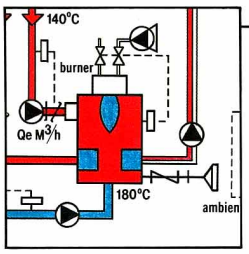


INTEGRATED HEATING : A COST-EFFICIENT SOLUTION TO HYDRONIC HEATING SYSTEMS

PROBLEM

A comprehensive choice of boilers is currently available on the Canadian market, with thermal efficiencies in the range of 80-97% of High Heating Value (HHV).

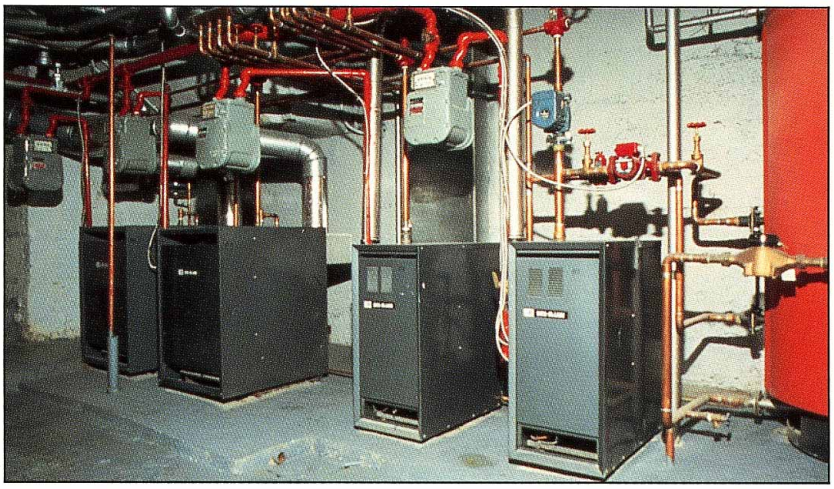
With higher purchase prices and installation costs than conventional units, high efficiency boilers require a fairly substantial initial cash outlay.

SOLUTION

The ideal solution to satisfy heating needs efficiently and at a lower cost, is an integrated system combining condensing or high efficiency boilers and conventional units. This type of system is as well suited to new housing as to renovation projects.

BENEFITS

- investments' minimization
- average seasonal efficiency very close to maximum potential
- possibility of providing domestic hot water from the same system.



Typical integrated heating system.

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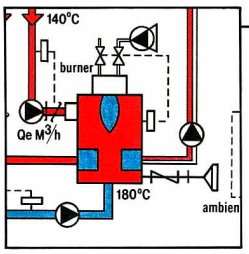


THEORETICAL DATA

CONSUMPTION CALCULATIONS

In view of a building's overall heat loss, cold air infiltration rates and inside gains, the degree-day method may be used to measure annual energy consumption.

This method is based on the assumption that at 18°C, solar and inside gains in an average building compensate energy requirements. With a lower outdoor temperature, heating is required indirect proportion to the number of degree-days.

HEATING DEGREE-DAYS

It is the number of degrees difference between the 18°C basic temperature and the average temperature recorded on any given day. With an average temperature above 18°C, no heating is required, and therefore no degree-day registered.

CONDENSATION PRINCIPLES

Methane - the major component of natural gas - consists of carbon and hydrogen. This means that natural gas combustion using oxygen from the air releases carbon dioxide, water vapor and heat.

In addition to the gases' perceptible heat, combustion products exhausted into the stacks also contain another form of energy, i.e. latent heat in the water vapor.

Cooling and condensing the water vapor releases the energy accumulated during the vaporization process, which can be recovered. This latent heat is far from negligible as it represents about 10% of HHV for a typical natural gas.

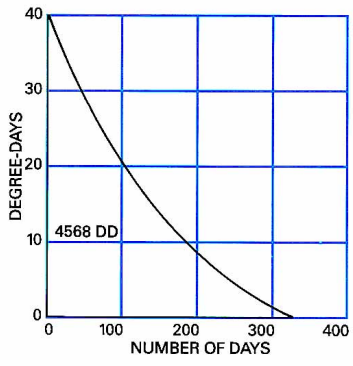
In the case of a typical natural gas burning without excess air (stoichiometric combustion), dew point is about 58°C; this figure decreases proportionately with the addition of excess air.

LOAD DURATION CURVE

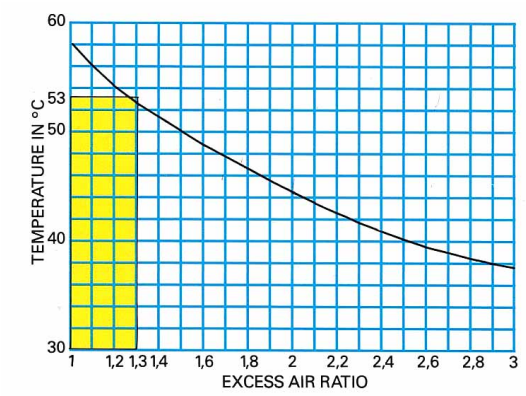
The histogram of average daily temperatures for a specific area is a necessary tool to determine the operating cycle of the boilers featured in an integrated system.
The above-mentioned histogram helps draw the load duration curve with the x-axis showing the number of heating days and the y-axis the number of degree-days, in decreasing order.

An analysis of the average seasonal load duration curve for the Montréal area indicates that the average coldest day is about 40 degree-days.

AVERAGE LOAD
DURATION CURVE
MONTRÉAL AREA



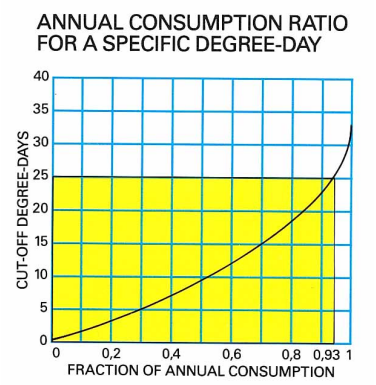
DEW POINT / EXCESS AIR RATIO



Generally speaking, heating systems are designed for a peak temperature of -29°C, with an extra 20-25% capacity. This means that a single heating unit operates at less than two thirds of its capacity most of the time.

Based on the average load duration curve for the Montréal area, another diagram is developed with the number of degree-days on the y-axis, the x-axis showing the total energy between 0 degree-day and the specific degree-day expressed as a fraction of the annual energy requirement.

This diagram is used to help select the units to be included in an integrated system.



SELECTION 0F BOILER CAPACITY (SPACE HEATING ONLY)

The diagram showing the annual consumption ratio for a specific degree-day reveals that a unit designed to meet the energy requirements of a building with a degree-day of 25, provides 93% of the building's annual energy requirements.

Consequently, a condensing or high efficiency boiler designed to meet a 25 degree-days requirement combined with a conventional boiler to meet peak demand provides the benefits of minimum capital investment as well as using the most efficient system 93% of the time.

This type of installation requires a control device to operate the condensing unit in priority, with the conventional boiler providing the extra power when required.

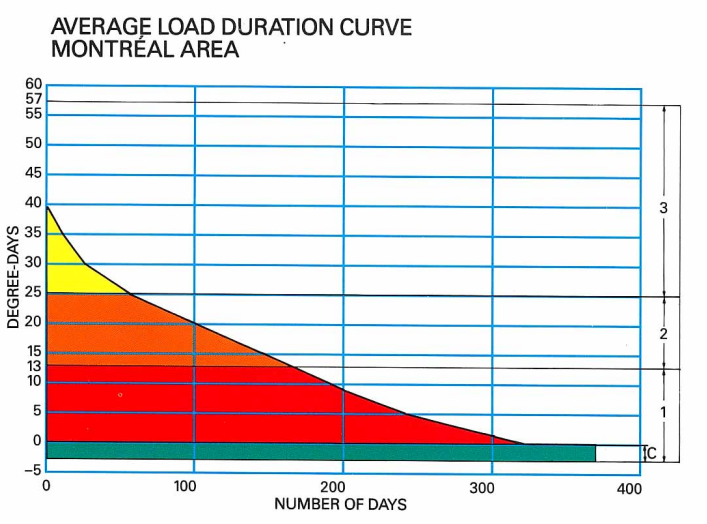
SELECTION 0F BOILER CAPACITY (WATER AND SPACE HEATING COMBINED)

It is possible to improve average seasonal efficiency further by adding the water heating function to the high efficiency boiler as well as a control device giving priority to water heating over space heating.

Optimum improvement is achieved by installing two condensing boilers, one of them only with a water heating function.

This integrated heating design would include the following:

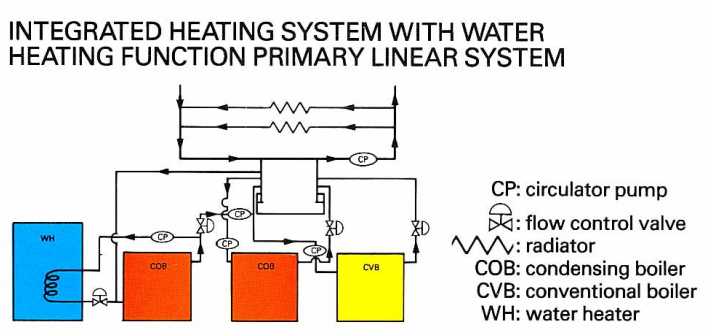
- A condensing boiler designed for about 13 degree-days is connected to the domestic water heating system, which is given priority;
- a second condensing boiler to meet space heating requirements between 13 and 25 degree-days;
- a conventional boiler to satisfy the building's peak energy requirements;
- a sequential control to draw basic requirements from the condensing boilers and peak requirements from the conventional unit.



C : domestic hot water
1 and 2 : condensing boilers
3 : conventional boiler

EXTRA CAPACITY TO PROVIDE FOR DOMESTIC HOT WATER

Studies undertaken by various manufacturers for the commercial and institutional sectors reveal that whenever hot water needs do not exceed 30% of space heating requirements, an integrated heating system does not require extra capacity.



The manufacturers' recommendations are summarized in the table below :

Water heater capacity / Space heater capacity	% of water heater capacity to be added to space heater capacity
0 - 30 %	0 %
40 %	10 %
50 %	20 %
60 %	30 %

TECHNOLOGICAL DATA

The hot water needed to meet space heating requirements in residential or commercial buildings may be produced with conventional, high efficiency or condensing boilers.

CONVENTIONAL BOLLERS

This type of equipment has been on the market for many years and designers are familiar with its features and characteristics.

These units have a steady state efficiency of about 75%-80% of HHV; average seasonal efficiency depends on installation and a new well designed system may yield about 70%.

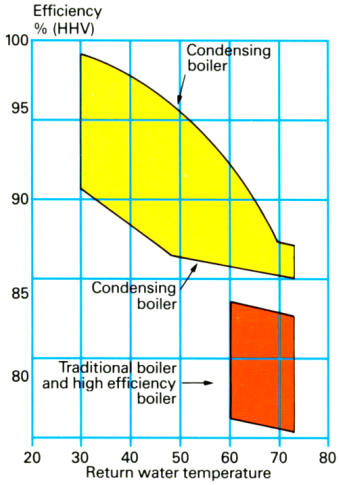
Conventional boilers share one main feature: they are most efficient over very long operating cycles - i.e. in winter.

HIGH EFFICIENCY BOILERS

These are in fact conventional equipment that has been upgraded by various methods such as enlarging the heat exchanger, controlling combustion air, fitting an electric ignition device or a combination of these.

These boilers have a steady state efficiency in the 80%-88% HHV range with a slightly lower average seasonal efficiency.

Because its seasonal and steady state efficiencies are very close, this type of equipment is especially recommended for short cycles.



CONDENS1NG BOILERS

Condensing boilers have been on the market for less than ten years. They cost more than high efficiency units and are therefore purchased by users interested in achieving the highest energy savings.

Steady state and average seasonal efficiencies of these appliances are similar, at about 92%-97% of HHV.

The colder the return water, the most efficient these units will prove to be; their efficiency further increases as the lengh of the operating cycle decreases.

The ideal heating system would therefore feature a condensing or high efficiency boiler to meet the residents' overall energy requirements. However, these units cost more than conventional boilers and combining both types could provide a very near maximum performance at the lowest cost.

ENERGY SAVING

Replacement of a space and water heating system with an integrated heating system.

Type of building :	17 apartment building

Heating system :

BEFORE	AFTER
1 x 237 kWh (808,000 BTU/hr) Warden King boiler model 30-11	2 x 29 kWh (100,000 BTU/hr) Weil-McLain condensing boilers
1 x 42 kWh (144, 600 BTU/hr) Dominion water heater, model 18-6 1 x 900 L (200 gallons) hot water storage tank 1 x gravity operated hydronic heating system	2 x 37 kWh (125,000 BTU/hr) Weil-McLain conventional boilers 1 x 500 L (110 gallons)* Viessmann tank *The system has been converted to a primary linear system with inside, outside and sequential controls.

Equipment selection :

Heating requirements at 57.5 degree-days	107 kWh (365,000 BTU/hr)*
1st boiler - 0-14 degree-days	67 %** of annual space heating plus domestic hot water consumption
2nd boiler - 14-28 degree-days	27 % of annual space heating consumption
3rd boiler - 28-57.5 degree-days	5 % of annual space heating consumption

*No extra capacity required to accommodate the water heating function.

**SimuItaneous requirements of space and water heating reduce this figure and increase the figure posted for the second boiler.

***Two conventional boilers have been installed in this demonstration project. This was only for study and measurement purposes. Under normal circumstances, only one such boiler is required.

Annual consumption :

BEFORE	AFTER
Oil #2 40,400 litres or 1,493 x 10^6 BTU or 1,575 MJ	Natural gas 957 M cu. Ft. Or 957 x 10^6 BTU or 1,009 MJ

Energy savings : 35,9 %

For more information, contact

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