

Technical Sheet

A DIRECT CONTACT WATER HEATER WITH AN INTEGRATED WATER VAPOUR PUMP: A HIGHLY EFFICIENT AND ENVIRONMENTALLY FRIENDLY SOLUTION WELL SUITED FOR HYDRONIC HEATING APPLICATIONS

BACKGROUND

Since energy consumption is an important part of any annual budget, energy saving is a key objective for building owners and administrators. High efficient equipment is an optimal solution providing valuable annual savings.

In 1998, during the building construction of the **NEUFCHÂTEL PROFESSIONAL FORMATION CENTRE** (Quebec), it was decided to utilize a high efficiency direct contact water heater, to provide hydronic heating. Direct contact water

heating technology is based on the direct heat transfer between hot combustion gases from a natural gas burner and the water to be heated using a counter current heat exchanger in the form of a vertical packed column. This technology is well suited for this application, with its inherent high thermal efficiency.



“Ultra-High Efficiency” direct contact water heater installed at the Neufchâtel Professional Formation Centre

LIMITATIONS

A direct contact water heater is based on the counter current heat exchanger concept. The efficiency is based on the inlet water temperature, which will limit the temperature at which the combustion gases will leave the equipment. The inlet water temperature is the coldest temperature the exhausted combustion gases

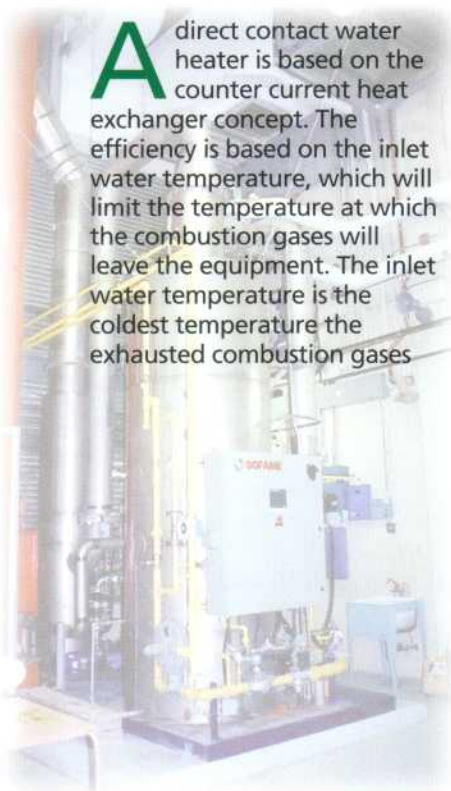
can reach. In the event of a high inlet water temperature, the water heater will yield a high combustion gases outlet temperature with a significant amount of residual energy, meaning a lower thermal efficiency.

For high temperature closed-loop applications, such as high temperature space heating

where the return water is still hot, the unit thermal efficiency drops drastically. The high efficiency inherent to the direct contact technology is then reduced. The Neufchâtel Professional Formation Centre is an example of a high temperature space heating application where such a situation of loss of efficiency would occur.

The temperature of the flue gases going out of the “Ultra-High Efficiency” direct contact water heater is lower than the space heating loop return water temperature.

**ULTRA-HIGH EFFICIENCY DIRECT CONTACT WATER HEATER
FOR SPACE HEATING APPLICATIONS**



AN INNOVATIVE SOLUTION

To avoid a drop in efficiency, it is possible to add a water vapour pump (WVP) to the standard direct contact water heater. The WVP recuperates residual energy from the water heater flue gases and puts this energy back in the system, leading to a constant high efficiency operation even under high return water temperature conditions. A flow diagram of the new technology is shown in figure 1, where a standard direct contact water heater is complemented by two side columns forming the WVP (a condenser and an evaporator).

Further, adding a WVP to the direct contact water heater will significantly decrease the NO_x formation, leading to a combined ultra-high efficiency and ultra-low NO_x emissions equipment. An integrated unit is available in the range of 300 kW to 15 MW, under the model name "Ultra-High Efficiency."

The "Ultra-High Efficiency" direct contact water heater was well suited for the Neufchâtel installation.

WVP PRINCIPLE

The WVP is a heat and mass transfer device composed of a condenser and an evaporator. The two additional direct contact columns operate just like the water heater. The condenser (right end column) recovers the residual sensible and latent heat from the combustion gases going out of the water heater by direct contact between cold water and the gases. In the left end column, called the evaporator, the energy extracted from the combustion gases is transferred to the incoming combustion air through direct contact between the air and hot water from the condenser (see figure 1).

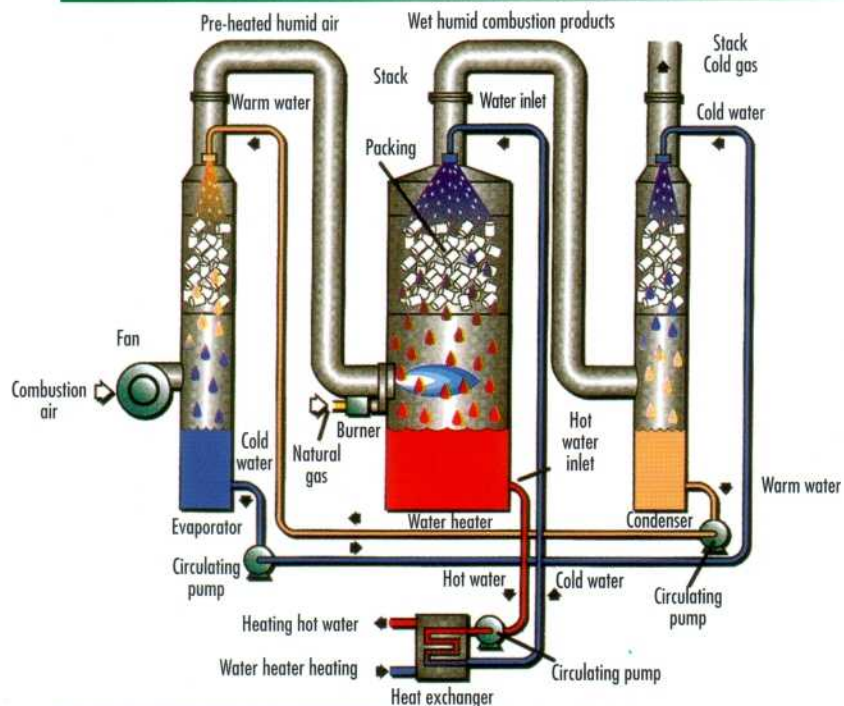


FIGURE 1: "Ultra-High Efficiency" principle

The combined action of the condenser, the evaporator and the water heater allows a recovery of up to 100% of the higher heating value (HHV) of the natural gas. Therefore, the temperature of the flue gases going out of the "Ultra-High Efficiency" direct contact water heater is lower than the space heating loop return water temperature and the efficiency loss typically occurring from the hot water inlet temperature is reduced.

In addition, the humidification of the combustion air occurring in the evaporator leads to an important reduction of NO_x formation during the combustion by decreasing the flame temperature.

NEUFCHÂTEL PROFESSIONAL FORMATION CENTRE INSTALLATION

The construction of the Neufchâtel Professional Formation Centre was a perfect opportunity to install

a "Ultra-High Efficiency" for a high temperature closed-loop space heating application.

THE UNIT

A 1.3 MW "Ultra-High Efficiency" unit was designed and installed at the Neufchâtel Formation Centre to fulfil the space heating needs of the building.

During the heating season, the equipment heats about 600 l/min of primary water from about 50°C to 60°C. The hydronic loop is heated

by the primary water through a plate heat exchanger which has close to 100% heat transfer efficiency.

EFFICIENCY AND ENERGY SAVINGS

Throughout the heating season, the unit global efficiency is nearly constant between 94% and 97% (based on HHV of natural gas). These efficiencies were obtained with a 47 to 51°C return water temperature to the water heater. Testing done with a prototype of the technology at the Natural Gas Technologies Centre (Boucherville, Quebec), with a 70°C return water temperature, resulted in a unit thermal efficiency above 90% (HHV). With a high return water temperature, the effect of the WVP is enhanced,

insuring a constant high efficiency. The WVP effectiveness is proportional to the amount of residual energy in the combustion gases exiting the water heater.

The "approach temperature", which is the temperature difference between the gas outlet of each direct contact column (gases of the water heater and condenser and air of the evaporator) and each water inlet is less than to 2°C. A small "approach temperature" corresponds to a maximal potential heat transfer in each column,

meaning that an optimal performance throughout the heating season is insured.

Inherent to efficiency, the percent energy savings and potential CO₂ reduction using the "Ultra-High Efficiency" technology are the same. These two criteria for the "Ultra-High Efficiency" direct contact water heater installed at the Neufchâtel Professional Formation Centre are shown in table 1. The improvement was calculated over a one year period (March 1999 to February 2000).

TABLE 1: Energy savings and CO₂ reduction using "Ultra-High Efficiency" at the Neufchâtel Professional Formation Centre (for a constant 50°C return water)

One year period: March 1999 to February 2000				
Equipment	Seasonal efficiency	Energy consumption	"Ultra-High Efficiency" compared to other equipment	
			Energy savings	CO ₂ reduction
"Ultra-High Efficiency" (direct contact water heater)	95%	4,725 GJ	-	-
High efficiency hot water boiler	90%	4,988 GJ *	5%	5%
Medium to low efficiency hot water boiler	75%	5,985 GJ *	21%	21%

* Extrapolated natural gas consumption based on the installed "Ultra-High Efficiency" unit consumption.

NO_x EMISSIONS

The levels of NO_x emissions measured at the Neufchâtel site are between 8 and 11

ppm (at 3% O₂), confirming the ultra-low NO_x performance of the technology.

AN ADVANTAGEOUS SOLUTION

“Ultra-High Efficiency” direct contact water heater provides numerous benefits:

- very high annual efficiency with hot return water temperature
- very low NO_x emissions
- lower flue gases temperature than the space heating loop return water temperature
- non pressurized equipment
- CO₂ emission reduction
- ease of construction

MULTIPLE APPLICATIONS

Several hot water applications, such as space heating and pasteurisation, operate with a high temperature closed loop system. Standard or advanced condensing systems experience a significant efficiency drop with a high temperature return water operation. Annual or seasonal efficiency are then considerably decreased. The “Ultra-High Efficiency”

direct contact water heater is perfectly suited for commercial, multi-family buildings, institutional and industrial high temperature closed loop applications, like the one of the Neufchâtel Professional Formation Centre, by offering constant high efficiency and low emissions.

For more information, please contact:



www.sofame-tech.com

500, Alphonse D. Roy, Montreal (Quebec) H1W 3Y8
Phone: (514) 523-6545 Fax: (514) 524-6183

sofame@sofame.com