Steam Curing

First, an overview of how much volume of vapour or steam is required to cure efficiently with steam.

Anwendungsbereiche von Dampferzeugern
Application Areas of Steam Generators

Picture 1

Angaben beruhen auf theoretische Berechnungen und Erfahrungen / *Indications made by theoretical calculations and experience*

Dampftemperatur 100°C / 1bar *Steam temperature 100°C / 1bar*		Dampferzeuger Leistung kg/h *Steam GenertorPower kg/h*										
		3 kg/h	6 kg/h	50 kg/h	150 kg/h	200 kg/h	300 kg/h	400 kg/h	500 kg/h	600 kg/h	700 kg/h	800 kg/h
Benötigte Luftmenge (m³/min) *Necessary quantity of air (m³/min)*		0,06	0,12	1,00	3,00	4,00	6,00	8,00	10,00	12,00	14,00	16,00
Benötigte Luftmenge (Liter/min) *Necessary quantity of air (Liter/min)*		60	120	1000	3000	4000	6000	8000	10000	12000	14000	16000
Diameter (mm)	100	3,2 m	6,4 m	53 m	159 m	212 m	318 m	425 m	531 m	637 m	743 m	849 m
	125	2,5 m	5,1 m	42 m	127 m	170 m	255 m	340 m	425 m	510 m	594 m	679 m
	150	2,1 m	4,2 m	35 m	106 m	142 m	212 m	283 m	354 m	425 m	495 m	566 m
	200	1,6 m	3,2 m	27 m	80 m	106 m	159 m	212 m	265 m	316 m	372 m	425 m
	225	1,4 m	2,8 m	24 m	71 m	94 m	142 m	189 m	236 m	283 m	330 m	377 m
	250	1,3 m	2,5 m	21 m	64 m	85 m	127 m	170 m	212 m	255 m	297 m	340 m
	300	1,1 m	2,1 m	18 m	53 m	71 m	106 m	142 m	177 m	212 m	248 m	283 m
	350	0,9 m	1,8 m	15 m	45 m	61 m	91 m	121 m	152 m	182 m	212 m	243 m
	400	0,8 m	1,6 m	13 m	40 m	53 m	80 m	106 m	133 m	159 m	186 m	212 m
	450	0,7 m	1,4 m	12 m	35 m	47 m	71 m	94 m	118 m	142 m	165 m	189 m
	500	0,6 m	1,3 m	11 m	32 m	42 m	64 m	85 m	106 m	127 m	149 m	170 m
	550	0,6 m	1,2 m	10 m	29 m	39 m	58 m	77 m	97 m	116 m	135 m	154 m
	600	0,5 m	1,1 m	8,8 m	27 m	35 m	53 m	71 m	86 m	106 m	124 m	142 m
	650	0,5 m	1,0 m	8,2 m	24 m	33 m	49 m	65 m	82 m	98 m	114 m	131 m
	700	0,5 m	0,9 m	7,6 m	23 m	30 m	45 m	61 m	76 m	91 m	106 m	121 m
	800	0,4 m	0,8 m	6,6 m	20 m	27 m	40 m	53 m	66 m	80 m	93 m	106 m
	900	0,4 m	0,7 m	5,9 m	18 m	24 m	35 m	47 m	59 m	71 m	83 m	94 m
	1000	0,3 m	0,6 m	5,3 m	16 m	21 m	32 m	42 m	53 m	64 m	74 m	85 m
	1100	0,3 m	0,6 m	4,8 m	14 m	19 m	29 m	39 m	48 m	58 m	68 m	77 m
	1200	0,3 m	0,5 m	4,4 m	13 m	18 m	27 m	35 m	44 m	53 m	62 m	71 m

Benötigte Dampfmenge für 1 m² Lineroberfläche = 3 kg/h. Benötigte Luftmenge für 1 kg/h Dampf = 0,02 m³/min
Steam volume required for 1 m² Linersurfuace = 3 kg/h. Air volume required for 1kg/h steam = 0,02 m³/min

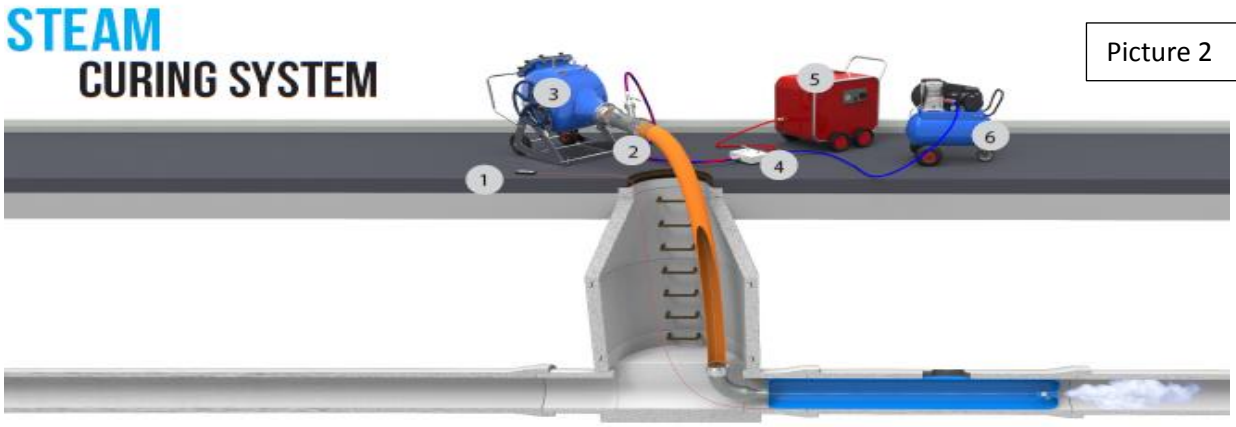
Now you have to be clear about the fact that steam is not particularly easy to spread. It's also not easy to regulate the temperature. For this reason we are mixing cold air to transport the steam and also to regulate the temperature.

Therefore, in the table (Picture 1) is described which air volume is required.

Basically, the compressor should generate as much volume as you need to supply the liner without add steam, with the necessary curing pressure, when the exhaust valve is fully opened.

The setup for steam curing is as follows:

Picture 2



Item	system
1	temperature wire
2	steam adapter
3	inversion drum
4	air/steam mixer
5	sanikom steam unit
6	air compressor

The steam outlet valve is at the end of the liner. The so-called valve may be a simple cut in the liner, or even tapered tube with a connection for a ball valve and hose.

The diameter or the opening of the steam outlet should be at least the following diameter.

(Picture 3):

Querschnitt Dampf Auslass / *diameter vapor outlet*		
DN	100	10-15mm
DN	125	15mm
DN	150	20mm
DN	200	25mm
DN	250	30mm
DN	300	30-35mm
DN	400	35-40mm
DN	500	40-45mm
DN	600	50mm

Picture 3

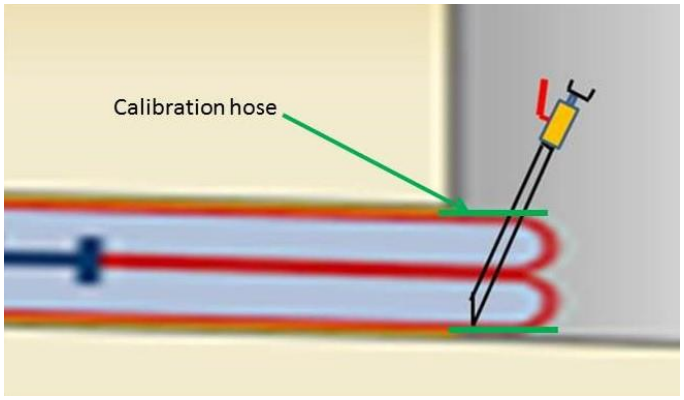
Ideally, you should be able to regulate the steam outlet. Therefore, it is recommended a pipe with the appropriate diameter to use to connect a hose with ball valve or directly with ball valve.

See picture 4:

Picture 4

The steam outlet lance is drilled in to the liner end and pushed down to the bottom of the liner. (See picture 5)

The steam outlet pipe is also used as condensate outlet! It can accumulate condensation in the liner, bcs, condensate influences the curing process of the Liner.



Picture 5

Temperature Measurement

The temperature is always measured at the liner start point and possibly also at the end of liner. For this purpose it is necessary to use a temperature gauge with measuring wire. The respective measuring wire is about 15-20cm inserted into the Pipe (in the bottom, below). The temperature must always be measured between the liner and the pipe wall.

Liner Protection

It is always important to ensure that the liner is protected from overstretching outside the pipe, by a suitable calibration hose (best is to use a double layer). Failure to do so may cause the liner to burst or cause unwanted vapour leakage.

Steam curing process

For curing you open the steam outlet to about 75%, providing the liner with cold compressed air and keeps the pressure in the liner uniformly prescribed at the curing pressure of each liner.

Now we start with the addition of steam. At the same time reducing the amount of cold air. But always hold the curing pressure in a stabilized level.

The more steam is added, the less cool air is required. The heating-up phase should be done slowly and continuously and not above 60°C. Consider to measure 60°C between the liner and the pipe wall, it takes about 80°C vapour / air mixture.

You have to monitor constantly and document the temperatures at all measuring points of liner.

If the temperature at the end of the liner will not rise as desired, it is because that the steam does not have enough speed to carry the temperature up to the liner end. To create this effect, I must open the steam outlet a little more… carefully. In the same way increase the amount of air from the compressor (cold air). In order to keep the temperature at the desired level, the amount of steam must also be increased ... all this while maintaining the same curing pressure.

Ideally, I measure the same temperature at the start point and the liner end.

If the temperature at the liner end is higher than the start point, the flow rate is too high. For this purpose, the steam outlet slightly reduce and in accordance with the steam and cold air intake reduce.

Keep 60°C for about 15 to 20 minutes and then raise the temperature.

In order to achieve the desired curing temperature, it should be slowly increase the amount of steam and at the same time reduce cold air.

The desired curing temperature and curing time as specified by the resin manufacturer.

As soon as the liner is fully cured, the cool-down phase is initiated. For this purpose, simply reduce the amount of steam and increase the cold air flow. **Watch out! ... Always maintaining the appropriate curing pressure!** The cooling should be up to the respective ambient temperature occur ... maintain this temperature then for about 20 minutes before the liner is made pressure less.

It is always important to ensure that the resulting condensate in curing process can escape. Because the condensate is significantly colder than the surrounding area. Should it not be possible to drain the condensate, the curing time will increase considerably. A small cut at the lowest point of the liner can escape the condensate.

Warning: if there a sacking be present in the pipe, the condensate accumulates in this area. Curing will be significantly slower than in the remaining region. The curing time must be extended accordingly.

The steam curing is not suitable for pipes with strong infiltration or with sacking (sink in the line system)!

We would recommend hot water curing!