E-13	- 4.46948109160869E-12	- 5.77343019165778E-12	- 6.12807319490068E-12	- 6.60153375773364E-12
b10	9.90505748737029E-16	2.30026347865589E-14	3.0092255009114E-14	3.19324854605846E-14	3.43704706428665E-14
b11	- 2.14911539166038E-18	- 6.79498383269801E-17	- 9.02465912532E-17	- 9.57401715467556E-17	- 1.02949714192938E-16
b12	1.49887674879598E-21	8.70363123671313E-20	1.17816063050417E-19	1.24951033078446E-19	1.34201741283296E-19

	180 psi	210 psi	240 psi	270 psi	300 psi
b0	22.8947248892114	25.3540281450143	27.7836402947758	30.1928068779549	32.5490631859773
b1	- 4.55207161849812	- 4.97000865887968	- 5.39579442883902	- 5.83281096196768	- 6.26582418922365
b2	0.732168951552373	0.79519803698385	0.860021272150402	0.927201202590034	0.994143804647672
b3	- 0.0694954823113049	-0.0753003986563483	-0.0813006091911251	-0.0875425708200516	- 0.0937882530621505
b4	0.004093627547469	0.00442954884494625	0.00477787244916503	0.00514101538338627	0.0055054879781882
b5	-0.000157335278548648	-0.000170088971685586	- 0.000183341667040004	-0.000197182047828832	- 0.000211104707573532
b6	0.00000407532699080213	0.00000440254123065756	0.00000474306680135608	0.00000509928768549135	0.00000545825033236529
b7	- 7.22626970903071E-8	- 7.80173735914557E-8	- 8.40127797047792E-8	- 9.02956679101829E-8	- 9.66358040676211E-8
b8	8.76671833508119E-10	9.45950268659163E-10	1.01818922476143E-9	1.09404208784826E-9	1.17067873487835E-9
b9	- 7.13535214818016E-12	- 7.69483140661034E-12	- 8.278640387426E-12	- 8.89305883367515E-12	- 9.51452448510712E-12
b10	3.71274295519131E-14	4.00139832014665E-14	4.30280120659123E-14	4.6208739200122E-14	4.94295909565393E-14
b11	- 1.11131179862275E-16	- 1.19686963682809E-16	- 1.28626207629955E-16	- 1.3809178939218E-16	- 1.47688593507934E-16
b12	1.44745802087034E-19	1.55755833791797E-19	1.67267025303755E-19	1.7950928903888E-19	1.91939265188147E-19

NPS 1 XX-STR Pipe (200 psi – 2000 psi) - Polynomial equation for blowdown mass flow [1000 lb/hr]

$$Mf=b0+b1\cdot L+b2\cdot L^{2}+b3\cdot L^{3}+b4\cdot L^{4}+b5\cdot L^{5}+b6\cdot L^{6}+b7\cdot L^{7}+b8\cdot L^{8}+b9\cdot L^{9}+b10\cdot L^{10}+b11\cdot L^{11}+b12\cdot L^{12}$$

Where: Mf denotes mass flow [1000 lb/hr] and L denotes equivalent straight length of pipe [ft]

	200 psi	400 psi	600 psi	800 psi	1000 psi
b0	19.6847663734161	32.5294004246772	43.8255237368848	54.0120038780905	63.3435007821701
b1	- 1.58537095062936	- 2.61462099910292	- 3.56522702492785	- 4.44563263755463	- 5.26751536164009
b2	0.0891290967779859	0.1459670975343	0.198981790029241	0.248325885789661	0.294545495848966
b3	- 0.00263405800138681	- 0.00430338413825741	- 0.00586478002903709	- 0.00732008928590465	- 0.00868448130276011
b4	0.0000394967129904186	0.0000646473522172429	0.0000881549527445202	0.000110061568599247	0.000130596758828161
b5	- 0.000000187655886500268	- 0.000000314568152094367	- 0.000000431512683714397	- 0.000000539889751684572	- 0.000000641101514855925
b6	- 3.22837724331155E-9	- 5.0923303633859E-9	- 6.87913128743199E-9	- 8.56047273188587E-9	- 1.01467461209214E-8
b7	6.65437660315783E-11	1.06478264919484E-10	1.44379438192952E-10	1.79909199779251E-10	2.13346323008578E-10
b8	- 5.76908418926441E-13	- 9.25783031319745E-13	- 1.256265406517E-12	- 1.56584261374568E-12	- 1.85704565608808E-12
b9	2.88339837102575E-15	4.63204322269464E-15	6.28737223268659E-15	7.83756725513262E-15	9.29549952234531E-15
b10	- 8.59191801388961E-18	- 1.38093013676049E-17	- 1.87467877980342E-17	- 2.33700930449779E-17	- 2.77178972892278E-17
b11	1.42210853505972E-20	2.28623946774734E-20	3.10389809892632E-20	3.86947664396138E-20	4.58940806680793E-20
b12	- 1.00904675438061E-23	- 1.62239226248396E-23	- 2.20271522764312E-23	- 2.74605491812994E-23	- 3.25698934645029E-23

	1200 psi	1400 psi	1600 psi	1800 psi	2000 psi
b0	71.9811788273001	80.0121091517036	80.0121091517036	94.4678791397977	100.945315998309
b1	- 6.04075494186925	- 6.76913322288284	- 6.76913322288284	- 8.1042896863961	- 8.71401828288675
b2	0.338168692264715	0.379354097840915	0.379354097840915	0.455112108483675	0.489839992742613
b3	- 0.00997342699947281	- 0.0111911392999421	- 0.0111911392999421	- 0.0134331734751966	- 0.0144622551040615
b4	0.000149993219746747	0.000168320976607261	0.000168320976607261	0.000202051298952514	0.000217538331699104
b5	- 0.000000736291636087879	- 0.000000826192095521072	- 0.000000826192095521072	- 0.000000990577157245068	- 0.000001065907039987 93
b6	- 1.16560707938314E-8	- 1.30838229222562E-8	- 1.30838229222562E-8	- 1.57394214483217E-8	- 1.69636026120773E-8
b7	2.450721052485E-10	2.75072291501628E-10	2.75072291501628E-10	3.30642936727042E-10	3.56227388805113E-10
b8	- 2.13319557210557E-12	- 2.394307135129E-12	- 2.394307135129E-12	- 2.8775871245704 4E-12	- 3.10004343043141E-12
b9	1.06778007493517E-14	1.19847876371006E-14	1.19847876371006E-14	1.44031314057904E-14	1.55162585922596E-14
b10	- 3.18398139785572E-17	- 3.57370811105531E-17	- 3.57370811105531E-17	- 4.29473593861423E-17	- 4.62661299921066E-17
b11	5.27190999658417E-20	5.91720645641993E-20	5.91720645641993E-20	7.11099025580232E-20	7.66047408022918E-20
b12	- 3.74135217613008E-23	- 4.19930596194473E-23	- 4.19930596194473E-23	- 5.04648791357614E-23	- 5.43644029148741E-23

NPS 1–1/4 SCH 80 Pipe (30 psi – 300 psi) - Polynomial equation for blowdown mass flow [1000 lb/hr]

$$Mf=b0+b1\cdot L+b2\cdot L^{2}+b3\cdot L^{3}+b4\cdot L^{4}+b5\cdot L^{5}+b6\cdot L^{6}+b7\cdot L^{7}+b8\cdot L^{8}+b9\cdot L^{9}+b10\cdot L^{10}+b11\cdot L^{11}+b12\cdot L^{12}$$

Where: Mf denotes mass flow [1000 lb/hr] and L denotes equivalent straight length of pipe [ft]

	30 psi	60 psi	90 psi	120 psi	150 psi
b0	30.5737910042419	69.8175137954066	96.1220625067689	105.875259897737	118.575643611448
b1	- 1.64130841193636	- 12.3673227779257	- 22.6181656388181	- 22.9637143790869	- 24.6947977792512
b2	0.112735082882588	1.7154730012916	3.7932123322028	3.78602580079436	4.03662161375176
b3	- 0.00647432882261728	- 0.146199629464314	- 0.365782869694447	- 0.362643925800032	- 0.385310290418071
b4	0.000276914014036933	0.0079572418896498	0.0217264479949451	0.0214622545099068	0.022757049225115
b5	- 0.0000085684070246696	- 0.000287415230096751	- 0.000839518012244896	- 0.000827372858105114	- 0.000875973224710827
b6	0.000000192039359431818	0.0000070626007384690 3	0.0000218319209378386	0.0000214789252636924	0.0000227119945198092
b7	- 3.13766242684073E-9	- 0.000000119328762007457	- 0.000000388401611564877	- 0.000000381577383796967	- 0.000000403012038435696
b8	3.72990607739045E-11	1.38023105913118E-9	4.72630784371031E-9	4.63727728388222E-9	4.89204015575831E-9
b9	- 3.15904986690819E-13	- 1.06792252034702E-11	- 3.85844850837505E-11	- 3.78096638753195E-11	- 3.98370372764558E-11
b10	1.80856020190589E-15	5.24554576490288E-14	2.01416776632353E-13	1.97107667651761E-13	2.07384392767335E-13
b11	- 6.25613805609278E-18	- 1.46342199255262E-16	- 6.05113402076386E-16	- 5.91272528020059E-16	- 6.21063005285282E-16
b12	9.82885937473466E-21	1.73718804135639E-19	7.9167112479087E-19	7.72159614269556E-19	8.09381077554323E-19

	180 psi	210 psi	240 psi	270 psi	300 psi
b0	131.738366075382	144.795154879158	157.665748850005	170.738496529218	183.565516431686
b1	- 26.7211298100619	- 28.7509104142374	- 30.7759295862522	- 33.0247620450782	- 35.2408347605922
b2	4.34494218915079	4.64668726337431	4.9465763048405	5.29373605681602	5.63337535734514
b3	- 0.414130952278176	- 0.441753643024939	- 0.469108410829427	- 0.501548717953778	- 0.533069752889816
b4	0.0244476099103697	0.0260405294616031	0.0276134650270119	0.0295096621325427	0.031341771014648
b5	- 0.000940937918036332	- 0.0010012713609053	- 0.00106070283716386	- 0.00113324866718022	- 0.00120301407326766
b6	0.000024397529769289	0.0000259426213247214	0.0000274612159788982	0.0000293344563522319	0.0000311284767512576
b7	- 0.000000432980978851349	- 0.000000460111743240311	- 0.000000486718100905564	- 0.000000519854965844367	- 0.000000551467513895167
b8	5.25689906055433E-9	5.58304555957258E-9	5.90213266589727E-9	6.30333640306037E-9	6.68459445663827E-9
b9	- 4.28195363581383E-11	- 4.54496886172529E-11	- 4.80160554023058E-11	- 5.12755083267144E-11	- 5.43600274125761E-11
b10	2.22985312265176E-13	2.36534895127179E-13	2.49714114073312E-13	2.66642968409963E-13	2.82587848533991E-13
b11	- 6.68066699690794E-16	- 7.08160249485813E-16	- 7.4700486376024E-16	- 7.97576801592543E-16	- 8.44942027393326E-16
b12	8.7111581915634E-19	9.22605796633845E-19	9.72236444481878E-19	1.03795390653488E-18	1.09907033706165E-18

NPS 1–1/4 SCH 80 Pipe (100 psi – 1000 psi) - Polynomial equation for blowdown mass flow [1000 lb/hr]

$$Mf=b0+b1\cdot L+b2\cdot L^{2}+b3\cdot L^{3}+b4\cdot L^{4}+b5\cdot L^{5}+b6\cdot L^{6}+b7\cdot L^{7}+b8\cdot L^{8}+b9\cdot L^{9}+b10\cdot L^{10}+b11\cdot L^{11}+b12\cdot L^{12}$$

Where: Mf denotes mass flow [1000 lb/hr] and L denotes equivalent straight length of pipe [ft]

	100 psi	200 psi	300 psi	400 psi	500 psi
b0	65.2256272594333	104.979152396083	141.254433274627	174.470277815938	205.269420091748
b1	- 2.98106699886004	- 4.64726598093941	- 6.2769978377267	- 7.81340184101508	- 9.26571595462456
b2	0.0845077493880355	0.130116966316026	0.175370985982373	0.218259893752866	0.258931731160649
b3	- 0.00113701730826144	- 0.00175054593625329	- 0.00235972179227716	- 0.00293760971321699	- 0.003485816297245
b4	0.00000568059006381155	0.00000897478334908529	0.0000121776329768468	0.0000152051410070726	0.0000180679643365571
b5	3.11637877388256E-8	4.31853346765983E-8	5.65569828687922E-8	6.95004727692135E-8	8.19803600427869E-8
b6	- 6.33932367178823E-10	- 9.29590113085714E-10	- 1.23708068660696E-9	- 1.53140975042409E-9	- 1.81260253155545E-9
b7	4.27182202993773E-12	6.31429112200678E-12	8.42116564283943E-12	1.04350833716873E-11	1.23568623726831E-11
b8	- 1.63128169450643E-14	- 2.41802154207952E-14	- 3.22728284653795E-14	- 4.00048377321786E-14	- 4.73801284869005E-14
b9	3.84064974686735E-17	5.7003004748442E-17	7.61072391792888E-17	9.43565022537577E-17	1.117606576799E-16
b10	- 5.53170380207843E-20	- 8.21574079398749E-20	- 1.09712060966913E-19	- 1.36030875513191E-19	- 1.61128531276943E-19
b11	4.48110294152758E-23	6.65792679369521E-23	8.89183840159643E-23	1.10254398195483E-22	1.30599394765979E-22
b12	- 1.56691567829353E-26	- 2.32861308807208E-26	- 3.11011430619586E-26	- 3.85650010697592E-26	- 4.56819669092772E-26

	600 psi	700 psi	800 psi	900 psi	1000 psi
b0	234.101104506254	261.229382177353	286.922432758808	311.267671130657	334.36696408844
b1	- 10.6458812541696	- 11.9602840117571	- 13.2202580630435	- 14.4251457576104	- 15.5784732345492
b2	0.297678947737362	0.334655517999187	0.370177342672148	0.404195585007819	0.436802899138385
b3	- 0.00400828826734178	- 0.00450708913003612	- 0.00498639067771988	- 0.00544561212894373	- 0.00588579867300924
b4	0.0000207919957187365	0.0000233895836409224	0.0000258802668939976	0.0000288267391031284	0.0000305510363039679
b5	9.39760149737459E-8	0.00000105505019766143	0.00000116701525933804	0.00000127424448739114	0.00000137796747182788
b6	- 2.08161061959615E-9	- 2.33923511062978E-9	- 2.58795502130479E-9	- 2.82625723280245E-9	- 3.05558508741659E-9
b7	1.41942426863622E-11	1.59531224230455E-11	1.76499058369312E-11	1.92757357973001E-11	2.08392752849065E-11
b8	- 5.44300035829258E-14	- 6.11778057384457E-14	- 6.76856707775908E-14	- 7.39215671524859E-14	- 7.99171460654903E-14
b9	1.28395214357238E-16	1.44316235399977E-16	1.5966933965979E-16	1.74380980174167E-16	1.88524204088922E-16
b10	- 1.85115056695136E-19	- 2.08072245703556E-19	- 2.30209233204625E-19	- 2.51421379129397E-19	- 2.71812919167309E-19
b11	1.50043024873625E-22	1.6865214760852E-22	1.86595864578998E-22	2.03789903318992E-22	2.20318367268263E-22
b12	- 5.24834778986081E-26	- 5.89930679250474E-26	- 6.52697958735359E-26	- 7.12842641188363E-26	- 7.70658483520163E-26

NPS 1–1/4 SCH 160 Pipe (30 psi – 300 psi) - Polynomial equation for blowdown mass flow [1000 lb/hr]

$$Mf=b0+b1\cdot L+b2\cdot L^{2}+b3\cdot L^{3}+b4\cdot L^{4}+b5\cdot L^{5}+b6\cdot L^{6}+b7\cdot L^{7}+b8\cdot L^{8}+b9\cdot L^{9}+b10\cdot L^{10}+b11\cdot L^{11}+b12\cdot L^{12}$$

Where: Mf denotes mass flow [1000 lb/hr] and L denotes equivalent straight length of pipe [ft]

	30 psi	60 psi	90 psi	120 psi	150 psi
b0	25.1811168687828	56.7895411693794	76.4486407919321	84.7384204925131	94.8294999239035
b1	- 1.48183522410589	- 10.526753803167	- 18.0107005198468	- 18.4429401156686	- 19.754858814852
b2	.109904277512238	1.50190315850936	3.03146518599325	3.04735959951001	3.23271789947859
b3	- 0.00664979604508316	- 0.130302001354769	-0 .293193547800462	- 0.292276658422697	- .308939883713789
b4	0.000289789957738044	0.00717736428321584	0.0174560345923312	0.017311900256845	0.018265485941178
b5	- 0.0000087253077727918	-0.000261487555362271	- 0.000675856795079054	- 0.000667744399721719	-0.000703742145294105
b6	0.000000178345349121692	0.0000046851473864653	0.0000176076242998706	0.0000173419051145682	0.00001826267629169
b7	- 2.42232446617229E-9	-0.00000010990567841368	- 0.00000313793528437916	- 0.00000030818075451737	- 0.00000324349579453881
b8	2.08280970640523E-11	1.27778083410295E-9	3.82518644341301E-9	3.7463134927027E-9	3.94085794269959E-9
b9	- 9.91899367637935E-14	- 9.93759266780011E-12	- 3.12871453109443E-11	- 3.05528834343319E-11	- 3.21242820762763E-11
b10	1.28500353738743E-16	4.90909937010005E-14	1.63671597914658E-13	1.59316076267491E-13	1.67430263804955E-13
b11	9.05012298382842E-19	- 1.37910184578514E-16	- 4.92948907094878E-16	- 4.7803155560894E-16	- 5.02118641946646E-16
b12	- 3.1490928059212E-21	1.65267879937872E-19	6.46919548203404E-19	6.2445899449858E-19	6.55528817090873E-19

	180 psi	210 psi	240 psi	270 psi	300 psi
b0	105.341419339264	115.681621286143	126.327747579394	136.749927764721	147.032589434544
b1	- 21.3196980450191	- 22.8648219898349	- 24.6653709947222	- 26.4136822301176	- 28.1833432603104
b2	3.46336908575073	3.68748790050731	3.96426076962302	4.22840640760866	4.49842442826243
b3	- 0.329999394420147	- 0.350240002014173	- 0.376056694643832	- 0.400379863973936	- 0.425384684656627
b4	0.0194778980175409	0.020635214464639	0.0221427043880941	0.0235490125708688	0.0250006108948721
b5	- 0.000749589729613967	- 0.000793157326376022	- 0.000850795555163258	- 0.000904122988083581	- 0.000959358174859139
b6	0.0000194347369311114	0.0000205449732733899	0.0000220326923166095	0.0000233988843049578	0.0000248186210569502
b7	- 0.00000034488889018950 96	-0.00000036429760196545 7	- 0.00000039060809088116	- 0.00000041459434573415	- 0.00000043960537403169 7
b8	4.18718480669317E-9	4.41948599232639E-9	4.73798478246045E-9	5.02617715456731E-9	5.32779144616165E-9
b9	- 3.41050976197748E-11	- 3.59697848858517E-11	- 3.85569956870553E-11	- 4.08789692052071E-11	- 4.33192698703356E-11
b10	1.77598794860279E-13	1.87154583414969E-13	2.00590493909631E-13	2.12536681965354E-13	2.25153875520548E-13
b11	- 5.32072290868875E-16	- 5.60169477726097E-16	- 6.00302482558572E-16	- 6.3558655859131E-16	- 6.73080213419154E-16
b12	6.93766800198951E-19	7.29559165664749E-19	7.81704838229804E-19	8.2690188800112E-19	8.75308353599354E-19

NPS 1–1/4 SCH 160 Pipe (150 psi – 1500 psi) - Polynomial equation for blowdown mass flow [1000 lb/hr]

$$Mf=b0+b1\cdot L+b2\cdot L^{2}+b3\cdot L^{3}+b4\cdot L^{4}+b5\cdot L^{5}+b6\cdot L^{6}+b7\cdot L^{7}+b8\cdot L^{8}+b9\cdot L^{9}+b10\cdot L^{10}+b11\cdot L^{11}+b12\cdot L^{12}$$

Where: Mf denotes mass flow [1000 lb/hr] and L denotes equivalent straight length of pipe [ft]

	150 psi	300 psi	450 psi	600 psi	750 psi
b0	65.22562725943327	104.9791523960829	141.2544332746267	174.470277815938	205.2694200917482
b1	-2.981066998860037	-4.647265980939412	-6.276997837726703	-7.813401841015079	-9.265715954624561
b2	0.08450774938803551	0.1301169663160257	0.1753709859823734	0.2182598937528664	0.2589317311606491
b3	-1.137017308261444E-3	-1.750545936253287E-3	-2.359721792277158E-3	-2.937609713216989E-3	-3.485816297244996E-3
b4	5.680590063811549E-6	8.974783349085286E-6	1.21776329768468E-5	1.520514100707257E-5	1.806796433655708E-5
b5	3.116378773882558E-8	4.318533467659831E-8	5.655698286879217E-8	6.950047276921345E-8	8.198036004278692E-8
b6	-6.339323671788226E-10	-9.295901130857136E-10	-1.237080686606958E-9	-1.531409750424091E-9	-1.812602531555446E-9
b7	4.271822029937727E-12	6.314291122006783E-12	8.42116564283943E-12	1.043508337168731E-11	1.235686237268311E-11
b8	-1.631281694506434E-14	-2.418021542079515E-14	-3.22728284653795E-14	-4.000483773217857E-14	-4.738012848690046E-14
b9	3.840649746867349E-17	5.7003004748442E-17	7.610723917928876E-17	9.435650225375766E-17	1.117606576798995E-16
b10	-5.531703802078432E-20	-8.215740793987492E-20	-1.097120609669126E-19	-1.360308755131911E-19	-1.611285312769434E-19
b11	4.48110294152758E-23	6.657926793695208E-23	8.891838401596426E-23	1.102543981954826E-22	1.305993947659789E-22
b12	-1.566915678293533E-26	-2.328613088072076E-26	-3.110114306195862E-26	-3.856500106975922E-26	-4.568196690927716E-26

	900 psi	1050 psi	1200 psi	1350 psi	1500 psi
b0	234.1011045062542	261.2293821773529	286.9224327588082	311.2676711306572	334.3669640884399
b1	-10.64588125416955	-11.96028401175714	-13.22025806304348	-14.42514575761038	-15.57847323454919
b2	0.297678947737362	0.334655517999187	0.3701773426721484	0.4041955850078192	0.4368028991383849
b3	-4.008288267341777E-3	-4.507089130036122E-3	-4.986390677719882E-3	-5.445612128943734E-3	-5.885798673009235E-3
b4	2.079199571873651E-5	2.33895836409224E-5	2.58802668939976E-5	2.826739103128395E-5	3.055103630396794E-5
b5	9.397601497374585E-8	1.055050197661429E-7	1.167015259338041E-7	1.274244487391143E-7	1.377967471827882E-7
b6	-2.081610619596148E-9	-2.339235110629782E-9	-2.587955021304793E-9	-2.826257232802452E-9	-3.055585087416592E-9
b7	1.419424268636215E-11	1.595312242304553E-11	1.764990583693121E-11	1.927573579730011E-11	2.083927528490648E-11
b8	-5.443000358292575E-14	-6.11778057384457E-14	-6.768567077759081E-14	-7.392156715248586E-14	-7.991714606549032E-14
b9	1.283952143572382E-16	1.443162353999769E-16	1.596693396597897E-16	1.743809801741665E-16	1.885242040889218E-16
b10	-1.851150566951358E-19	-2.080722457035562E-19	-2.302092332046246E-19	-2.514213791293968E-19	-2.718129191673092E-19
b11	1.500430248736254E-22	1.686521476085198E-22	1.865958645789979E-22	2.037899033189919E-22	2.203183672682633E-22
b12	-5.248347789860806E-26	-5.899306792504742E-26	-6.526979587353592E-26	-7.128426411883631E-26	-7.706584835201631E-26

NPS 1-1/4 XX-STR Pipe (30 psi – 300 psi) - Polynomial equation for blowdown mass flow [1000 lb/hr]

$$Mf=b0+b1\cdot L+b2\cdot L^2+b3\cdot L^3+b4\cdot L^4+b5\cdot L^5+b6\cdot L^6+b7\cdot L^7+b8\cdot L^8+b9\cdot L^9+b10\cdot L^{10}$$

Where: Mf denotes mass flow [1000 lb/hr] and L denotes equivalent straight length of pipe [ft]

	30 psi	60 psi	90 psi	120 psi	150 psi
b0	14.9285989792464	31.5988223311969	39.704758913496	44.6593414128781	50.2036804893357
b1	- 1.04815215288931	- 5.79243170806096	- 7.93517467513998	- 8.30268461645687	- 8.92121214961795
b2	0.0805692522347677	0.755127356185719	1.11171201236025	1.14365931931033	1.21390942163975
b3	- 0.00452113835265556	- 0.0567607291503385	- 0.0874620173690618	- 0.0893578323337056	- 0.0943626558029225
b4	0.000172410958136684	0.00259941047280865	0.00412851834816348	0.00420240572855067	0.00442546875042488
b5	- 0.0000044328891997 1925	- 0.0000756733868176181	- 0.000122771460347546	- 0.0001246806645499	- 0.000131070935638597
b6	7.67137958599022E-8	0.00000142831170894412	0.00000235380768696107	0.00000238665859059951	0.00000250601306664026
b7	- 8.79565675719402E-10	- 1.74012904529734E-8	- 2.90211842366091E-8	- 2.9392779999221E-8	- 3.08362437435641E-8
b8	6.39629170289418E-12	1.31952054136927E-10	2.22140127739555E-10	2.24791098012963E-10	2.35677727568407E-10
b9	- 2.6678009193471E-14	- 5.66030179710223E-13	- 9.60139297950586E-13	- 9.70944234692011E-13	- 1.01745180292033E-12
b10	4.85485730167777E-17	1.04882483902244E-15	1.79017534532393E-15	1.80934393865897E-15	1.89524035130679E-15

	180 psi	210 psi	240 psi	270 psi	300 psi
b0	55.9929415073921	61.8295554514416	67.6643911169749	73.4143913632305	79.0654648636142
b1	- 9.68514170617804	- 10.5138842414631	- 11.3889275954257	- 12.2644674008609	- 13.1421723851436
b2	1.30782150050555	1.41181479517727	1.52403741784325	1.6361446102382	1.74936788241556
b3	- 0.101356246024946	- 0.109155768945017	- 0.117670907766187	- 0.126156986065104	- 0.134762223806636
b4	0.00474610699352285	0.00510477809989752	0.0054991156024108	0.00589143144111555	0.00629020359539084
b5	- 0.000140437496680672	- 0.000150931166408758	- 0.000162521097312173	- 0.000174038350412629	- 0.000185762427595153
b6	0.0000026834588330557	0.0000028824367793864 7	0.0000031028934524227 5	0.0000033217961757323	0.0000035448454762370 3
b7	- 3.30054455524567E-8	- 3.54393240638211E-8	- 3.81420540236634E-8	- 4.08242385292005E-8	- 4.35590646276188E-8
b8	2.52175724185533E-10	2.70694731740383E-10	2.91294444804782E-10	3.11729067841575E-10	3.32574983720403E-10
b9	- 1.08840608689396E-12	- 1.16807872681472E-12	- 1.25682004042204E-12	- 1.34482164577359E-12	- 1.43462830091893E-12
b10	2.02700987709185E-15	2.17500967530411E-15	2.34002856370053E-15	2.50362908870876E-15	2.67063544081078E-15

NPS 1–1/4 XX-STR Pipe (200 psi – 2000 psi) - Polynomial equation for blowdown mass flow [1000 lb/hr]

$$Mf=b0+b1\cdot L+b2\cdot L^{2}+b3\cdot L^{3}+b4\cdot L^{4}+b5\cdot L^{5}+b6\cdot L^{6}+b7\cdot L^{7}+b8\cdot L^{8}+b9\cdot L^{9}+b10\cdot L^{10}+b11\cdot L^{11}+b12\cdot L^{12}$$

Where: Mf denotes mass flow [1000 lb/hr] and L denotes equivalent straight length of pipe [ft]

	200 psi	400 psi	600 psi	800 psi	1000 psi
b0	43.6062335289419	71.9066526497603	96.8106963609457	119.266338172078	139.833257698417
b1	- 1.959479895402	- 3.22519045432481	- 4.39399916867514	- 5.47547569099505	- 6.48416344571189
b2	0.055050319862245	0.0901075851797983	0.122781735492721	0.153156016681889	0.181576284186314
b3	- 0.00074041133538377 2	- 0.00121244750029232	- 0.00165279566328282	- 0.00206244566630561	- 0.00245949052554 63
b4	0.00000376275125832928	0.00000626159619627293	0.00000856792693764352	0.00001070540617778 77	0.00001270214617549 49
b5	1.89463064896706E-8	2.89601338170282E-8	3.88385451532065E-8	4.82141998618756E-8	5.70924540576251E-8
b6	- 3.99705542200535E-10	- 6.3464822266694E-10	- 8.59080869729841E-10	- 1.06973784431894E-9	- 1.26796752721732E-9
b7	2.70743311767531E-12	4.32131221306444E-12	5.85678484735299E-12	7.29600981285756E-12	8.64924091174562E-12
b8	- 1.03576919905801E-14	- 1.65621883535831E-14	- 2.24570296433938E-14	- 2.79798155281165E-14	- 3.31711809675286E-14
b9	2.44062345367943E-17	3.90592105733765E-17	5.29719950580531E-17	6.60040597183729E-17	7.8252532458705E-17
b10	- 3.51676963289099E-20	- 5.63067541628136E-20	- 7.6371247512945E-20	- 9.51637665995786E-20	- 1.128251595028E-19
b11	2.84954687813294E-23	4.56354593172558E-23	6.19010760842983E-23	7.71347845390872E-23	9.14510297538606E-23
b12	- 9.96547846893694E-27	- 1.59620958619879E-26	- 2.16521621089069E-26	- 2.69811082597762E-26	- 3.19889994294288E-26

	1200 psi	1400 psi	1600 psi	1800 psi	2000 psi
b0	139.833257698417	176.564689435005	193.047993450761	208.416708592415	222.683760431647
b1	- 6.48416344571189	- 8.32504733289002	- 9.16625048068161	- 9.96016647907119	- 10.705719253898
b2	0.181576284186314	0.233649623116255	0.257518916318248	0.280098340337572	0.301345389633564
b3	- 0.00245949052554 63	- 0.00314909694898002	- 0.00347151512171303	- 0.00377661329999713	- 0.00406380327198931
b4	0.00001270214617549 49	0.00001635201733544 71	0.00001802038566317 84	0.00001959550822475 37	0.00002107582860940 33
b5	5.70924540576251E-8	7.36314211916346E-8	8.1328959065701E-8	8.86957968587836E-8	9.56845049296488E-8
b6	- 1.26796752721732E-9	- 1.63406050701877E-9	- 1.80304226122207E-9	- 1.96377999120324E-9	- 2.11562747235143E-9
b7	8.64924091174562E-12	1.11456679930543E-11	1.22967017600172E-11	1.33907242540741E-11	1.44236606943631E-11
b8	- 3.31711809675286E-14	- 4.27446843087479E-14	- 4.71570434752502E-14	- 5.13497838326642E-14	- 5.53076493248386E-14
b9	7.8252532458705E-17	1.00836656906872E-16	1.11243617632022E-16	1.2113152751492E-16	1.30464685505038E-16
b10	- 1.128251595028E-19	- 1.45387329510779E-19	- 1.60390782555637E-19	- 1.74645228429156E-19	- 1.88099299668102E-19
b11	9.14510297538606E-23	1.17844759898387E-22	1.30005321119586E-22	1.41558531006862E-22	1.52462737744029E-22
b12	- 3.19889994294288E-26	- 4.12214724726793E-26	- 4.54750611236533E-26	- 4.95161661119205E-26	- 5.33301979646777E-26

NPS 1-1/2 SCH 80 Pipe (30 psi – 300 psi) - Polynomial equation for blowdown mass flow [1000 lb/hr]

$$Mf=b0+b1\cdot L+b2\cdot L^2+b3\cdot L^3+b4\cdot L^4+b5\cdot L^5+b6\cdot L^6+b7\cdot L^7+b8\cdot L^8+b9\cdot L^9+b10\cdot L^{10}$$

Where: Mf denotes mass flow [1000 lb/hr] and L denotes equivalent straight length of pipe [ft]

	30 psi	60 psi	90 psi	120 psi	150 psi
b0	42.1146250888351	96.5111548579694	134.244296101145	149.536698998176	166.794964551823
b1	- 1.92010882057698	- 14.5730239017738	- 27.0855522634502	- 28.3501735417613	- 30.3187663238896
b2	0.110564893567586	1.69571417576699	3.77841991820781	3.9177666762336	4.159184615007
b3	- 0.00520199597799504	- 0.118972522146035	- 0.296044162576578	- 0.306109807735718	- 0.324302282189317
b4	0.000176543656183613	0.00521190320755704	0.0139326968505582	0.0143895752134385	0.0152332320610053
b5	- 0.0000041458752736029 2	- 0.000147207620671373	- 0.000413420777273845	- 0.000426722333911004	- 0.00045160008609902
b6	6.61819217689744E-8	0.00000271912765986534	0.00000791324528466933	0.00000816502331320805	0.00000863990674652216
b7	- 7.03109687587297E-10	- 3.26005821220667E-8	- 9.74424361271344E-8	- 0.000000100520859978758	- 0.000000106361944928814
b8	4.75827824472376E-12	2.44189093389733E-10	7.45113844492527E-10	7.68541032899308E-10	8.1319129097182E-10
b9	- 1.85799399531136E-14	- 1.03742284372733E-12	- 3.2179169568987E-12	- 3.31874865836867E-12	- 3.51159295593359E-12
b10	3.19011514461173E-17	1.90743190715811E-15	5.99573832362991E-15	6.18314234362422E-15	6.5425564504934E-15

	180 psi	210 psi	240 psi	270 psi	300 psi
b0	184.31994304115	202.371945274603	220.700481605036	238.518067139825	256.499235880748
b1	- 32.3624169708049	- 34.755461215714	- 37.4096853248278	- 39.9098259068315	- 42.6436133202203
b2	4.39920411801604	4.69612177361316	5.03786910138022	5.35035906513505	5.70526850861221
b3	- 0.341710597553633	- 0.363902611095063	- 0.389933555201501	- 0.41329639346646	- 0.440377741429821
b4	0.0160175953339597	0.0170368643344505	0.0182458686680642	0.0193177748155624	0.0205758587258807
b5	- 0.000474233837133056	- 0.000504040686202978	- 0.000539654013354886	- 0.000570960566471623	- 0.00060801259784772
b6	0.0000906482705866628	0.0000962991209012384	0.0001030852723217 26	0.0001090134546017 61	0.0001160716795533 12
b7	- 0.00000111520498423248	- 0.00000118432064225272	- 0.00000126763554575351	- 0.00000134006878423979	- 0.00000142669819313088
b8	8.52210840092414E-10	9.0479844444571E-10	9.68373800913153E-10	1.02343724535859E-9	1.08952386340187E-9
b9	- 3.67866721549234E-12	- 3.90490789428014E-12	- 4.17904949071522E-12	- 4.41576462729923E-12	- 4.70066688100704E-12
b10	6.85170240662822E-15	7.27196545883285E-15	7.78216143682878E-15	8.22160139442269E-15	8.75171343251251E-15

NPS 1-1/2 SCH 80 Pipe (200 psi – 2000 psi) - Polynomial equation for blowdown mass flow [1000 lb/hr]

$$Mf=b0+b1\cdot L+b2\cdot L^2+b3\cdot L^3+b4\cdot L^4+b5\cdot L^5+b6\cdot L^6+b7\cdot L^7+b8\cdot L^8+b9\cdot L^9+b10\cdot L^{10}$$

Where: Mf denotes mass flow [1000 lb/hr] and L denotes equivalent straight length of pipe [ft]

	200 psi	400 psi	600 psi	800 psi	1000 psi
b0	142.383639188543	233.000844675809	313.72251981011	386.941525443435	454.27157178241
b1	- 6.51846202104193	- 10.4779347485955	- 14.2072715508114	- 17.684788147782	- 20.943336472759
b2	0.200020677774293	0.317856375200767	0.430163747452796	0.535404136936353	0.634322360220372
b3	- 0.00334680582300632	- 0.00528974812285971	- 0.00715008382618171	- 0.00889633239712487	- 0.0105393351344401
b4	0.0000329902353166203	0.0000519846172812593	0.0000702155065593781	0.000087342580467832	0.000103464743808553
b5	- 0.00000020258570678369 3	- 0.00000031861623750454 9	- 0.00000043014887024223 3	- 0.00000053497941497255 5	- 0.00000063368660707679 3
b6	7.96320334031514E-10	1.25077067961089E-9	1.68804489041545E-9	2.09917307456954E-9	2.4863570292851E-9
b7	- 2.00327547654699E-12	- 3.14352585763064E-12	- 4.24147698339572E-12	- 5.27400837773165E-12	- 6.24653010141829E-12
b8	3.118092096735E-15	4.88935701027318E-15	6.59584738708513E-15	8.20092567063436E-15	9.7128633448718E-15
b9	- 2.73376833563569E-18	- 4.2842899118031E-18	- 5.77874597978375E-18	- 7.18457173790003E-18	- 8.50891721133897E-18
b10	1.03201664554977E-21	1.61661392615204E-21	2.18026462904411E-21	2.71054218840894E-21	3.21011469558454E-21

	1200 psi	1400 psi	1600 psi	1800 psi	2000 psi
b0	516.827129303515	575.131868173659	629.604965886891	680.558323134065	727.981609824896
b1	- 24.0216954771242	- 26.9267762027523	- 29.6750029206047	- 32.2796007889276	- 34.7316879679946
b2	0.728060204792631	0.816679044285857	0.90070768894206	0.980549603186375	1.05584778921746
b3	- 0.01209802173328	- 0.0135722937580245	- 0.0149714202334711	- 0.0163021318302829	- 0.0175577323114413
b4	0.000118767945114276	0.000133244986362393	0.000146990316789818	0.000160070125131794	0.000172413855748383
b5	- 0.00000072741002083387	- 0.00000081681183351203	- 0.00000090029374964334 6	- 0.00000098045372587644	- 0.00000105610779903102
b6	2.85406964250821E-9	3.20197638890025E-9	3.53244975353058E-9	3.84708607487364E-9	4.14404279083773E-9
b7	- 7.17028154062567E-12	- 8.04430239507926E-12	- 8.87463281947018E-12	- 9.6652942021492E-12	- 1.04115282372149E-11
b8	1.11491383023645E-14	1.2508117246153E-14	1.37992842367003E-14	1.50289122003603E-14	1.61894358415565E-14
b9	- 9.76709451639286E-18	- 1.09575779261392E-17	- 1.2088736470666E-17	- 1.31660847087026E-17	- 1.41828717245309E-17
b10	3.68475903486176E-21	4.13387131419769E-21	4.56062617241842E-21	4.9671115834035E-21	5.35074074329191E-21

NPS 1-1/2 SCH 160 Pipe (30 psi – 300 psi) - Polynomial equation for blowdown mass flow [1000 lb/hr]

$$Mf=b0+b1\cdot L+b2\cdot L^{2}+b3\cdot L^{3}+b4\cdot L^{4}+b5\cdot L^{5}+b6\cdot L^{6}+b7\cdot L^{7}+b8\cdot L^{8}+b9\cdot L^{9}+b10\cdot L^{10}+b11\cdot L^{11}+b12\cdot L^{12}$$

Where: Mf denotes mass flow [1000 lb/hr] and L denotes equivalent straight length of pipe [ft]

	30 psi	60 psi	90 psi	120 psi	150 psi
b0	33.521473396542	76.9510134901665	107.099251922676	117.615139997806	131.824006260363
b1	- 1.72792090352261	- 13.3273399434519	- 25.1903864126645	- 25.423550420271	- 27.4297589363023
b2	0.115745897218168	1.8240881452417	4.21870206899556	4.18085868763806	4.47893780512217
b3	- 0.0066279922431161	- 0.154246094716721	- 0.406337524339388	- 0.399763811013588	- 0.427199415013876
b4	0.00028924774361485	0.00835606947021613	0.0241121022133835	0.0236297200347431	0.0252176169590432
b5	- 0.00000932572876116458	- 0.000300964514444057	- 0.000930921780497551	- 0.000910057995191507	- 0.000970310352839284
b6	0.000000221253371018241	0.0000073829191134912	0.0000241901237345872	0.0000236066213061246	0.0000251503576362105
b7	- 3.85259374123524E-9	- 0.000000124623056910565	- 0.000000430026329328121	- 0.000000419075093894478	- 0.000000446166789480374
b8	4.85928865205589E-11	1.44094038055778E-9	5.228660884146E-9	5.08944621790993E-9	5.41465003364871E-9
b9	- 4.30605721917053E-13	- 1.11505390060889E-11	- 4.26484758564552E-11	- 4.14666405233848E-11	- 4.40830569343833E-11
b10	2.53075478558867E-15	5.48077207244307E-14	2.22410083915974E-13	2.16002316873183E-13	2.29435930926857E-13
b11	- 8.8168764546822E-18	- 1.53113554931445E-16	- 6.67389360067216E-16	- 6.47362355816228E-16	- 6.86927456098029E-16
b12	1.37285430432115E-20	1.82198466213686E-19	8.71849429529048E-19	8.44468112364255E-19	8.94947983405254E-19

	180 psi	210 psi	240 psi	270 psi	300 psi
b0	146.355563424034	160.95158210516	175.197510121316	189.684884088375	203.799382976815
b1	- 29.6718227529798	- 32.0129670303289	- 34.2398732545896	- 36.7134428507803	- 39.1136769300826
b2	4.82231071914451	5.17945463549411	5.50784666343033	5.88752071356784	6.25368317133333
b3	- 0.459413668786854	- 0.492708028232788	- 0.522537691829678	- 0.557857057217248	- 0.591786315297433
b4	0.0271109663532018	0.029057210192156	0.0307656509801003	0.0328228723860807	0.0347939887193929
b5	- 0.00104314988409276	- 0.0011176723274495	- 0.00118197924879402	- 0.00126045722627254	-0.0013355129217949
b6	0.0000270415133726145	0.0000289679067571943	0.0000306049706782409	0.0000326262038401749	0.0000345566170776346
b7	- 0.000000479806921472282	- 0.000000513925340355879	- 0.000000542498612518751	- 0.000000578167089409543	- 0.000000612193972502366
b8	5.82433581521264E-9	6.23795864945376E-9	6.57925305677065E-9	7.01005831740747E-9	7.42061313211197E-9
b9	- 4.74328215163398E-11	- 5.07978811440317E-11	- 5.3530546705572E-11	- 5.70213927407044E-11	- 6.0344783022833E-11
b10	2.46961665139025E-13	2.6446641703362E-13	2.784263015269E-13	2.9650376435753E-13	3.13695575232139E-13
b11	- 7.39740958192616E-16	- 7.92128913693221E-16	- 8.33011172655874E-16	- 8.86825966562882E-16	- 9.37941723259611E-16
b12	9.64327876928184E-19	1.03255784146729E-18	1.08435927028302E-18	1.15398506375666E-18	1.22002055602855E-18

NPS 1-1/2 SCH 160 Pipe (200 psi – 2000 psi) - Polynomial equation for blowdown mass flow [1000 lb/hr]

$$Mf=b0+b1\cdot L+b2\cdot L^{2}+b3\cdot L^{3}+b4\cdot L^{4}+b5\cdot L^{5}+b6\cdot L^{6}+b7\cdot L^{7}+b8\cdot L^{8}+b9\cdot L^{9}+b10\cdot L^{10}+b11\cdot L^{11}+b12\cdot L^{12}+b13\cdot L^{13}+b14\cdot L^{14}$$

Where: Mf denotes mass flow [1000 lb/hr] and L denotes equivalent straight length of pipe [ft]

	200 psi	400 psi	600 psi	800 psi	1000 psi
b0	114.658344956279	187.700548115253	252.767023483276	311.809725522995	366.119538519859
b1	- 6.22949334100901	- 10.0169523199685	- 13.5810313497123	- 16.9060816748169	- 20.0226794811496
b2	0.224288551207904	0.356664513156644	0.482619721798361	0.60069657874846	0.711701571884694
b3	- 0.00423815314050823	- 0.00670511736374648	- 0.00906214750885322	- 0.0112754103552465	- 0.0133580844525776
b4	0.0000437174248080711	0.0000689682543952932	0.0000931452062528914	0.00011586606315183 8	0.000137255672462601
b5	- 0.00000234231063799411	- 0.00000036882741998081	- 0.00000049787294805059	- 0.00000061920936958 0254	- 0.00000073346520056 8093
b6	3.5804777772828E-10	5.62768245181585E-10	7.59289603807069E-10	9.44173567817824E-10	1.11829682779204E-9
b7	2.93384826702452E-12	4.60989774737712E-12	6.21918532263E-12	7.73307419277337E-12	9.15907895380305E-12
b8	- 1.82580489615734E-14	- 2.86372859074548E-14	- 3.86145402037299E-14	- 4.80051066086968E-14	- 5.6851918273325E-14
b9	3.38999345452927E-17	5.29257705840491E-17	7.12678913229079E-17	8.85534845715622E-17	1.04844813381614E-16
b10	4.54397967194744E-20	7.24592112560447E-20	9.81793837651179E-20	1.22280544204858E-19	1.44955386013534E-19
b11	- 3.4018894536421E-22	- 5.36404885079158E-22	- 7.2443025884217 2E-22	- 9.01145381643777E-22	- 1.06755837422874E-21
b12	6.88301085230299E-25	1.08340530266311E-24	1.46242167087363E-24	1.81880727857964E-24	2.15446759660956E-24
b13	- 6.54087813450051E-28	- 1.02874007593686E-27	- 1.38831265182058E-27	- 1.72648773098585E-27	- 2.04501907578998E-27
b14	2.48940713961187E-31	3.91343529673215E-31	5.28055260252593E-31	6.56648220262469E-31	7.77776802504792E-31

	1200 psi	1400 psi	1600 psi	1800 psi	200 psi
b0	416.591612812996	463.643692182064	507.6123884058	548.749502028465	587.04627444458
b1	- 22.9679121278966	- 25.7478605842509	- 28.3783429152349	- 30.8721213349404	- 33.2205032007198
b2	0.816921581521978	0.91640637398711	1.01075703713065	1.10043147089852	1.1850185069562
b3	- 0.0153343214214919	- 0.0172036733141441	- 0.0189780467444471	- 0.0206660611582804	- 0.0222590127472524
b4	0.000157562735019212	0.000176774742375882	0.000195018679336086	0.000212382832691741	0.000228771576741343
b5	- 0.00000841972970036136	- 0.00000944638124635989	- 0.00001042159216641 59	- 0.00001135002740181 42	- 0.00001222636533721 55
b6	1.2837098504488E-9	1.44022614934121E-9	1.58895868459125E-9	1.73057342585274E-9	1.86425519570977E-9
b7	1.05137502815248E-11	1.17955737868106E-11	1.30134409421583E-11	1.4173354243999E-11	1.52681233801512E-11
b8	- 6.52582100811944E-14	- 7.3212818608065E-14	- 8.07732595157027E-14	- 8.79745461208912E-14	- 9.47717097773071E-14
b9	1.20333387954871E-16	1.34991186651733E-16	1.48935593362607E-16	1.62219587832148E-16	1.74759221516889E-16
b10	1.66462632858113E-19	1.86808042038204E-19	2.06080220207299E-19	2.2443234587941E-19	2.41748139137675E-19
b11	- 1.22559900449249E-21	- 1.37513514096904E-21	- 1.51709942031571E-21	- 1.65232259303714E-21	- 1.77993840513951E-21
b12	2.47330552313166E-24	2.77499767113689E-24	3.06151029848509E-24	3.33443582504158E-24	3.59201401189774E-24
b13	- 2.3476152407111E-27	- 2.63394451163287E-27	- 2.90590700633876E-27	- 3.16498274984611E-27	- 3.40949184971647E-27
b14	8.92852456877291E-31	1.00174327105409E-30	1.10517920187135E-30	1.20371677798427E-30	1.29671426413924E-30

NPS 1-1/2 XX-STR Pipe (30 psi – 300 psi) - Polynomial equation for blowdown mass flow [1000 lb/hr]

$$Mf=b0+b1\cdot L+b2\cdot L^2+b3\cdot L^3+b4\cdot L^4+b5\cdot L^5+b6\cdot L^6+b7\cdot L^7+b8\cdot L^8+b9\cdot L^9+b10\cdot L^{10}$$

Where: Mf denotes mass flow [1000 lb/hr] and L denotes equivalent straight length of pipe [ft]

	30 psi	60 psi	90 psi	120 psi	150 psi
b0	22.6049953544939	49.5901055219234	64.5330272229621	72.1290385041665	80.8890003021853
b1	- 1.36798719027292	- 8.53114555978754	- 13.0172447410193	- 13.4973755055716	- 14.4944767027729
b2	0.0993116186074962	1.07171573524585	1.82807296996391	1.86155626613465	1.97939316001706
b3	- 0.00564466109191971	- 0.0787481634373299	- 0.143977985684417	- 0.145452978616843	-0.154105764797501
b4	0.000225955999448662	0.00355296378476949	0.0068011587693909	0.0068394195679137	0.0072337903506446
b5	- 0.00000617137640361609	- 0.000102364368713717	- 0.000202355659212725	- 0.00020288304180519	- 0.00021437322145276
b6	0.000000113228337307049	0.0000019175005216 4346	0.0000038811998482 5902	0.0000038830250868 8114	0.0000041004552186 4132
b7	- 1.36465992263669E-9	- 2.32272181072864E-8	- 4.78686698653744E-8	- 4.78149188715971E-8	- 5.04718495949193E-8
b8	1.03215978578047E-11	1.75339879240995E-10	3.66503795059096E-10	3.65639704234171E-10	3.85846602669681E-10
b9	- 4.43150986073608E-14	- 7.49447347672377E-13	- 1.58446077367893E-12	- 1.5791638542915E-12	- 1.66608355222159E-12
b10	8.22699651650006E-17	1.38460723265085E-15	2.95476992357272E-15	2.94251421376064E-15	3.10397501523909E-15

	180 psi	210 psi	240 psi	270 psi	300 psi
b0	89.987886450612	99.0448388503399	108.273054644005	117.342233866225	126.279575649328
b1	- 15.6702668519066	- 16.8852905344076	- 18.2533120683031	- 19.6086626634883	- 20.9732432621244
b2	2.12330652498032	2.27248190904648	2.44819197195444	2.62159016809778	2.7971615263381
b3	- 0.164780388343224	- 0.1758409081018	- 0.189184210642243	- 0.20231711571125	- 0.215639544848761
b4	0.00772149577497587	0.00822662719184665	0.00884476143179241	0.00945230636123575	0.0100689479403548
b5	- 0.000228579414796904	- 0.000243290935776067	- 0.000261460648801106	- 0.00027930650818608	- 0.000297420149530327
b6	0.0000043689632538 6672	0.0000046470241189 4921	0.0000049926490059 1918	0.0000053319899724 034	0.0000056763725857 3197
b7	- 5.37481218564787E-8	- 5.71412339575232E-8	- 6.1378469311413E-8	- 6.55378672554845E-8	- 6.97582281888384E-8
b8	4.10726710532603E-10	4.36496909532515E-10	4.68791675974941E-10	5.00489944698901E-10	5.3264632773136E-10
b9	- 1.7729544613843E-12	- 1.88366098898794E-12	- 2.02277951259116E-12	- 2.15932108686526E-12	- 2.29780989184008E-12
b10	3.30224107619955E-15	3.50764386217646E-15	3.76633409169075E-15	4.02022567111324E-15	4.27769395190266E-15

NPS 1–1/2 XX-STR Pipe (200 psi – 2000 psi) - Polynomial equation for blowdown mass flow [1000 lb/hr]

$$Mf=b0+b1\cdot L+b2\cdot L^{2}+b3\cdot L^{3}+b4\cdot L^{4}+b5\cdot L^{5}+b6\cdot L^{6}+b7\cdot L^{7}+b8\cdot L^{8}+b9\cdot L^{9}+b10\cdot L^{10}+b11\cdot L^{11}+b12\cdot L^{12}$$

Where: Mf denotes mass flow [1000 lb/hr] and L denotes equivalent straight length of pipe [ft]

	200 psi	400 psi	600 psi	800 psi	1000 psi
b0	69.7992194701433	114.789481123865	154.57545546329	190.535045827031	223.522716938853
b1	- 3.1260757979465	- 5.10198370199316	- 6.94076257945315	- 8.64733809022394	- 10.2419292779412
b2	.0879787461618376	.1425831480033	0.193889861411377	0.241727695772644	0.286561767183676
b3	- 0.00118343012969353	- 0.0019184605676376	- 0.00260966326094148	- 0.00325460238790488	- 0.00385932789533913
b4	0.00000599339351009194	0.00000989036374763784	0.000013511888575161	0.000016879185955694 9	0.000020029867399557 1
b5	3.07270363168973E-8	4.61884564685576E-8	6.16546834092752E-8	7.63591789288493E-8	9.02999378839291E-8
b6	- 6.43208064268683E-10	- 1.0077459365491E-9	- 1.35960744241151E-9	- 1.69066872927913E-9	- 2.00262127005286E-9
b7	4.35209278937725E-12	6.85767610005868E-12	9.26538551417188E-12	1.15277845459128E-11	1.36579345330694E-11
b8	- 1.66432969222128E-14	- 2.6277844786387E-14	- 3.55218689554216E-14	- 4.42041381427603E-14	- 5.23767105197875E-14
b9	3.92105134674252E-17	6.19661413779396E-17	8.37842281947895E-17	1.04272359051596E-16	1.23555431731464E-16
b10	- 5.64946221868002E-20	- 8.93243580780289E-20	- 1.20790181905877E-19	- 1.50334929601427E-19	- 1.78140255974696E-19
b11	4.57738725713547E-23	7.23934995304191E-23	9.79021271352111E-23	1.21852016069424E-22	1.44391142656969E-22
b12	- 1.60076581849565E-26	- 2.53209363497761E-26	- 3.42444935589639E-26	- 4.26224863574479E-26	- 5.05068341606754E-26

	1200 psi	1400 psi	1600 psi	1800 psi	2000 psi
b0	254.100936413288	282.557934552193	309.096312690258	333.871792632103	356.89685559845
b1	- 11.7438190509481	- 13.1593090705424	- 14.4951204909585	- 15.7578446748738	- 16.9451311633284
b2	0.328909355287927	0.368904806399129	0.406723558906968	0.442553230467214	0.476312672377851
b3	- 0.00443073577570841	- 0.00497071484652346	- 0.00548136835827005	- 0.00596526460911416	- 0.00642150051195736
b4	0.0000229991099943519	0.0000258046167802489	0.0000284509442148148	0.0000309518319013184	0.0000333097540486195
b5	0.00000103648820880647	0.00000116290817867424	0.00000128391086499098	0.00000140003693054174	0.00000150973316697939
b6	- 2.29913848789959E-9	- 2.57968682479228E-9	- 2.84640976034842E-9	- 3.10058788288027E-9	- 3.34053030833657E-9
b7	1.56807624913204E-11	1.75944730906177E-11	1.94122665001076E-11	2.1142932140352E-11	2.27766249928106E-11
b8	- 6.01350028837424E-14	- 6.7474638127941E-14	- 7.44442895873401E-14	- 8.1077668065502E-14	- 8.73394975756328E-14
b9	1.41858322044929E-16	1.5917346524357E-16	1.75613553697326E-16	1.91257971343337E-16	2.06026522621902E-16
b10	- 2.04530196743623E-19	- 2.29495958577588E-19	- 2.53198439715886E-19	- 2.75751816661261E-19	- 2.97043085863266E-19
b11	1.65782047789744E-22	1.86018576994373E-22	2.0523046058109E-22	2.23510000151097E-22	2.4076700582469 2E-22
b12	- 5.79893438693061E-26	- 6.50680619267307E-26	- 7.17882406506393E-26	- 7.81820817000712E-26	- 8.42183832318934E-26

NPS 2 SCH 80 Pipe (30 psi – 300 psi) - Polynomial equation for blowdown mass flow [1000 lb/hr]

$$Mf=b0+b1\cdot L+b2\cdot L^2+b3\cdot L^3+b4\cdot L^4+b5\cdot L^5+b6\cdot L^6+b7\cdot L^7+b8\cdot L^8+b9\cdot L^9+b10\cdot L^{10}$$

Where: Mf denotes mass flow [1000 lb/hr] and L denotes equivalent straight length of pipe [ft]

	30 psi	60 psi	90 psi	120 psi	150 psi
b0	70.4583176128624	165.607537316829	243.646913047917	277.769825286008	305.269689313751
b1	- 2.54325159258245	- 21.8723864994776	- 48.3235412203211	- 54.501038775213	- 56.4911932537501
b2	0.123502206020222	2.35380082704496	6.65111197868073	7.62244774035829	7.78946837637106
b3	- 0.00525694168143537	- 0.157952286164773	- 0.516607618528942	- 0.599146946047951	- 0.608530871120124
b4	0.00016910504477725	0.00674181021997633	0.0241708175536343	0.02826708701769	0.0286115249555228
b5	- 0.00000385264176624745	- 0.000187436184621346	- 0.000714224553065332	- 0.000840302719508519	- 0.000848684560813812
b6	6.01157777005303E-8	0.00000342791621053881	0.0000136284706870931	0.0000161066089898776	0.0000162426976060396
b7	- 6.22371722614396E-10	- 4.08325179848387E-8	- 0.000000167416943374304	- 0.000000198549812081147	- 0.000000200006197849688
b8	4.06035332865334E-12	3.04517453695687E-10	1.2777550037421E-9	1.5195673654918E-9	1.52942482477046E-9
b9	- 1.50321085377695E-14	- 1.28983988042202E-12	- 5.50970819717768E-12	- 6.56716393631121E-12	- 6.60538860817844E-12
b10	2.39619622641996E-17	2.36651696095086E-15	1.02527567444875E-14	1.22433034606995E-14	1.23079913877809E-14

	180 psi	210 psi	240 psi	270 psi	300 psi
b0	335.073223564047	366.674147726521	398.314423920363	429.688351471722	461.404895885084
b1	- 59.6295753838041	- 63.6699534436543	- 67.9101600191395	- 72.2091753792012	- 76.8916756799691
b2	8.14815032837947	8.64454834336173	9.17276534028483	9.71020612750124	10.3135544447576
b3	- 0.634402020358503	- 0.671260770137674	- 0.710742475716888	- 0.750981040870324	- 0.796845457166783
b4	0.0297786509315616	0.0314630218522562	0.0332747572142579	0.0351231012198929	0.037249130378833
b5	- 0.000882475154049256	- 0.000931533587982636	- 0.000984461767611467	- 0.00103849151432848	- 0.00110101907218993
b6	0.0000168794678161006	0.0000178064885858638	0.0000188090348325725	0.0000198327734112303	0.000021022753953682
b7	- 0.000000207764947837981	- 0.000000219072831970911	- 0.000000231326233281302	- 0.000000243840458122978	- 0.000000258435396299673
b8	1.58831027017852E-9	1.67415463619485E-9	1.76733318387597E-9	1.86249824204491E-9	1.97377664665758E-9
b9	- 6.85829118262538E-12	- 7.22690759369546E-12	- 7.62759605350922E-12	- 8.03681134914235E-12	- 8.51632367940093E-12
b10	1.27772228217853E-14	1.34608529403749E-14	1.42049017985052E-14	1.49647210213317E-14	1.58566109620962E-14

NPS 2 SCH 80 Pipe (300 psi – 3000 psi) - Polynomial equation for blowdown mass flow [1000 lb/hr]

$$Mf=b0+b1\cdot L+b2\cdot L^{2}+b3\cdot L^{3}+b4\cdot L^{4}+b5\cdot L^{5}+b6\cdot L^{6}+b7\cdot L^{7}+b8\cdot L^{8}+b9\cdot L^{9}+b10\cdot L^{10}+b11\cdot L^{11}+b12\cdot L^{12}+b13\cdot L^{13}+b14\cdot L^{14}$$

Where: Mf denotes mass flow [1000 lb/hr] and L denotes equivalent straight length of pipe [ft]

	300 psi	600 psi	900 psi	1200 psi	1500 psi
b0	355.040147618771	587.833449608803	790.066987999916	970.486949084282	1133.41395265007
b1	- 18.8598372626088	- 31.134832236411	- 42.2976416136915	- 52.5251508153494	- 61.9442584212212
b2	0.675699341406273	1.10751379208127	1.50324223476987	1.86728395680491	2.20344597457912
b3	- 0.0127403147447074	- 0.0208100831686643	- 0.0282253170330019	- 0.0350556778517416	- 0.0413678012779037
b4	0.000131258931453603	0.000213981935347648	0.000290097407872087	0.000360252537779494	0.000425106938747521
b5	- 0.000000702692996722492	- 0.000011440657585414	- 0.000015505271213735 9	- 0.000019252975039622 4	- 0.000002271821271464 14
b6	1.0732939547787E-9	1.74523774967158E-9	2.3645366701832E-9	2.93571865759016E-9	3.46395842718575E-9
b7	8.7933053961984E-12	1.42952841896131E-11	1.93666394188952E-11	2.40445106189832E-11	2.83706488606426E-11
b8	- 5.46797751457434E-14	- 8.87808729426995E-14	- 1.20237301172365E-13	- 1.49260332808211E-13	- 1.76106451991545E-13
b9	1.01316520133695E-16	1.63960852232354E-16	2.21862397566702E-16	2.75316044278936E-16	3.24786959185509E-16
b10	1.37094587508967E-19	2.25226532279658E-19	3.05964447790487E-19	3.80317656140189E-19	4.48960232329287E-19
b11	- 1.02121865336107E-21	- 1.66439117946739E-21	- 2.25635148897411E-21	- 2.80221920821687E-21	- 3.30681237715802E-21
b12	2.06461312327272E-24	3.36074540898875E-24	4.55455372462941E-24	5.65565023722673E-24	6.6736908310085E-24
b13	- 1.96129969500793E-27	- 3.19078580233182E-27	- 4.32358645994224E-27	- 5.36852345425248E-27	- 6.33472408903941E-27
b14	7.46297241288053E-31	1.21372016753918E-30	1.64447211253585E-30	2.04184000184835E-30	2.4092847418564E-30

	1800 psi	2100 psi	2400 psi	2700 psi	3000 psi
b0	1281.14639455223	1413.69917564774	1528.16862872696	1619.7598700676	1664.71800923538
b1	- 70.653615735588	- 78.5899481516364	- 85.5206113551486	- 91.1673172440502	- 93.8258144534297
b2	2.51532192349429	2.79997530536371	3.04870296770716	3.25167022831804	3.34368986544959
b3	- 0.0472307262857307	- 0.0525833971942847	- 0.057260862435544	-0.0610795558023887	- 0.0627770979351205
b4	0.000485379841408168	0.000540409678131255	0.000588499756791163	0.00062776979614656	0.000645022905580395
b5	- 0.000002593973632724 53	- 0.000002888099985833 98	- 0.000003145142535932 55	- 0.000003355076334830 74	- 0.000003446558424947 72
b6	3.95521110863792E-9	4.40371018206031E-9	4.79565366730999E-9	5.11586803331628E-9	5.25420844434373E-9
b7	3.23935470344458E-11	3.60664158580092E-11	3.92765862488649E-11	4.18983575696592E-11	4.30302310652995E-11
b8	- 2.0107656221531E-13	- 2.23873469321202E-13	- 2.43798340612799E-13	- 2.6007509549271E-13	- 2.67040363453284E-13
b9	3.70822043888127E-16	4.12849602691669E-16	4.49580941894323E-16	4.79603771405707E-16	4.92150079691202E-16
b10	5.12713592454492E-19	5.70918916365794E-19	6.21805537045198E-19	6.63289439333175E-19	6.82518138338864E-19
b11	- 3.77594710655512E-21	- 4.20424227938861E-21	- 4.5786335403228 8E-21	- 4.8842575602753 2E-21	- 5.0186017272643 3E-21
b12	7.62035344936122E-24	8.48459651655206E-24	9.24006336169998E-24	9.85689043783343E-24	1.01257238476535E-23
b13	- 7.23325332935489E-27	- 8.05354694306074E-27	- 8.7705986680203E-27	- 9.35610901048363E-27	- 9.61031085460017E-27
b14	2.75101115329116E-30	3.06298111295996E-30	3.33568825172988E-30	3.55837837170098E-30	3.65483531892592E-30

NPS 2 SCH 160 Pipe (30 psi – 300 psi) - Polynomial equation for blowdown mass flow [1000 lb/hr]

$$Mf=b0+b1\cdot L+b2\cdot L^{2}+b3\cdot L^{3}+b4\cdot L^{4}+b5\cdot L^{5}+b6\cdot L^{6}+b7\cdot L^{7}+b8\cdot L^{8}+b9\cdot L^{9}+b10\cdot L^{10}+b11\cdot L^{11}+b12\cdot L^{12}$$

Where: Mf denotes mass flow [1000 lb/hr] and L denotes equivalent straight length of pipe [ft]

	30 psi	60 psi	90 psi	120 psi	150 psi
b0	53.3440848681805	125.280112404467	183.843362014573	206.873606582265	228.501083062608
b1	- 2.22366687532843	- 19.1895092283311	- 42.7553487946656	- 46.4707768417142	- 48.8796132190657
b2	.126848555801767	2.44486852715367	7.08842283369013	7.73926814242435	8.07585752802314
b3	- 0.00649110932527494	- 0.19880821795988	- 0.678007040192581	- 0.744339833605143	- 0.775283365617383
b4	0.000255474020658506	0.0105523982075764	0.0400268891024499	0.0441444085746994	0.0459661514269973
b5	- 0.00000718825052858336	- 0.00376440502558992	- 0.00153895915018917	- 0.0017038704386175	- 0.00177462563210811
b6	0.000000138641602326737	0.00000920744926124153	0.0000398445354827052	0.0000442685679527164	0.0000461294719301349
b7	- 1.74794868114602E-9	- 0.000000155678222598313	- 0.000000705879049793328	- 0.000000786884159155513	- 0.000000820484109088834
b8	1.29833572204031E-11	1.80961617688291E-9	8.55302705084501E-9	9.56704141300473E-9	9.98314239568656E-9
b9	- 3.67251576240284E-14	- 1.4128368595146E-11	- 6.95068738992824E-11	- 7.80314753121685E-11	- 8.14984129984987E-11
b10	- 1.97350010063001E-16	7.03574274317602E-14	3.60974635188677E-13	4.06916090640099E-13	4.25451445351693E-13
b11	1.89927171973654E-18	- 2.00298333161387E-16	- 1.0778930871062E-15	- 1.22100448476187E-15	- 1.27830161267835E-15
b12	- 4.46852093491587E-21	2.45163066865079E-19	1.39958836447795E-18	1.59503356297552E-18	1.6726691807277E-18

	180 psi	210 psi	240 psi	270 psi	300 psi
b0	251.344404547289	274.68349546697	298.360754675958	322.665970458742	346.152386562713
b1	- 51.6983412508817	- 54.9822060158716	- 58.5667706364581	- 62.6901911981493	- 66.5324591199321
b2	8.44945487061781	8.9203837075281	9.4451452456216	10.0825479841213	10.658835999741
b3	- 0.807036894121608	- 0.849432877929877	- 0.896965001933144	- 0.956557757824401	- 1.00934381724839
b4	0.047698254685998	0.0501211556647628	0.0528405557342761	0.0563239191775699	0.0593637564170573
b5	- 0.00183726641457847	- 0.00192853746329987	- 0.00203087136692699	- 0.00216411406514093	- 0.00227902560262212
b6	0.000047667714263139	0.0000499966464881249	0.0000526022026372123	0.0000560417284841569	0.0000589779576253759
b7	- 0.000000846405081794632	- 0.000000887192181097917	- 0.000000932688895121416	- 0.000000993511464245888	- 0.000001044941877233323
b8	1.02815310249908E-8	1.07708189467351E-8	1.1314593543145E-8	1.20507031101718E-8	1.26672305884692E-8
b9	- 8.37903341803494E-11	- 8.77288687016489E-11	- 9.20862550955379E-11	- 9.80637218305685E-11	- 1.03019397143432E-10
b10	4.36589284312031E-13	4.56842969558718E-13	4.79125490052939E-13	5.10153625947016E-13	5.35583295305977E-13
b11	- 1.30888336253798E-15	- 1.36869952698273E-15	- 1.4340404541126E-15	- 1.52666747302681E-15	- 1.60154519258432E-15
b12	1.70807276961781E-18	1.78471681134603E-18	1.86765357057753E-18	1.98791501884097E-18	2.08345866501224E-18

NPS 2 SCH 160 Pipe (300 psi – 3000 psi) - Polynomial equation for blowdown mass flow [1000 lb/hr]

$$Mf=b0+b1\cdot L+b2\cdot L^{2}+b3\cdot L^{3}+b4\cdot L^{4}+b5\cdot L^{5}+b6\cdot L^{6}+b7\cdot L^{7}+b8\cdot L^{8}+b9\cdot L^{9}+b10\cdot L^{10}+b11\cdot L^{11}+b12\cdot L^{12}+b13\cdot L^{13}+b14\cdot L^{14}$$

Where: Mf denotes mass flow [1000 lb/hr] and L denotes equivalent straight length of pipe [ft]

	300 psi	600 psi	900 psi	1200 psi	1500 psi
b0	258.34138944006	428.307684904575	575.551769883156	706.72990377903	825.063488984108
b1	- 13.7451330668213	- 22.7998510857383	- 31.0020896224874	- 38.5062852729458	- 45.4106363472524
b2	.491819073309712	0.810671711651755	1.10169165744481	1.36906321371544	1.61575677739536
b3	- 0.00926791127404687	- 0.0152283037205189	- 0.0206824873572367	- 0.02570028062323	- 0.0303338503541475
b4	0.000095454554261978 1	0.00015656243801013	0.00021255186524429 4	0.00026409492703352	0.00031170857310521
b5	- 0.00000051091334529717	- 0.00000083698440021087	- 0.00000113597955248406	- 0.00000141134003412695	- 0.00000166576015893153
b6	7.80226017910263E-10	1.27667245248679E-9	1.73222571678758E-9	2.15194684663667E-9	2.53980392735154E-9
b7	6.39199666189383E-12	1.04570680536708E-11	1.41877735447336E-11	1.76247670861261E-11	2.08011776995678E-11
b8	- 3.97406400390228E-14	- 6.49378262086471E-14	- 8.80780847434992E-14	- 1.09404164542894E-13	- 1.29116133061141E-13
b9	7.36028546245229E-17	1.19900608867146E-16	1.62492140590566E-16	2.01777646203645E-16	2.38103674053896E-16
b10	9.97958702773371E-20	1.64866627993798E-19	2.24274987457951E-19	2.78869680439027E-19	3.29264905905055E-19
b11	- 7.42579213542225E-22	- 1.21769688495 96E-21	- 1.65320382889876E-21	- 2.05420555943624E-21	- 2.42469638768668E-21
b12	1.50102987671064E-24	2.45857181095312E-24	3.33684149736667E-24	4.14577980488359E-24	4.89327483217333E-24
b13	- 1.42580874916187E-27	- 2.33414712383239E-27	- 3.1675273183001E-27	- 3.93523075605229E-27	- 4.64466808834847E-27
b14	5.4251143181269E-31	8.8784864607544E-31	1.20474331455323E-30	1.49669025103532E-30	1.76648966157317E-30

	1800 psi	2100 psi	2400 psi	2700 psi	3000 psi
b0	932.243544797897	1028.33729074478	1111.28328810692	1177.56632652664	1210.33462071991
b1	- 51.7873568934979	- 57.5960421864266	- 62.6685748273774	- 66.7961229371871	- 68.7795329598897
b2	1.8443946298975	2.05305843386021	2.23539669848558	2.3839874125329	2.45306288667146
b3	- 0.0346336808530437	- 0.0385594521485312	- 0.0419901120512147	- 0.0447869536646041	- 0.0460642959508434
b4	0.00035592041786554	0.000396290395561958	0.000431569346872449	0.000460335938999654	0.000473334400481835
b5	- 0.00000190209282571489	- 0.00000211789519264408	- 0.00000230648662735763	- 0.00000246028025610593	- 0.00000252925866291629
b6	2.9002087280125E-9	3.22931767099259E-9	3.51694316654028E-9	3.75149513532149E-9	3.85592245216043E-9
b7	2.375286583406E-11	2.64479742046391E-11	2.88033730844533E-11	3.07245254007935E-11	3.15782774442122E-11
b8	- 1.47438351914544E-13	- 1.6416763678585E-13	- 1.7878962822812E-13	- 1.9071576060792E-13	- 1.95973771292879E-13
b9	2.71888247162722E-16	3.02732517149183E-16	3.29699696906502E-16	3.51694518851932E-16	3.61181813237708E-16
b10	3.76019558421401E-19	4.18725839706947E-19	4.5600983609255E-19	4.86423923550193E-19	5.00864151607875E-19
b11	- 2.7688756943753E-21	- 3.08317402223332E-21	- 3.3577734049 1084E-21	- 3.58175965787544E-21	- 3.68300102958304E-21
b12	5.58783489890379E-24	6.22206953542529E-24	6.77625852706313E-24	7.2282975567703E-24	7.43100865449813E-24
b13	- 5.30393266299586E-27	- 5.90592645030241E-27	- 6.43197128673775E-27	- 6.86105201431287E-27	- 7.05278207676289E-27
b14	2.01722418062549E-30	2.24617462601249E-30	2.44624663785974E-30	2.60943947747919E-30	2.68220349208509E-30

NPS 2 XX-STR Pipe (30 psi – 300 psi) - Polynomial equation for blowdown mass flow [1000 lb/hr]

$$Mf=b0+b1\cdot L+b2\cdot L^2+b3\cdot L^3+b4\cdot L^4+b5\cdot L^5+b6\cdot L^6+b7\cdot L^7+b8\cdot L^8+b9\cdot L^9+b10\cdot L^{10}$$

Where: Mf denotes mass flow [1000 lb/hr] and L denotes equivalent straight length of pipe [ft]

	30 psi	60 psi	90 psi	120 psi	150 psi
b0	42.2838541120974	96.9209075564565	134.873108814526	150.263732815953	167.584301522262
b1	- 1.92446535762944	- 14.6208030286033	- 27.2113504446733	- 28.4969384284775	- 30.4692334681662
b2	.110696454480259	1.70030487497426	3.79580349030506	3.93851086644513	4.18026655012686
b3	- 0.00520677290931896	- 0.119254536006251	- 0.297398030791537	- 0.307750097373328	- 0.325964417447508
b4	0.000176785604240007	0.00522318259761841	0.0139961671777901	0.0144672688585219	0.0153118386468681
b5	- 0.00000415612181328245	- 0.000147506743815976	- 0.000415299108437483	- 0.000429038444957946	- 0.000453941048507312
b6	6.64588087674548E-8	0.00000272441263866116	0.00000794912945070837	0.00000820950997904236	0.00000868483839959427
b7	- 7.07657804215729E-10	- 3.26619493741306E-8	- 9.7883678993637E-8	- 0.000000101070128149148	- 0.000000106916409706803
b8	4.80231299214523E-12	2.44638071578193E-10	7.48484244481269E-10	7.72750002479567E-10	8.17438334687628E-10
b9	- 1.88108200208866E-14	- 1.03929703801492E-12	- 3.23246049295676E-12	- 3.33695690973417E-12	- 3.52996001048574E-12
b10	3.24063480308399E-17	1.91083204294935E-15	6.02281867444584E-15	6.21711625414849E-15	6.57681790099206E-15

	180 psi	210 psi	240 psi	270 psi	300 psi
b0	185.187226219056	203.298915462084	221.715931245927	239.61983076917	257.675370851103
b1	- 32.5205598943555	- 34.9137534823448	- 37.5838629879581	- 40.0973450707667	- 42.8400111413496
b2	4.42100996607293	4.71743239590798	5.06152129371518	5.37572013747181	5.73164900704571
b3	- 0.343414898554748	- 0.36554850106273	- 0.391771926948829	- 0.415262003856269	- 0.442416149557579
b4	0.0160977540245067	0.0171137371366916	0.0183321134804699	0.0194097918426628	0.0206711332106096
b5	- 0.000476612075727204	- 0.000506311168638541	- 0.000542209373099888	- 0.000573682523106499	- 0.000610828359647847
b6	0.00000911035067681662	0.00000967323794223467	0.00001035740213591	0.0000109533421581762	0.0000116609260755668
b7	- 0.0000001120811229344	- 0.00000011896442037791 1	- 0.00000012736513645304 4	- 0.00000013464627405840 6	- 0.00000014333062164716 8
b8	8.56498235519477E-10	9.08862744744014E-10	9.72972726217178E-10	1.02832162144285E-9	1.09457037061616E-9
b9	- 3.69718509018923E-12	- 3.92243904204461E-12	- 4.19890739871439E-12	- 4.43684282514757E-12	- 4.72244015235275E-12
b10	6.88620886497673E-15	7.30459890624276E-15	7.81915678397766E-15	8.26085202349321E-15	8.79225157803454E-15

NPS 2 XX-STR Pipe (300 psi – 3000 psi) - Polynomial equation for blowdown mass flow [1000 lb/hr]

$$Mf=b0+b1\cdot L+b2\cdot L^{2}+b3\cdot L^{3}+b4\cdot L^{4}+b5\cdot L^{5}+b6\cdot L^{6}+b7\cdot L^{7}+b8\cdot L^{8}+b9\cdot L^{9}+b10\cdot L^{10}+b11\cdot L^{11}+b12\cdot L^{12}+b13\cdot L^{13}+b14\cdot L^{14}$$

Where: Mf denotes mass flow [1000 lb/hr] and L denotes equivalent straight length of pipe [ft]

	300 psi	600 psi	900 psi	1200 psi	1500 psi
b0	198.515994357109	329.349305760384	442.480118043423	543.145951011658	633.874207686424
b1	- 10.5853540278185	- 17.6110284244106	- 23.961988871766	- 29.7649803005853	- 35.0997618025746
b2	0.378442258305751	0.625988319776852	0.851499206438703	1.0584412635645	1.249249621037
b3	- 0.00712874107923249	- 0.0117565599515981	- 0.0159837652357453	- 0.0198683466550425	- 0.0234532691598678
b4	0.000073407796862 1997	0.000120854336626736	0.000164251393709483	0.000204157521524279	0.00024099985294172
b5	- 0.000000392860822113639	- 0.000006460347671253 71	- 0.000008777925993152 81	- 0.000010909940628523 9	- 0.000012878709753859 3
b6	5.99874112274473E-10	9.85331438659138E-10	1.33844687733386E-9	1.6634344815867E-9	1.96358573349175E-9
b7	4.91441890461045E-12	8.07064567972405E-12	1.0962547558151E-11	1.36237600844797E-11	1.60818569402682E-11
b8	- 3.05509320689632E-14	- 5.01143067786587E-14	- 6.80519978604876E-14	- 8.45649467049796E-14	- 9.98197797161807E-14
b9	5.65682396172876E-17	9.25119180911429E-17	1.25528448507608E-16	1.55949770738035E-16	1.84063706076463E-16
b10	7.67872781927111E-20	1.27321740215586E-19	1.73371878173967E-19	2.15633362405173E-19	2.54626769069272E-19
b11	- 5.71021698532453E-22	- 9.39941321979253E-22	- 1.27753614275513E-21	- 1.58800479865433E-21	- 1.87470986652629E-21
b12	1.15413563933325E-24	1.89762970710735E-24	2.57845111791731E-24	3.20477342276504E-24	3.78323688826315E-24
b13	- 1.09624937220683E-27	- 1.80153105544768E-27	- 2.44755933408227E-27	- 3.04196125120435E-27	- 3.59097903399008E-27
b14	4.17104664200329E-31	6.85240892383675E-31	9.30895919945873E-31	1.15693980196747E-30	1.36573302653165E-30

	1800 psi	2100 psi	2400 psi	2700 psi	3000 psi
b0	715.972519695282	789.532676523209	853.001925004005	903.659326077461	928.828152780533
b1	- 40.0215597949384	- 44.5037071926178	- 48.4177129088946	- 51.5982747714155	- 53.1502289113336
b2	1.42591502531085	1.58714325422112	1.72803959913906	1.84268841921783	1.8970114065024
b3	- 0.0267768166072545	- 0.0298115375567383	- 0.0324636849970694	- 0.0346224527728134	- 0.0356290544225559
b4	0.000275178780261803	0.000306392706821881	0.000333671318147689	0.000355878448095002	0.000366132952521302
b5	- 0.000001470591335 08164	- 0.000001637470474 24386	- 0.000001783310602 04713	- 0.000001902045198 48218	- 0.000001956500973 4779
b6	2.24226389652505E-9	2.49678188887388E-9	2.71923465723787E-9	2.90032536770951E-9	2.98283183385125E-9
b7	1.83641373629711E-11	2.04486258826298E-11	2.22701891080026E-11	2.37535447999333E-11	2.44279569329622E-11
b8	- 1.13988053932628E-13	- 1.26928064780969E-13	- 1.38237157525059E-13	- 1.47445783869132E-13	- 1.51602047892308E-13
b9	2.10194293846107E-16	2.34057064370042E-16	2.54919089087838E-16	2.71902658405702E-16	2.79414115182794E-16
b10	2.90755676412882E-19	3.23766715161837E-19	3.52578965789877E-19	3.76063088856299E-19	3.874197150748E-19
b11	- 2.14079937875554E-21	- 2.38385979318533E-21	- 2.59618138715783E-21	- 2.76913788767334E-21	- 2.84902843986667E-21
b12	4.32025279420429E-24	4.81077288398564E-24	5.23930895657087E-24	5.58836799940468E-24	5.74841807987674E-24
b13	- 4.10072401379564E-27	- 4.56632705875419E-27	- 4.97311343408968E-27	- 5.30444882968444E-27	- 5.45586652763824E-27
b14	1.5596059390485E-30	1.73668871038756E-30	1.8914055433472E-30	2.01742420686841E-30	2.07489764951537E-30

NPS 2-1/2 SCH 80 Pipe (30 psi – 300 psi) - Polynomial equation for blowdown mass flow [1000 lb/hr]

$$Mf=b0+b1\cdot L+b2\cdot L^{2}+b3\cdot L^{3}+b4\cdot L^{4}+b5\cdot L^{5}+b6\cdot L^{6}+b7\cdot L^{7}+b8\cdot L^{8}+b9\cdot L^{9}+b10\cdot L^{10}+b11\cdot L^{11}+b12\cdot L^{12}$$

Where: Mf denotes mass flow [1000 lb/hr] and L denotes equivalent straight length of pipe [ft]

	30 psi	60 psi	90 psi	120 psi	150 psi
b0	101.189985252337	243.835496052876	381.223354279362	445.93599313017	482.637206320204
b1	- 3.09818314294091	- 31.3959324668175	- 84.2855208825951	- 103.559769264416	- 104.385592568818
b2	0.13633244745574	3.71119536413418	13.5001365463194	17.4361106711423	17.262279112371
b3	- 0.00586210633737726	- 0.297606480301951	- 1.26175390918616	- 1.68702842980323	- 1.65622193382746
b4	0.000211576571908991	0.0160367644050814	0.0732348826869235	0.100473370358434	0.0981268176461454
b5	- 0.0000058840782963276	- 0.00058797575698264	- 0.00277754900310649	- 0.0038910761237645	- 0.0037858178034974
b6	0.000000120513451351359	0.0000148586423159343	0.0000710588449240347	0.000101393083238851	0.00009834386030368
b7	- 1.76717922458375E-9	- 0.000000260321602613431	- 0.000001244785305083 68	- 0.000001807319673894 48	- 0.000001748060457672 2
b8	1.80391392523005E-11	3.14434820762433E-9	1.49128666213118E-8	2.20355515370268E-8	2.12549347462901E-8
b9	- 1.22979133792754E-13	- 2.56100105105792E-11	- 1.19728203339442E-10	- 1.80268362417157E-10	- 1.73389175190996E-10
b10	5.20349133692681E-16	1.33862584450302E-13	6.1329590569961E-13	9.43226776635117E-13	9.04397280387665E-13
b11	- 1.17750896209234E-18	- 4.03896090468353E-16	- 1.80142479669891E-15	- 2.84149504664032E-15	- 2.71462957686592E-15
b12	9.60744810103084E-22	5.32271721735837E-19	2.29074751324179E-18	3.73008537176046E-18	3.54772570073258E-18

	180 psi	210 psi	240 psi	270 psi	300 psi
b0	526.678108739331	574.379028354883	623.494838975705	672.460305436477	720.802107129246
b1	- 108.802070621908	- 115.723124833129	- 123.475834921812	- 131.467555259003	- 139.496919317955
b2	17.7652503799217	18.8025152496503	19.9824124550**64**	21.2104341525399	22.4458905745365
b3	- 1.69406301081924	- 1.79018836777593	- 1.89973561467875	- 2.01442169864589	- 2.12966335670163
b4	0.099984035953971	0.105587395160567	0.111964495027023	0.118672622442275	0.125400435014979
b5	- 0.00384665910649924	- 0.0040608792748326	- 0.00430409452300027	- 0.00456106925405411	- 0.00481822238221719
b6	0.0000996952251962693	0.000105227739365407	0.000111490602603037	0.000118137229008204	0.000124771853438938
b7	- 0.0000017684403451707	- 0.0000018663780481659	- 0.0000019768670526037 7	- 0.0000020946778638601 2	- 0.0000022119485847688 8
b8	2.14599754122972E-8	2.26470554421133E-8	2.3980995866292E-8	2.54106874318856E-8	2.68293560682885E-8
b9	- 1.74701461752022E-10	- 1.84359560430055E-10	- 1.9516231955346E-10	- 2.06808689155032E-10	- 2.18323487014174E-10
b10	9.09181411266031E-13	9.59436654734583E-13	1.01533501117558E-12	1.07601701002924E-12	1.13575713837809E-12
b11	- 2.72182516827405E-15	- 2.87231078741198E-15	- 3.03853744384178E-15	- 3.2205220664327E-15	- 3.39874837426426E-15
b12	3.54568542365862E-18	3.74184699112661E-18	3.95659875299153E-18	4.19425579312437E-18	4.42546789121972E-18

NPS 2-1/2 SCH 80 Pipe (300 psi – 3000 psi) - Polynomial equation for blowdown mass flow [1000 lb/hr]

$$Mf=b0+b1\cdot L+b2\cdot L^{2}+b3\cdot L^{3}+b4\cdot L^{4}+b5\cdot L^{5}+b6\cdot L^{6}+b7\cdot L^{7}+b8\cdot L^{8}+b9\cdot L^{9}+b10\cdot L^{10}+b11\cdot L^{11}+b12\cdot L^{12}+b13\cdot L^{13}+b14\cdot L^{14}$$

Where: Mf denotes mass flow [1000 lb/hr] and L denotes equivalent straight length of pipe [ft]

	300 psi	600 psi	900 psi	1200 psi	1500 psi
b0	536.396043672562	886.421944359779	1191.51703573799	1464.21613275528	1710.7967915287
b1	- 28.4498484100323	- 46.6732351596438	- 63.3188130950805	- 78.6000890082232	- 92.6894908715025
b2	1.0209560337766	1.66134276515275	2.25086188824613	2.79416180012486	3.29634127438786
b3	- 0.0192636020993249	- 0.0312280251254114	- 0.042272404400105	- 0.0524632678685474	- 0.0618896975089492
b4	0.000198538697871571	0.00032117100592142	0.000434531635306827	0.000539190794875126	0.000636032183271403
b5	- 0.00000106312051555581	- 0.00000171738180136111	- 0.00000232271830596721	- 0.00000028817746093827	- 0.00000339918134918381
b6	1.62415376820827E-9	2.62011820344962E-9	3.54240413613584E-9	4.39442071568084E-9	5.1831380805597E-9
b7	1.33070349732694E-11	2.14621202312061E-11	2.90148458833807E-11	3.59923755632947E-11	4.24515658982275E-11
b8	- 8.2764264189917E-14	- 1.333048020059E-13	- 1.8015231985167 8E-13	- 2.23441733705298E-13	- 2.63524527300935E-13
b9	1.53432940079191E-16	2.46253587383109E-16	3.32486194910924E-16	4.12209814800509E-16	4.86073789332091E-16
b10	2.07131692295594E-19	3.37868637455395E-19	4.58104519357874E-19	5.69024766444206E-19	6.71502047549472E-19
b11	- 1.54484342443439E-21	- 2.49837332304922E-21	- 3.37995375297695E-21	- 4.1941677226491E-21	- 4.94751852287819E-21
b12	3.12383779369145E-24	5.04523280936445E-24	6.82312792759022E-24	8.46547178547895E-24	9.98539999722499E-24
b13	- 2.96778016092224E-27	- 4.79030653020512E-27	- 6.47734961642436E-27	- 8.03590303908034E-27	- 9.47843574733641E-27
b14	1.12933443291178E-30	1.82220197954052E-30	2.46370798599407E-30	3.05638656934812E-30	3.60497966986238E-30

	1800 psi	2100 psi	2400 psi	2700 psi	3000 psi
b0	1934.6887221508	2135.76396033478	2309.50183631897	2448.50532796097	2516.4735912056
b1	- 105.734783027132	- 117.626877479346	- 128.011105831658	- 136.453592849528	- 140.374214311998
b2	3.76276313462866	4.18851679427742	4.56044556519692	4.86307596735163	4.99813159214152
b3	- 0.0706538451353035	- 0.0786553296786532	- 0.0856454323691958	-0.0913337563504336	- 0.0938219016940406
b4	0.000726111066371834	0.000808353528288003	0.000880200841269288	0.000938668766192522	0.000963945950677999
b5	- 0.00000388057746305985	- 0.00000432010083704353	- 0.00000470406765360411	- 0.00000501652522477769	- 0.00000515053886902465
b6	5.91709296159207E-9	6.58727884317378E-9	7.17272250113307E-9	7.64905183507361E-9	7.85177579482295E-9
b7	4.84625340644707E-11	5.39502465749682E-11	5.87443514483143E-11	6.26460914421846E-11	6.43038678485414E-11
b8	- 3.00829292727377E-13	- 3.3489000104098E-13	- 3.64643714680559E-13	- 3.88856072090746E-13	- 3.99063115859138E-13
b9	5.54826458931202E-16	6.17616396115678E-16	6.72455947111742E-16	7.1706938941478E-16	7.35489071987833E-16
b10	7.66858304225678E-19	8.53835511981932E-19	9.29869532729975E-19	9.91811987265153E-19	1.01979827058799E-18
b11	- 5.64866064945525E-21	- 6.28860080594999E-21	- 6.84775934955901E-21	- 7.30296708266071E-21	- 7.49931203525406E-21
b12	1.14000578397523E-23	1.26913518740879E-23	1.38195576395155E-23	1.47379351757718E-23	1.51310788186962E-23
b13	- 1.08210932544582E-26	- 1.20467137595973E-26	- 1.31175033059421E-26	- 1.39891120822121E-26	- 1.43609493534906E-26
b14	4.11559965902198E-30	4.58172042547669E-30	4.98894777990408E-30	5.32041987336774E-30	5.46153197737169E-30

NPS 2-1/2 SCH 160 Pipe (30 psi – 300 psi) - Polynomial equation for blowdown mass flow [1000 lb/hr]

$$Mf=b0+b1\cdot L+b2\cdot L^2+b3\cdot L^3+b4\cdot L^4+b5\cdot L^5+b6\cdot L^6+b7\cdot L^7+b8\cdot L^8+b9\cdot L^9+b10\cdot L^{10}$$

Where: Mf denotes mass flow [1000 lb/hr] and L denotes equivalent straight length of pipe [ft]

	30 psi	60 psi	90 psi	120 psi	150 psi
b0	84.6534161961313	200.461969695427	300.695501159672	345.747700751219	377.999509688299
b1	- 2.81189484264403	- 25.1596630394682	- 59.0861851533504	- 68.3308006965338	- 70.1906025555182
b2	.129613277432942	2.63365868787787	8.08466536856268	9.57202479271636	9.68676139486514
b3	- 0.00547798014389642	- 0.174389494265211	- 0.62571058082023	- 0.752852226669928	- 0.756978211837639
b4	0.000181837457382794	0.00740023845730752	0.0292071824731965	0.0355306969296975	0.0355967115715129
b5	- 0.0000043928025089083 1	- 0.000205321560421836	- 0.000861640677439058	- 0.00105646160939906	- 0.0010559855551196
b6	7.41191549426101E-8	0.00000375432378145079	0.0000164217744871689	0.0000202530464257557	0.0000202115458114953
b7	- 8.42894362481644E-10	- 4.47528923685227E-8	- 0.00000020154724411821	- 0.000000249693728535321	- 0.000000248889622183344
b8	6.12682915229842E-12	3.34135735722485E-10	1.53714160029038E-9	1.91116928191922E-9	1.90330537290676E-9
b9	- 2.56304879002872E-14	- 1.41715154640262E-12	- 6.62436006908498E-12	- 8.26019761548884E-12	- 8.22038842421817E-12
b10	4.68562781051138E-17	2.60361977792441E-15	1.2321099318146E-14	1.54006457017606E-14	1.53176580849455E-14

	180 psi	210 psi	240 psi	270 psi	300 psi
b0	414.323755774554	452.67155828245	491.736623228602	530.682402550764	568.914798322544
b1	- 73.9640799940695	- 78.7001796860156	- 84.028083239988	- 89.488170704484	- 94.8671823733224
b2	10.1163923505348	10.689233767151	11.3631237760839	12.0547913267188	12.7318484832869
b3	- 0.787835951916147	- 0.830041086145699	- 0.880897753749311	- 0.933028492550301	- 0.983802005771262
b4	0.0369828049489947	0.0389036934924159	0.0412524264466648	0.0436562307979134	0.0459893407124292
b5	- 0.00109595506612513	- 0.00115178084411964	- 0.00122070707839566	- 0.00129114736086923	- 0.00135935210718874
b6	0.0000209620609276497	0.0000220157278297923	0.0000233256249082644	0.0000246626018654919	0.0000259549352616132
b7	- 0.000000258005498463653	- 0.000000270850421110043	- 0.000000286900492945658	- 0.000000303264501938 98	- 0.000000319062178762388
b8	1.97229965740376E-9	2.06978486769614E-9	2.19207273810498E-9	2.31663530827564E-9	2.43677206805288E-9
b9	- 8.51598759026972E-12	- 8.93455103646562E-12	- 9.46123396463655E-12	- 9.99727706108763E-12	- 1.05138896385476E-11
b10	1.58649345845018E-14	1.66412120653831E-14	1.76204583092733E-14	1.86164008135688E-14	1.95756749425269E-14

NPS 2-1/2 SCH 160 Pipe (300 psi – 3000 psi) - Polynomial equation for blowdown mass flow [1000 lb/hr]

$$Mf=b0+b1\cdot L+b2\cdot L^2+b3\cdot L^3+b4\cdot L^4+b5\cdot L^5+b6\cdot L^6+b7\cdot L^7+b8\cdot L^8+b9\cdot L^9+b10\cdot L^{10}+b11\cdot L^{11}+b12\cdot L^{12}+b13\cdot L^{13}+b14\cdot L^{14}$$

Where: Mf denotes mass flow [1000 lb/hr] and L denotes equivalent straight length of pipe [ft]

	300 psi	600 psi	900 psi	1200 psi	1500 psi
b0	437.607804205895	723.933775541306	973.056036300659	1195.52224314308	1396.55819805527
b1	- 23.2223356325711	- 38.2258982980698	- 51.8949840303502	- 64.4318234857158	- 75.9851734743814
b2	.832636619124409	1.36020046632228	1.84452372655837	2.29049375376862	2.70254484319976
b3	- 0.0157044997018472	- 0.0255628372357617	- 0.0346371799555718	- 0.0430034791700397	- 0.0507392904991912
b4	0.000161825177286874	0.000262880108574249	0.000356022369913795	0.000441947873723213	0.000521425346473501
b5	- 0.00000866419976844894	- 0.00000140559777692025	- 0.00000190297426749199	- 0.00000236197262256755	- 0.00000278661871693535
b6	1.32349280293344E-9	2.14433676008483E-9	2.90214063882747E-9	3.60165475977796E-9	4.24899116720329E-9
b7	1.08433925841087E-11	1.75644316042625E-11	2.37701331409719E-11	2.94992385610389E-11	3.48004363308128E-11
b8	- 6.74335530888795E-14	- 1.0909035060363E-13	- 1.4758254356872E-13	- 1.83126389574736E-13	- 2.16023536856845E-13
b9	1.24973887354687E-16	2.01497750933412E-16	2.72349419770915E-16	3.37808105063515E-16	3.98430238083411E-16
b10	1.68949585464636E-19	2.76610628461751E-19	3.75409248781436E-19	4.66488112062016E-19	5.50598144343791E-19
b11	- 1.25913118582255E-21	- 2.04481391889626E-21	- 2.76918210577912E-21	- 3.43773425741111E-21	- 4.05604701836522E-21
b12	2.5458036888086E-24	4.12912149220379E-24	5.58995507633316E-24	6.93848596776826E-24	8.18596508564957E-24
b13	- 2.41849790753519E-27	- 3.92040106490837E-27	- 5.30658106467533E-27	- 6.58631389393757E-27	- 7.77027059842001E-27
b14	9.20286524176367E-31	1.49127590028937E-30	2.01837656293928E-30	2.50502768344956E-30	2.95528479402919E-30

	1800 psi	2100 psi	2400 psi	2700 psi	3000 psi
b0	1578.9700303402	1742.71704620552	1884.16689055634	1997.33797258377	2052.78157318878
b1	- 86.674966395389	- 96.4178000854113	- 104.926087920367	- 111.85010179547	- 115.087269791853
b2	3.08503299421852	3.43414322018458	3.73917636103421	3.98770025649218	4.09946532249481
b3	- 0.057927912321932	- 0.0644906448436758	- 0.0702251762280733	- 0.0748986218670223	- 0.07695891156152
b4	0.000595318507228883	0.00066277982529811	0.00072172947927342	0.000769777112343129	0.000790711505871214
b5	- 0.00000318154130001796	- 0.00000354208919610399	- 0.00000385714893566764	- 0.00000411396270681495	- 0.00000422495418368894
b6	4.8511490341012E-9	5.40093888711372E-9	5.88130072467603E-9	6.27292640486616E-9	6.44078418328782E-9
b7	3.97319116483017E-11	4.42336819469204E-11	4.81681359205645E-11	5.13750727127048E-11	5.27481619489118E-11
b8	- 2.46630743682051E-13	- 2.74572857744522E-13	- 2.98991232887686E-13	- 3.18896864178563E-13	- 3.27347967009191E-13
b9	4.54847717461281E-16	5.06362286559597E-16	5.51369389791613E-16	5.88067934969798E-16	6.03299954861728E-16
b10	6.28794197712078E-19	7.00124957100385E-19	7.62523177054689E-19	8.13344764208456E-19	8.36621811605878E-19
b11	- 4.63121360410227E-21	- 5.1561361160238E-21	- 5.61503721936762E-21	- 5.98902020569891E-21	- 6.1518736904102E-21
b12	9.34651315073835E-24	1.04057475031021E-23	1.13316793550594E-23	1.20863401316349E-23	1.2412288303127E-23
b13	- 8.87177951562478E-27	- 9.87715117681821E-27	- 1.07559702253831E-26	- 1.14722627131723E-26	- 1.17804945368614E-26
b14	3.37420122821842E-30	3.7565595177161E-30	4.09078220980447E-30	4.36320168210048E-30	4.48016489651603E-30

NPS 2-1/2 XX-STR Pipe (30 psi – 300 psi) - Polynomial equation for blowdown mass flow [1000 lb/hr]

$$Mf=b0+b1\cdot L+b2\cdot L^2+b3\cdot L^3+b4\cdot L^4+b5\cdot L^5+b6\cdot L^6+b7\cdot L^7+b8\cdot L^8+b9\cdot L^9+b10\cdot L^{10}$$

Where: Mf denotes mass flow [1000 lb/hr] and L denotes equivalent straight length of pipe [ft]

	30 psi	60 psi	90 psi	120 psi	150 psi
b0	58.7817373359546	136.992840424837	197.605501474375	223.427484511342	246.766517940927
b1	- 2.32738533848745	- 19.0096963771596	- 39.511924922339	- 43.3554437923861	- 45.4539387409443
b2	.124833985773088	2.10468629546981	5.47079150120504	6.03910280535445	6.26250357693378
b3	- 0.00592638200788742	- 0.14345493654032	- 0.426569347056382	- 0.473691983977165	- 0.489208257942389
b4	0.000214337666598849	0.00617604775333876	0.020010342048317	0.0223190675713219	0.0230028055415171
b5	- 0.00000552148831445665	- 0.000172547601331393	- 0.000592392495886201	- 0.000662895844641906	- 0.000682376693242108
b6	9.78523811208779E-8	0.0000031646007016649	0.0000113195319733722	0.0000126980177177896	0.0000130608824769079
b7	- 1.15546379075698E-9	- 3.77596229845297E-8	- 0.000000139203467493902	- 0.000000156456072362604	- 0.000000160838598087102
b8	8.63886398739152E-12	2.81887606940389E-10	1.0633385251609E-9	1.19696256674651E-9	1.22999480171318E-9
b9	- 3.68663821984211E-14	- 1.19472732033176E-12	- 4.58834771696158E-12	- 5.17141024048937E-12	- 5.31249021195975E-12
b10	6.82461560230092E-17	2.19283664140033E-15	8.54319345986646E-15	9.63882923091807E-15	9.89939041394428E-15

	180 psi	210 psi	240 psi	270 psi	300 psi
b0	271.702098127548	297.263422948271	323.00654221341	349.202161726281	374.993329776842
b1	- 48.2548629605988	- 51.4369581459293	- 54.8510048385565	- 58.6323439324986	- 62.4282914988522
b2	6.58991550592151	6.97477218679279	7.39562768564211	7.87848295420583	8.36605354947125
b3	- 0.512966585021036	- 0.541360975250177	- 0.572611062496988	- 0.60915802609741	- 0.646164289599486
b4	0.0240747701400752	0.0253692245170648	0.0267968272950469	0.0284866512238702	0.0302005263589933
b5	- 0.000713352633146846	- 0.000751029527268271	- 0.000792600490164065	- 0.00084221410032425	- 0.000892590954563941
b6	0.0000136431177909355	0.0000143551530482609	0.0000151406289276792	0.0000160836663320578	0.0000170420276385345
b7	- 0.000000167914052564794	- 0.000000176603558708806	- 0.000000186185089017622	- 0.000000197740350857003	- 0.000000209491261700985
b8	1.28355822139007E-9	1.34956530289959E-9	1.42231016785251E-9	1.51034710916409E-9	1.5999233054604E-9
b9	- 5.54199609270423E-12	- 5.82561762129939E-12	- 6.13802251279571E-12	- 6.51715701045542E-12	- 6.90309351801667E-12
b10	1.03243005235169E-14	1.08506467948353E-14	1.14301093605828E-14	1.21349495546363E-14	1.2852705531924E-14

NPS 2-1/2 XX-SRT Pipe (300 psi – 3000 psi) - Polynomial equation for blowdown mass flow [1000 lb/hr]

$$Mf=b0+b1\cdot L+b2\cdot L^{2}+b3\cdot L^{3}+b4\cdot L^{4}+b5\cdot L^{5}+b6\cdot L^{6}+b7\cdot L^{7}+b8\cdot L^{8}+b9\cdot L^{9}+b10\cdot L^{10}+b11\cdot L^{11}+b12\cdot L^{12}+b13\cdot L^{13}+b14\cdot L^{14}$$

Where: Mf denotes mass flow [1000 lb/hr] and L denotes equivalent straight length of pipe [ft]

	300 psi	600 psi	900 psi	1200 psi	1500 psi
b0	288.689148812294	478.352490783215	642.855226747513	789.4771131773	921.790982043266
b1	- 15.3527143912492	- 25.4175145948357	- 34.5521431432991	- 42.913070715861	- 50.6082102671731
b2	0.549618276247842	0.903868102284303	1.22787750615839	1.5256687777589	1.80050416505787
b3	- 0.0103594884272353	- 0.0169804881119587	- 0.0230526017247634	- 0.0286407999947653	- 0.033802377412398
b4	0.000106710725531612	0.000174585538236147	0.000236917152352921	0.000294317479209258	0.00034735451756146
b5	- 0.000000571208379952655	- 0.000009333367038326622	- 0.000012662289576792 4	- 0.000015728742824 9778	- 0.000018562682490 4578
b6	8.72369943571086E-10	1.42373043336427E-9	1.93089094729306E-9	2.39827407921352E-9	2.83030248338059E-9
b7	7.14704976130295E-12	1.1661689139167E-11	1.58148857005716E-11	1.96424441491558E-11	2.31804544568154E-11
b8	- 4.44384048734232E-14	- 7.24205163844539E-14	- 9.81817158994421E-14	- 1.21930383770338E-13	- 1.43886308795592E-13
b9	8.23200792835115E-17	1.33726054279624E-16	1.8114361353051E-16	2.24888780278193E-16	2.65349507574719E-16
b10	1.1151262429471E-19	1.83819398759125E-19	2.49945272399248E-19	3.1075742188912E-19	3.66891969960423E-19
b11	- 8.30169704977808E-22	- 1.35790757510301E-21	- 1.84271004938778E-21	- 2.28930455934511E-21	- 2.70197614536844E-21
b12	1.67821126788247E-24	2.74173530111099E-24	3.71943160156516E-24	4.6203218799279E-24	5.45291538528523E-24
b13	- 1.59416625678744E-27	- 2.60301222794701E-27	- 3.53074247969103E-27	- 4.38570208684932E-27	- 5.1759030715096E-27
b14	6.06583175846417E-31	9.90125426855329E-31	1.34289797957782E-30	1.66802539632669E-30	1.96853874086247E-30

	1800 psi	2100 psi	2400 psi	2700 psi	3000 psi
b0	1041.68042669106	1149.19783560753	1242.02025089645	1316.230547472	1352.83311904717
b1	- 57.7183026572536	- 64.1958336778582	- 69.8525741894764	- 74.4577368407521	- 76.6556191361484
b2	2.05532180968026	2.28788395100036	2.49110587860756	2.65680141404697	2.73318392336432
b3	- 0.0385938846444854	- 0.0429684566537907	- 0.0467913779008276	- 0.0499097041465994	- 0.0513209805945668
b4	0.00039661871990992	0.000441599725564684	0.000480909593310936	0.000512980884453005	0.000527335996621581
b5	- 0.000002119598739 87506	- 0.000002360035488 48743	- 0.000002570166325 33442	- 0.000002741624139 12631	- 0.000002817780001 77706
b6	3.23187757894915E-9	3.59852084721923E-9	3.91897945921524E-9	4.18048907168411E-9	4.29574032330842E-9
b7	2.64690978229223E-11	2.94718470616188E-11	3.20961940529858E-11	3.42377682424946E-11	3.51801825390989E-11
b8	- 1.64299890532034E-13	- 1.82937827799857E-13	- 1.99228529393992E-13	- 2.12523584854124E-13	- 2.18325937623286E-13
b9	3.02988826926394E-16	3.37349762006358E-16	3.67389780015688E-16	3.91911484826326E-16	4.0237365491387E-16
b10	4.18989733790716E-19	4.66577035086489E-19	5.08141411098227E-19	5.42033481904131E-19	5.58003958376047E-19
b11	- 3.08545307755349E-21	- 3.43562407396048E-21	- 3.74162865640187E-21	- 3.99128725953663E-21	- 4.1030944140442E-21
b12	6.22676569650041E-24	6.93337123918952E-24	7.55090636037524E-24	8.05477132647195E-24	8.2785842873807E-24
b13	- 5.91042209136583E-27	- 6.58109929628247E-27	- 7.16725966764752E-27	- 7.64553914458873E-27	- 7.85720526385024E-27
b14	2.24789269713163E-30	2.50296271796876E-30	2.72589576782598E-30	2.90780128654051E-30	2.98812614028335E-30

Appendix B

Sample Designs

The decimal places shown in these calculations are intended to demonstrate the design process, and do not indicate accuracy or precision.

Item	Description
Steam drum dimensions	42 inch ID X 20 ft 8 inches with 2:1 semi-ellipsoidal heads
Drop in water level during blowoff	4.0 inches
Pressure	250 psig ≈ 265 psia
Blowoff line	1 NPS Sch 80, equivalent length 20 ft

Design Conditions

Table 1

The equation numbers shown below reference the equations in the general discussion in this guide.

Volume of Discharge Water

Volume of water discharged from steam drum during blowoff:

h_b = 1.75 ft

h_a = 1.42 ft

L = 20.67 ft

R = 1.75 ft

2) $$V_{fb} = \left[R^2 \cos^{-1}\left(\frac{R-h_b}{R}\right) - (R-h_b)\sqrt{2Rh_b - h_b^2} \right] L + \pi \frac{R}{2} h_b^2 \left(1 - \frac{h_b}{3R}\right)$$

$$V_{fb} = \left[(1.75)^2 \cos^{-1}\left(\frac{1.75-1.75}{1.75}\right) - (1.75-1.75)\sqrt{2(1.75)(1.75)-(1.75)^2} \right] 20.67 +$$

$$3.142\left(\frac{1.75}{2}\right)(1.75)^2\left(1-\frac{1.75}{3(1.75)}\right)$$

$$V_{fb} = 105 ft^3$$

3) $$V_{fa} = \left[R^2 \cos^{-1}\frac{R-h_a}{R} - (R-h_a)\sqrt{2Rh_a - h_a^2} \right] L + \pi \frac{R}{2} h_a^2 \left(1 - \frac{h_a}{3R}\right)$$

$$V_{fa} = \left[(1.75)^2 \cos^{-1}\left(\frac{1.75-1.42}{1.75}\right) - (1.75-1.42)\sqrt{2(1.75)(1.42)-(1.42)^2} \right] 20.67 +$$

$$3.142\left(\frac{1.75}{2}\right)(1.42)^2\left(1-\frac{1.42}{3(1.75)}\right)$$

$V_{fa} = 79.7 ft^3$

1) $V_D = V_{fb} - V_{fa}$

$V_D = 105 - 79.7$

$V_D = 25.3 ft^3$

Blowoff Time

The boiler blowoff time is calculated from equation 4 after determining the mass of waster discharged from the boiler (equation 5) and the mass flow rate of the fluid in the blowoff pipe. Determine the mass flow rate of water and steam (m) discharged from the boiler by finding the value on the appropriate chart, or by calculation using the appropriate equation from Appendix A. **Note that all terms and all digits shown in an equation must be used to determine the mass flow rate**. From the chart for a NPS 1 schedule 80 pipe with an equivalent pipe length of 20 ft. at a boiler pressure of 265 psia, the mass flow rate (m) of the water/steam mixture is:

m = 28,000 lbm/hr or
m = 28,000/60 = 466.7 lbm/min or
m = 466.7/60 = 7.8 lbm/sec

The density of water in the boiler drum is calculated from the specific volume (v_D) of water in the drum, where the specific volume (v_D) of water is listed in ASME Steam Tables.

$$\rho_D = 1 / v_D$$

$$\rho_D = \frac{1}{0.018728}$$

$$\rho_D = 53.4 lbm / ft^3$$

5) $$M = V_D \rho_D$$

$$M = (25.3)(53.396)$$

$$M = 1350.9 lbm$$

4) $$BT = \frac{M}{m}$$

$$BT = \frac{1350.9}{7.8}$$

$$BT = 173.2 \sec$$

Sizing Vent Pipe

Equation 6 is used to find the percentage of water that flashes to steam. Equation 7 is the rate at which the steam must be vented from the blowoff vessel. The properties of water and steam are listed in ASME Steam Tables.

h_{1B} = enthalpy of water in the boiler = 381.76 Btu/lbm
h_{1T} = enthalpy of water in blowoff vessel = 187.63 Btu/lbm @ 17 psia
h_{fg} = latent heat of vaporization = 965.42 Btu/lbm
m = 7.8 lbm/sec.

6) $$F = \frac{h_{1B} - h_{1T}}{h_{fg}}$$

$$F = \frac{381.76 - 187.63}{965.42}$$

$$F = 0.2$$

8) $m_s = mF$

$m_s = 7.8(0.2)$

$m_s = 1.6$ lbm/sec

The required vent diameter, equations 7 and 9:

7) $$A_v = \frac{m_s}{\rho_{sv} V_{sv}}$$

$$A_v = \frac{1.6}{(.0404)(50)}$$

$$A_v = 0.8 ft^3$$

9) $$D_v = \sqrt{\frac{4A_v}{\pi}}$$

$$D_v = \sqrt{\frac{4(0.8)}{3.142}}$$

$$D_v = 1.0 \text{ ft or } 12 \text{ inches}$$

Determine the pressure drop in the vent, equations: 10, 11, and 12.

12) $$Re = \frac{\rho_{sv} V_{sv} D_v}{\mu}$$

$$Re = \frac{(0.0404)(50)(1)}{0.0000084}$$

$$Re = 243059$$

11) $$f = \frac{0.25}{\left(\text{Log}\left[\frac{\varepsilon}{3.7 D_v} + \frac{5.74}{Re^{0.9}}\right]\right)^2}$$

$$f = \frac{0.25}{\left(\text{Log}\left[\frac{0.0025}{3.7} + \frac{5.74}{(243059)^{0.9}}\right]\right)}$$

$$f = 0.026$$

v_{sv} = 24.755 ft^3/lb, from steam tables at P = 16 psia

Note that "log" indicates logarithm to base 10.

ε/D_v = 0.0025, relative roughness of vent pipe ID.
V_{sv} = 50 ft/sec
ρ_{sv} = 0.0404 lbm/ft^3
μ = 8.4(10^{-6}) lbm/ft-hr

10) $$\Delta P_v = f \frac{L_v}{12 D_v} \upsilon_{sv} \left(\frac{3600G}{10^5} \right)^2$$

$$\Delta P_v = .026 \frac{20}{12(1)} 24.755 \left(\frac{3600\left(\frac{1.6}{0.8}\right)}{(10)^5} \right)^2$$

$$\Delta P_v = 0.006 psi$$

Pressure drop is acceptable**.**

Vertical Blowoff Vessel

The required area for the steam space is defined by equation 13, and the diameter is found from equation 14.

From steam tables:

v_s = 23.39 ft^3/lb at the blowoff vessel pressure of 17 psia.

$\rho_s = 1/v_s$ = 1/23.390 = 0.0428 lbm/ft^3

13) $$A_R = \frac{m_s}{\rho_S V_S}$$

$$A_R = \frac{1.6}{(.0428)(11)}$$

$$A_R = 3.4 ft^2$$

14) $$D_{t\,min} = \sqrt{\frac{4A_R}{\pi}}$$

$$D_{t\,min} = \sqrt{\frac{4(3.4)}{3.142}}$$

$$D_{t\,min} = 2.1 ft$$

The vessel diameter may be adjusted to control the vessel height. Based on the diameter (D_{tmin} = 2.1 ft), the high and normal water levels will be determined from equations 15 and 16.

Set $D_t = D_{tmin}$.

15) $$H_N = \frac{4V_D(1-F)}{\pi D_t^2} + \frac{D_t}{6}$$

$$H_N = \frac{4(25.3)(1-0.2)}{3.142(2.1)^2} + \frac{2.1}{6}$$

$$H_N = 6.2ft$$

16) $$H_h = \frac{8V_D(1-F)}{\pi D_t^2} + \frac{D_t}{6}$$

$$H_h = \frac{8(25.3)(1-0.2)}{3.142(2.1)^2} + \frac{2.1}{6}$$

$$H_h = 12ft$$

The length of the cylindrical part of the vessel:

17) $$H_t = H_h + 1.75D_t$$

$$H_t = 12 + 1.75(2.1)$$

$$H_t = 15.7ft$$

The diameter of the vessel may be modified to change the height of the vessel as required.

Location of the blowoff vessel inlet:

18) $$D_2 = H_h + D_t$$

$$D_2 = 12 + 2.1$$

$$D_2 = 14.1ft$$

COOLING TIME

Equations 19, 20, 21, 22, 25 and 26 are used to determine the time for the water to cool from 212 °F to the discharge temperature (140 °F).

h_t = 180.18 Btu/lbm, enthalpy of water at 212°F; from steam tables

h_s = 107.98 Btu/lbm, enthalpy of water at discharge temperature, 140°F; from steam tables

h_c = 3 Btu/hr-ft^{2}ºF (typical heat transfer coefficient) for air at 70 ºF.

19) $Q1 = M(1 - F)(h_t - h_s)$ $Q1 = 1350.9(1 - 0.2)(180.18 - 107.98)$

$Q1 = 78028Btu$

22) $A_{sc} = \pi D_t \left(H_N - \frac{D_t}{4}\right)$

$A_{sc} = 3.142(2.1)\left(6.2 - \frac{2.1}{4}\right)$

$A_{sc} = 37.5ft^2$

25) $A_h = 0.345\pi D_t^{\,2}$

$A_h = 0.345(3.142)(2.1)^2$

$A_h = 4.8ft^2$

26) $A_t = A_{sc} + A_h$

$A_t = 37.5 + 4.8$

$A_t = 42.2ft^2$

$\Delta T = \left(\frac{T_b + T_d}{2}\right) - Ta$

$\Delta T = \left(\frac{212 + 140}{2}\right) - 72$

$\Delta T = 104^\circ F$

20) $q_r = h_c A_t \Delta T$

$q_r = 3(42.2)104$

$q_r = 13168 Btu / hr$

21) $t = \frac{Q_1}{q_r}$

$t = \frac{78028}{13168}$

$t = 5.9 hr$

Horizontal Vessel

The design conditions for the horizontal vessel are the same as the design conditions for the vertical vessel.

V_s = 11 ft/sec, velocity of steam in the steam space.
m_s = 1.6 lbm/sec, mass flow rate of steam in the steam space.
ν_s = 23.39 ft^3/lb at the blowoff vessel pressure of 17 psia, from steam tables.

$\rho_s = 1/\nu_s = 1/23.390 = 0.0428$ lbm/ft^3

A_R = 3.4 ft^2, area of steam space.

Equation 28 is used to find the diameter of the vessel.

θ = Assume an initial value of θ: 180°

28) $D_t = 2\sqrt{\frac{A_R}{\pi - .05(0.0175\theta - \sin\theta)}}$

$D_t = 2\sqrt{\frac{3.4}{3.142 - 0.5[0.0175(180) - \sin 180]}}$

$D_t = 3.0 ft$

If the diameter is not satisfactory, choose another value for θ until a satisfactory result is obtained.

30) $$H_h = \frac{D_t}{2}\left(1\text{-}\cos\frac{\theta}{2}\right)$$

$$H_h = \frac{3}{2}\left(1-\cos\frac{180}{2}\right)$$

$$H_h = 1.5\text{ft}$$

29) $$L_t = \frac{2V_d\,(1-F) - \pi\,\frac{D_t}{4}\,H_h^{\,2}\left(1-\frac{2H_h}{3D_t}\right)}{\frac{D_t^{\,2}}{4}\cos^{-1}\left(1-\frac{2H_h}{D_t}\right) - \left(\frac{D_t}{2}-H_h\right)\sqrt{D_tH_h - H_h^{\,2}}}$$

$$L_t = \frac{2\,(25.3)\,(1-0.2) - 3.142\,\frac{(3)}{4}\,(1.5)^2\left(1-\frac{2\,(1.5)}{3\,(3)}\right)}{\frac{(3)^2}{4}\cos^{-1}\left(1-\frac{2\,(1.5)}{3}\right) - \left(\frac{3}{2}-1.5\right)\sqrt{3\,(1.5)-(1.5)^2}}$$

$$L_t = 10.7\text{ft}$$

Note: $\cos^{-1}$ is in radians.

Locate the normal water level, H_N

The following equation defines the normal water level in the vessel. Note that the equation must be solved by iteration because of its complexity.

31) $$V_d\,(1\text{-}F) = \left\{\frac{D_t^{\,2}}{4}\text{-}\cos^{-1}\left(1\text{-}\frac{2H_N}{D_t}\right)\text{-}\left(\frac{D_t}{2}\text{-}H_N\right)\sqrt{D_tH_N\text{-}H_N^{\,2}}\right\}Lt + \pi\,\frac{D_t}{4}\,H_N^{\,2}\left(1\text{-}\frac{2H_N}{3D_t}\right)$$

$$V_d\,(1\text{-}F) = 25.3\,(1-0.2) = \left\{\frac{(3)^2}{4} - \cos\left(1-\frac{2H_N}{3}\right) - \left(\frac{3}{2}-H_N\right)\sqrt{3H_N\text{-}H_N^{\,2}}\right\}10.7 +$$

$$3.142\,\frac{(3)}{4}\,H_N^{\,2}\left(1-\frac{2H_N}{3(3)}\right)$$

After considerable iteration:

$H_N = 0.9ft.$

Blowoff Time

The time to cool water from one blowoff cycle is determined from Equation 21. The area of the vessel containing the water is located below the normal water level. The water cools from 212°F to the discharge temperature (140°F).

33) $$\varphi=2\cos^{-1}\frac{2\left(\frac{D_t}{2}-H_N\right)}{D_t}$$

$$\varphi = 2\cos^{-1}\frac{2\left(\frac{3.0}{2}-0.9\right)}{D_t}$$

$$\varphi=133^\circ F$$

32) $$A_{sc} = 0.0175\frac{D_t}{2}\varphi L_t$$

$$A_{sc} = 0.0175\left(\frac{3}{2}\right)(145)10.7$$

$$A_{sc} = 37.4ft^2$$

34) $$A_h = 0.694\pi D_t H_N$$

$$A_h = 0.694\,(3.142)\,(3)\,0.9$$

$$A_h = 5.8ft^2$$

26) $$A_t = A_{sc} + A_h$$

$$A_t = 37.4 + 5.8$$

$$A_t = 43.2ft^2$$

20) $q_r = h_c A_t \Delta T$

$q_r = 3(43.8)(176 - 72)$

$q_r = 13666 Btu / hr$

23) $t = \frac{Q_1}{q_r}$

$t = \frac{78028}{13666}$

$t = 5.7 hrs$