

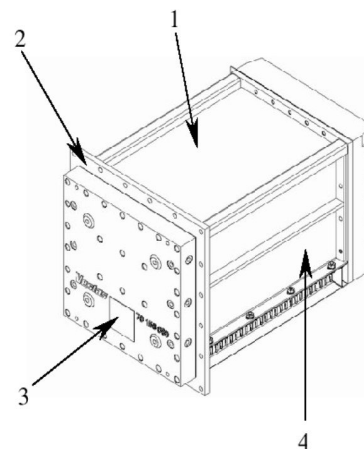
**Material selection and production description of Vestas aircoil coolers**

Vestas aircoil A/S manufacture charge air coolers, for a wide range of two and four stroke diesel engines. The material selection for the individual coolers, are based on the customers requirements and Vestas aircoil experience. Listed below are examples of material for the individual components as well as production methods for a Vestas aircoil charge air cooler.

**Materials**

**1. Tube bundle:**

The tube bundle is made of tubes and fins. The tubes can be made of either: Aluminium-Brass, CuNiFe10, or CuNiFe30. The most common material is used by Vestas aircoil is CuNiFe10, as it combines high resistance to flow erosion with good heat transfer. In very special cases, titanium tubes are available. All fins are made from pure Cu.



**2. Tube plates**

The material for the tube plates varies with the type of coolant used. If the cooler runs with seawater, or other types of aggressive coolants, Rolled Naval Brass is recommended. If the coolant is fresh water, the tube plates can also be made from electro galvanized steel or un-treated steel, all to customer specification.

**3. Water boxes**

Water boxes for “OEM” coolers are normally made from cast iron. All depending on the inside working pressure, the most often used is GG25. When working with proto types, the water boxes are most commonly welded from carbon steel.

In the aftermarket, stainless steel 316L is used where no “pattern” exists for casting of water boxes. It also possible to use customers own water box design where appropriate.

**4. Side plates / covers**

The side plates can be designed as either pressurized or un-pressurized. All depending on the application, the side plate is welded or cast. When cast, the quality is always GGG40 or above. Fabricated carbon steel is common for most “insert” type air coolers.

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### **Production methods**

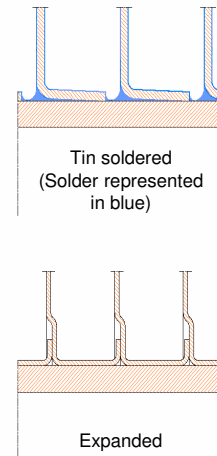
The production of the coolers can be divided into two main categories:

#### Tube bundle:

Vestas aircoil are capable of producing the tube bundle in two different ways: **“Tin soldered”** and **“Expanded”**.

The main difference is the connection between the fins and tubes.

In the **“Tin soldered”** version, the complete element is immersed into a bath of tin, which then makes a secure bond between the tubes and fins. This solution has been used since production of the first charge air cooler manufactured by Vestas aircoil in 1956. It is the more costly solution, but one which provides a slightly higher efficiency and corrosion resistance and a more rigid construction. It will last longer than any other construction method available today.



The **“Expanded”** cooler block is based on the latest technology. The fins are attached to the tube by pushing a ceramic bullet through the tube, and thereby expanding the tube to ensure a secure attachment of the fin. The expanded coolers are the more price competitive of the cooler types, without compromising quality. This method remains approved by our OEM clients.

For coolers where high efficiency is required in a limited area, a **compact tube bundle** is developed. This tube bundle is solely made in an expanded version and mainly used in four stroke engines. The compact tube bundle combines high efficiency and quality in a limited space.

#### 2. Assembly:

The assembly process is made by an experienced staff. The tubes bundles are mounted in the tube plates, and the tubes ends are expanded to the tube plate by means of computer controlled robots to ensure a permanent pressure tight seal. No “re-rolling” is ever required. After the expansion process, the tube ends are machined to minimize The pressure drop of the coolant.

When these procedures are finished, the final assembly of the cooler is carried out.

After completion of the cooler, all coolers are pressure tested to 1.5 times the operation pressure. If required by the customer, class rule can be arranged at the workshop.