HI-SMART

HI-SMART: HIGHER EDUCATION PACKAGE FOR NEARLY ZERO ENERGY AND SMART BUILDING DESIGN

MODULE #3

CHAPTER 2: CONDENSING BOILERS

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MŰEGYETEM 1782

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ENERGIAKLUB CLIMATE POLICY INSTITUTE APPLIED COMMUNICATIONS

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3.2.1 BASICS OF THEORY

DIRECTIVES

A large percentage of buildings across Europe are heated by gas boilers. Excellent technology has undergone great development over the decades, but energy efficiency and environmental protection are inevitable with these devices as well. The European Commission has formulated the requirements for gas boiler heat production through two directives.

813/2013/EU directive:

Nearly five million homes in the European Union use a common, open chimney system. Existing space heating boilers and combined boilers in dwellings with a common open flue system cannot be replaced by efficient condensing boilers for technical reasons. The requirements of this Regulation allow non-condensing boilers specifically designed for such assembly to remain on the market in order to avoid unnecessary costs for consumers, to give manufacturers time to develop boilers using more efficient heating technology and to allow sufficient time for Member States to draw up national building regulations. This Regulation establishes requirements for the placing on the market and putting into service of space heating appliances and combined heating installations with a rated thermal input not exceeding 400 kW. From 26 September 2015, the efficiency of heating installations and the seasonal space heating efficiency shall not be lower than 86%. The efficiency measured at 100% measured heat output must not fall below 86% and the efficiency measured at 30% measured heat output must not fall below 94%.

From 26 September 2018, nitrogen oxide emissions from heating installations, expressed as nitrogen oxides, shall not exceed 56 mg / kWh for gas-fired boilers.

814/2013/EU directive:

Environmentally conscious design must not affect the operation or costs of water heaters or hot water storage tanks, nor must they have an adverse effect on health or safety. This regulation applies to the environmentally conscious design of water heaters with a rated thermal input of up to 400 kW and hot water storage tanks with a storage volume of up to 2,000 liters. [1]

According to the reductions presented above, only condensing boilers can be installed in buildings. Condensing boilers are combustion plants that use natural gas or LPG for combustion. Equipment operating with efficiency and emission values in accordance with the directives comes from the utilization of latent heat that can be extracted during condensation.

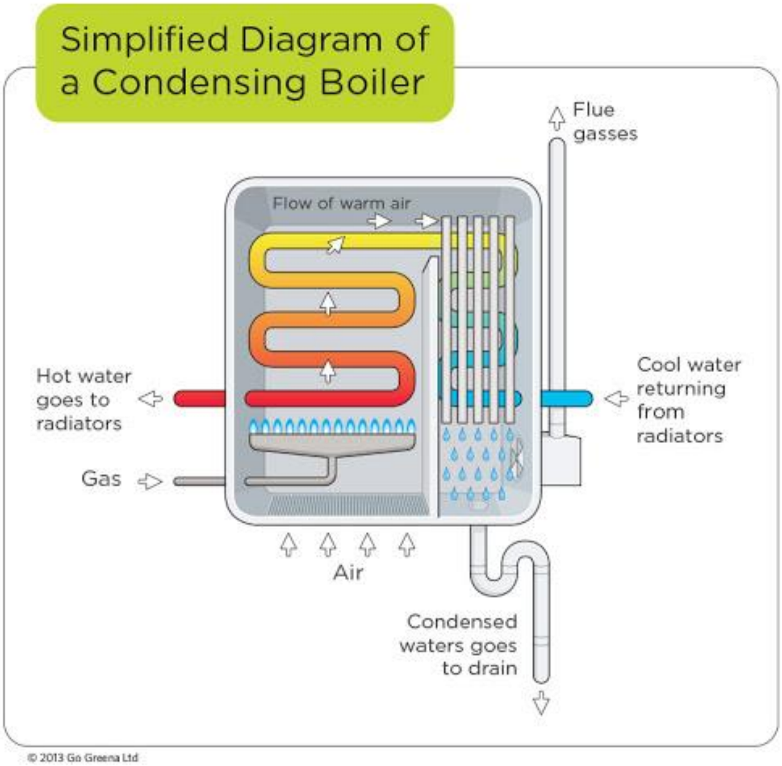

Figure 3.2.1: Operation of a condensing boiler (www.gogreena.co.uk)

The operation of the condensing boilers is shown in Figure 3.2.1. The condition for condensation is to reach the dew point temperature of the combustion product, when the moisture content of the combustion product precipitates. The hidden heat of the phase change can be utilized, increasing the efficiency of the boiler. The dew point temperature can be reached with a return temperature below 55 ° C. The boiler heat exchanger is made of acid-resistant material because the condensate is acidic. The condensate is connected to a sewage network. For boilers with a unit capacity of more than 70 kW, the condensate must be neutralized. The boilers can operate with modulating power, adapting to changing needs. The modulation interval can be 1:6, 1:10, and so on. Due to the low flue gas temperature, the chimney can also be made of plastic. Flue gas systems will be discussed in more details later.

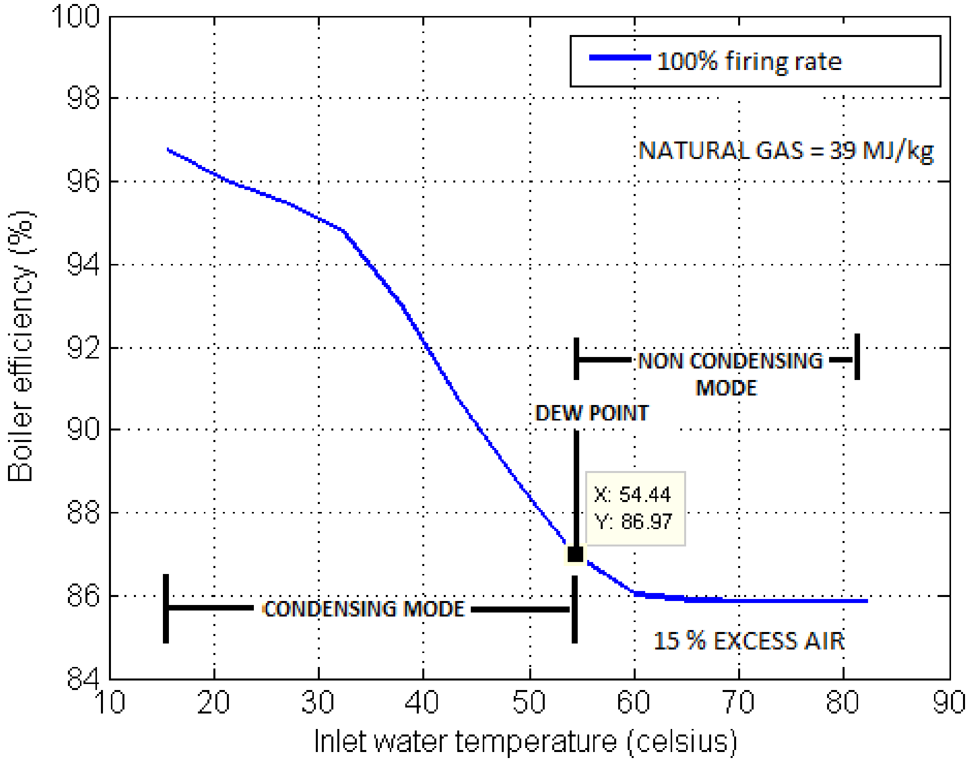

Figure 3.2.2: Operation of a condensing boiler 2

Figure 3.2.2 shows the evolution of the boiler efficiency as a function of the return temperature. It can be seen that in condensing mode, the boiler efficiency increases continuously as the return water temperature decreases. Above a return temperature of approx. 55 ° C, the condensation mode is interrupted. The curve shown in the figure is a value measured in the 100% modulation range, but the characteristic shows similar characteristics in all ranges.

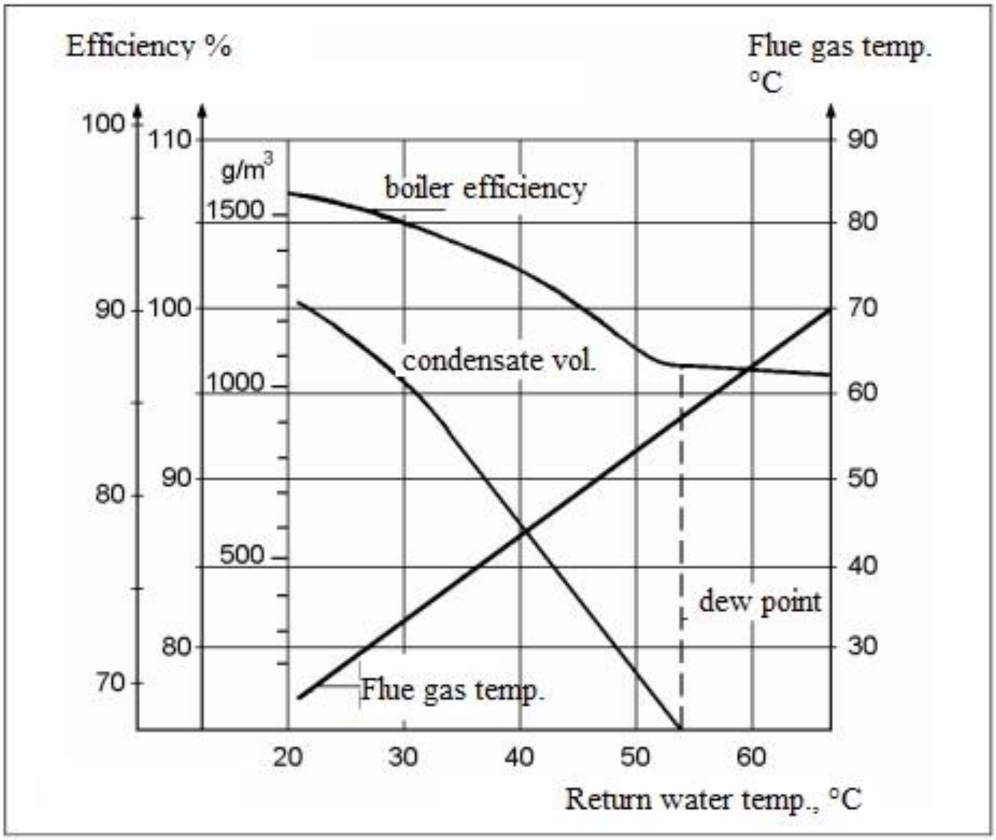

Figure 3.2.3: Operation of a condensing boiler 3

Figure 3.2.3 illustrates the operation of the condensing boiler in a complex manner. As a function of the return temperature, parameters are also illustrated in this case. It can be seen that below the dew point temperature, the flue gas temperature decreases linearly, the amount of condensate increases monotonically, and the efficiency also increases.

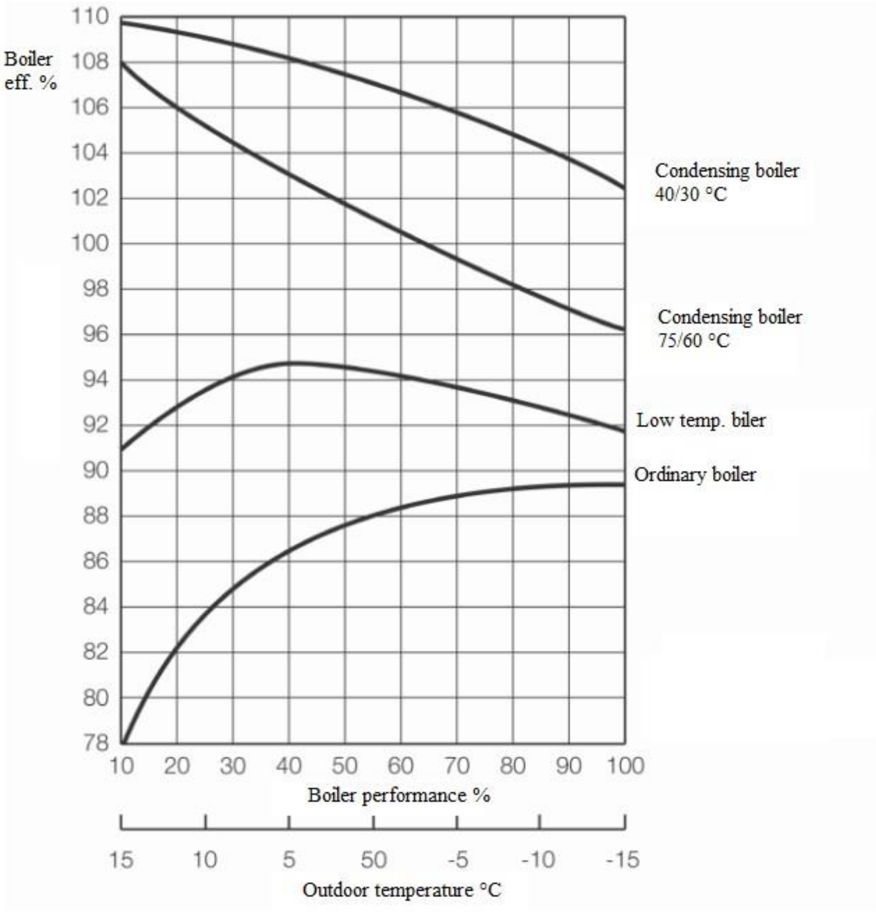

Figure 3.2.4: Operation of a condensing boiler 4

Figure 3.2.4 shows the operation of a conventional gas boiler, a low temperature boiler and two condensing boilers with different temperature stages. The horizontal axis shows the boiler load as well as the outside temperature. It can be seen that with conventional gas boilers we can achieve the most efficient efficiency at maximum performance. In the case of low temperature boilers, it can be seen that the efficiency is the most favorable at part load, but these boilers are not able to utilize the hidden heat of condensation. In the case of condensing boilers, the character shown in the previous figures is due. It also follows from the above characteristics that condensing boilers are perfectly suited for supplying low temperature heating systems. To reach high efficiency it is also important to size a radiator system to low heating water temperature. It also follows from the operating characteristics that these devices produce domestic hot water with less favorable conditions.

3.2.2 FLUE GAS SYSTEMS

EN 15287-2 includes requirements for chimney systems. Of course, each Member State also has its own national regulations. In the following, we present the generally valid rules, layouts and principles.

In addition to energy efficiency and environmental protection, perhaps the most important requirement is safe operation. As boilers are typically located indoors and in flats (this is certainly not the case for large boiler house arrangements), the combustion air supply must be separated from the room air for safe operation.

Typically, condensing boilers are separated combustion chambers, i.e. the combustion air is taken from the outside and the combustion product leaves through a chimney. These devices are called "C" type boilers. The international notation system distinguishes between different arrangements. The first group includes equipment operating with a natural draft. This is less typical solution in modern devices. Today, fan exhaust is typically used, which has two types. In one case the fan is located in front of the burner and in the other case after the burner. Figure 3.2.5 shows some examples of these solutions.

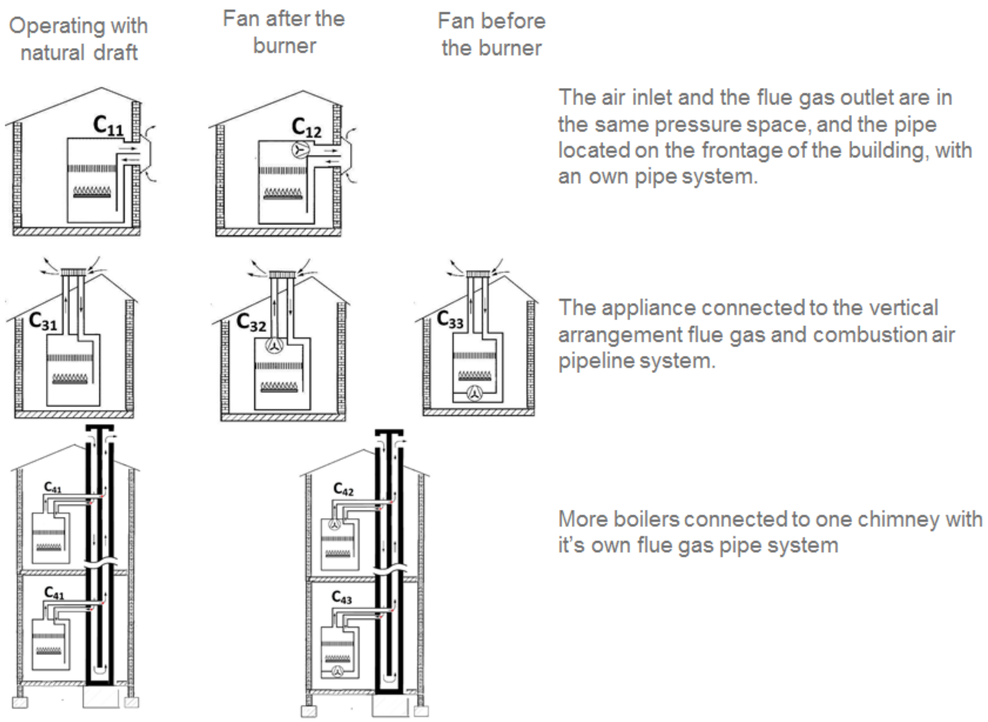

Figure 3.2.5: "C" type chimney connections

Type "C12" flue gas system is permitted in most countries. Figure 3.2.6 shows the danger of this system. The chimney was led through a façade on each floor of the ten-storey building. The individual chimneys work properly, but the combustion products flow into the apartment or flats above it. In Hungary, this arrangement is not permitted even if the safety conditions are met. In the case of the building type shown in Figure 3.2.6, the question may arise as to how the gas supply of dwellings can be upgraded without a proper flue system. This is still a problem, millions of people across Europe struggling with this question, for which there is no universally accepted solution yet.

Figure 3.2.6: C12 chimney system example

In the case of condensing boilers, the most commonly used solution is the overlay system, or chimney-mounted system. An example of these is shown in Figure 3.2.7. Chimney systems must always be sized. For sizing, we introduce the concept of a chimney circuit.

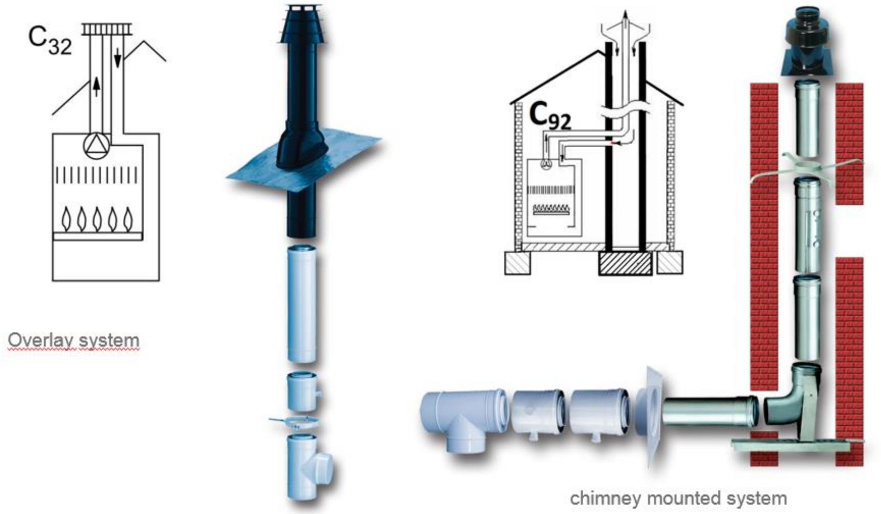

Figure 3.2.7: Typical chimney designs for condensing boilers (www.almeva.hu)

The flue system has an effective pressure and draft. This cover must overcome the inlet resistance of the combustion air, the resistance of the appliance, the frictional and shape resistances in the chimney and, last but not least, the environmental effects, e.g. the wind pressure acting on the chimney. In the case of fan-operated boilers, the same principle is followed, only in that case the desired available pressure difference must be provided to the fan operating in the device.

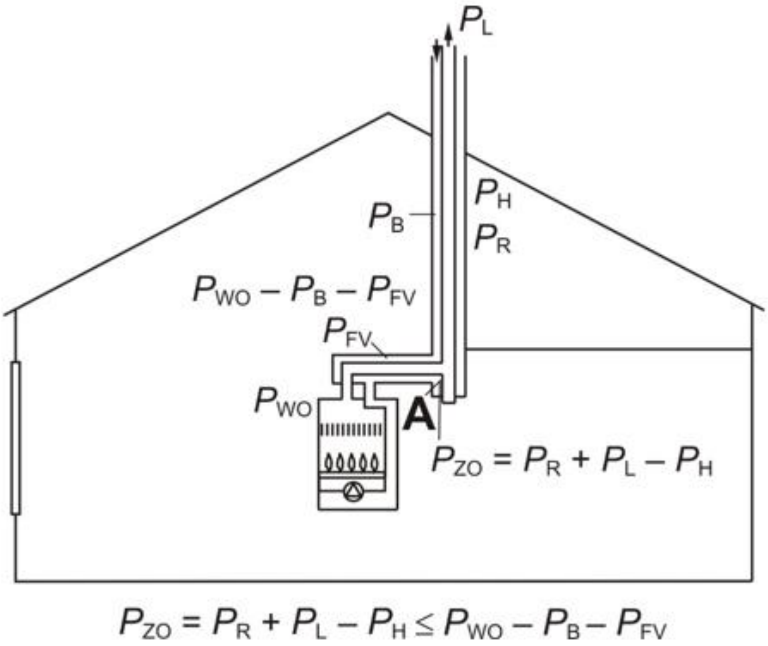

Figure 3.2.8: Chimney sizing

Symbols in the Figure 3.2.8:

pW - Draft requirement for the combustion plant

pb - Air inlet flow resistance

pFV - Flue pipe resistance

Pr - Flow resistance of the flue gas passage

pH - Theoretical draft of the flue gas path

pL - Wind pressure

pZ - Cover for the introduction of the flue of the vertical section of the flue

In order for the process to be self-sustaining, the introduction of combustion air must be ensured in all cases. If this is not done for some reason, the flue gas drain process will be stalled and backflow may occur.

The resistance of the flue gas system can be sized in the following way.

$$P_R = S_E \cdot \left(\lambda \cdot \frac{L}{D_h} + \sum_{n}^{10} \zeta_n \right) \cdot \frac{\rho_m}{2} \cdot w_m^2 + S_{EG} \cdot P_G$$

FLUE GAS DISCHARGE

The basic operating condition of the boilers is the availability of fuel. In the case of natural gas firing, we use gas, which arrives at the connection point of the residential building or apartment at a given pressure. There, if necessary, we reduce the pressure, measure the amount consumed, and then lead it to the boiler on the installed piping system. The typical gas pressure requirement of the boilers is between 23-33 mbar. During sizing, the gas network must be designed in such a way that the available pressure is properly managed. For large systems, a pressure regulator may be required for each device. The piping system must meet special requirements, only a qualified piping system can be used for this purpose. Regulation may vary from country to country. In some countries, the use of plastic wiring is allowed, in contrast to e.g. In Hungary, this is only possible with a pipeline laid in the ground. Typical piping materials are steel and copper. Welding technology welded or pressed on steel pipes, soldered or pressed on copper.

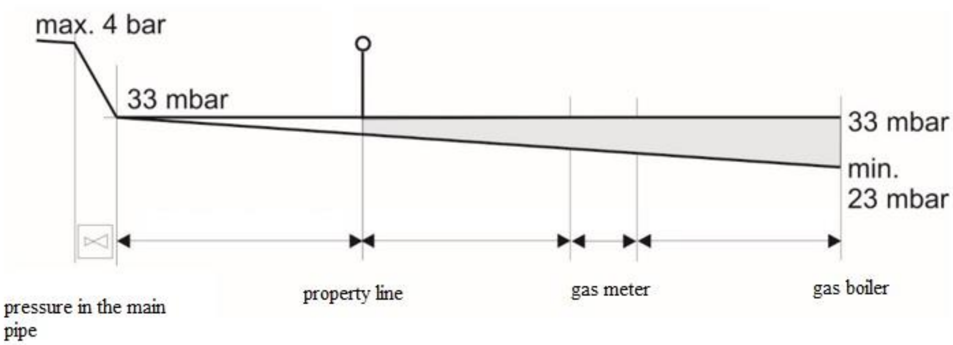

Figure 3.2.9: Gas distribution pressure drop

The pipeline system pressure diagram is shown in Figure 3.2.9. The basis of hydraulic sizing is given by the following equation.

$$\Delta p = \left(\lambda \frac{l}{d} + \sum \zeta\right) \frac{\rho_{gas}}{2} {v_{gas}}^2$$

Δp – pressure drop in the pipeline system, Pa

λ – friction factor,

l – pipeline length, m

d – pipe diameter, m

∑ζ – shape resistances,

ρgas – density of the gas kg/m3

vgas – gas velocity, m/s

3.2.3 INSTALLATION EXAMPLES

CONDENSING BOILER WITH DHW STORAGE

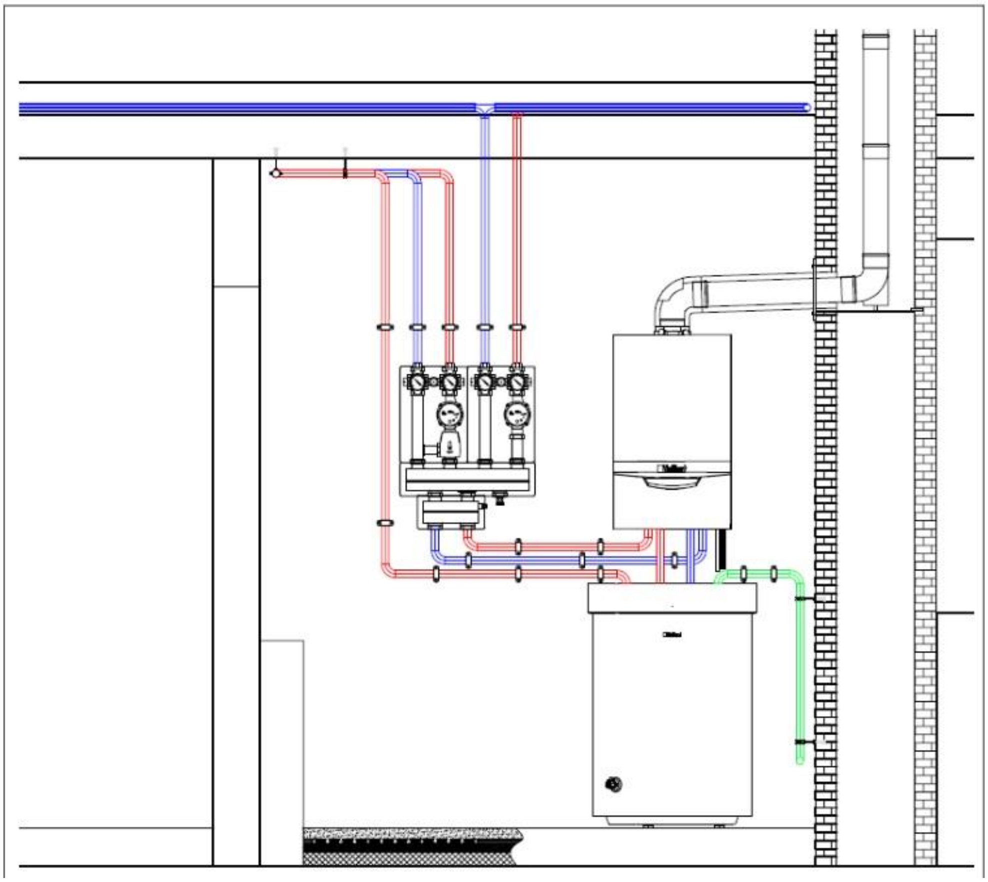

Figure 3.2.10: Condensing boiler with DHW storage (www.vaillant.hu)

In the example shown in Figure 3.2.10, we can see a classic family house solution. The wall-mounted condensing boiler also supplies heating and domestic hot water. Domestic hot water is produced in priority switching, which means that when the tank temperature falls below a limit temperature, the boiler starts to deal primarily with its heating. The boiler has an integrated routing valve. On the heating side, the boiler's heating pipe pair is connected to a manifold, from which it supplies a direct and a mixed heating circuit. The direct circuit has radiators, while the mixed circuit has a floor heating system. There is a hydraulic separator between the manifold and the boiler, which separates the primary and secondary heating circuits. This avoids adverse effects on the pumps. The domestic hot water tank is an indirectly heated tank.

In the case of flue gas discharge, the horizontal section has a concentric arrangement, while the vertical section flows in a chimney, where the smoke flows in a pipe assembly and the air in the built-in chimney. This type of arrangement provides a favorable solution for a classic renovation.

CONDENSING BOILER WITH HEAT PUMP, DHW, AND SOLAR SYSTEM

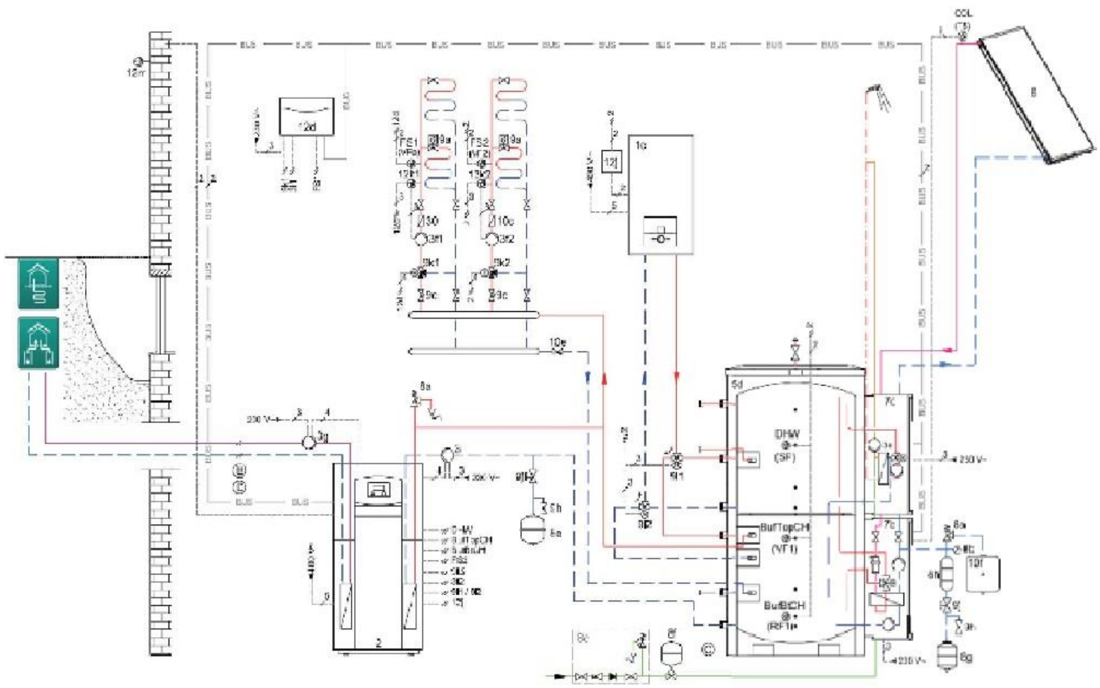

Figure 3.2.11: Condensing boiler with heat pump, DHW and solar system (www.vaillant.hu)

The arrangement shown in Figure 3.2.11 is a much more complex technical solution. In this case, hybrid operation characterizes the building in which a condensing boiler and an air-to-water heat pump operate. Both heat generators are connected to a heating buffer tank. Heat is generated by either the heat pump or the condensing boiler at a rate determined by the building automation. A routing valve is connected between the two heat generators. The system starts from the buffer tank to the surface heating system. The heat pump would also provide an option for cooling purposes, but in this common system this is not feasible because domestic hot water is also produced via the buffer tank with a fresh water modular solution. A solar collector also helps to heat the storage.

CONDENSING BOILER WITH SURFACE HEATING, DHW, AND SOLAR SYSTEM

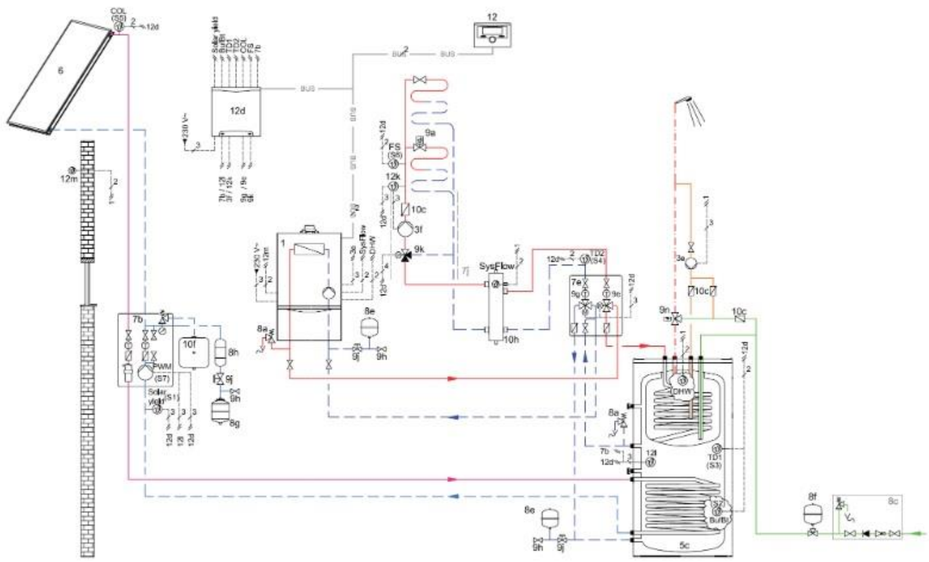

Figure 3.2.12: Condensing boiler with surface heating, DHW, and solar system

Figure 3.2.12 shows a condensing boiler connected to a hydraulic module. The module has a routing valve that allows the heating water to run in the direction of either heating or domestic hot water production. In this case too, the heating secondary side is connected to the primary side via a hydraulic separator. On the secondary side, the system provides surface heating. In the case of domestic hot water production, the heating return pipe is reconnected to the DHW tank cold water connection. This minimizes the return temperature, which increases the efficiency of the boiler. The double heat exchanger tank is also equipped with a solar system.

3.2.4 BIBLIOGRAPHY

[1] 813/2013/EU directive

[2] Barna Lajos, Érces Norbert – Gas supply educational material (BME)

[3] EN 15287-2 Standard

[4] EN 483 Standard

[5] Vaillant and other manufacturer heating products

The views and opinions expressed in this publication are the sole responsibility of the author(s) and do not necessarily reflect the views of the European Commission.

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