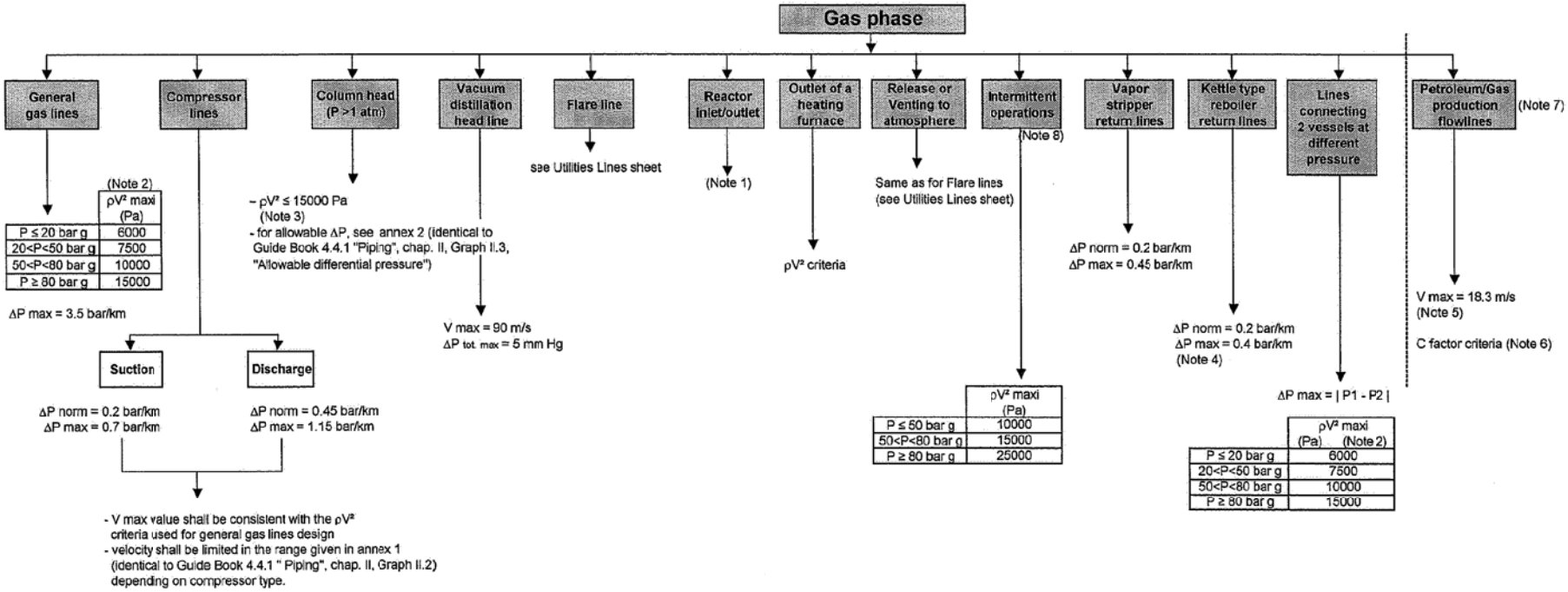
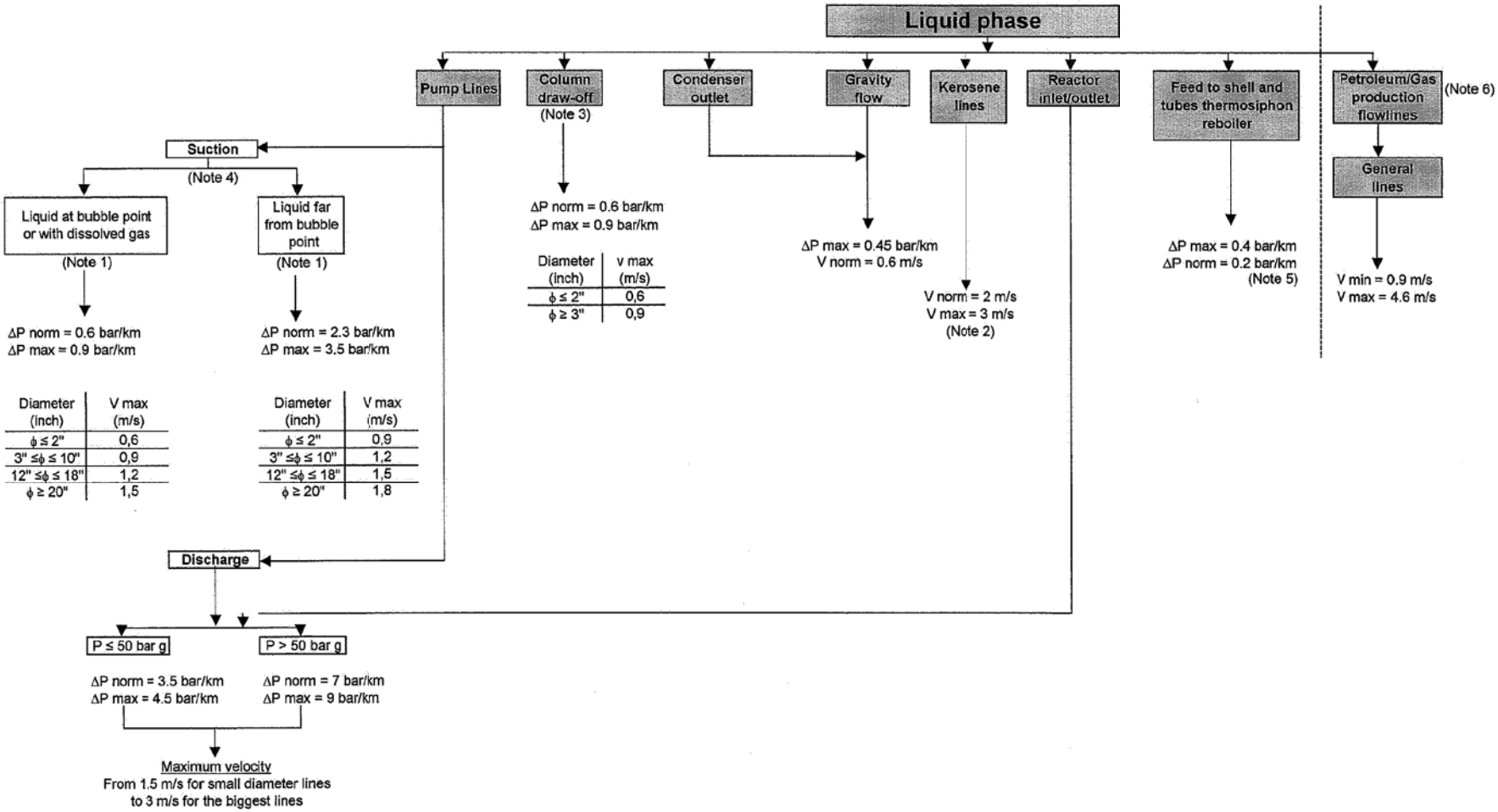


Note :
1 Reactor inlet / outlet lines shall be sized on the basis of the pressure drop allocated to the reaction loop, or on the basis of a ρV² criteria.
2 For gases and steam, it may be allowed to exceed this limit when the conditions allow it (steam let down stations for instance) or require it (revamping of instance). However, 25000 Pa is the value not to be exceeded.
3 ρV² criteria is considered for high pressure columns.
4 These criteria are available for the pre-design of such lines. The Heat Transfer Department (P315) is in charge of the final design.
5 However, this minimal velocity should not be interpreted as an absolute criteria. Higher velocities are accpetable when pipe routing/valve choice/placement are done to mnimize or isolate noise.
6 Identical C values are used for mixed phase or gas flowlines in petroleum/gas production (see mixed phase logigram).
7 For more details, see API 14E - Section 2 "Piping Design".
8 Compressor anti surge lines design is on the basis of the irtermittent operations lines criteria.



Note :

1. When calculating pressure drops for very hot liquid (T > 300 °C), it is recommended to remain conservative and to provide an additional safety margin to take into account ΔP due to expansion loops.
2. At the inlet of a storage vessel or the inlet of a loading point (over a length between 50 to 100 meters) for JP1, JP4, Kerosene and lamp oil, V max = 1 m/s due to static electricity risks.
3. If draw-off flows towards a pump suction, a vertical pipe portion (at least 3 m long) shall be installed as close as possible to the tower, immediately after the nozzle.
4. The NPSH available has to be in accordance with the installed pump required NPSH. For alternative or reciprocative pumps, the NPSH has to be calculated, according to specific procedure taking into account fluid acceleration.
5. When natural circulation reboiler is fed by a liquid draw-off tray, a vertical pipe portion (at least 3 meters long) shall be installed at the outlet of the column, with V max = 0.45 m/s all along the pipe portion
   Those criteria are available for pre-design, but in any case the Heat Transfer Department (P315) is in charge of the design of such process lines.
6. For more details, see API 14E - Section 2 "Piping Design".

Mixed Phase

General mixed phase lines

V avg = 10 to 23 m/s
(ρV^2) avg = 5000 to 10000 Pa
(15000 Pa maxi)

Condenser outlet (Note 2)

ΔP max = 0.45 bar/km
V norm = 0.6 m/s

Reactor inlet/outlet

(Note 3)

Forced flow reboiler return line

- Constraint of a continuous flow regime (annular or dispersed in most of cases)
- (ρV^2) avg ≤ 6000 Pa

Outlet line of a heating furnace

Atmospheric transfer line
Carbon steel small unit : 3 bar/km
Alloy steel small unit : 5 to 7 bar/km
Alloy steel big unit : 2 to 3 bar/km
Total allocated ΔP : 0.5 bar

Vacuum transfer line
% sound velocity : 80
Total allocated ΔP : 0.35 bar

Return line attached to natural circulation reboiler (Note 6)

- Constraint of an annular flow (Note 1)
- Friction and acceleration pressure drops in the exit piping should never exceed approximatively 0.35 times the total driving head

Empirical formulae enable to estimate the optimum diameter and pressure drop :

$$\phi_{opt} = 0.737 \cdot Q_V^{0.42} \cdot \left(\frac{\rho_V}{\rho_L \cdot x}\right)^{0.167}$$

$$\Delta P = 2 \times 10^7 \cdot \rho_m \cdot V_m \cdot \frac{L}{D}$$

with

ϕ opt	in inches
Qv	vapor volume flowrate in m3/h
ρ v	vapor density in kg/m3
ρ L	liquid density in kg/m3
x	weight vaporized fraction
ΔP	pressure drop in bar
ρ m	average density of the mixed phase in kg/m3
V m	average velocity of the mixed phase in m/s
L	piping lenght in m
D	pipe diameter in m

Petroleum/Gas production flowlines (Note 9)

Solid-free fluids

C ≤ 100 for continuous service
C ≤ 125 for intermittent service
(Notes 4, 7 & 8)
} for Carbon Steel pipes

C ≤ 150-200 for continuous service
C ≤ 250 for intermittent service
} for Corrosion Resistant Alloys pipes

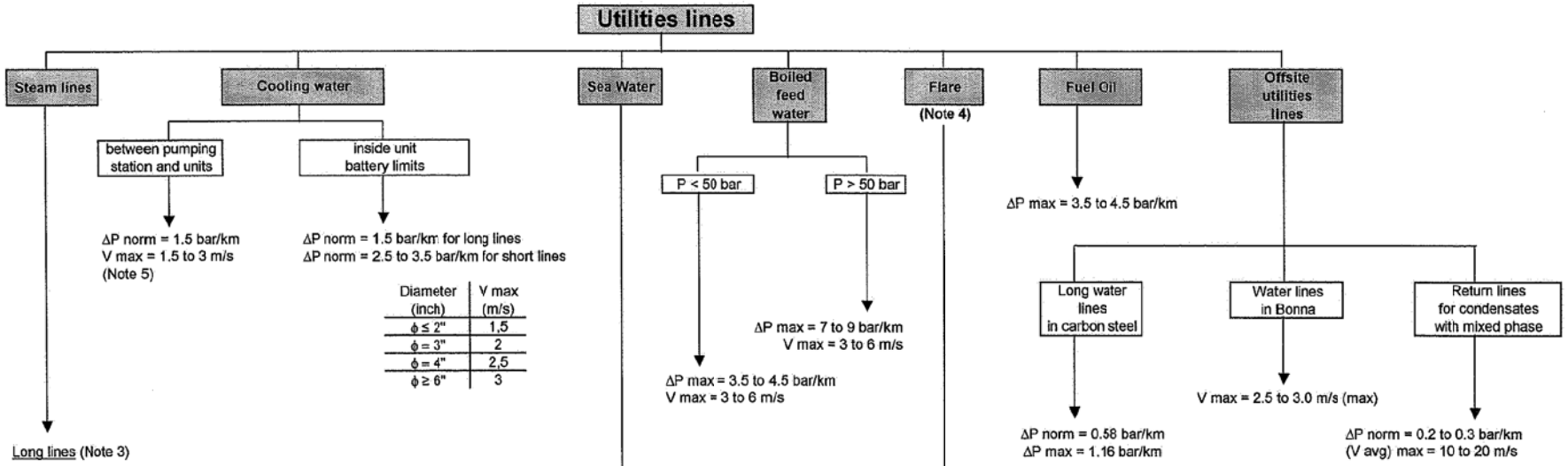
V min = 3 m/s (Note 5)

Note :

1. For calculations and chart use, average specific gravity and average velocity of the mixed phase shall be consider.
2. Same criterion as for condenser inlet with average density method.
3. Reactor inlet/outlet lines shall be sized on the basis of the pressure drop allocated to the reaction loop or on the basis of a ρv^2 criterion.
4. According to API 14E, the C criterion can be increased depending on the material pipe properties (corrosion resistance, thickness).
5. Especially for long lines with elevation changes, in order to minimize slugging of separation equipment
6. For more details, see Engineering Book 4.2.5 "Reboilers", chapter IV. In any case, the Heat Exchanger Department is in charge of the design of those lines.
7. The empirical constant C is defined by the following empirical equation (see API 14 E, Fifth Edition, 1991) :

$$\rho \cdot V_e^2 = 1.488 \cdot C^2$$ with : Ve is the fluid erosional velocity (m/s)
ρ is the gas/liquid mixture density at flowing pressure and temperature (kg/m^3)

8. C values up to 250 have been successfully used (BP used C values equal to 400, but such values are not recommended by API 14E).
9. For more details, see API 14E - Section 2 "Piping Design".



	ΔP norm (bar/km)	ΔP max (bar/km)
1 bar	0,12	0,24
10-30 bar	0,23	0,92
40 bar	0,35	0,92

&

Diameter (inch)	V max (m/s) saturated steam	V max (m/s) superheated steam	ρV² maxi (Pa)
ϕ ≤ 2"	10	15	15000
3" ≤ϕ ≤ 8"	30	40	15000
ϕ ≥ 10"	40	60	15000

(Note 2)

Short lines

	ΔP norm (bar/km)	ΔP max (bar/km)
1 bar	0,46	0,92
10-30 bar	1,16	2,3
40 bar	1,16	2,3

&

Diameter (inch)	V max (m/s) saturated steam	V max (m/s) superheated steam	ρV² maxi (Pa)
ϕ ≤ 2"	10	15	15000
3" ≤ϕ ≤ 8"	30	40	15000
ϕ ≥ 10"	40	60	15000

(Note 2)

Note : 1 Critical velocity Vcrit is calculated using the following formula (for ideal gas): $v_{crit} = \sqrt{\frac{2 \cdot \gamma}{\gamma + 1} \cdot \frac{R \cdot T_a}{PM}}$

with :
- Vcrit in m/s
- γ = isentropic expansion (Cp/Cv for ideal gas)
- R = 8314 J/°K/kmol
- Ta = fluid temperature upstream relief-valve in °K
- PM = fluid molecular weight (kg/kmoles)

This criterion can change, depending on Client's standards, and can reach 0.7 V crit

2 For important variable pressure drop (in a pressure let down for instance), higher ΔP may be allowed and the ρ V² limit can be extended to 25000 Pa

3 Special attention must be brought to the pressure drop of long lines (in off sites for example) feeding turbines in order to enable delivery and extraction of steam at the conditions specified for these machines.

4 Flare system design is the subject of a specific guide book. Specific computer programs ("TORCHE" or "Flarenet") **must be used for the design.**

5 ΔP max criterion is a case by case analysis