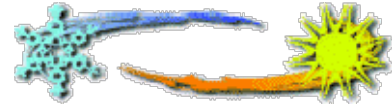


AIR CONDITIONING ON BOARD



Cruising is always a nice thing, but in summer the inside of the boat often gets too hot; We are already used to air-conditioning in our car, in offices, in hotels: why waste a nice day? Good air-conditioning can be a "do it yourself" installation. In this article we explain first the theory of summer cooling and winter heating and then the available systems and finally a practical example of an installation.



In the picture above, tools (not many nor specific tools (indeed) needed for the installation of a marine air-conditioner. In the picture below, some of the components used for the air distribution of the air-conditioning system.: flexible duct of different sizes, splitter plenums and distribution plenums, duct nipples and air grill in different shapes and sizes to match the cabin decor.



Everybody who owns a boat with a small or medium-size cabin or has a minimum of sailing experience knows that the warmest place of the boat in summer is the cabin, where the temperature is always few degrees higher than the external temperature on hot summer days: The sensation of heat created by the warm still air increases if we are not moving with air flow through the vessel which may be limited by small accesses and hatches. It is obvious that as boats are made from different materials and have different shapes and configurations, we can find more or less comfortable cabins; another variable is the possibility of ventilation and therefore the quantity, size and position of doors, hatches etc. We have so far considered the problems of the summer season, but if you use the boat in the cooler periods as well, even if the cabin feels slightly warmer than outside, it will never reach a comfortable temperature if you do not install a heating system. Many boat owners give up using their boat in the hottest or coldest period of the year exactly for this reason. Or in summer they simply cannot use the cabin as it is more comfortable staying outside. Cabins become very uncomfortable when the sun shines, no wind and air gets heavier and heavier....

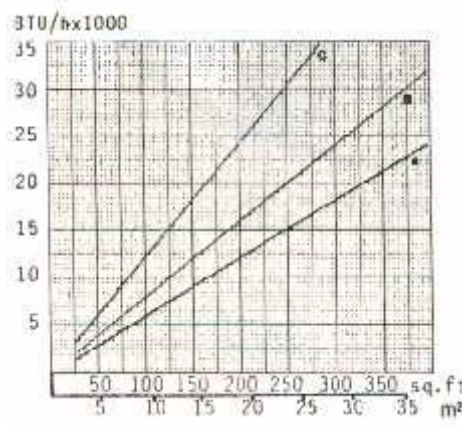
May be you still remember 'that July 199.. when I could not sleep for an entire week because of heat, mosquitos, and marina noise'. There are an infinity of types and models of boats but all, even in different ways, have the same problems.

Nowadays we can find in the market a wide choice of systems which will solve this summer inconvenience satisfactorily. The market offers air-conditioning units specifically designed for marine

Table A

The capacity needed to air-condition a room is expressed in Btu/h. In order to calculate the value you must calculate the room surface of each cabin (drawing above) and consider its position in the boat. This table gives the capacity value expressed in btu/h from the surface value.

use. The range of these systems includes units for any size of boats, with cabins of small, medium or large size. We will deal here of the small units and boats, but it must be said that the same manufacturers make very large units for very large vessels. The most interesting thing, which is the good news of recent years, is that the 'small' systems are quite easy to install and reasonably inexpensive. Considering the advantages of the air-conditioning on a boat, the installation of an air-conditioning system is quite simple and anybody with a bit of "do it yourself" experience and a with few, non specific tools, will be capable of a successful installation of a compact system. This article will give you all the necessary information to complete your installation.



- a) below deck cabin
- b) under deck or deck saloon
- c) upper deck saloon

When more rooms are to be conditioned, the addition of each individual capacity gives the total capacity needed for the boat. When more rooms are to be conditioned, see the paragraph "Contemporary loads".



Below you will find a short theoretical chapter with tables, numbers and coefficients: it is obvious that in order to air-condition a space, as each boat has different sizes and characteristics, it is necessary to combine the different components supplied by the manufacturers, and to do this, you need positive figures of the

requirement. You do not need to go back to school, nor to look for the physics school book: with these tables and formulas you will know immediately the capacity you need. Our purpose is in fact clear your doubts and answer your questions. Air-conditioning is quite common already in any application, lets make it easy also for onboard air-conditioning. We find it already on even small cars, in houses it is more and more common, not to say of the offices which are widely air-conditioned for a better quality of life. Then we ask why a leisure boat, which is the long dreamed place to spend our vacations must be not livable in summer which is when we like to have holidays. This first part of the article deals with the evaluation of the boat characteristics and the needs, which will then be used to choose the correct system and model of air-conditioner more suitable to our boat.

GLOSSARY

- Btu/h:** British Thermal Unit. The unit to measure the heat capacity. It is 1/4 of Calorie.
- Calorie:** Heat capacity measure. One calorie is the heat needed to increase of one degree C. one litre of water.
- Reverse cycle:** It is a technical way to modify the refrigeration circuit in order to produce heat.
- Fan coil:** It is a heat exchanger or evaporator equipped with a fan.
- Evaporator:** Heat exchanger between refrigerant and air or between refrigerant and water.
- Heat exchanger:** Technical component used to transfer heat from one fluid to another.
- Climate control** An air-conditioner with an automatic control which maintains the preset

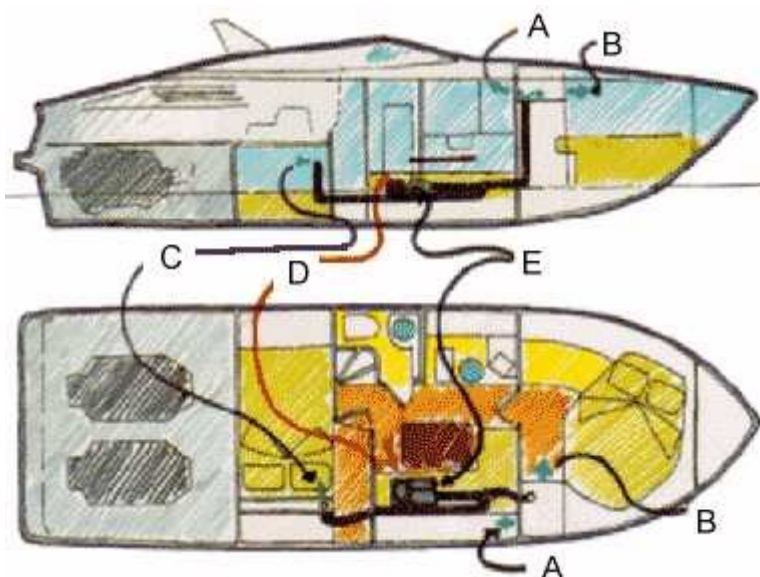
system: temperature.

What air-conditioning means

Air-conditioning means to modify the temperature and humidity of a room in order to achieve a more comfortable living condition. An air-conditioning system has the capacity to take, treat and deliver the air of room cooled and dehumidified to the correct values. An air-conditioner has normally also the capacity to heat the room when it is equipped either with the reverse cycle system or with an electrical heater. an air-conditioner is also supplied with a room temperature control (thermostat), a on/off switch and a fan speed control with multiple speeds. If the air-conditioner has also the heat function, then the control panel gives also the choice between cooling and heating. This choice can also be automatically made, in such a way that once you set the desired temperature, the air-conditioner control will choose automatically the functioning mode to reach and maintain the set temperature. In this case the air-conditioner becomes an environmental control system.

Air ducting

A. Saloon delivery grill
 B. Owner's cabin delivery grill
 C. Guest's cabin delivery grill
 D. Air intake grills
 E. Compact self-contained air conditioner, installed under the seats of the dinette



Types of air-conditioners

There are three types of air-conditioners:

A) Independent direct expansion units as self contained or two part units which are used to air-condition one or two rooms close to one another. The air-conditioner treats the room air and delivers the air back directly to the room recirculation, through air ducting with sizes from 75 to 175 mm which avoids making complicated and long distribution systems. An interesting version of the independent unit is the split model which is built in two parts: a compressor assembly and a separate evaporator/fan assembly which can be installed several metres apart from the compressor, saving cabin space and permitting the air-conditioning installation in boats where there is no space for both components in one piece. The temperature control is made by stopping and running the compressor and also by controlling the fan speed.

B) central units with direct expansion circuit to several evaporators (fan coils). These are very common units used in land installations where they can be called 'multi-split'. In marine applications there are some installations made with this configuration where one (large) compressor cools several evaporators. Unfortunately this simplified configuration makes the system inflexible and it tends to become unbalanced, particularly when the thermal load is reduced at night and with the large compressor balanced for the high load

of the day, it becomes far in excess of the reduced night load. This situation can cause an increase in the fan coil noise into the cabins. In addition to this, the piping for the refrigerant connection to each fan coil could become a weak point if not correctly designed and installed: as any leak will stop the entire system and the repair could be a real hassle. With this type of system it is not possible to connect several compressors in parallel on the same circuit; each compressor must have its independent circuit connected to its evaporators. The temperature of each room is controlled by stopping the fan of that room or by stopping the refrigerant flow to that fan coil. In either case again the system becomes unbalanced if not properly designed as the compressor capacity is still the same while the fan coil load is reduced.

C) central systems with chilled (or heated) water distribution to several fan coils each installed in the room to be air-conditioned. In this case the central system, which can be made with one or more compressors, cools (or heats) the water of a closed water circuit which is pumped to each fan coil. This type of unit has several advantages: the distribution system of the chilled (or heated) water has the same characteristics as a heating circuit but instead of a boiler there is one or more chiller compressors and at the place of the radiator in each room there are the fan coils. Each fan coil is completely independent from the central unit, which is set to keep the fresh water circuit temperature at a preset value (normally +12C in summer mode and +40C in winter mode); all the fan coils are connected in parallel to the fresh water circuit and the room temperature.

Cooling mode

The airconditioner, when used in cool mode (summer use), is a refrigerating unit which subtracts the heat from the room air (directly in the direct expansion systems, and indirectly with an intermediate fluid in case of 'chiller' systems. The heat removed together with the heat generated by the compressor working, must be then dissipated outside the air-conditioned space. The marine air-conditioner uses a special marine heat exchanger to dissipate the heat to the sea water, which is circulated by a pump.

Heating mode

The same airconditioner which produces 'cold' in summer, can produce heat in winter. In order to produce heat the air-conditioner must be equipped either by a "reverse cycle valve" or by an electric resistor. The reverse valve is special 4 ways valve which can "reverse" the refrigerating circuit so that the evaporator becomes a condenser and the condenser becomes an evaporator. In this way the heat is taken from the sea water (which is consequently cooled) and given to the room air which is heated. This heat is sufficient for Mediterranean climate, with mild winter temperature and, more important, sea water temperature above 0° C. The sea water temperature must be carefully considered as the air-conditioner efficiency drops dramatically if the sea water temperature drops below 10 c. If this happens the air-conditioner loses efficiency and it can no longer be used. In this case for cold seas it is advisable to install



The pictures show the use of the air distribution grills, their shape and some of the possible installations. As the cold air is heavier than warm air, the cold air falls therefore the cooled air should be dispersed across the deck head or at least upwards. This is achievable also by realigning the grill blades. The air grill has also a high impact on the inside decor.



system equipped with electrical heating, which doesn't lose efficiency in cold waters. In the market are also available air-conditioners equipped with electrical heating.

Sea water cooling of the air-conditioner

Because of the heat rejected overboard by an air-conditioner when cooling, and the consequent problems in typical marine installation, all marine air-conditioners are water cooled, in other words the air-conditioner dissipates the heat into the sea water, using a special marine heat exchanger in which the sea water is circulated by means of a pump. Of course a "land" air-conditioner could also be installed but due to external noise and water ingress the result will hardly be satisfactory. The pump used to circulate the sea water should be rated for continuous duty and built to marine specifications. It is normally used a marine centrifugal pump in 230V which is installed below the water line as the standard centrifugal pump is not self priming.

Safety

The marine air-conditioning has two aspects which must be well considered for safety reasons:

- a) The system is connected to mains supply (normally 230V) and it is essential that the connections follow the safety rules.
- b) The air-conditioner unit (or its fan coils) must recirculate the cabin air and possibly a small percentage of external air. The air intake should never come from contaminated compartment or even worse, from the engine or generator room. In fact in case of a problem in the exhaust system of the engine or generator, the exhaust gas is lethal to man and if the air-conditioner takes and delivers these gasses it will be extremely dangerous or even lethal to the people on board.

Air distribution - Recirculation and air exchange

The air-conditioning of a compartment may work only by treating the air of the room temperature. The majority of the air-conditioners work with recirculation only as the air-conditioner treats and delivers back to the ambient the same air taken from the room. The use of fresh air is not normal practice, as there is normally more than sufficient "natural" air exchange in the original yacht project, from ventilators, hatches, doors and generally "passage" to the external ambient for breathing and odour removal. The air exchange becomes a must for yachts above 25-30 metres and for boats designed for personnel carriers. When handling air (air-conditioning) it is necessary to keep in mind the following rules:



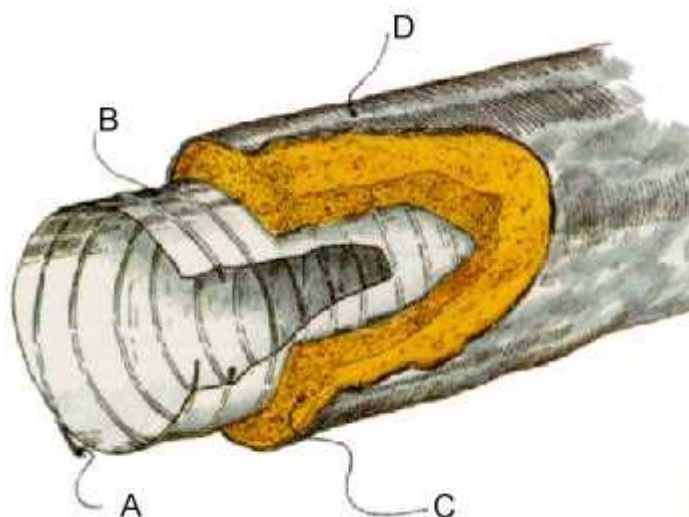
- Cold air is heavier than warm air and therefore always falls, and for this reason, in order to achieve a good temperature distribution of the air-conditioned space, it is advisable that the treated (cold) air is delivered towards the ceiling, vertically or horizontally. This rule is valid particularly for the spaces of the areas used during the day, such as the dinette and the saloon and wheelhouse; as these areas suffer the maximum solar effect which increases the heat load to be dissipated. In order to get a minimum temperature gradient, the air is ideally delivered across the deck head or at least towards the top of the space and therefore takes advantage of the

natural convection which pushes the cold air down and lifts the warm air.

- The winter heating, in a Mediterranean climate, needs less capacity than the summer cooling and it is advisable to give a priority to the configuration for the cooling effect rather than the heating which will be achieved without too much effort.
- Toilets and the galley space (if apart) are normally not conditioned and it is good practice to keep them slightly depressurised by using an extractor fan: in this way odours will be kept inside these spaces and the extractor will take air from the other rooms which are conditioned. External air will be therefore taken from the deck area (saloon), helping the fresh air exchange, and the conditioned air will also cool toilets and the galley.
- The ducting of the conditioned air must be as simple as possible to reduce the pressure drop; short and straight ducting is the rule, while elbows, bends and generally "winding" paths are to be avoided. Complex "networks" must be avoided as they cause pressure drop and reduce the air-conditioner capacity and effectiveness dramatically.
- All the air-conditioners have a "nominal" capacity expressed in Btus/h or Watts/h; however this maximum capacity is strictly related to the air treated by the air-conditioner and drop at the same rate as the air flow. Therefore we recommend that the air circuit is as short and simple as possible, particularly if the maximum capacity of the air-conditioner is needed.
- The air intake for the air-conditioner is also important. Air intake must be straight back to the air-conditioner through a grill or opening which does not cause any pressure drop.

The diameter to be considered is the inside diameter

- A. Steel spring
- B. Inside duct: textile with PVC
- C. Insulating material: rockwool
- D. Outside skin: Craft paper



Air delivery grills

The treated air must be delivered and diffused into the area to be air-conditioned, in such a way that it doesn't bother people by causing a draught and should be quiet, by avoid too high an air speed, and for this reason air grills have to be installed of a size adequate for the air-conditioner capacity. The market offers a variety of grills in metal, wood and plastic; it is also possible to make custom made grills incorporated in the yacht furniture. If well studied, grills can be aesthetically pleasing and matching the internal decor.

Intake grill

The air-conditioner or fan coil must take the air from the room to treat it. The space where the air-conditioner is installed must be in direct communication with the room to be conditioned. In this case it is not necessary for an intake grill as the air is drawn freely. The intake grill is needed for the decor purpose only, as the intake must be "masked" , but other solutions for the air intake can be found with improved appearance. When the treated air from an air-conditioner is delivered to several cabins, one must consider that the air from these cabin must return to the air- conditioner. Often cabin doors are not tight, but it must be checked that the air passage is enough, otherwise the air- conditioner will run at a reduced capacity due to a restricted return. A passage for the return air can sometimes be found through a locker which is common to both cabins.

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