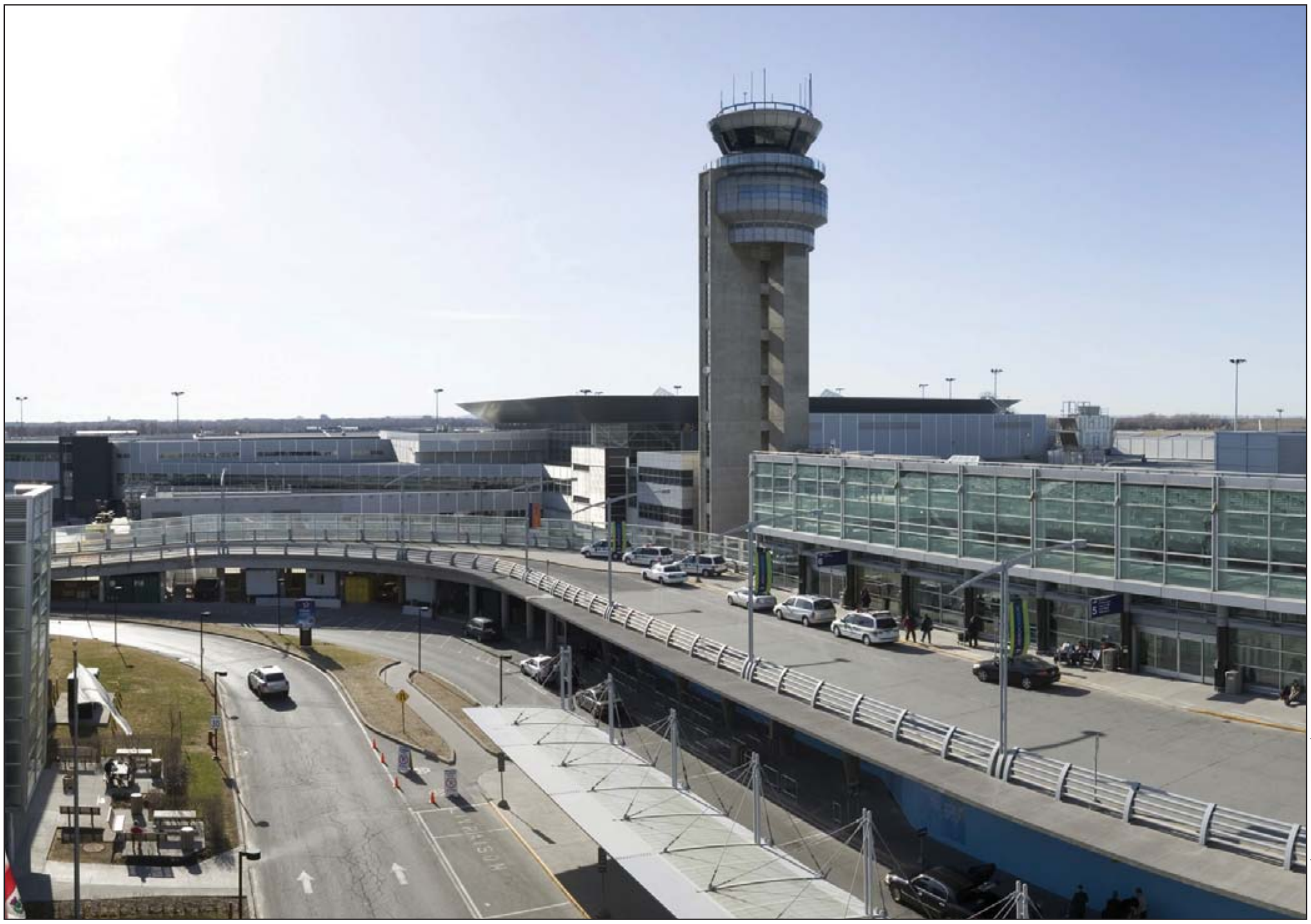

Photo: Aéroports de Montréal

A high-efficiency heating plant was installed as the existing one could no longer keep pace with the airport's growth.

Heating Montréal's Airport

By Jacques Lagacé, P.Eng., Member ASHRAE, **and Pierre Roussel, P.Eng.,** Member ASHRAE

In 2000, Aéroports de Montréal (ADM) expanded its existing air terminal to cope with increasing passenger traffic. The overall surface area is doubled, which meant that the existing plant could no longer meet the needs of the terminal.

The original air terminal was built in 1960. A common practice then was to provide heating energy to the terminal by a remote central heating plant located away from the runways and control tower. This was done to prevent the vapor plume, given off by exhaust combustion gases during low outdoor temperatures, from hindering activities of air traffic controllers. These vapor plumes commonly are formed by the condensation of water droplets in suspension in subcooled combustion gases.

The heating plant was used to generate high temperature water (HTW) (400°F [204°C]) routed to the main terminal building via an underground tunnel almost one mile (1.6 km) long. Over its course, the HTW piping was subject to substantial heat losses, which were dissipated to the exterior by means of several ventilation systems. These losses accounted for an appreciable loss of efficiency of the main plant. Furthermore, the total capacity of the existing plant proved to be insufficient to meet the needs of the expansion. Considering the heat losses, the considerable investments necessary to increase the capacity of the existing heating plant, and the limited possibilities of installing energy-saving

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measures, the decision was made to build a new thermal plant integrated into the new construction. This only could be done if a dependable plume elimination system was provided.

Figure 1 shows the general arrangement of the air terminal, including the main thermal plant and the location of the control tower. This plant houses all the equipment required to produce chilled water (CW) (44°F [6.7°C]), low temperature water (LWT) (105°F [40.6°C]) and medium temperature water (MTW) (240°F [115.6°C]). The equipment was selected based on individual energy efficiency and heat recovery potential to keep operating expenses at a minimum.

Four new chillers providing a total cooling capacity of 2,260 tons (7946 kW) with an average power demand of 0.53 kW/ton (0.15 kW/kW) are complemented by the existing chillers and are connected to a common chilled water distribution loop extending more than 1.3 miles (2.1 km) in length.

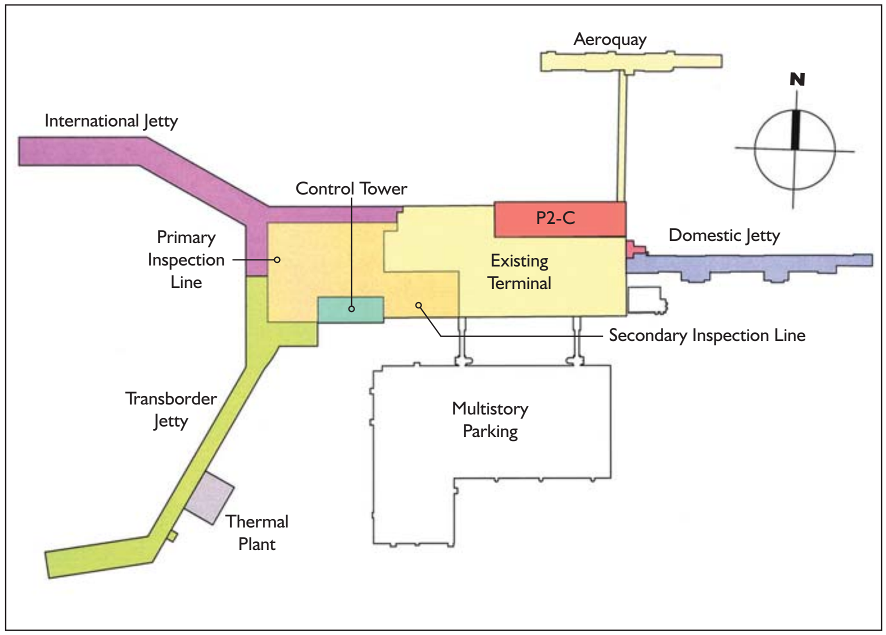

Figure 1: General arrangement of Aéroports de Montréal.

The new chillers are connected in series by pairs to increase the temperature differential to 18°F (10°C). The first chillers (1,330 ton [4676 kW]) reduce the chilled water temperature from 60°F to 49°F (15.6 to 9.4°C). The second chillers (930 ton [3270 kW]) lower the temperature from 49°F to 42°F (9.4 to 5.6°C). This 18°F (10°C) temperature differential allows the reduction of the chilled water flow rate, and consequently, the size of distribution piping.

The heat generated by the first 1,330 ton (4676 kW) chillers is released to the atmosphere using dedicated cooling towers. The heat from the second 930 ton (3270 kW) chillers is reclaimed (17,080 MBtu/h or 5004 kW) to generate part of the LTW. Although when heating loads are low or nonexistent, the heat is rejected, partly or completely through the cooling towers.

A schematic showing the principle of production of heat carrying fluids summarizes the complexity of the installation (*Figure 2*). Heat distribution equipment using low temperature water are commonly found to be heating coils, heat plate exchangers (for 100% fresh air systems), small unit heaters and a few convectors. This low temperature water is generated by reclaiming the heat from the chillers or other heat recovery equipment and is supplemented, if necessary, by injection of medium temperature water. Injection takes place at local pumping stations.

The terminal's main source of heating uses medium temperature hot water. Equipment having large heating loads such as air curtains, vestibules or garage doors in the luggage handling facilities is connected to the medium temperature network.

Medium temperature water is produced by four 450 hp (4414 kW) boilers (water tube type) heating the water from 165°F to 240°F (74°C to 115.6°C) at full load conditions. Each boiler is equipped with a dual fuel burner (natural gas and Number 2 oil), providing the possibility of obtaining combustion efficiencies of 82% with natural gas and 84% with oil.

The main constraint for the new boiler room was that the plume produced by the exhaust gases during cold weather operation must be invisible, so as not to hinder the activities of the air traffic controllers. This plume, usually dense and opaque, is caused by condensation of vapor found in exhaust gases when mixed with cold and/or humid outside air. In standard boiler operation, this water vapor is exhausted to the atmosphere and gives a net efficiency value that reflects the difference between the higher and lower heating values of the fuel used.

As shown in *Figure 1*, the proximity of the boilers' exhaust stacks to the air control tower presented a challenge.

After several analyses, the piping diagram and equipment used for the treatment of exhaust gases from boilers and energy recovery are summarized in *Figures 3 and 4.*

The plume reduction process is complex. The first step is to run the boilers' flue gases (±340°F [±171°C]) through the direct contact economizer. Water, called gray water, is sprinkled in direct contact with the flue gas. The gray water is cooled from 140°F to 50°F (60°C to 10°C) by passing it through a series of heat plate exchangers. The major part of the heat recovered is supplied to the low temperature water loop through a dedicated heat plate exchanger Ex1. Heat plate exchanger Ex2 is supplied with chilled water at 44°F (6.7°C) Therefore, the temperature of saturated gas leaving this exchanger will be 60°F (15.6°C). Technical data for the exchanger requires that effluent gases' temperature averages 10°F (5.6°C) higher than the gray water temperature. Heat given off to the chilled water loop is recovered by the chillers capable of heat recovery. The overall efficiency of the combustion process obtained amounts to 99%. The direct contact economizer allows reclamation of a large part of the heat contained in the flue gases, which is usually lost to the atmosphere (4,270 MBtu/h or 1251 kW per boiler).

The primary purpose of the gray water circulated in the direct contact economizer is to absorb the latent and sensible heat contained in the hot exhaust gas from the boilers. In doing so, it also absorbs a large part of pollutants that otherwise would be released in the atmosphere. An automatic chemical treatment system neutralizes the acidic portion of the grey water before being rejected to the sewers. The direct contact economizers act as air scrubbers for hot flue gases and helps reduce by a significant amount greenhouse gas emissions.

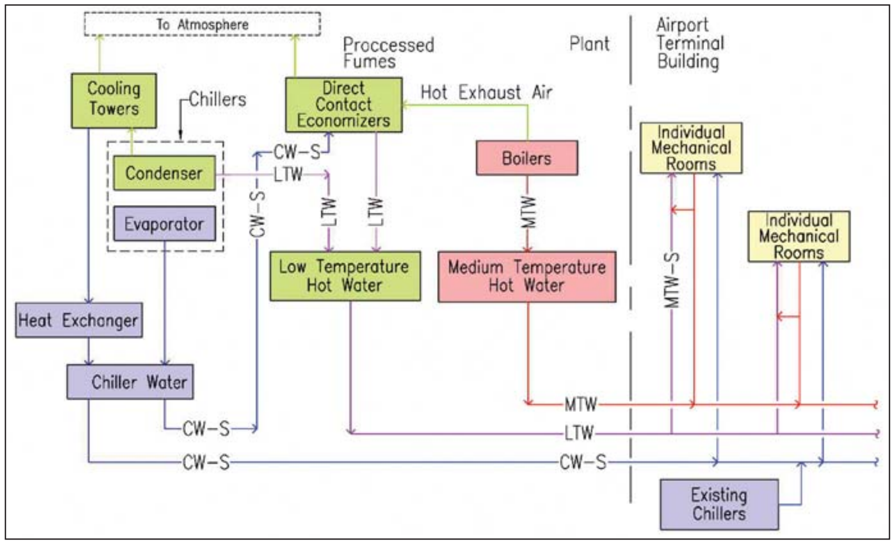

Figure 2: Principle of production of heat carrying fluids.

The 60°F (15.6°C) saturated flue gases leaving the direct contact economizer have to be mixed with hot dry air so the mixture can be exhausted to the atmosphere with minimal chances of

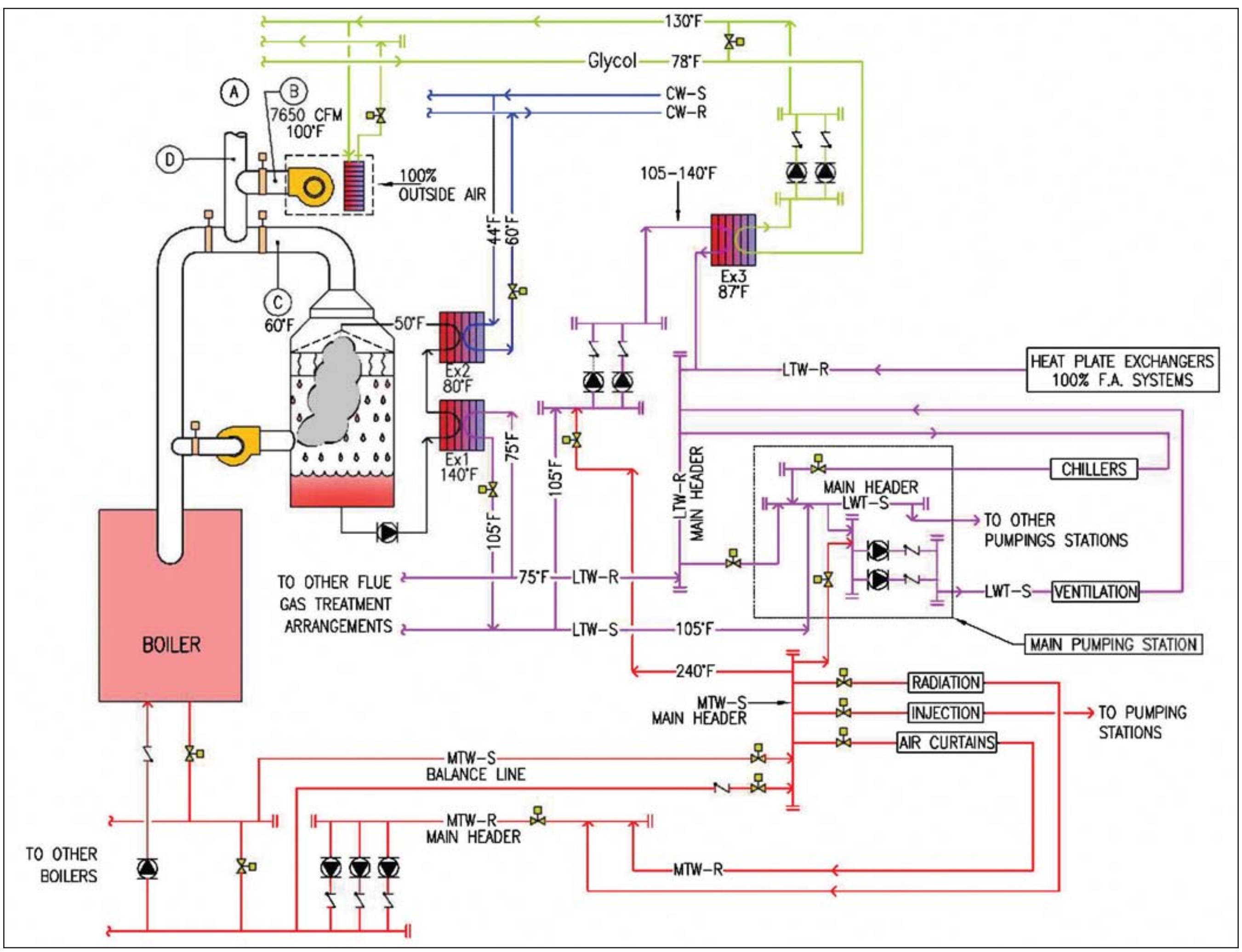

Figure 3: Piping diagram and equipment used for energy recovery and the treatment of exhaust gases from boilers.

forming a visible plume (under normal winter conditions).

The psychrometric chart seen in *Figure 5* represents the process lines in the exhaust flue gases and each point of interest mentioned is as follows.

Line $\overline{AE}$ on the psychrometric chart is tangential to the saturation line at Point A corresponding to the expected minimum outside temperature (–20°F [–29°C]), which is considered the theoretical no plume process line. Any moist air process taking place along this line will not be subject to vapor condensation formation at Point A, preventing the formation of a vapor plume.

Point C represents the gas leaving the direct contact economizer after being cooled by heat plate exchangers, which is 10°F (5.6°C) higher than the grey water supply. Point B represents the temperature of the dilution air system (100% transferred air, dry and heated at 100°F [37.8°C]).

The mixture of gases released to the atmosphere (humid exhaust gases with dry air) corresponds to Point E on the chart and will prevent the creation of a vapor plume. The proportion of dilution air (line $\overline{CE}$) to total evacuated gases (line $\overline{BE}$) is high (85%). Considering that the dilution air has to be heated before being mixed and then exhausted, leads to an important reduction of the overall efficiency of the process. Therefore, the process line $\overline{AE}$ was considered as the theoretical no-plume process line.

***Figure 4:** Flue gas plume reduction installation (direct contact economizer at left and heat plate exchangers for heat recovery of gray water at right).*

After discussions and results from wind studies, it was agreed that a certain visible plume could be tolerated, as long as this plume was not opaque. A proportion of 60/40 (line $\overline{AD}$) shows on the psychrometric chart an area where condensation can take place. This fog will be apparent only if outside air is still and will be immediately dispersed if any wind is present.

Psychrometric calculations show that 7,650 cfm of 100°F (3610 L/s of 37.8°C) air is the optimal amount of dry air to be added to flue gases. Heat exchanger (Ex3) is supplied with LTW on one side and a 50% glycol solution on the other side, giving a total exchange of 2,772 MBtu/h (812 kW). The glycol solution supplies the heating coil that strictly supplies dry heated outside air for dilution.

The primary philosophy of the heating plant concept is to use coherent and simple systems along with standard components to lower the cost of operation and maintenance. The components installed are standard equipment rather than costly, complicated custom-built units. The main expenditure for the exhaust treatment system is the direct contact economizer. Considering standard equipment is installed, maintenance is simplified and straightforward since the operations and maintenance staff is familiar with such equipment. All four groups of "boiler–direct contact economizer–blower–pumps–heat exchangers–dilution systems" are identical. That concept provides huge flexibility in operation because only three of the four groups are sufficient to supply the heating demand. At any time, a group can be shut down to be inspected or to maintain part of the system or because a problem occurs.

An airport must maintain services in almost any situation. To prevent the loss of the heating and cooling plant, a large part of the controls operation can be carried out directly on the equipments, even if the direct digital controls automated system is down. When the heat generated by the heating plant exceeds the demand, the heat is rejected into the fresh air system. This avoids using conventional cooling towers to reject the heat, and it allows more fresh air to be brought into the building. This results in better indoor air quality, better energy efficiency and reduction of the possibility of creating a vapor plume associated with using cooling towers.

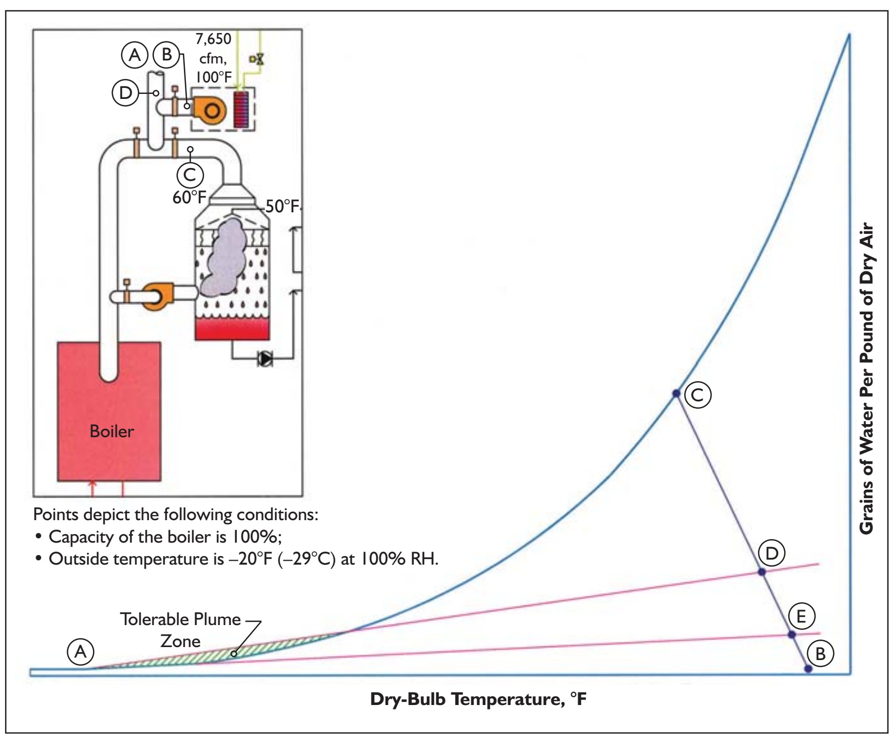

***Figure 5:** Psychrometric chart representing the process lines in the exhaust flue gases.*