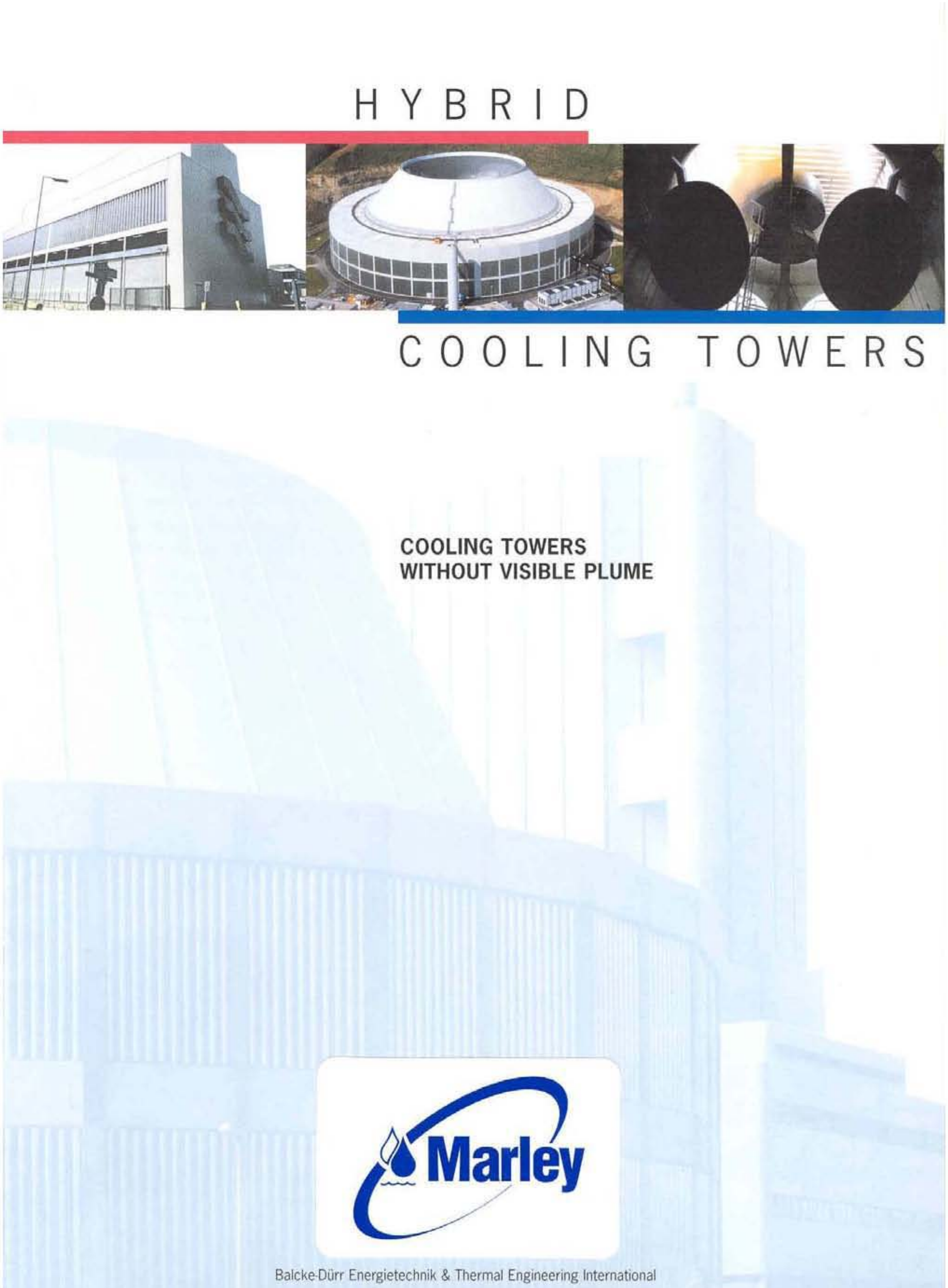
Attachment 1
Major Components; Vendor Data and Reference Information

1. Marley/Balcke-Durr; Hybrid Cooling Towers
2. Marley/Balcke-Durr Hybrid Tower; Data, Performance Curves, and Pricing
3. Balcke; GKN 2 Hybrid Tower
4. Johnston Pump; Circ Water Pumps Data and Performance Curves
5. Mercer Rubber; Expansion Joints
6. Northwest Pipe; AWWA Concrete Lined Pipe


HYBRID
COOLING TOWERS
COOLING TOWERS
WITHOUT VISIBLE PLUME
Marley
Balcke-Dürr Energietechnik & Thermal Engineering International

VISIBLE PLUME – AN AVOIDABLE PROBLEM

Every wet cooling tower generates a visible plume which can be very extensive particularly in cold and/or humid weather. It is the physical functioning principle of a wet cooling tower, in which the water to be cooled is essentially cooled by evaporating a small proportion thereof, which causes the plume. When it leaves the cooling tower, the visible plume therefore consists only of small water droplets and is normally neither dangerous nor environmentally hazardous.

Such plume can, however, lead to negative reactions such as:

- complaints and objections from local residents
- problems relating to acceptance and approval at plant locations
- corrosion and ice formation on components in the vicinity
- endangering of nearby traffic routes (roads and railways) in the case of larger cooling towers
- in the case of very large cooling towers a considerable amount of shadow is caused in the vicinity which can have negative effects, for example, on agricultural areas

Visible cooling tower plume in most cases harmless but nevertheless giving grounds for complaint, in particular in cold weather and when there are traffic routes in close proximity

This was the reason why Balcke-Dürr developed the concept of the "hybrid cooling tower" several decades ago. In principle this hybrid cooling tower is a wet cooling tower in which the plume is mixed with a dry, hot air stream prior to leaving the cooling tower. This air stream is generated in heat exchangers, the water to be cooled serving as the heating medium. No additional energy is therefore required to heat the air. The quantity of hot air added is such that the plume leaving the cooling tower is undersaturated and remains undersaturated even when it is mixed with the ambient air. Consequently it remains invisible.

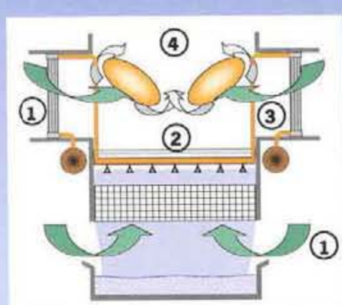
Normally, cooling with the plume being invisible is only possible when a dry cooling tower without evaporation is used. This involves, however, higher capital investment costs and the cold water temperature achieved are higher compared to those of a wet cooling tower.

Hybrid cooling towers of the Balcke-Dürr design are amongst the technically most advanced cooling towers of this type. To date we have built such towers exclusively as round structures which are best suited to the large flow rates of water to be cooled (please refer to pages 6/7). Some examples of our hybrid cooling towers are set out on the following pages.

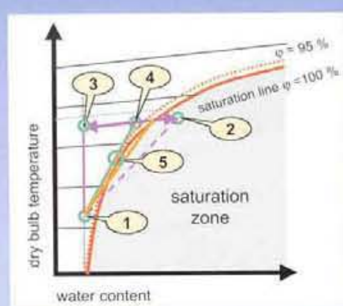
The problem: visible plume

The solution: Balcke-Dürr hybrid cooling tower

PHYSICAL FUNCTIONING PRINCIPLE OF A HYBRID COOLING TOWER:



Principle sketch of a hybrid cooling tower. The method of operation of a hybrid cooling tower is illustrated in the "Mollier h, x-diagram" on the right side.



1. Ambient air being fed to the cooling tower.
2. Plume leaving the cooling fill (the so-called wet section of the cooling tower). When emerging from purely wet cooling towers, this plume mixes with the ambient air. In this case the cooling tower plume mixes with the ambient air along the mixing line (dotted connecting line between 1 and 2).
3. Heated air stream leaving the dry section heat exchanger. The air is heated in the dry section at a constant level of humidity.
4. Mixed air streams from wet and dry sections. The air leaves the cooling tower in this state. The mixing line (green connecting line between 1 and 4) distinguishes the possible degrees to which the exhaust air is mixed with the ambient air.
5. Smallest distance between the mixing line and the saturation line (humidity of the air = 100 %) when the air leaving the hybrid cooling tower mixes with the ambient air. If the mixing line does not intersect or touch the saturation line, then no water condenses out. In this case the plume is not visible.

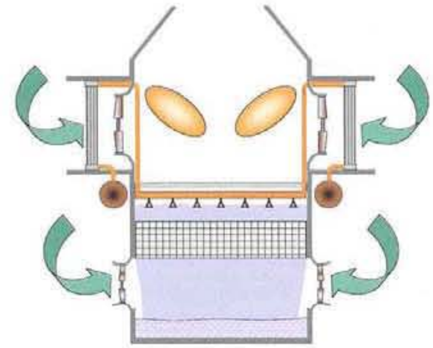
THE TOP CLASS – HYBRID COOLING TOWER OF A ROUND DESIGN

Balcke-Dürr hybrid cooling towers are the ideal solution for power stations and chemical plants in which large water flows need to be cooled. Recirculation and interference occur in large cell-type cooling towers, i.e. the hot cooling tower plume is sucked back into the air inlets. This significantly reduces the thermal performance of the cooling tower and additional cells would have to be built in order to compensate for the reduction in performance. Recirculation and interference problems are hardly ever experienced in round cooling towers due to their greater overall height.

A round hybrid cooling tower also requires less space than a large cell-type plant. Finally less piping is needed, as in round cooling towers only one hot water pipe leads to the cooling tower whilst in cell-type cooling towers one individual pipe has to be allocated to each cell.

Round hybrid cooling towers have separate forced draught fans in front of the wet and dry sections. Whilst the speed of the wet section fans is adjusted to ensure the required cooling water temperature, the appropriate speed adjustment of the dry section fans controls the required hot air flow rate for plume-free operation. Optimal, energy-saving process control can therefore be achieved in such cooling towers.

Another positive aspect is the architectural design of hybrid cooling towers.



Hybrid cooling tower with forced draught fans

Hybrid cooling towers of a round design equipped with sound attenuators for a combined heat and power station in Germany. (Fig. 1+2)

Round cooling tower for an Italian refinery. (Fig. 3)

Hybrid cooling tower of a round design equipped with sound attenuators for a German nuclear power plant – the definite world champion of its class. (Fig. 4)

Fig. 2

Fig. 3

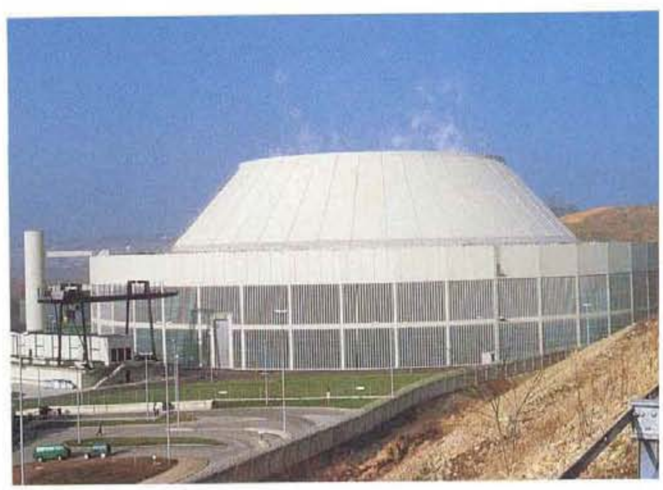


Fig. 4

Fig. 1