Application Note

Nessie® Wood Concept
Design of NWC and Nozzles for Wood Drying

When designing systems for wood drying, some specific items have to be taken into account both in relation to kiln and wood type but also in relation to the water hydraulic system. It is crucial to have systems that can operate for long periods without any maintenance and service. The Danfoss concept for lumber drying is a system ensuring long service life, no maintenance and a system made on basis of high pressure water hydraulic regulation.

The crucial element of the Nessie® high pressure water humidification unit is extreme fast steam generation. In fact, the range of droplets before steam generation is extremely shorter compared with traditional low pressure systems. Combined with drop sizes 7 times smaller, the result is the most even and all-embracing evaporation in the market – greatly beneficial to the lumber drying process and product quality.

Behind this effect is not only the Nessie high pressure water humidification unit producing the requisite pressure and water dosage.
A vital part of the system is the nozzles distributing the water into the kiln. Nozzles have been a Danfoss speciality for decades. They are tailored for water application, and a filter mounted on the Nessie high-pressure water humidification unit ensures maximum life reducing service costs substantially.
The droplet size delivered depends exclusively on the nozzle pressure. High pressure causes smaller droplets, and smaller droplets mean faster steam generation.
For even and far-reaching atomization of the water, relatively many nozzles with smaller capacity are superior to few nozzles with large capacity. However, the number of nozzles is greatly dependent on the design of the kiln concerned.

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1. Nozzles

1.1 Nozzle data and adapters

Nozzle data

All nozzles available are made in AISI stainless steel 304 or 316 with an outer thread of M13x1.
The nozzle must be made of stainless steel due to the harsh environment in the drying kilns.

Danfoss nozzles:

Liter per min.	Liter per hour	US Gallon per min	US Gallon per hour	Spray angle	Max. pressure	Ordering code
0.182	10.92	0.048	2.88	60º	*100 bar*	*TBA**
0.208	17.04	0.075	4.5	60º	*100 bar*	*TBA**
0.42	25.2	0.11	6.6	60º	130 bar	180Z1910
0.92	55.2	0.24	14.4	60º	130 bar	180Z1915
1.25	75.0	0.33	19.8	60º	130 bar	180Z1918
2.17	130	0.70	42.0	60º	130 bar	180z1924
2.87	172	0.76	45.6	60º	130 bar	180Z1926
3.13	188	0.83	49.8	60º	130 bar	180Z1937
3.36	202	0.89	53.4	60º	130 bar	180Z1927
5.74	344	1.52	91.2	60º	130 bar	180Z1931
2.38	130	0.70	42.0	80º	130 bar	180Z2024

-Liters and gallons per min is measured at 100 bar.
-Ordering codes is for 10 pieces pack.
* Brass nozzle body with 9/16" 28 UNEF thread, to be advised

Adapters for nozzles:

Adaptor thread	Nozzle	Ordering code
G ¼"	M13 x 1	
G ¼"	9/16" 28 UNEF	180ZTBA *)
M12-L Press fitting	M13 x 1	180Z0009

*) To be advised

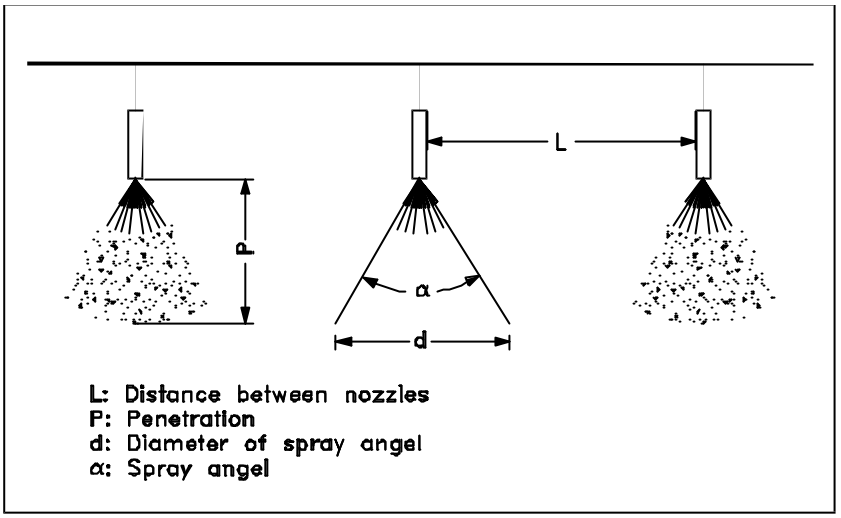
Other adapters are available on request.

1.2 Nozzle Location in Kiln

The relation between nozzle location and heating coils must be considered in order to obtain an even and homogeneous steam distribution. Spraying directly on the heating coils is not required to obtain evaporation, as the large water surface produced by the small droplets creates fast evaporation.

The nozzles must be placed right in the hot air stream being circulated by the fans and thus ensuring an evenly generated steam surface against the lumber pile.
A homogeneous steam surface against the lumber pile is achieved by placing the nozzles as close to the heating coils as possible and in all the longitudinal direction of the elements and thus the drying kiln.
The location of the nozzles in the longitudinal direction appears from below drawing.

Distance L between nozzles may be calculated on basis of the given parameters like P and d, where P is the penetration length of water and d is expressed in the cone diameter where all water is evaporated.
Under normal conditions where nozzles spray against or at right angels to the hot air stream, and the nozzles applied are low-capacity nozzles, the penetration length in which a total evaporation of the water is effected will be approx. 0.4 m.



At that distance and with a cone angle of 60 degrees, the cone diameter is approx. 1.4 m, and furthermore certain dispersion owing to air turbulence must be added. With a cone diameter of 1.4 m, a minimum distance between nozzles of approx. L = 1.5 meters is required.

2. Design of NWC and nozzles

The following parameters must be considered when dimensioning the capacity of unit and number of nozzles placed in the kiln:

- Number of kilns
- Water consumption
- Type of nozzle

2.1 Water consumption for NWC

Number of kilns to be operated depends on the minimum and maximum water consumption.
Below sheet states the max and min water consumption per type of NWC under normal conditions:

Capacity	NWC25-2	NWC25-4	NWC25-6.3	NWC25-10	NWC25-12.5	NWC50-25	NWC50-32
Max. L/hour	110	300	500	800	1050	2100	2700
Max. gpm	0.57	1.54	2.53	4.18	4.84	11.45	14.53
Min. L/hour	25	75	120	200	250	525	675
Min. gpm	0.14	0.39	0.63	1.05	1.21	2.86	3.63

2.2 Water consumption during heating and conditioning periods

Calculation of the exact water consumption is rather difficult, as the moisture content of the wood is depending on whether the wood is freshly sawn, if it is soft or hard wood and on the plank thickness. It is crucial to prevent the wood from being dried during the heating phase, i.e. the psychometric difference must be kept as low as possible, e.g. 1-2 ^{o} C/34-36 ^{o}F.

As a rule of thumb, minimum 2 – 3 litres of water per m^3 equal 1.24 – 1.87 gallon of water per 1000 bft. wood per hour are required during the heat and conditioning phase in a low temperature kiln of approx. 50 – 70 ^{o}C / 122 – 158 ^{o}F.

2.3 Sizing of NWC and Nozzles

With 240 litres/63 gallons as maximum water consumption per hour, the following NWC is to be selected:

NWC25-4 with maximum 300 litres/92 gallons per hour.

Optimum water evaporation in the hot air stream is achieved with the lowest capacity nozzle: 25/6.6 gallons per hour.

At 240 litres/63 gallons per hour, a total number of 10 nozzles is required.

The kiln length, however, is also a parameter to be considered, as the minimum distance between nozzles is approx. 1.5 m. Fewer nozzles may be possible by using the 55 litres/14.5 gallons nozzle per hour. Then only 4 – 5 nozzles are required.

3. Piping and Fittings

All pipes and fittings must be made of stainless steel to withstand the harsh environment in the kiln.

Following requirements are determinant for the pipe sizing:

- Water velocity in pipe
- Wall thickness and thus the pipe stiffness

The velocity of water inside pipe in water hydraulic systems must never exceed 7m/sec equal to 21ft/sec.

Recommended pipe type is M12 or ½" seemless stainless steel (AISI 304) hydraulic pipe

Pipe types must withstand working pressure of minimum 200 bar equal to 2800 psi.
A M12 / ½" has a normal working pressure of 200 bar equal to 2800 psi.
A 3-time safety margin is still obtained.

The bite type tube fitting also called press type fitting is fittings applicable for securing optimum performance in relation to tightness and stability.

4. Energy and Conversion Sheet

Required energy for evaporating cold water sprayed into the kiln is drawn from heating sources like coils and burners.

From below sheet the required energy for evaporating maximum water flow per NWC type appears.

Capacity	NWC25-2	NWC25-4	NWC25-6.3	NWC25-10	NWC25-12.5	NWC50-25	NWC50-32
KW=Kj/s	100	275	460	730	960	1920	2500
BTU/h	350,000	940,000	1,560,000	2,500,000	3,300,000	6,600,000	8,500,000

Above required energy are approx. values

Calculation criteria:

- Heating up water = 4,19 x (t_{Kiln} - $t_{water\ inlet}$) = kW.
- Evaporation of water = 0.7 kW per litre water.
- $t_{water\ inlet}$ set to 5 ^{o}C equal to 41 ^{o}F.
- t_{Kiln} set to 55 ^{o}C equal to 154 ^{o}F.

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