Module 14.3

Sizing Condensate Return Lines

Sizing Condensate Lines

The four main types of condensate line, as mentioned in Module 14.2, are shown in Table 14.3.1:

Table 14.3.1 The four basic types of condensate line

Type of condensate line	Condensate line is sized to carry the following
Drain lines to trap	Condensate
Discharge lines from traps	Flash steam
Common return lines	Flash steam
Pumped return lines	Condensate

Sizing of all condensate lines is a function of:

- **Pressure -** The difference in pressure between one end of the pipe and the other. This pressure difference may either promote flow, or cause some of the condensate to flash to steam.
- **Quantity -** The amount of condensate to be handled.
- **Condition -** Is the condensate predominately liquid or flash steam?

With the exception of pumped return lines which will be discussed in Module 14.4, the other three main types of condensate line and their sizing, will be covered in this Module.

Sizing drain lines to traps

It should not be assumed that the drain line (and trap) should be the same size as the plant outlet connection. The plant may operate at a number of different operating pressures and flowrates, especially when it is temperature controlled. However, once the trap has been correctly sized, it is usually the case that the drain line will be the same size as the trap inlet connection, (see Figure 14.3.1).

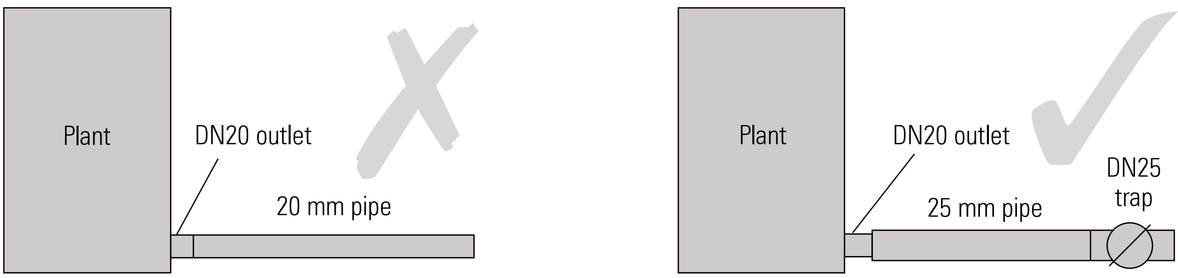


Fig. 14.3.1 The drain line should not be sized on the plant connection

Regarding the conditions inside the drain line, as there is no significant pressure drop between the plant and the trap, no flash steam is present in the pipe, and it can be sized to carry condensate only.

When sizing the drain line, the following will need consideration:

- The condensing rate of the equipment being drained during full-load.
- The condensing rate of the equipment at start-up.

  At plant start-up, the condensing rate can be up to three times the running load – this is where the temperature difference between the steam and colder product is at its maximum.

  The drain line, trap, and discharge line also have to carry the air that is displaced by the incoming steam during this time.

The sizing routine for the steam trap will have to consider both of these variables, however, in general:

- For steam mains drainage, the condensate load for each drain trap is typically 1% of the steam capacity of the main based on drain points at 50 m intervals, and with good insulation.

  For most drain points, sizing the trap to pass twice the running load at the working pressure (minus any backpressure) will allow it to cope with the start-up load.

- On constant steam pressure processes such as presses, ironers, unit heaters, radiant panels and boiling pans, sizing the traps on approximately twice the running load at the working pressure (less any backpressure) will provide sufficient capacity to cope with the start-up load.
- On temperature controlled applications, the steam pressure, the plant turndown, the set temperature and steam trap location need to be considered in detail, and the trap needs to be sized to cater for both the full and minimum load conditions. If these conditions are not known it is recommended that the steam trap be sized on 3 x the running load at the running differential pressure. This should satisfy the start-up condition and provide proper drainage at minimum loads.

  When the trap is sized in this way, it will also cater for the start-up load. Consequently, if the drain line to the trap is sized on the trap size, it will never be undersized.

For practical purposes, where the drain line is less than 10 m, it can be the same pipe size as the steam trap selected for the application. Drain lines less than 10 m long can also be checked against Appendix 14.3.1 and a pipe size should be selected which results in a pressure loss at maximum flowrate of not more than 200 Pa per metre length, and a velocity not greater than 1.5 m/s. Table 14.3.2 is an extract from Appendix 14.3.1.

On longer drain lines (over 10 m), the pressure loss at maximum flowrate should not be more than 100 Pa/m, and a velocity not greater than 1 m/s.

Table 14.3.2 Flow of water in heavy steel pipes

Flowrate		Capacity kg/h									
Pipe size Ø		15 mm	20 mm	25 mm	32 mm	40 mm	50 mm	65 mm	80 mm	100 mm	
Pa/m	mbar/m	<0.15 m/s			0.15 m/s					0.3 m/s	
90.0	**0.900**	173	403	745	1 627	2 488	4 716	9 612	14 940	30 240	
92.5	**0.925**	176	407	756	1 652	2 524	4 788	9 756	15 156	30 672	
95.0	**0.950**	176	414	767	1 678	2 560	4 860	9 900	15 372	31 104	
97.5	**0.975**	180	421	778	1 699	2 596	4 932	10 044	15 552	31 500	**1.0 m/s**
100.0	**1.000**	184	425	788	1 724	2 632	5 004	10 152	15 768	31 932	
120.0	**1.200**	202	472	871	1 897	2 898	5 508	11 196	17 352	35 100	
140.0	**1.400**	220	511	943	2 059	3 143	5 976	12 132	18 792	38 160	
160.0	**1.600**	234	547	1 015	2 210	3 373	6 408	12 996	20 160	40 680	
180.0	**1.800**	252	583	1 080	2 354	3 589	6 804	13 824	21 420	43 200	
200.0	**2.000**	266	619	1 141	2 488	3 780	7 200	14 580	22 644	45 720	
220.0	**2.200**	281	652	1 202	2 617	3 996	7 560	15 336	23 760	47 880	
240.0	**2.400**	288	680	1 256	2 740	4 176	7 920	16 056	24 876	50 400	**1.5 m/s**
260.0	**2.600**	306	713	1 310	2 855	4 356	8 244	16 740	25 920	52 200	
280.0	**2.800**	317	742	1 364	2 970	4 536	8 568	17 388	26 928	54 360	
300.0	**3.000**	331	767	1 415	3 078	4 680	8 892	18 000	27 900	56 160	

Example 14.3.1

An item of plant, using steam at constant pressure, condenses 470 kg of steam an hour at full-load. The pipework between the plant item and the steam trap has an equivalent length of 2 m.

Determine the size of pipe to be used.

Revised load allowing for start-up = 470 kg/h x 2 = 940 kg/h.

As the pipe length is less than 10 metres, the maximum allowable pressure drop is 200 Pa/m.

Using Table 14.3.1, by looking across from 200 Pa/m it can be seen that a 25 mm pipe has a capacity of 1 141 kg/h, and would therefore be suitable for the expected starting load of 940 kg/h.

Checking further up the 25 mm column, it can be seen that a flowrate of 940 kg/h will incur an actual pressure drop of just less than 140 Pa/m flowing through a 25 mm pipe.

Sizing discharge lines from traps

The section of pipeline downstream of the trap will carry both condensate and flash steam at the same pressure and temperature. This is referred to as two-phase flow, and the mixture of liquid and vapour will have the characteristics of both steam and water in proportion to how much of each is present. Consider the following example.

Example 14.3.2

An item of plant uses steam at a constant 4 bar g pressure. A mechanical steam trap is fitted, and condensate at saturation temperature is discharged into a condensate main working at 0.5 bar g.

Determine the proportions by mass, and by volume, of water and steam in the condensate main.

Part 1 - Determine the proportions by mass

From steam tables:

At 4.0 bar g h_f = 640.7 kJ/kg

At 0.5 bar g h_f = 464.1 kJ/kg h_{fg} = 2 225.6 kJ/kg

Equation 2.2.5 is used to determine the proportion of flash steam:

$$\text{Proportion of flash steam} = \frac{(h_f \text{ at } P_1) - (h_f \text{ at } P_2)}{h_{fg} \text{ at } P_2}$$ **Equation 2.2.5**

Where:

P_1 = Initial pressure

P_2 = Final pressure

h_f = Specific liquid enthalpy (kJ/kg)

h_{fg} = Specific enthalpy of evaporation (kJ/kg)

$$\text{Proportion of flash steam} = \frac{(640.7 - 464.1)}{2225.6} \times \frac{100}{1} = 7.9\%$$

Clearly, if 7.9% is flashing to steam, the remaining 100 – 7.9 = 92.1% of the initial mass flow will remain as water.

Part 2 - Determine the proportions by volume

Based on an initial mass of 1 kg of condensate discharged at 4 bar g saturation temperature, the mass of flash steam is 0.079 kg and the mass of condensate is 0.921 kg (established from Part 1).

Water:

The density of saturated water at 0.5 bar g is 950 kg/m³,

$$\text{and the volume occupied by 0.921 kg} = \frac{0.921}{950} = 0.001 \text{ m}^3$$

Steam:

From steam tables, specific volume (v_g) of steam at 0.5 bar g = 1.15 m³/kg

The volume occupied by the steam is 0.079 kg x 1.15 m³/kg = 0.091 m³

The total volume occupied by the steam and condensate mixture is:

0.001 m³ (water) + 0.091 m³ (steam) = 0.092 m³

By proportion (%):

$$\textbf{The water occupies} = \frac{0.001}{0.092} \times \frac{100}{1} = \textbf{1\% space}$$

$$\textbf{The steam occupies} = \frac{0.091}{0.092} \times \frac{100}{1} = \textbf{99\% space}$$

From this, it follows that the two-phase fluid in the trap discharge line will have much more in common with steam than water, and it is sensible to size on reasonable steam velocities rather than use the relatively small volume of condensate as the basis for calculation. If lines are undersized, the flash steam velocity and backpressure will increase, which can cause waterhammer, reduce the trap capacity, and flood the process.

Steam lines are sized with attention to maximum velocities. Dry saturated steam should travel no faster than 40 m/s. Wet steam should travel somewhat slower (15 to 20 m/s) as it carries moisture which can otherwise have an erosive and damaging effect on fittings and valves.

Trap discharge lines can be regarded as steam lines carrying very wet steam, and should be sized on similarly low velocities.

Condensate discharge lines from traps are notoriously more difficult to size than steam lines due to the two-phase flow characteristic. In practice, it is impossible (and often unnecessary) to determine the exact condition of the fluid inside the pipe.

Although the amount of flash steam produced (see Figure 14.3.2) is related to the pressure difference across the trap, other factors will also have an effect.

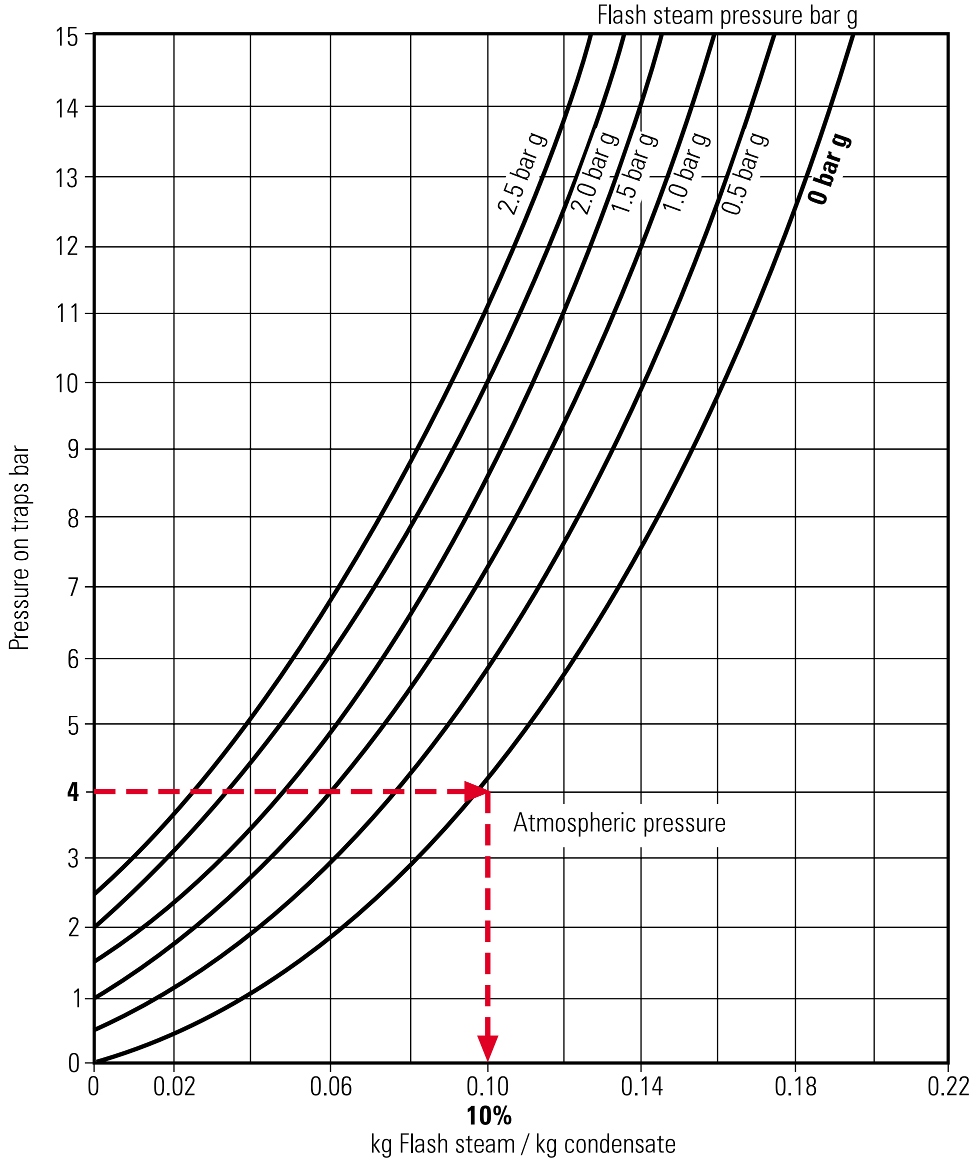


Fig. 14.3.2 Quantity of flash steam graph

Factors having a bearing on two-phase flow inside a pipe, include:

- If the condensate on the upstream side of the trap is cooler than the saturation temperature (for example: a thermostatic steam trap is used), the amount of flash steam after the trap is reduced. This can reduce the size of the line required.
- If the line slopes down from the trap to its termination, the slope will have an effect on the flow of condensate, but to what magnitude, and how can this be quantified?

- On longer lines, radiation losses from the line may condense some of the flash steam, reducing its volume and velocity, and there may be a case for reducing the line size. But at what point should it be reduced and by how much?
- If the discharge line lifts up to an overhead return line, there will be times when the lifting line will be full of cool condensate, and times when flash steam from the trap may evaporate some or all of this condensate. Should the rising discharge line be sized on flash steam velocity or the quantity of condensate?
- Most processes operate some way below their full-load condition for most of their running cycle, which reduces flash steam for most of the time. The question therefore arises: is there a need for the system to be sized on the full-load condition, if the equipment permanently runs at a lower running load?
- On temperature controlled plant, the pressure differential across the trap will itself change depending on the heat load. This will affect the amount of flash steam produced in the line.

Recommendations on trap discharge lines

Because of the number of variables, an exact calculation of line size would be complex and probably inaccurate. Experience has shown that if trap discharge lines are sized on flash steam velocities of 15 to 20 m/s, and certain recommendations are adhered to, few problems will arise.

Recommendations:

1. Correctly sized trap discharge lines which slope in the direction of flow and are open-ended or vented at a receiver, will be non-flooded and allow flash steam to pass unhindered above the condensate (Figure 14.3.3). A minimum slope of 1 in 70 (150 mm drop every 10 m) is recommended. A simple visual check will usually confirm if the line is sloping - if no slope is apparent it is not sloping enough!

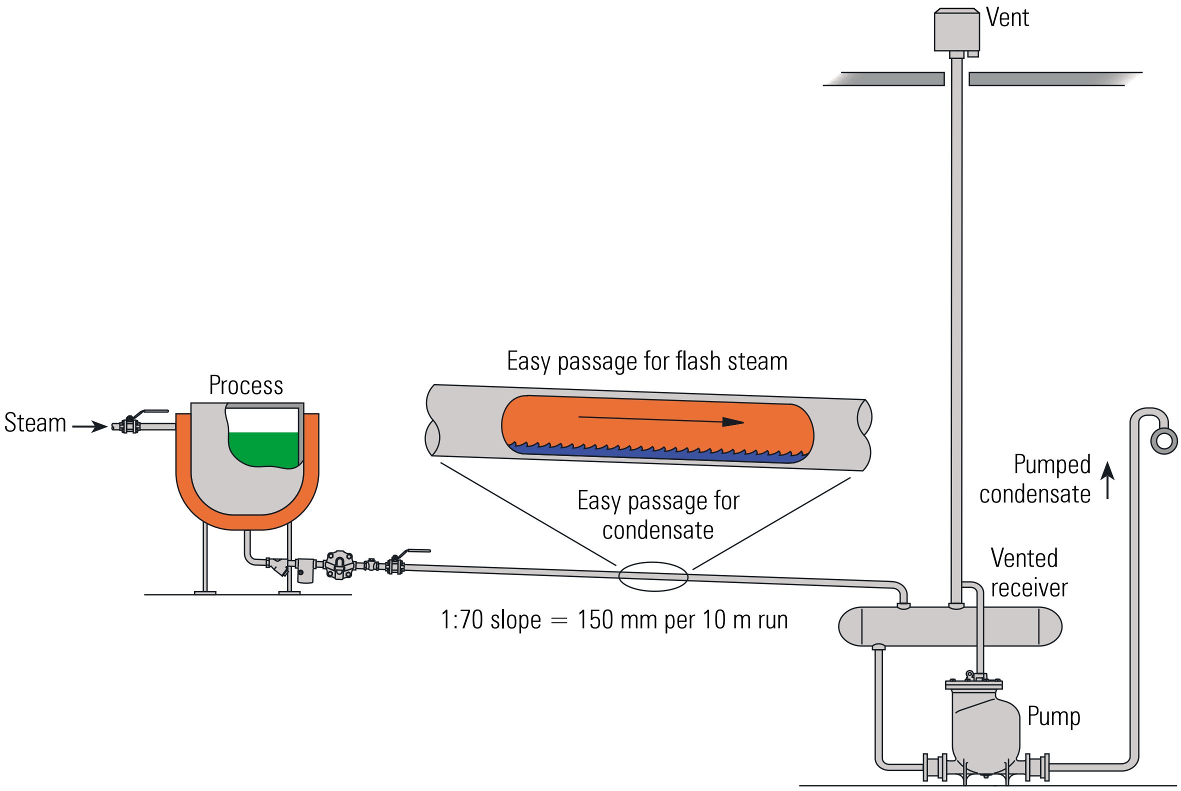


Fig. 14.3.3 Discharge line sloping 1:70 in the direction of flow

2. If it is unavoidable, non-pumped rising lines (Figure 14.3.4) should be kept as short as possible and fitted with a non-return valve to stop condensate falling back down to the trap. Risers should discharge into the top of overhead return lines. This stops condensate draining back into the riser from the main after the trap has discharged, to assist the easy passage of flash steam up the riser.

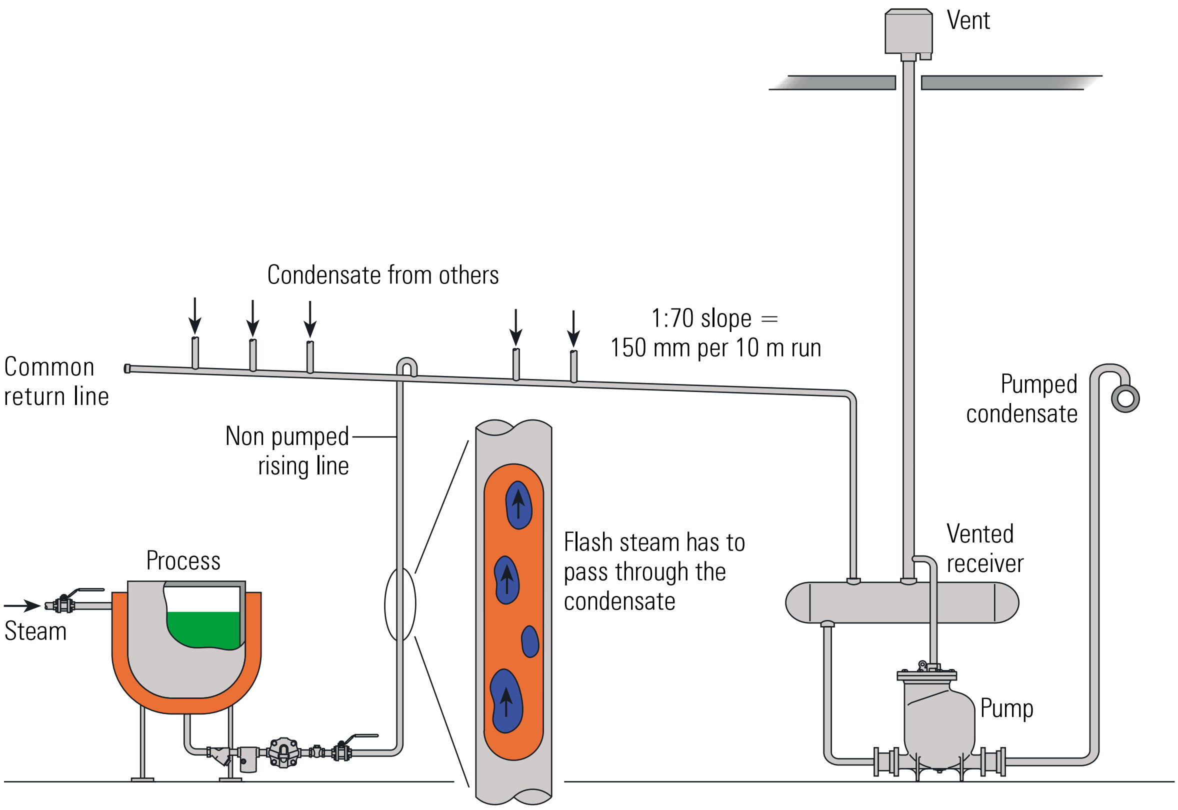


Fig. 14.3.4 Keep rising lines short and connect to the top of return lines

It is sensible to consider using a slightly larger riser, which will produce a lower flash steam velocity. This will reduce the risk of waterhammer and noise caused by steam trying to force a path through the liquid condensate in the riser.

Important: A rising line should only be used where the process steam pressure is guaranteed to be higher than the condensate backpressure at the trap outlet. If not, the process will waterlog unless a pumping trap or pump-trap combination is used to provide proper drainage against the backpressure.

3. Common return lines should also slope down and be non-flooded (Figure 14.3.4). To avoid flash steam occurring in long return lines, hot condensate from trap discharge lines should drain into vented receivers (or flash vessels where appropriate), from where it can be pumped on to its final destination, via a flooded line at a lower temperature.

Condensate pumping is dealt with in more detail in Module 14.4.

The condensate pipe sizing chart

The condensate pipe sizing chart (Figure 14.3.5) can be used to size any type of condensate line, including:

- Drain lines containing no flash steam.
- Lines consisting of two-phase flow, such as trap discharge lines, which are selected according to the pressures either side of the trap.

The chart (Figure 14.3.5):

- Works around acceptable flash steam velocities of 15 - 20 m/s, according to the pipe size and the proportion of flash steam formed.
- Can be used with condensate temperatures lower than the steam saturation temperature, as will be the case when using thermostatic steam traps.
- Is used to size trap discharge lines on full-load conditions. It is not necessary to consider any oversizing factors for start-up load or the removal of non-condensable gases.
- May also be used to estimate sizes for pumped lines containing condensate below 100°C. This will be discussed in Module 14.4.

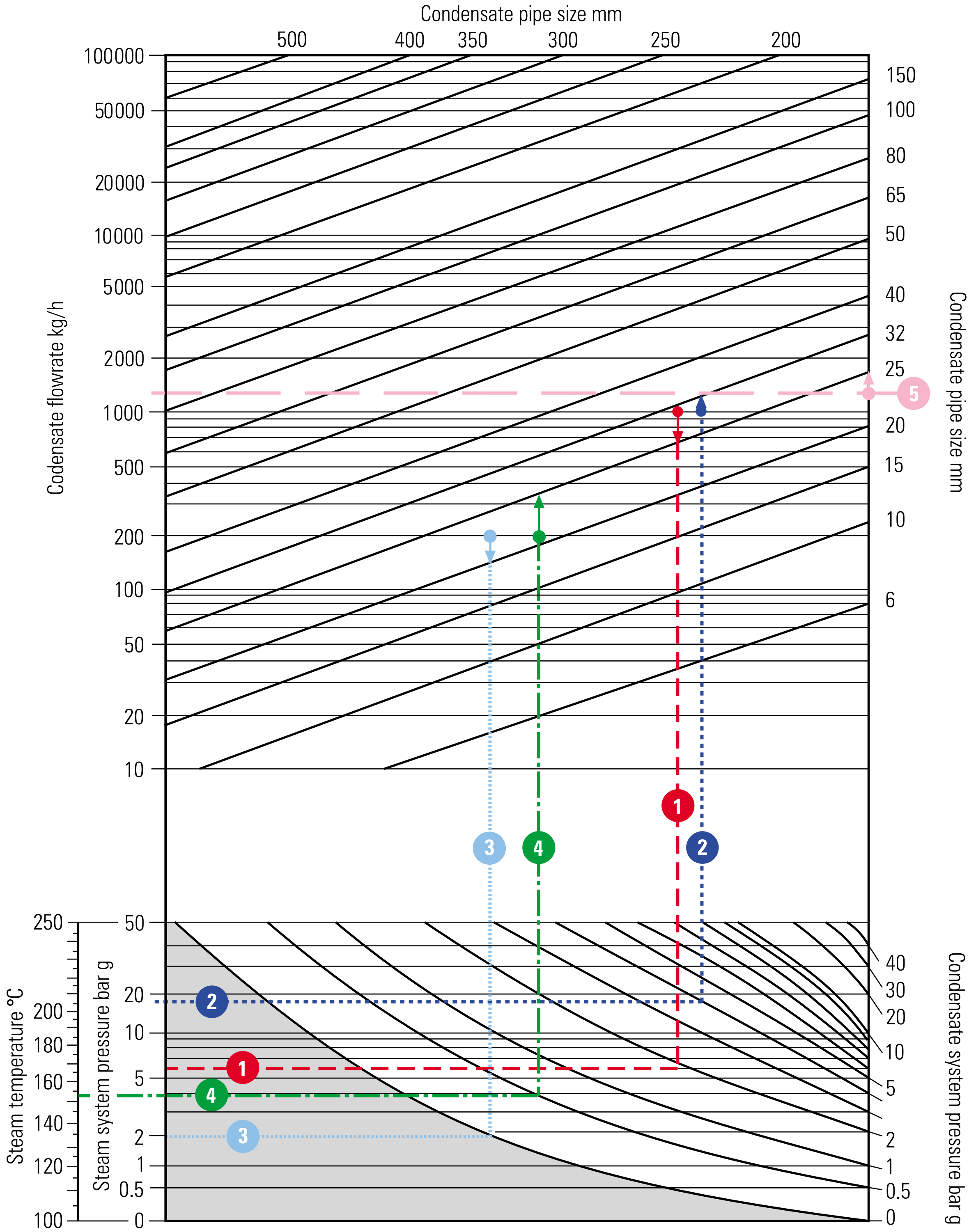


Fig. 14.3.5 Condensate pipe sizing chart

Using the condensate pipe sizing chart (Also available in Appendix 14.3.2)

Establish the point where the steam and condensate pressures meet (lower part of the chart, Figure 14.3.5). From this point, move vertically up to the upper chart to meet the required condensate rate. If the discharge line is falling (non-flooded) and the selection is on or between lines, choose the lower line size. If the discharge line is rising, and therefore likely to be flooded, choose the upper line size.

Note: The reasoning employed for the sizing of a steam trap is different to that used for a discharge line, and it is perfectly normal for a trap discharge line to be sized different to the trap it is serving. However, when the trap is correctly sized, the usual ancillary equipment associated with a steam trap station, such as isolation valves, strainer, trap testing chamber, and check valve, can be the same size as the trapping device selected, whatever the discharge line size.

Example 14.3.3 ❶ on the chart (Figure 14.3.6)

A steam trap passing a full-load of 1 000 kg/h at 6 bar g saturated steam pressure through a falling discharge line down to a flash vessel at 1.7 bar g.

As the discharge line is non-flooded, the lower figure of 25 mm is selected from the chart (Figure 14.3.4).

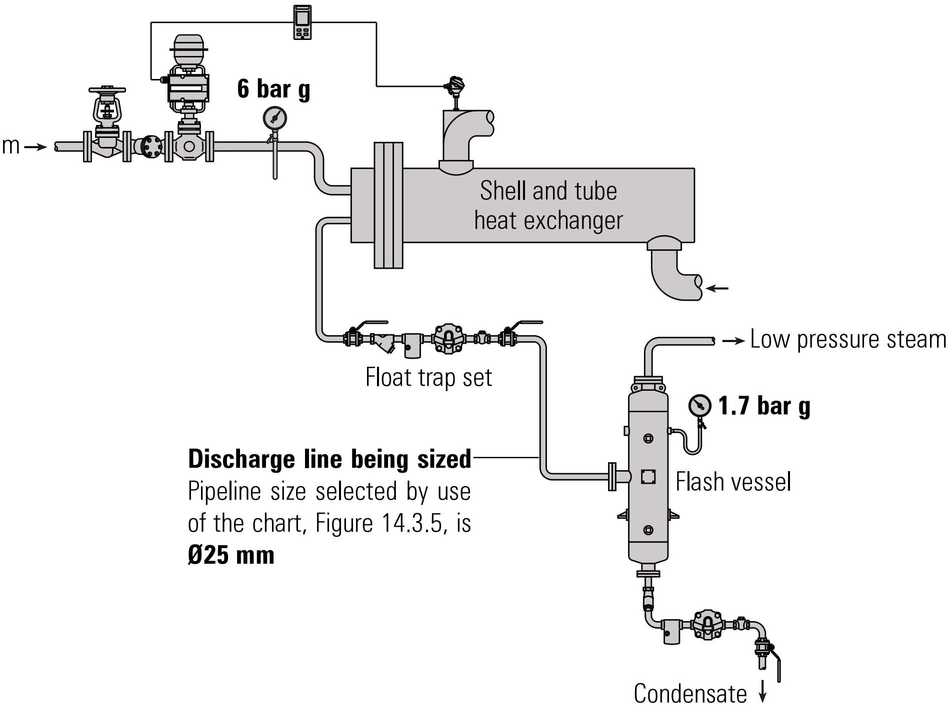


Fig. 14.3.6 A non-flooded pressurised trap discharge line (refer to Example 14.3.3)

Example 14.3.4 ❷ on the chart (Figure 14.3.7)

A steam trap passing a full-load of 1 000 kg/h at 18 bar g saturated steam pressure through a discharge line rising 5 m up to a pressurised condensate return line at 3.5 bar g.

Add the 0.5 bar static pressure (5 m head) to the 3.5 bar condensate pressure to give 4 bar g backpressure.

As the discharge line is rising and thus flooded, the upper figure of 32 mm is selected from the chart, (Figure 14.3.4).

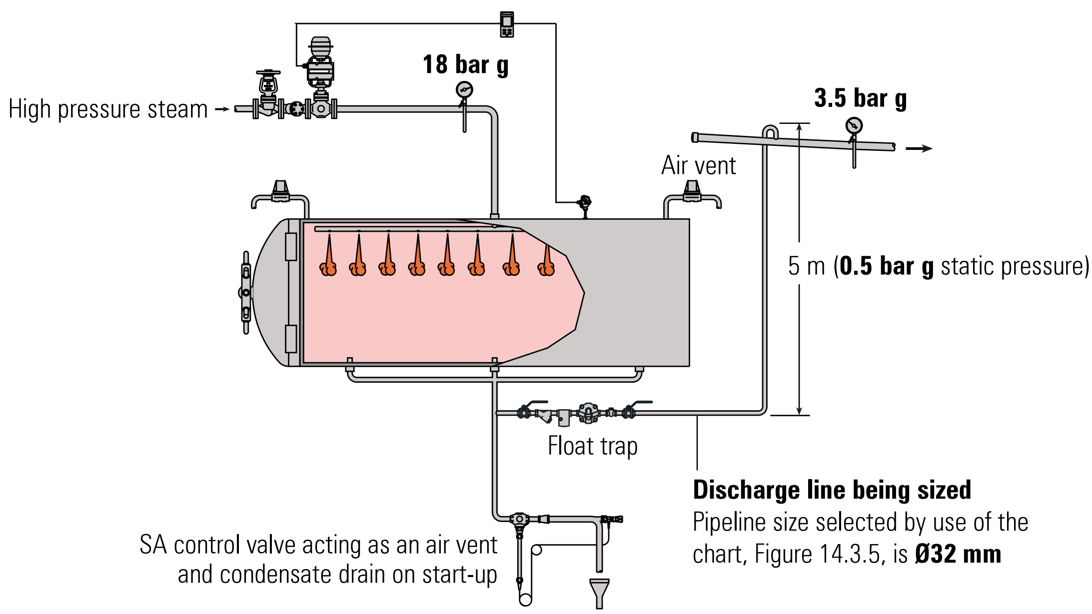


Fig. 14.3.7 A flooded trap discharge line (refer to Example 14.3.4)

Example 14.3.5 (3) on the chart (Figure 14.3.8)

A steam trap passing a full-load of 200 kg/h at 2 bar g saturated steam pressure through a sloping discharge line falling down to a vented condensate receiver at atmospheric pressure (0 bar g).

As the line is non-flooded, the lower figure of 20 mm is selected from the chart, (Figure 14.3.4).

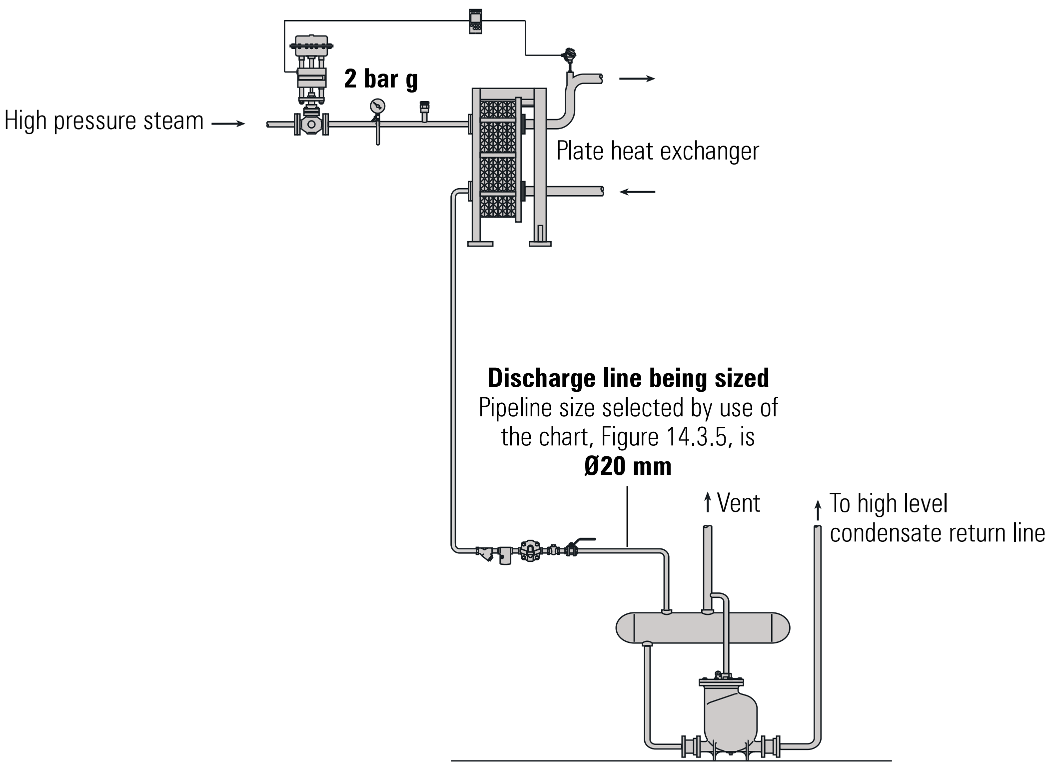


Fig. 14.3.8 A non-flooded vented trap discharge line (refer to Example 14.3.5)

Example 14.3.6 (4) on the chart (Figure 14.3.9)

A pump-trap passing a full-load of 200 kg/h at 4 bar g saturated steam space pressure through a discharge line rising 5 m up to a non-flooded condensate return line at atmospheric pressure.

The 5 m static pressure contributes the total backpressure of 0.5 bar g.

As the trap discharge line is rising, the upper figure of 25 mm is selected from the chart, (Figure 14.3.4).

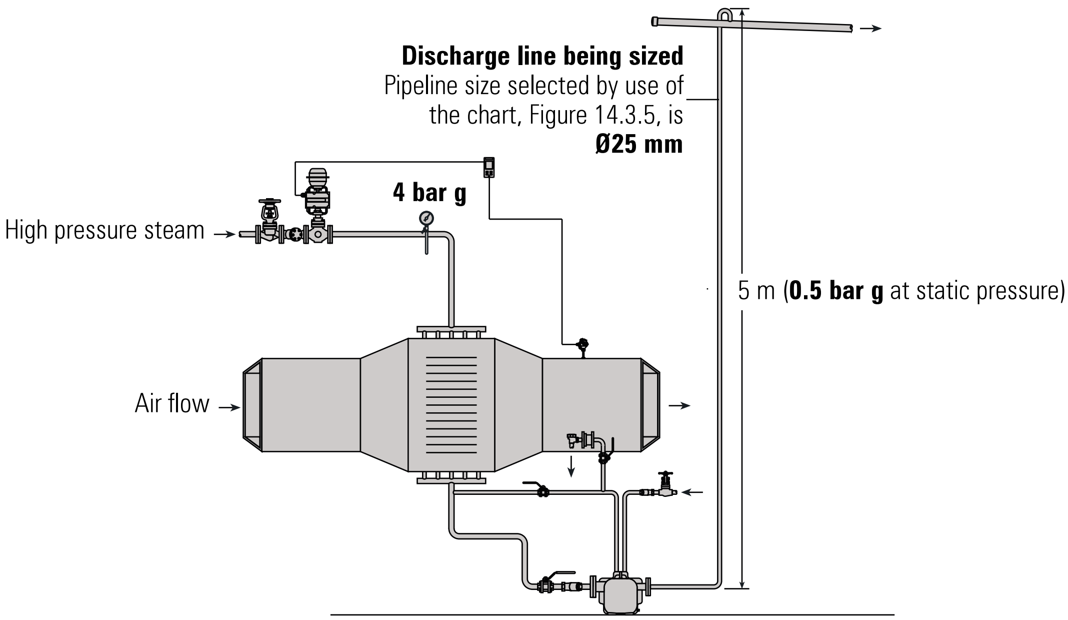


Fig. 14.3.9 A flooded trap discharge line (refer to Example 14.3.6)

Example 14.3.7 5 on the chart (Figure 14.3.10)

Consider a condensate load of 200 kg/h to a receiver and pump. The pump discharge rate for this mechanical type pump is taken as six times the filling rate, hence, the condensate rate taken for this example is 6 x 200 = 1 200 kg/h.

Because the condensate will have lost its flash steam content to atmosphere via the receiver vent, the pump will only be pumping liquid condensate. In this instance, it is only necessary to use the top part of the chart in Figure 14.3.5. As the line from the pump is rising, the upper figure of 25 mm is chosen.

Note: If the pumped line were longer than 100 m, the next larger size must be taken, which for this example would be 32 mm. A useful tip for lines of 100 m or less is to choose a discharge pipe which is the same size as the pump. For further details refer to Module 14.1 'Pumping condensate from vented receivers'.

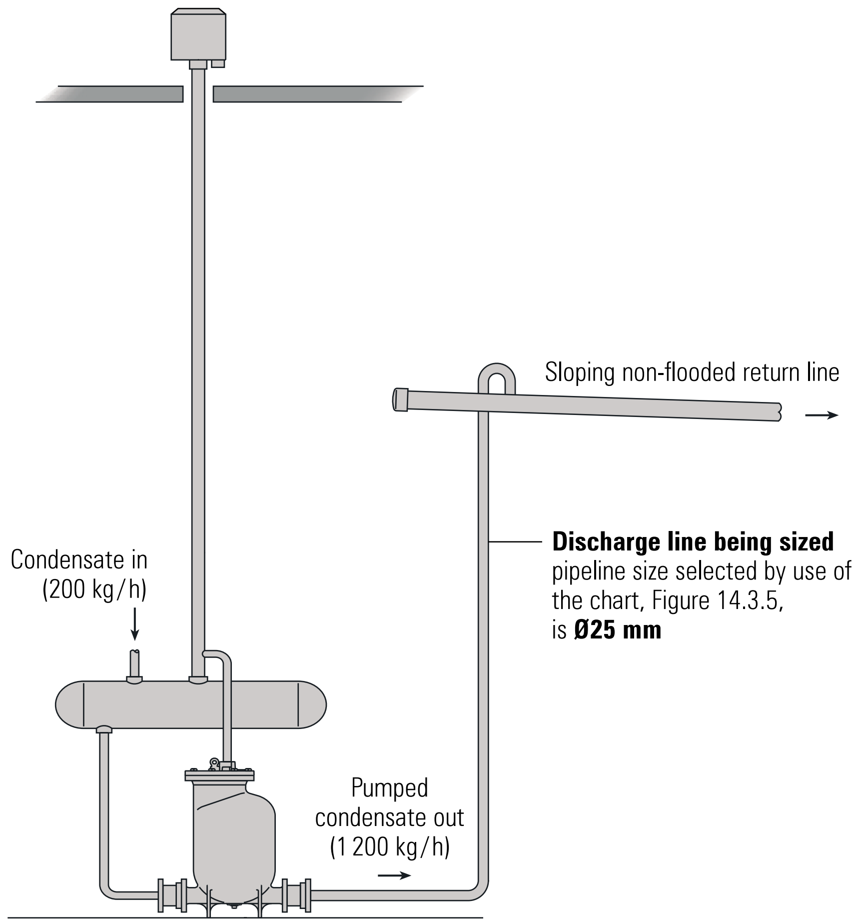


Fig. 14.3.10 A discharge line from the condensate pump (refer to Example 14.3.7)

Common return lines - falling lines

It is sometimes necessary to connect several trap discharge lines from separate processes into a common return line. Problems will not occur if the following considerations are met:

- The common line is not flooded and slopes in the direction of flow to an open end or a vented receiver, or a flash vessel if the conditions allow.
- The common line is sized on the cumulative sizes of the branch lines, and the branch lines are sized from Figure 14.3.5.

Example 14.3.8

Figure 14.3.11 shows three heat exchangers, each separately controlled and operating at the same time. The condensate loads shown are full loads and occur with 3 bar g in the steam space.

The common line slopes down to the flash vessel at 1.5 bar g, situated in the same plant room. Condensate in the flash vessel falls via a float trap down to a vented receiver, from where it is pumped directly to the boiler house.

The trap discharge lines are sized on full-load with steam pressure at 3 bar g and condensate pressure of 1.5 bar g, and as each is not flooded, the lower line sizes are picked from the graph.

Determine the condensate line sizes for the falling discharge lines and common lines.

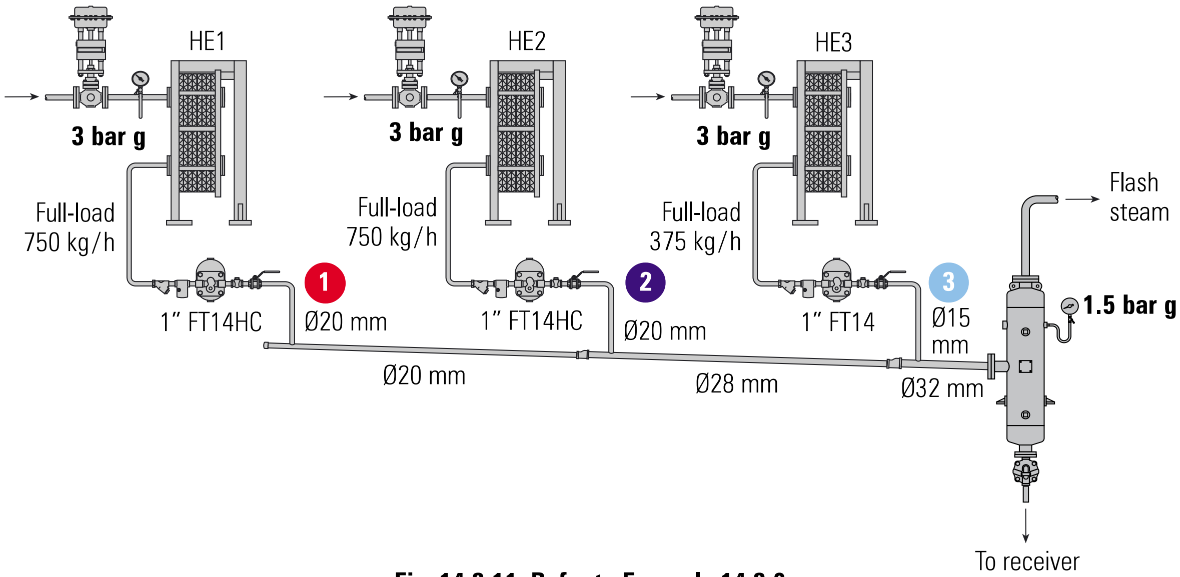


Fig. 14.3.11 Refer to Example 14.3.8

Using Appendix 14.3.2, Condensate pipe sizing chart:

Line (1) picked as 20 mm, (2) picked as 20 mm, (3) picked as 15 mm

The bore of the common line connecting two discharge lines can be found by calculating the square root of the sum of the squares of the bores of the two discharge lines, as shown below:

Common line for (1) + (2), $= \sqrt{20^2 + 20^2} = 28$ mm : Pick a DN25 pipe (see note below)

Common line for ((1) + (2))+ (3) $= \sqrt{28^2 + 15^2} = 32$ mm : Pick a DN32 pipe

Note: The theoretical dimension of 28 mm for the common line (1) + (2) does not exist as a nominal bore in commercial pipe sizes. The internal diameters of pipes can be larger or smaller than the nominal bore depending on the pipe schedule. For example, for a DIN 2448 steel pipe, the internal diameter for a 25 mm pipe is about 28.5 mm, while that for a 25 mm Schedule 40 pipe is about 26.6 mm.

Where the calculated bore is not much greater than the nominal bore, it is practical to choose the next lower size pipe. In this instance, a nominal bore 25 mm pipe may be selected. If, however, the calculated bore is not near the nominal bore, then the next larger nominal bore pipe should be selected. Common sense should be applied.

Common return lines - rising lines

It is sometimes unavoidable for condensate discharge and common lines to rise at some point between the trap and the point of final termination. When this is the case, each discharge line is sized by moving up to the next size on the chart, as previously discussed in this Module.

Example 14.3.9

Figure 14.3.12 shows the same three heat exchangers as in Example 14.3.8.

However, in this instance, the common line rises 15 m and terminates in an overhead non-flooded condensate return main, giving the same backpressure of 1.5 bar as in Example 14.3.8. Each of the discharge lines is sized as a rising line.

Determine the condensate line sizes for the discharge lines and common lines.

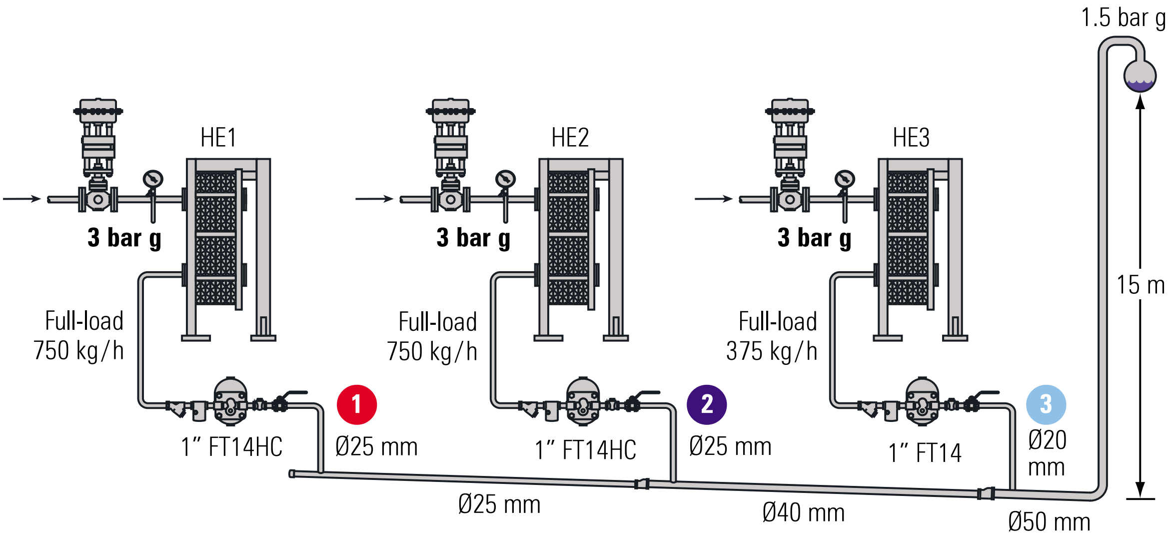


Fig. 14.3.12 Refer to Example 14.3.9

Using Appendix 14.3.2, Condensate pipe sizing chart:

Line (1) picked as 25 mm, (2) picked as 25 mm, (3) picked as 20 mm

Because the common line is rising, it can be seen that each of the discharge lines is a size larger than in Example 14.3.8 even though the backpressure is the same at 1.5 bar g.

The bore of the common line connecting two discharge lines can be found by calculating the square root of the sum of the squares of the bores of the two discharge lines, as shown below:

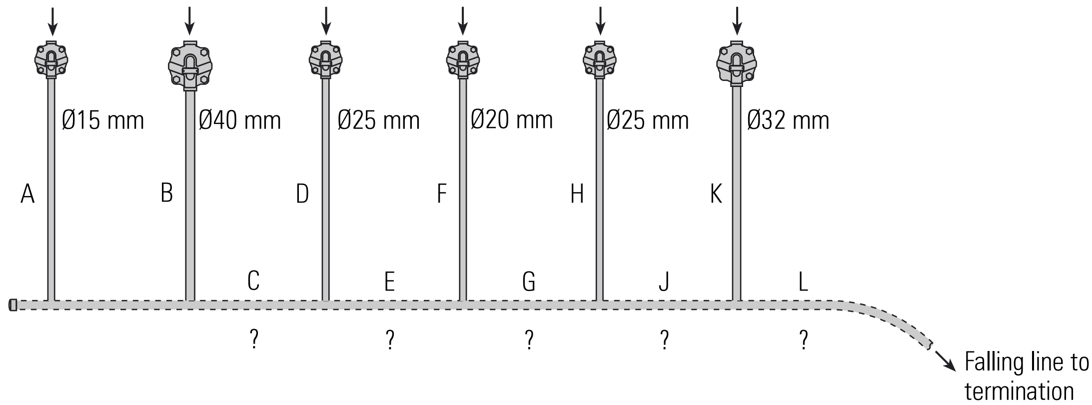
Common line for (1) + (2), $= \sqrt{25^2 + 25^2} = 36$ mm : Pick a DN40 pipe

Common line for ((1) + (2))+ (3) $= \sqrt{36^2 + 20^2} = 42$ mm : Pick a DN50 pipe

Note: For rising lines, the chosen nominal bore pipe should always be larger than the calculated bore.

Example 14.3.10 - Falling common line

Calculating the common line sizes for the application shown in Fig. 14.3.12 which falls to a final termination point:



Line	Pipeline diameter (mm)	Commercial pipe size selected (DN)
A	15	
B	40	
C	$\sqrt{40^2+15^2} = 43$*	40*
D	25	
E	$\sqrt{25^2+43^2} = 50$	50
F	20	
G	$\sqrt{20^2+50^2} = 54$	65
H	25	
J	$\sqrt{25^2+54^2} = 60$	65
K	32	
L	$\sqrt{32^2+60^2} = 68$*	65*

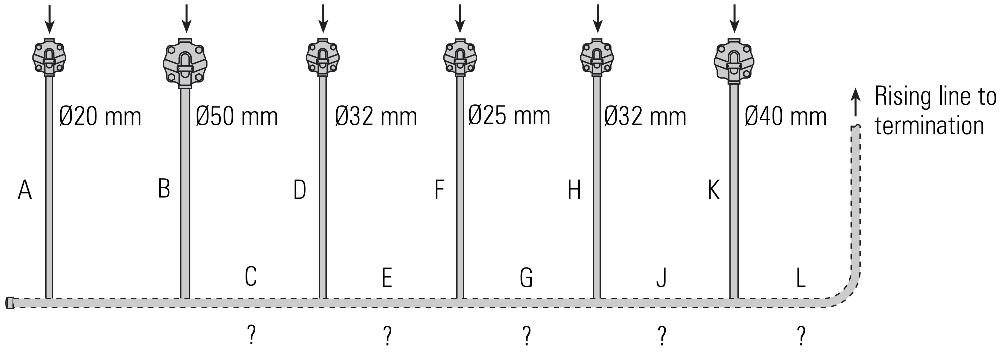
Fig. 14.3.13

*Close to nominal bore size

Example 14.3.11 - Rising common line

Calculating the common line sizes for the application shown in Fig. 14.3.14 which rises to a final termination point:

Note that the steam loads are the same as Example 14.3.10, but the discharge lines are one size larger due to the rising common line.



Line	Pipeline diameter (mm)	Commercial pipe size selected (DN)
A	20	
B	50	
C	$\sqrt{50^2+20^2} = 54$*	50*
D	32	
E	$\sqrt{32^2+54^2} = 63$	65
F	25	
G	$\sqrt{25^2+63^2} = 68$*	65*
H	32	
J	$\sqrt{32^2+68^2} = 75$	80
K	40	
L	$\sqrt{40^2+75^2} = 85$*	80*

Fig. 14.3.14 *Close to nominal bore size

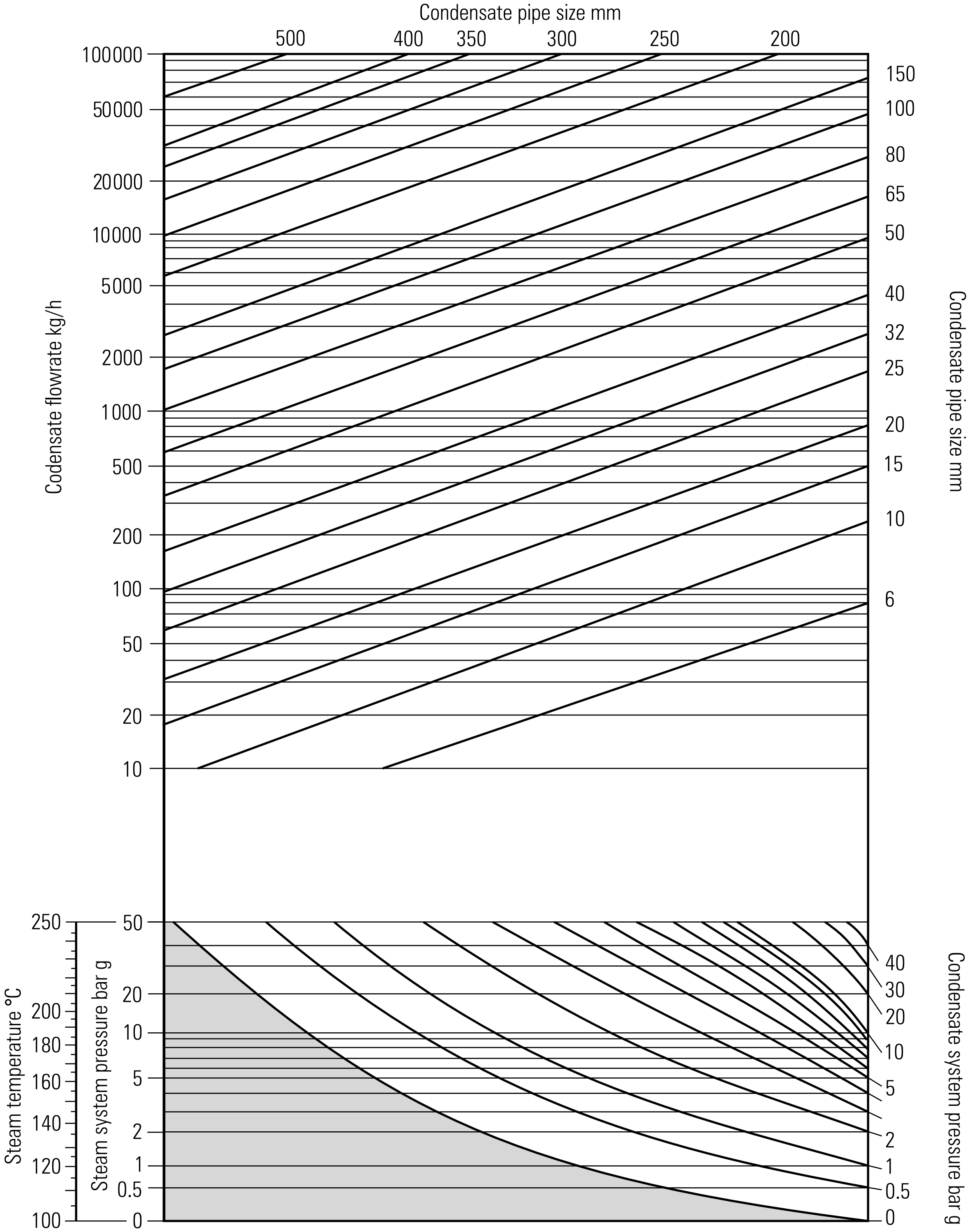
The procedure shown in Examples 14.3.10 and 14.3.11 can be simplified by using Appendix 14.3.3.

For example, where pipes A and B (20 mm and 50 mm) join, the minimum required pipe diameter is shown as 54 mm. Clearly, the user would fit the next largest size of commercial pipe available, unless the calculated bore is close to a nominal bore size pipe.

Appendix 14.3.1 Flow of water in heavy steel pipes

Flowrate		kg/h									
Pipe size Ø		**15 mm**	**20 mm**	**25 mm**	**32 mm**	**40 mm**	**50 mm**	**65 mm**	**80 mm**	**100 mm**	
Pa/m	**mbar/m**	**<0.15 m/s**			**0.15 m/s**					**0.3 m/s**	
10.0	**0.100**	50	119	223	490	756	1 447	2 966	4 644	9 432	
12.5	**0.125**	58	133	252	554	853	1 634	3 348	5 220	10 656	
15.0	**0.150**	65	151	277	616	943	1 807	3 708	5 760	11 736	
17.5	**0.175**	68	162	302	670	1 026	1 966	4 032	6 264	12 744	
20.0	**0.200**	76	176	328	720	1 105	2 113	4 320	6 732	13 680	
22.5	**0.225**	79	187	349	770	1 177	2 254	4 608	7 164	14 580	**0.5**
25.0	**0.250**	83	198	371	814	1 249	2 387	4 860	7 596	15 408	**m/s**
27.5	**0.275**	90	209	389	857	1 314	2 513	5 112	7 992	16 200	
30.0	**0.300**	94	220	410	900	1 379	2 632	5 364	8 352	16 956	
32.5	**0.325**	97	230	428	940	1 440	2 747	5 616	8 712	17 712	
35.0	**0.350**	101	241	446	979	1 498	2 858	5 832	9 072	18 432	
37.5	**0.375**	104	248	464	1 015	1 555	2 966	6 048	9 396	19 116	
40.0	**0.400**	112	259	479	1 051	1 609	3 071	6 264	9 720	19 764	
42.5	**0.425**	115	266	497	1 087	1 663	3 175	6 480	10 044	20 412	
45.0	**0.450**	119	277	511	1 123	1 717	3 272	6 660	10 368	21 024	
47.5	**0.475**	122	284	526	1 156	1 768	3 370	6 876	10 656	21 636	
50.0	**0.500**	126	292	540	1 188	1 814	3 463	7 056	10 944	22 212	
52.5	**0.525**	130	299	558	1 220	1 865	3 553	7 236	11 232	22 788	
55.0	**0.550**	130	306	572	1 249	1 912	3 636	7 416	11 520	23 364	
57.5	**0.575**	133	317	583	1 282	1 958	3 744	7 596	11 808	23 904	
60.0	**0.600**	137	324	598	1 310	2 002	3 816	7 776	12 060	24 444	
62.5	**0.625**	140	331	612	1 339	2 048	3 888	7 920	12 312	24 984	
65.0	**0.650**	144	338	626	1 368	2 092	3 996	8 100	12 600	25 488	
67.5	**0.675**	148	346	637	1 397	2 131	4 068	8 280	12 852	25 992	
70.0	**0.700**	151	353	652	1 422	2 174	4 140	8 424	13 068	26 496	
72.5	**0.725**	151	356	662	1 451	2 218	4 212	8 568	13 320	27 000	
75.0	**0.750**	155	364	677	1 476	2 257	4 284	8 748	13 572	27 468	
77.5	**0.775**	158	371	688	1 505	2 297	4 356	8 892	13 788	27 972	
80.0	**0.800**	162	378	698	1 530	2 336	4 464	9 036	14 040	28 440	**1**
82.5	**0.825**	166	385	709	1 555	2 372	4 536	9 180	14 256	28 872	**m/s**
85.0	**0.850**	166	389	724	1 580	2 412	4 608	9 324	14 472	29 340	
87.5	**0.875**	169	396	734	1 606	2 448	4 680	9 468	14 724	29 772	
90.0	**0.900**	173	403	745	1 627	2 488	4 716	9 612	14 940	30 240	
92.5	**0.925**	176	407	756	1 652	2 524	4 788	9 756	15 156	30 672	
95.0	**0.950**	176	414	767	1 678	2 560	4 860	9 900	15 372	31 104	
97.5	**0.975**	180	421	778	1 699	2 596	4 932	10 044	15 552	31 500	
100.0	**1.000**	184	425	788	1 724	2 632	5 004	10 152	15 768	31 932	
120.0	**1.200**	202	472	871	1 897	2 898	5 508	11 196	17 352	35 100	
140.0	**1.400**	220	511	943	2 059	3 143	5 976	12 132	18 792	38 160	
160.0	**1.600**	234	547	1 015	2 210	3 373	6 408	12 996	20 160	40 680	
180.0	**1.800**	252	583	1 080	2 354	3 589	6 804	13 824	21 420	43 200	**1.5**
200.0	**2.000**	266	619	1 141	2 488	3 780	7 200	14 580	22 644	45 720	**m/s**
220.0	**2.200**	281	652	1 202	2 617	3 996	7 560	15 336	23 760	47 880	
240.0	**2.400**	288	680	1 256	2 740	4 176	7 920	16 056	24 876	50 400	
260.0	**2.600**	306	713	1 310	2 855	4 356	8 244	16 740	25 920	52 200	
280.0	**2.800**	317	742	1 364	2 970	4 536	8 568	17 388	26 928	54 360	
300.0	**3.000**	331	767	1 415	3 078	4 680	8 892	18 000	27 900	56 160	

Appendix 14.3.2 Condensate pipe sizing chart



Appendix 14.3.3 Common pipe sizing table

D1 = Connecting branch size (N.B.)
D2 = Common pipe size

D2	D1 - Connecting branch size (NB)								
	15	**20**	**25**	**32**	**40**	**50**	**65**	**80**	**100**
15	21	25	29	35	43	52	67	81	101
16	22	26	30	36	43	52	67	82	101
17	23	26	30	36	43	53	67	82	101
18	23	27	31	37	44	53	67	82	102
19	24	28	31	37	44	53	68	82	102
20	25	28	32	38	45	54	68	82	102
21	26	29	33	38	45	54	68	83	102
22	27	30	33	39	46	55	69	83	102
23	27	30	34	39	46	55	69	83	103
24	28	31	35	40	47	55	69	84	103
25	29	32	35	41	47	56	70	84	103
26	30	33	36	41	48	56	70	84	103
27	31	34	37	42	48	57	70	84	104
28	32	34	38	43	49	57	71	85	104
29	33	35	38	43	49	58	71	85	104
30	34	36	39	44	50	58	72	85	104
31	34	37	40	45	51	59	72	86	105
32	35	38	41	45	51	59	72	86	105
33	36	39	41	46	52	60	73	87	105
34	37	39	42	47	52	60	73	87	106
35	38	40	43	47	53	61	74	87	106
36	39	41	44	48	54	62	74	88	106
37	40	42	45	49	54	62	75	88	107
38	41	43	45	50	55	63	75	89	107
39	42	44	46	50	56	63	76	89	107
40	43	45	47	51	57	64	76	89	108
41	44	46	48	52	57	65	77	90	108
42	45	47	49	53	58	65	77	90	108
43	46	47	50	54	59	66	78	91	109
44	46	48	51	54	59	67	78	91	109
45	47	49	51	55	60	67	79	92	110
46	48	50	52	56	61	68	80	92	110
47	49	51	53	57	62	69	80	93	110
48	50	52	54	58	62	69	81	93	111
49	51	53	55	59	63	70	81	94	111
50	52	54	56	59	64	71	82	94	112
51	53	55	57	60	65	71	83	95	112
52	54	56	58	61	66	72	83	95	113
53	55	57	59	62	66	73	84	96	113
54	56	58	60	63	67	74	85	97	114
55	57	59	60	64	68	74	85	97	114
56	58	59	61	64	69	75	86	98	115
57	59	60	62	65	70	76	86	98	115

D2	D1 - Connecting branch size (NB)								
	15	**20**	**25**	**32**	**40**	**50**	**65**	**80**	**100**
58	60	61	63	66	70	77	87	99	116
59	61	62	64	67	71	77	88	99	116
60	62	63	65	68	72	78	88	100	117
61	63	64	66	69	73	79	89	101	117
62	64	65	67	70	74	80	90	101	118
63	65	66	68	71	75	80	91	102	118
64	66	67	69	72	75	81	91	102	119
65	67	68	70	72	76	82	92	103	119
66	68	69	71	73	77	83	93	104	120
67	69	70	72	74	78	84	93	104	120
68	70	71	72	75	79	84	94	105	121
69	71	72	73	76	80	85	95	106	121
70	72	73	74	77	81	86	96	106	122
71	73	74	75	78	81	87	96	107	123
72	74	75	76	79	82	88	97	108	123
73	75	76	77	80	83	88	98	108	124
74	76	77	78	81	84	89	98	109	124
75	76	78	79	82	85	90	99	110	125
76	77	79	80	82	86	91	100	110	126
77	78	80	81	83	87	92	101	111	126
78	79	81	82	84	88	93	102	112	127
79	80	81	83	85	89	93	102	112	127
80	81	82	84	86	89	94	103	113	128
81	82	83	85	87	90	95	104	114	129
82	83	84	86	88	91	96	105	115	129
83	84	85	87	89	92	97	105	115	130
84	85	86	88	90	93	98	106	116	131
85	86	87	89	91	94	99	107	117	131
86	87	88	90	92	95	99	108	117	132
87	88	89	91	93	96	100	109	118	133
88	89	90	91	94	97	101	109	119	133
89	90	91	92	95	98	102	110	120	134
90	91	92	93	96	98	103	111	120	135
91	92	93	94	96	99	104	112	121	135
92	93	94	95	97	100	105	113	122	136
93	94	95	96	98	101	106	113	123	137
94	95	96	97	99	102	106	114	123	137
95	96	97	98	100	103	107	115	124	138
96	97	98	99	101	104	108	116	125	139
97	98	99	100	102	105	109	117	126	139
98	99	100	101	103	106	110	118	127	140
99	100	101	102	104	107	111	118	127	141
100	101	102	103	105	108	112	119	128	141

Questions

1. As a simple rule, what can condensate drain lines be sized on?

a| The plant condensate outlet connection ☐
b| The plant steam inlet connection ☐
c| The trap inlet connection with the correct sized trap ☐
d| It is unimportant to size drain lines correctly ☐

2. For steam mains and constant pressure processes, how is start load estimated?

a| Twice the running load at the rated pressure ☐
b| Three times the running load at a third of the rated pressure ☐
c| Ten times the running load at half the rated pressure ☐
d| The running load at twice the rated pressure ☐

3. On which pressure loss should drain lines be sized?

a| 100 Pa/m ☐
b| They need only be sized on velocity ☐
c| 200 Pa/m ☐
d| 200 Pa/m for lines less than 10 m and 100 Pa/m for lines over 10 m ☐

4. What is the major factor that influences the size of the trap discharge lines?

a| The size of the trap ☐
b| The size of the drain line ☐
c| The amount of flash steam produced in the discharge line ☐
d| The amount of condensate flowing ☐

5. Using Appendix 14.3.1, which size of drain line 1.5 m long should be chosen for a constant pressure process with a maximum running load of 450 kg/h?

a| 20 mm ☐
b| 32 mm ☐
c| 25 mm ☐
d| 15 mm ☐

6. Three discharge lines 25 mm, 50 mm, 65 mm are to branch into a common line discharging into a vented receiver. What should be the nominal size of the common line into the receiver?

a| 100 mm ☐
b| 80 mm ☐
c| 65 mm ☐
d| 50 mm ☐

Answers

1: c, 2: a, 3: d, 4: c, 5: a, 6: a