+GF+ Offline Tool – Documentation of calculation formulas and equations

Pressure drops

Along pipe

(1) $$\Delta p = f \cdot \frac{L \cdot \rho \cdot v^2}{200 \cdot d}$$

where
ρ: density [kg/m^3]
v: velocity [m/s]
f: friction factor
L: pipe length [m]
d: inner pipe diameter [m]

For turbulent flow (Re>2320), f is constant at 0.02. For laminar flow (Re < 2320):

(2) $$f = \frac{64}{\mathrm{Re}}$$

where
Re: Reynolds number [-]
k: roughness [m]
ν: kinematic viscosity [m^2/s]

(3) $$\mathrm{Re} = \frac{v \cdot d}{\nu}$$

(4) $$\Delta p_{Fi} = \sum \zeta \cdot \frac{v^2 \cdot \rho}{2 \cdot 10^5}$$

where
ξ: contraction coefficient [-]
v: velocity [m/s]
ρ: density [kg/m^3]

(5) $$\Delta p_{Va} = \left(\frac{Q}{k_v}\right)^2 \frac{\rho}{1000}$$

where
Q [m^3/h]: pipe flow
k_v [m^3/h]: valve flow characteristic
ρ [kg/m^3]: density

Over fittings

(1.7) $$\Delta p_{Fi} = \sum \zeta \cdot \frac{v^2 \cdot \rho}{2 \cdot 10^5}$$

where
ξ: contraction coefficient [-]
v: velocity [m/s]
ρ: density [kg/m^3]

Over Valves

The pressure drop over a valve is defined in [+GF+ Product Catalogue p. 138].

(1.8) $$\Delta p_{Va} = \left(\frac{Q}{k_v}\right)^2 \frac{\rho}{1000}$$

where	Q [m³/h]:	pipe flow
	k_v [m³/h]:	valve flow characteristic
	ρ [kg/m³]:	density

Condensation

Minimum insulation preventing condensation

(6)
$$p'(T) = 101325 \cdot 10^{A}$$
$$A = A_0 - \frac{A_1}{T} - A_2 \cdot Log\,T - A_3 \cdot 10^{\frac{-T}{A_4}} + A_5 \cdot 10^{\frac{-A_6}{T}}$$

where
$A_0 = 20.82648355$
$A_1 = 2948.997118$
$A_2 = 5.02808$
$A_3 = 29811.33781$
$A_4 = 32.923061$
$A_5 = 25.21934913$
$A_6 = 1302.8503$
T: absolute temperature in Kelvin

(7) $$p(T) = \varphi \cdot p'(T)$$

where φ [-]: relative air humidity

(8) $$T_{dew} = 37.58 - \frac{4042.9}{Ln\,p(T) - 23.5771}$$

(9)
$$T_i = T_f - \frac{(T_f - T_a) \cdot R_c}{R_{total}}$$
$$T_{pur} = T_i - \frac{(T_f - T_a) \cdot R_i}{R_{total}}$$
$$T_s = T_{pur} - \frac{(T_f - T_a) \cdot R_j}{R_{total}}$$

where	T_i [°C]:	temperature of outer media pipe
	T_f [°C]:	flow temperature
	T_a [°C]:	air temperature
	T_{pur} [°C]:	temperature of outer PUR
	T_s [°C]:	temperature of outer casing pipe (surface temperature)
	R_i [mK/W]:	thermal resistance of insulation
	R_c [mK/W]:	thermal resistance of carrier pipe
	R_j [mK/W]:	thermal resistance of casing pipe
	R_{total} [mK/W]:	thermal resistance

Heat loss

Traditional Heat Loss

(10) $$\phi = U(T_f - T_a)$$ [W/m]

where U [W/mK]: heat transmission coefficient of a single pipe

	T_f [°C]:	flow temperature
	T_a [°]:	air temperature

(11) $$U = \frac{1}{R_i + R_c + R_j + R_a}$$ [W/mK]

where	R_i [mK/W]:	thermal resistance of insulation
	R_c[mK/W]:	thermal resistance of carrier pipe
	R_j [mK/W]:	thermal resistance of casing pipe
	R_a [mK/W]:	thermal resistance of air

(12) $$R_i = \frac{1}{2\pi\lambda_i} \cdot Ln\left(\frac{D_i}{d}\right)$$
$$R_c = \frac{1}{2\pi\lambda_c} \cdot Ln\left(\frac{d}{d_i}\right)$$
$$R_j = \frac{1}{2\pi\lambda_j} \cdot Ln\left(\frac{D}{D_i}\right)$$
$$R_a = \frac{1}{\pi \cdot h \cdot D}$$
[mK/W]

where	D_i [m]:	internal diameter carrier pipe
	D [m]:	external diameter casing pipe
	d_i [m]:	internal diameter carrier pipe
	d [m]:	external diameter carrier pipe
	λ_i [W/mK]:	thermal conductivity of insulation
	λ_c [W/mK]:	thermal conductivity of carrier pipe
	λ_j [W/mK]:	thermal conductivity of casing pipe
	h [W/m ^{2} K]:	heat transfer coefficient of air

(13) $$h = h_c + h_r$$ [W/mK]

where	h_c [W/m ^{2} K]:	convective heat transfer coefficient
	h_r [W/m ^{2} K]:	radiation heat transfer coefficient

(14) $$h_c = 0.023 \frac{V^{0.8} \cdot k^{0.6} \cdot (\rho \cdot c_p)^{0.4}}{D^{0.2} \cdot \nu^{0.4}}$$ [W/m ^{2} K]

where	V [m/s]:	air velocity
	k [W/mK]:	thermal conductivity of air
	ρ [kg/m ^{3}]:	air density
	c_p [J/kgK]:	specific heat of air
	D [m]:	casing pipe diameter
	ν [m ^{2} /s]:	kinematic viscosity of air

(15) $$h_r = 4 \cdot \varepsilon \cdot \sigma \cdot T^3$$ [W/m ^{2} K]

where	ε [-]:	emittance
	σ [W/m ^{2} K ^{4}]:	Stefan-Bolzmann constant
	T [K]:	air temperature in Kelvin

Temperature along pipe

(22) $$T_x = \Delta T \cdot Exp\left(\frac{-U \cdot L}{\dot{m} \cdot c_p}\right) + T_s$$ [°C]

where	ΔT [°C]:	temperature difference between inlet and surroundings
	U [W/mK]:	heat transmission coefficient
	L [m]:	pipe length
	$\dot{m}$ [kg/s]:	mass flow of media
	c_p [J/kgK]:	specific heat at constant pressure
	T_s [°C]:	surrounding temperature

(23) $$\dot{m} = \left(\frac{\frac{Q}{1000} \cdot \rho_m}{3600} \right)$$ [kg/s]

where	Q [l/h]:	media flow
	ρ_m [kg/m^3]:	density of media

(24) $$t = \frac{Ln\left(\frac{\Delta T}{\Delta T_x}\right) \cdot c_p \cdot m_{media}}{3600 \cdot U}$$ [h]

where	m_{media} [kg/m]:	load of content
	ΔT_x [°C]:	temperature difference between cool down temperature and surroundings
	ΔT [°C]:	temperature difference between inlet and surroundings
	U [W/mK]:	heat transmission coefficient
	L [m]:	pipe length
	c_p [J/kgK]:	specific heat at constant pressure

(25)
$$T_i = T_f - \frac{(T_f - T_a) \cdot R_c}{R_{total}}$$
$$T_{pur} = T_i - \frac{(T_f - T_a) \cdot R_i}{R_{total}}$$
$$T_s = T_{pur} - \frac{(T_f - T_a) \cdot R_j}{R_{total}}$$

where	T_i [°C]:	temperature of outer media pipe
	T_f [°C]:	flow temperature
	T_a [°C]:	air temperature
	T_{pur} [°C]:	temperature of outer PUR
	T_s [°C]:	temperature of outer casing pipe (surface temperature)
	R_i [mK/W]:	thermal resistance of insulation
	R_c [mK/W]:	thermal resistance of carrier pipe
	R_j [mK/W]:	thermal resistance of casing pipe
	R_{total} [mK/W]:	thermal resistance

Pipe dimensioning

Specify Velocity and Dimension

(16) $$d_i = 18.8 \cdot \sqrt{\frac{Q}{v}}$$ [mm]

Where
d_i: inner pipe diameter [mm]
Q: flow rate [m^3/h]
v: flow velocity [m/s]

(17) $$d_i = 18.8 \cdot \sqrt{\frac{Q}{v}} \Leftrightarrow Q = \frac{d_i^2 \cdot v}{18.8^2}$$

Specify Flow and Velocity

For this calculation (4.1) can be directly used.

(16) $$d_i = 18.8 \cdot \sqrt{\frac{Q}{v}}$$ [mm]

Where
d_i: inner pipe diameter [mm]
Q: flow rate [m^3/h]
v: flow velocity [m/s]

Specifying Flow and Dimension

Rearrangement of (4.1) is necessary for isolation of the velocity.

(4.5) $$d_i = 18.8 \cdot \sqrt{\frac{Q}{v}} \Leftrightarrow d_i^2 = 18.8^2 \cdot \frac{Q}{v} \Leftrightarrow v = \frac{18.8^2 \cdot Q}{d_i^2}$$ [m/s]

Pipe supports

(18) $$L_A = f_{LA} \cdot \sqrt[3]{\frac{E_c \cdot J_R}{q}}$$

where

	f_{LA} [-]:	factor (0.8…0.92. For supported beam 0.8 is used and 0.92 is used for a subjected beam)
	E_c [N/mm²]:	modulus of elasticity
	J_R [mm⁴]:	moment of inertia
	q [N/mm]:	load

Expansion/Contraction

Change in Length

(19) $$\Delta L = \alpha \cdot L \cdot \Delta T$$ [mm]

where

α [1/°C]:	thermal coefficient of expansion
L [m]:	pipe length
ΔT [°C]:	temperature difference

(20) $$\sigma = \alpha \cdot E \cdot \Delta T$$ [N/mm²]

where

α [mm/mK]:	thermal coefficient of expansion
E [N/mm²]:	modulus of elasticity
ΔT [°C]:	temperature difference

Flexible Length

(21) $L_B = c \cdot \sqrt{d \cdot \Delta L}$ [mm]

where c [-]: material constant
d [mm]: pipe or jacket diameter
L [-]: change in pipe length

Installation

Weight

COOL-FIT 2.0

Dimension	OD_display	Weight kg/m
32	75	1,14
40	90	1,534
50	90	1,722
63	110	2,711
75	125	3,405
90	140	4,32
110	160	5,692
140	200	9,021

SDR11

Dimension	OD_display	Weight kg/m
20	0	0,113
25	0	0,173
32	0	0,274
40	0	0,434
50	0	0,673
63	0	1,06
75	0	1,48
90	0	2,14
110	0	3,18
125	0	4,12
140	0	5,13
160	0	6,74
180	0	8,51
200	0	10,5
225	0	13,3
250	0	16,3
280	0	20,5
315	0	25,9
355	0	32,9
400	0	41,7
450	0	52,8

SDR17

Dimension	OD_display	Weight kg/m
50	0	2,9
63	0	3,6
75	0	4,3
90	0	5,1
110	0	6,3
125	0	7,1
140	0	8
160	0	9,1
180	0	10,2
200	0	11,4
225	0	12,8
250	0	14,2
280	0	15,9
315	0	17,9
355	0	20,1
400	0	22,7
450	0	25,5

iFIT

Dimension	OD_display	Weight kg/m
16	0	0,118
20	0	0,154
25	0	0,289
32	0	0,354

Sanipex MT

Dimension	OD_display	Weight kg/m
16	0	0,135
20	0	0,185
26	0	0,285
32	0	0,393
40	0	0,605
50	0	0,886
63	0	1,265

Jointing time along pipe

Awaiting input

CO2 Emissions

(22) $$CO_2 = c \cdot m \cdot L$$ [kg CO2]

where
- c [-]: material constant
- m [kg/m]: weight per meter
- L [-]: pipe length

c for COOL-FIT 3.13

c for Carbon	1.92
c for Stainless	5.71
c for Copper	4.27

Pipe Supports

COOL-FIT 2.0

Dimension	Distance
[mm]	[m]
32 / 75	1,60
40 / 90	1,70
50 / 90	1,70
63 / 110	1,85
75 / 125	1,95
90 / 140	2,00
110 / 160	2,10
140 / 200	2,35

ecoFIT SDR11

Dimension	20°C	30°C	40°C	50°C	60°C
[mm]	[m]	[m]	[m]	[m]	[m]
20	0,575	0,550	0,500	0,450	0,400
25	0,650	0,600	0,550	0,550	0,500
32	0,750	0,750	0,650	0,650	0,550
40	0,900	0,850	0,750	0,750	0,650
50	1,050	1,000	0,900	0,850	0,750
63	1,200	1,150	1,050	1,000	0,900
75	1,350	1,300	1,200	1,100	1,100
90	1,500	1,450	1,350	1,250	1,150
110	1,650	1,600	1,500	1,450	1,300
125	1,750	1,700	1,600	1,550	1,400
140	1,900	1,850	1,750	1,650	1,500
160	2,050	1,950	1,850	1,750	1,600
180	2,150	2,050	1,950	1,850	1,750
200	2,300	2,200	2,100	2,000	1,900
225	2,450	2,350	2,250	2,150	2,050
250	2,600	2,500	2,400	2,300	2,100
280	2,750	2,650	2,550	2,400	2,200
315	2,900	2,800	2,700	2,550	2,350
355	3,100	3,000	2,900	2,750	2,550
400	3,300	3,150	3,050	2,900	2,700
450	3,500	3,300	3,200	3,050	2,900

ecoFIT SDR17

Dimension	20°C	30°C	40°C	50°C	60°C
[mm]	[m]	[m]	[m]	[m]	[m]
50	0,955	0,910	0,819	0,773	0,682
63	1,092	1,046	0,955	0,910	0,819
75	1,228	1,183	1,092	1,001	0,910
90	1,365	1,319	1,228	1,137	1,046
110	1,500	1,456	1,365	1,319	1,183
125	1,592	1,547	1,456	1,410	1,274
140	1,729	1,683	1,592	1,501	1,501
160	1,865	1,774	1,683	1,592	1,456
180	1,956	1,865	1,774	1,683	1,592
200	2,093	2,002	1,911	1,820	1,729
225	2,229	2,138	2,047	1,956	1,865
250	2,340	2,275	2,184	2,093	1,911
280	2,502	2,411	2,320	2,184	2,002
315	2,639	2,548	2,457	2,320	2,138
355	2,821	2,730	2,639	2,502	2,320
400	3,003	2,866	2,775	2,639	2,457
450	3,185	3,003	2,912	2,775	2,639

iFIT

Dimension	Distance
[mm]	[m]
16	1,00
20	1,00
25	1,50
32	2,00

Sanipex MT

Dimension	Distance
[mm]	[m]
16	1,00
20	1,00
26	1,50
32	2,00
40	2,00
50	2,50
63	2,50