

*When designing a condensing gas boiler, it is important to choose the material that offers the greatest number of advantages for the manufacture of the heat exchanger. Aluminium-silicium currently brings together the maximum number of favourable characteristics to provide answers to the issues involved in the construction of commercial mono-block boilers.*

# ALUMINIUM

## THE MATERIAL OF THE FUTURE FOR HEAT EXCHANGERS IN HIGH OUTPUT CONDENSING GAS BOILERS

### >> ALUMINIUM-SILICIUM AND HEATING

This is a metal, the discovery of which, credited to the Dane, Christian Oersted, is relatively recent (nineteenth century). In 1827, Friedrich Wöhler (1800-1882) produced pure aluminium for the first time from a reduction of aluminium chlorite using potassium. Aluminium, after a number of successive corrections, was revealed as a new metal at the Universal Exhibition in Paris in 1855.

It is the metal most frequently encountered in the earth's crust, which presents characteristics such that it attracts the attention of the most varied industrial fields (Packaging, Aeronautics, Automobile, Explosives, anti-rust Paints).

The packaging industry concentrates more particularly on its expansion qualities to produce packaging films of a thickness of 0.004 mm (laminated) or even 0.0004 mm (hammered) for wrapping chocolate bars.

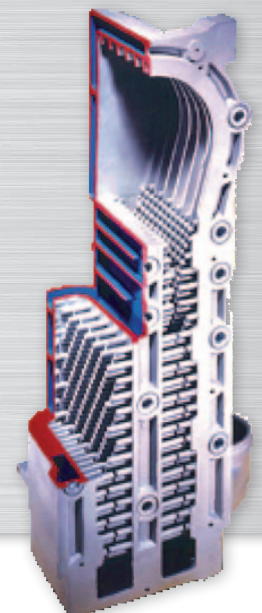
The aeronautics, automobile and other industries gain a considerable advantage from its lightness (2.702 g/cm<sup>3</sup>) in pure or alloy form, which makes it possible to produce parts approximately three times lighter than if they were made from steel or copper. Depending on its uses and the characteristics

sought, alloys based on Zinc, Copper, Silicium and Magnesium exist.

Of the alloys referred to above, aluminium-silicium presents characteristics that are particularly conducive to being used in heating.

These alloys, from the AlSi (Aluminium-Silicium) group, have a similar composition to eutectic, which gives them excellent casting properties. An Eutectic is a mixture of two pure substances, which melt and solidify at a constant temperature, contrary to other mixtures. This alloy behaves, in fact, like a pure substance in terms of melting, with very good fluidity characteristics.

This suitability for casting comes into its own in the manufacture of boiler bodies with very complex geometries, which increase the exchange surfaces and improve the hydraulic flow. The objective is to enhance heat transfer in a very compact volume.



## >> EXCELLENT COEFFICIENT OF THERMAL CONDUCTIVITY

MATERIAL	THERMAL CONDUCTIVITY (W.M <sup>-1</sup> .K <sup>-1</sup> ) VALUES FOR A TEMPERATURE OF 20°C
Steel	46
Stainless Steel (18% Chromium, 8% Nickel)	26
Aluminium (99.9% purity)	237

For aluminium, the coefficient of heat transmission is five times better than that of steel and seven times better than that of stainless steel.

As aluminium clearly conducts heat better, in choosing this material, we can significantly reduce the exchange surfaces to achieve the same output transmission to the heating circuit.

At an equivalent output, aluminium heating bodies are therefore significantly more compact.

## >> LESS WEIGHT

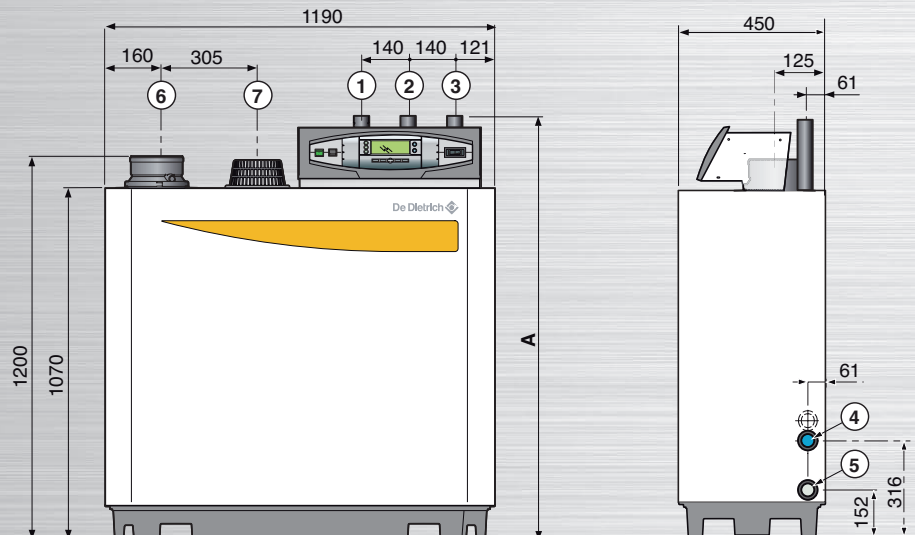
MATERIAL	DENSITY (G/CM <sup>3</sup> )
Steel	7,3
Stainless Steel	8
Aluminium (alloy)	2,7

As it is very light, aluminium is often chosen in the aeronautics and automobile industries to reduce the weight of equipment: indeed, it is three times lighter than stainless steel or copper.

Over and above the compactness of aluminium exchangers, combined with the excellent thermal conductivity of the material, we can therefore also take advantage of significant weight reduction compared with the use of other materials. It therefore becomes possible to design boilers that take up considerably less space, with a significantly lower weight burden on walls and floors, whence greater latitude in configuring boiler room installation.

## >> EXAMPLE OF DIMENSIONAL AND WEIGHT CHARACTERISTICS OF THE DE DIETRICH C 230 ECO RANGE

0,54 m<sup>2</sup> floor space  
Weight empty = 200 kg / 217 kW  
I.e. less than 1 kg / kW



## >> UNEQUALLED PHYSICAL RESISTANCE

### **NO WEAK POINTS, GUARANTEEING THE LONGEVITY OF THE HEATING BODY**

In the construction of steel or stainless steel heating bodies, weld assemblies, folds, pressed parts are all sensitive areas, which are susceptible to the constraints relating to the operation of a boiler.

The changes in temperature relating to the operation of the boiler are the root cause of stress in the materials. These physical constraints, more particularly found in welds and lock seams, weaken the metals.

A boiler body constructed of components in Aluminium-Silicium with a homogenous thickness does not incorporate folds or welds and therefore presents corrosion-resistant characteristics particularly conducive to being used in condensing applications. This is all the more valuable in that the principle of condensation means bringing metal surfaces into contact with condensates, which are by their very nature acidic and therefore particularly corrosive to metals, especially if they are put under stress or weakened.

### **IDEAL MECHANICAL RESISTANCE TO OPTIMISE THE LOW TEMPERATURE RETURN PRINCIPLE**

The homogeneity of AlSi and its flexibility enable its use with considerable temperature differentials (up to 30 K) between the boiler flow and return with no risk of metal fatigue caused by these repeated thermal shocks throughout a heating season, which could lead to the breakage of components.

This temperature differential phenomenon between the flow and the return is often the result of daily operation of an installation in which the change in flow rate in the secondary circuits is caused by the constant opening and closing of 3-way valves.

This enables maximum exploitation of the boiler's efficiency: as they are not susceptible to thermal shocks, we can define low

temperature returns that enhance the condensation of the combustion gases inside the exchanger, and therefore the effect of heat recovery.

### **CHEMICAL RESISTANCE MAKING IT IDEAL FOR CONDENSATION**

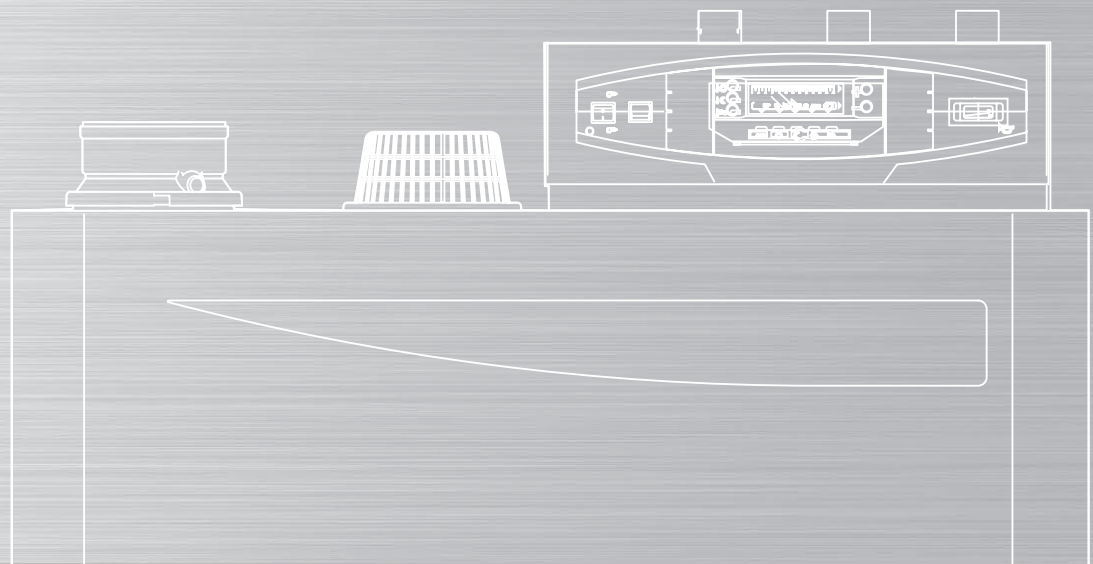
In a condensing boiler, each individual point is all the more exposed in that it is in contact with the condensates, which are acidic and therefore particularly corrosive to metals.

Aluminium's good resistance to corrosion is due to the ability of its surface to become passive, i.e. inert to corrosion. On contact with water or oxygen, a non-porous protective layer of aluminium oxide is formed naturally: this is alumina, or the «passivation layer».

It is this property of aluminium that protects the exchange surface of the heating body in contact with flue gases against the aggression of condensates and renders this metal very suitable for the principle of condensation. In the condensation phase, the run-off of condensates over the exchange surface ensures that the body in AlSi is self-cleaning by preventing the deposit of residues and non-combusted materials, which could impair correct heat transfer, whilst conserving the self-protecting aluminium layer, thus guaranteeing its resistance to corrosion.

Moreover, aluminium is not particularly sensitive to the pitting corrosion often related to the use of filling water with a high mineral content. Stainless steel, for example, is susceptible to concentrations of chlorides of more than 100mg/L (depending on their type). As for copper, it is particularly susceptible to sulphates, which quickly leads to perforation.

Aluminium is also inert in air and the alumina layer effectively protects it from oxidation by oxygen.





## >> THE ALUMINIUM-SILICIUM BOILER AND WATER QUALITY IN THE HEATING INSTALLATION

To operate optimally, a boiler requires clean water of a quality compatible with contact with the metals used to construct it. This is true of all boilers that use water as the heat-carrying fluid, regardless of their operating principle (traditional, superheated water, steam, condensation, etc.) and the material from which they are constructed (steel, stainless steel, copper or aluminium).

The water quality in a heating installation is measured using specific parameters, such as (among others):

- The pH (level of acidity or alkalinity of the water)
- The hardness (dissolved limestone content)
- The conductivity (approximation of its total mineral content)
- The level of chlorides, sulphates, etc.

These elements may vary from region to region, the water supply origin (public mains network, borehole, rainwater, etc.) and the materials and condition of the pipes that carry it.

Certain parameters have to be checked systematically, regardless of the material from which the boiler is constructed (no abrasive particles in suspension in the water, avoid water with too high a limestone content, etc). Conversely, the pH check is essential but the values to be observed vary. Indeed, generally speaking, metals corrode in the presence of acid, but each metal has a particular resistance, and a predefined pH range must be observed to prevent quick

is very broad. It can easily withstand contact with water, even if it is not treated.

The use of aluminium and the principle of heat recovery by condensation are nonetheless very advanced recent techniques. The recommendations on high pH levels, deeply rooted in operational habits and the texts on good practices, were established before these changes in technical direction and were unable to take them into account.

The recommendation of a pH higher than 9.7 – a criterion which is easy to check and implement (addition of sodium hydroxide to mains water, for example) – is incompatible with aluminium, however: its passivation layer dissolves when the pH exceeds 8.5. It then becomes susceptible to corrosion and deteriorates even more quickly if the environment is alkaline. It is therefore the wish to protect the other materials in the heating installation that weakens aluminium, occasionally leading to perforation.

Fortunately, the good old fashioned method of treating heating networks with sodium hydroxide and/or tannins is a thing of the past. Technical advances in the field of water treatment have been made with much more effective corrosion inhibitors for iron alloys (cast iron, steel, etc.) and for copper. Besides, modern installations are increasingly «multi-material» and treatments have evolved accordingly. The current molecules, such as phosphates and molybdates, which are now widespread, are wholly compatible with a heating body in aluminium.

Material	pH zone													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Iron / Steel	Red						Green				Grey			
Copper	Red						Green				Red			
Bronze	Red						Green				Red			
Aluminium	Red			Green						Red				

and irreversible corrosion. This table shows why it is customary to install protective water treatment in a heating network: steel and cast iron, which are traditionally used in plumbing and heating, corrode easily on contact with water, as the pH of water distribution net work (between 6.5 and 9 for reasons of potability, very rarely exceeding 8.5) is not naturally compatible with these alloys.

Conversely, aluminium presents good resistance to neutral or even acidic pH. It is one of the metals that is most resistant to corrosion. Its pH tolerance range

**Recommendations on water treatment for use in an aluminium-silicium boiler are therefore simply a matter of common sense:**

- As for all other boilers, water which is a little hard and has an average mineral content will prevent the formation of deposits that may impair adequate heat exchange.
- As for corrosion, this type of equipment would be quite capable of dealing with untreated water, but the other metals used in the network would suffer as a result. It is therefore simply necessary to choose a

treatment compatible with aluminium (that does not increase the pH of the water).

- For an installation on an existing network, to check the compatibility of the treatment (simple pH measurement). Should it be higher than 8.5, straightforward drainage followed by reconditioning is sufficient, which is highly recommended in all cases to prevent clogging in the new boiler by particles and residues present in the old installation.

Out of respect for implementation of the codes of practice, it would be possible to fully exploit the advantages of an efficient installation with an aluminium-silicium generator.

#### Conclusions:

The main properties that make aluminium-silicium the material of choice are its low density, its mechanical resistance, its resistance to corrosion, its longevity, its ductility, its formability and its conductivity. Furthermore, its practically infinite recyclability without the loss of properties, is the icing on the cake of its numerous characteristics, which are particularly advantageous in the field of heat exchange and, more particularly, in the deployment of gas condensing technology.



ALUMINIUM  
PRESENTS  
**GOOD  
RESISTANCE  
TO NEUTRAL  
OR EVEN ACIDIC  
PH.**



Owing to this unique combination of properties, a fair number of boiler manufacturers previously faithful to other materials are starting to adopt it. It is therefore a material of the future in the world of heating.

