210.64

CLIENT	PROJECT	
PREPARED BY / JOB ENGR	APPROVED BY / SUPV ENGR	DATE ISSUED

PIPE LINE SIZING GUIDE
EQUIPMENT AND/OR SYSTEM

Velocity, Pressure Drop, Pipe Wall Stress and Wall Thickness

Codes - ANSI B-31.1 Power Piping Code
- ASME - Boiler & Pressure Vessel Code Section I
- ANSI B-31.7 Nuclear Power Piping

References - Crane Technical Paper 410
- Properties of Fluids, ASME Steam Tables, 1967

1 - Velocity - Use for preliminary or approximate size only.
Available pressure drop to be used for final sizing.

$$V = \frac{W\,v}{60\,A} = \frac{W\,v\,3.056}{d^2}$$

V = Velocity, ft/min

W = Flow, lb per hour

v = Specific volume, cu ft/lb, at estimated average operating conditions

A = Cross-sectional area based on average inside diameter, sq ft

d = Average inside diameter of pipe, in.

Item	Range of Velocities		See Sheet 2 for Numbered Notes Below
	Fossil Fuel	Nuclear	
Main Steam	10,000 to 20,000 ft/min	5,000 to 10,000 ft/min	2 & 3
Hot Reheat	6,000 to 20,000 ft/min	*	2 & 3
Cold Reheat	5,000 to 15,000 ft/min	*	2 & 3
Boiler Feed Discharge	10 to 25 ft/sec	*	3
Boiler Feed Suction - Deaeration Installation	4 to 7 ft/sec	*	1
**Condensate Pump Discharge	8 to 15 ft/sec	*	
Condensate Pump Suction	2 to 4 ft/sec	*	1 & 4
Heater Drain - Upstream of Control Valve	4 to 7 ft/sec - (No Flashing)	*	
Heater Drain - Downstream of Control Valve	4,000 to 20,000 ft/min (Flashing)	*	4
Heater Drain Pump Discharge	8 to 15 ft/sec	*	
Heater Drain Pump Suction	2 to 4 ft/sec	*	1

* Same Range of Velocities as for Fossil Fuel

** Also for Boiler Feed Suction in a Deaerating Condenser Installation

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PIPE LINE SIZING GUIDE (Cont'd)
EQUIPMENT AND/OR SYSTEM

1 - Velocity (Cont'd)

Item	Range of Velocity: Fossil Fuel	Range of Velocity: Nuclear	See Numbered Notes Below	
Extraction Steam - Superheated	7,000 to 15,000 ft/min	*	5 & 8	
Extraction Steam - Saturated	4,000 to 10,000 ft/min	*	5 & 8	
Extraction Steam - Wet	4,000 to 7,000 ft/min	*	5	
Misc Steam Service - Superheated	7,000 to 20,000 ft/min	*		
Misc Steam Service - Saturated	4,000 to 10,000 ft/min	*		
Misc Steam Service - Wet	4,000 to 7,000 ft/min	*		
Misc Water Service - Normal	4 to 10 ft/sec (depending on material selected; use 4 to 5 ft/sec for brass, and 7 to 10 ft/sec for steel)	*		
Heavy Oil	(not applicable due to viscosity variation)		6 & 9	R2
Light Oil	4 to 10 ft/sec	*	7	
Fuel Gas - Nominal 100 Psig	7,000 to 16,000 ft/min	*		R2
Fuel Gas 250 Psig	3,000 to 8,000 ft/min	*		

Notes:
1 - Use this velocity range unless the velocity or resultant pressure drop is limited by the NPSH requirements of the pump.

2 - For main systems, the pipe line sizes shall be based on an economic balance of pipe costs versus pumping costs. For computer program use Pipeline Sizing Program No. 059.

3 - For minor systems and miscellaneous small lines, the pipe line sizes shall be the smallest pipe that can be used with a pressure drop less than 2 psi per 100 equivalent ft.

4 - Drains to condenser and/or drains going to lower pressure heater will be a flashing mixture with velocities not to exceed 20,000 ft/minute.

5 - The maximum pressure drop in each system should be approximately 3 percent of extraction steam inlet pressure corresponding to the Maximum Calculated (or Expected) capability (or Valves Wide Open Capability).

6 - The pressure at the pump suction must be at least 1 psi above atmospheric pressure.

7 - The pressure at the pump suction must be above atmospheric pressure.

8 - The velocities in large diameter low pressure stage extraction steam lines may be as high as 20,000 ft/min.

9 - Refer to Hydraulic Institute Standards curves for pressure drop charts at various viscosities.

* Same Range of Velocities as for Fossil Fuel

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PIPE LINE SIZING GUIDE (Cont'd)
EQUIPMENT AND/OR SYSTEM

2 - Pressure Drop - The first calculation for pressure drop should be based on a reasonable velocity in the pipe line. If the calculated pressure drop in the system is more than 10% of the outlet pressure, then recalculate the pressure drop in the system in sections. Each section should be approximately 100 equivalent feet.

The pressure drop in the system can be changed by selecting a different velocity, line size and using more than one pipe for the total flow or any combination thereof.

Use the Darcy equation $H = f \frac{L}{D} \frac{V^2}{2g}$ in the following form to give psi of pressure drop for the pipe run:

$$H = \frac{3.36 \times 10^{-6} f W^2 v L}{d^5}$$

H = Pressure drop, psi

f = Friction factor - See Crane (Technical Paper 410 Copyright 1957) pp A-23, A-24 and A-25

L = Pipe Run in equivalent lineal feet - See Crane pp - A-27, A-30 and A-31 for determining equivalent length of bends, valves and fittings

v = Specific volume, cu ft/lb, at estimated average operating conditions

W = Operating flow rate at operating conditions, lb/hr

d = Average inside diameter of pipe, inches

Average value for f for commercial steel pipe for turbulent flow may be obtained by using the following formula developed from the curve shown on Crane page A-23:

$$f = 20.92 \times 10^{-3} \times d^{-0.1901}$$

f = Friction factor

d = Average inside diameter of pipe, inches

Combining these equations, the equation for calculating pressure drop is:

$$H = \frac{7.029 \times 10^{-8} W^2 v L}{d^{5.19}}$$ (for fully turbulent flow only)

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REV: 1 (General) (4/22/71)

EBASCO THERMAL ACCOUNT NO. 8.1

DATE 6/2/70	PIPE LINE SIZING GUIDE (Sheet 3 of 7)	MNE- 65
APPROVED / CHIEF MECHANICAL NUCLEAR ENGR	EBASCO SERVICES INCORPORATED	STANDARD DESIGN CRITERIA

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PIPE LINE SIZING GUIDE (Cont'd)

EQUIPMENT AND/OR SYSTEM

2 - Pressure Drop (Cont'd)

The average inside pipe diameter for any specified pressure drop in the system can be calculated directly by transforming this equation to:

$$d = \left[\frac{7.029 \times 10^{-8} \; W^2 \; v \; L}{H}\right]^{\frac{1}{5.19}}$$

Note: For determining the pressure drop in standard weight (Schedule 40) pipe for cold water and compressed air systems, use the tables as shown in Crane pp B-14 and B-15 respectively. For other than standard weight pipe, the pressure drop must be calculated in accordance with the above.

For highly pressurized systems, it may be necessary to adjust the calculated pressure drop to compensate for compressibility of the fluid.

Compensation is not normally required for boiler feed pump discharge systems.

Additional Notes

a - Maximum pressure drop

(1) Main Steam - 90 percent of allowable pressure drop at Maximum Calculated (or Expected) Throttle Flow between superheater outlet and high pressure turbine inlet.

(2) Hot Reheat and Cold Reheat - 100 percent of allowable pressure drop at flow corresponding to Maximum Calculated (or Expected) Throttle Flow between high pressure turbine outlet and low pressure turbine inlet minus pressure drop through reheater.
Approximate ratios - pressure drop in the hot reheat piping is between 2 and 4 times the pressure drop in the cold reheat piping, based on typical results from economic evaluations.

(3) Heater Drains - Preliminary Line sizing at flow corresponding to Maximum Calculated (or Expected) Throttle Flow - From receiver to control valve inlet, use 1 PSI pressure drop plus or minus static head. From control valve outlet to its downstream receiver use 3 PSI pressure drop plus or minus static head.

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PIPE LINE SIZING GUIDE (Cont'd)
EQUIPMENT AND/OR SYSTEM

2 - Pressure Drop (Cont'd)

a - Maximum pressure drop (Cont'd)

(3) (Cont'd)

For heater drain piping from the outlet of the control valve, the suggested pipe schedule shall be one schedule heavier than the standard weight schedule. The suggested material shall be chrome molybdenum in accordance with ASTM A-335 Gr P 11. The pipe run of the heater drain piping from the control valve outlet shall be as short as possible.

(4) Extraction Steam - 100 percent of allowable pressure drop between turbine nozzle and extraction feedwater inlet nozzle at flow corresponding to Maximum Calculated (or Expected) Throttle Flow.

3 - Pipe Wall Stress

See the applicable codes for the allowable pipe wall stresses.

Use straight line interpolation for stress values falling between various temperature intervals indicated in the Codes.

4 - Minimum Wall Thickness - See Note (a) on Sheet 6

Use the following equations:

Based on OD

$$t_m = \frac{PxD}{2(SE + Py)} + C$$

Based on ID - See Note (b) on Sheet 6

$$t_m = \frac{P \times ID + 2\,SEC + 2yPC}{2\,(SE + Py - P)} + B$$

ID = Maximum inside diameter of pipe, in.

D = Maximum outside diameter of pipe, in.

P = Design pressure, psi

t_m = Calculated minimum pipe wall thickness, in. - See Note (c) on Sheet 7

SE = Allowable stress in material due to internal pressure at the design temperature, psi.

C = Allowance for minimum structural stability

= 0.065" for 1/2 to 3-1/2 in. nominal pipe size

= 0.000" for 4 in. nominal pipe size and larger

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REV:

EBASCO THERMAL ACCOUNT NO. 8.1

DATE 1/26/72 APPROVED / CHIEF MECHANICAL NUCLEAR ENGR	PIPE LINE SIZING GUIDE (Sheet 5 of 7)	MNE-65
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PIPE LINE SIZING GUIDE (Cont'd)
EQUIPMENT AND/OR SYSTEM

4 - Minimum Wall Thickness (Cont'd)

B = .038" for pipe ordered to specified machined ID with tapered backing ring and extruded pipe specified by ID with tapered backing ring.

= .000" for the above pipe with flat backing ring or other types of pipe with any design guide M-4 backing ring.

y = a coefficient having values as follows:

Tem F	900 and Below	950	1000	1050	1100	1150 and Above
*Ferritic Steels	0.4	0.5	0.7	0.7	0.7	0.7
**Austenitic Steels	0.4	0.4	0.4	0.4	0.5	0.7

Notes: (a) - For atmospheric or open ended discharge the internal and thrust forces shall be factored into the determination of the inlet nozzle pipe size and its corresponding minimum wall thickness. See Design Guide M4-23 for specific design of Nozzles for Safety and Relief Valves.

(b) - Use maximum possible inside diameter allowable under the ASTM specification with all its tolerances on wall thickness and outside diameters, except for the following:

For Pipe Ordered to Specified Machined ID

i - For tapered backing ring use maximum machined ID = ID + .086"

ii - For flat backing ring use maximum ID = ID + .01"

For Extruded Pipe Specified by ID

i - For tapered backing ring use maximum machined ID = ID + Mfr ID Tol + .076"

ii - For flat backing ring use maximum ID = ID + Mfr ID Tol

Cameron Extruded Pipe Mfr ID Tol

6" to 22"	+	1/8" - 0"
Over 22" to 30"	+	5/32" - 0"
Over 30" to 42"	+	3/16 - 0"

(c) - (See page 7)

* Carbon steel and intermediate, Croloys (Chrome Moly)
** Stainless Steel

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PIPE LINE SIZING GUIDE (Cont'd)
EQUIPMENT AND/OR SYSTEM

Notes: (Cont'd)

(c) - Select nominal wall thickness of pipe by adding mill tolerance to calculated minimum wall, and choosing the next highest standard wall thickness available from Manufacturer. U S Mill tolerance for seamless pipe is 12-1/2 percent of nominal wall thickness, and for plate pipe is 0.010 in.

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DATE 1/26/73 APPROVED CHIEF MECHANICAL NUCLEAR ENGR	PIPE LINE SIZING GUIDE (Sheet 7 of 7)	MNE-65
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