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Innovative technologies in the buildings for the breeding of dairy species: *geothermal energy* application and correlations with energy saving.

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Introduction

Among the possible renewable energies, the geothermal one is perhaps the most interesting in terms of sustainable development, representing a form of alternative energy, that is clean, free, renewable and available everywhere.

The use of underground heat as reservoir has always been a great opportunity more or less exploited by man over time; due to the coupling with the heat pump system, such exploitation has reached a very good value for money.

The term geothermal identifies several technologies that are united by the use of subsoil for energy purposes and, by convention, refers to the exploitation of "hot" underground, with temperatures above 40°C.

Excluding hydrogeological phenomena anomalies, the temperature of the subsoil is between 12 and 14°C, with possible periodic oscillations contained within 4°C. Also basements that do not have particular geo-lithological details can be exploited for energy purposes in the civil, industrial and general manufacturing fields.

The expression "*low enthalpy geothermal energy*" refers generally to the type of technology that exploits those portions of subsurface, up to 200m deep, lacking hydrogeological anomalies.

The study aims to investigate the possibility of geothermal energy exploitation for zootechnical facilities for the dairy cows breeding, specifically suggesting the coupling of the geothermal refrigeration system for milk with the geothermal probes.

In particular, after having detailed the innovative aspects of this new technology, commercially applied to civilian buildings, the application of geothermal probes is proposed either in the pre-cooling process of the milk counter, before entering the cooling tank, or inside of the existing refrigeration system through the replacement of air-cooled condenser, thus of the water one, with a geothermal heat exchanger.

After checking the technical feasibility, we proceeded to the conceptual design of an installation by running the comparison with the current refrigeration systems in terms of energy savings, as well as the estimated cost of installation and the payback times.

Finally, we offer ideas for potential uses of geothermal probes outside the milking operations, in order to achieve further energy savings and to improve *animal welfare* in the milking parlor.

1. The heat engine heat pump

1.1 Functioning of the heat pump and thermodynamic notions

The heat pump (PC) is a cyclic heat engine whose components operate so as to achieve a transfer of thermal energy from a source at a lower temperature to a higher temperature. In most common applications (civil, industrial and industrial) these machines are called heat pumps and operate reversibly to operate both to heat and to cool environments, body or fluids depending on the need. The name of the heat pump derives by analogy from the operation of the hydraulic pump that lifts water from a lower level to a higher altitude, thus opposing the natural flow originated by the force of gravity.

The operating principle is based on the phase change of refrigerant fluid along the thermodynamic cycle that it does. The cooling is obtained by evaporating of the refrigerant at pressures and temperatures which are the lowest in the entire cycle. Pressure and temperature are then raised by the intervention of a compressor which generates mechanical compression of the refrigerant fluid, that after this process, is at the state of superheated steam with values that are the highest in the cycle. The heating is obtained through reverse overheating of the refrigerant and its subsequent condensation. The cycle ends with the mechanical expansion of the fluid through a special valve until it repeats the cycle of evaporation. The four main components that allow the operation of the heat pump (refrigeration system compression), are:

- evaporator;
- compressor;
- condenser;
- expansion valve (or rolling valve);

A refrigerating machine operates exchanges of heat between two environments with different temperature. Suppose to outline these areas with two tanks (Serb) 1 and 2, respectively at the temperatures T_1 and T_2, with $T_1 < T_2$. The Coolant (1), vaporizes running through all the evaporator and removes the heat from serb1; at the exit from the evaporator it is compressed by the diabatic compressor, then it proceeds in a heat exchanger where it is first desuperheated and then condensed (this transformation generates a supply heat from the fluid to Serb2), the fluid is then drawn through the throttling valve which undergoes an expansion to return to the initial pressure and temperature values.

1.2 System efficiency

The thermodynamic cycle used by the heat pump, between two tanks at T_1 and T_2 temperature, with $T_2>T_1$, can be used either for heating or cooling of fluid or environments. In both cases it is possible to define an energy performance coefficient representing the ratio of useful energy produced and consumed energy by the machine. We have to define Q_1 as the heat exchanged with the source temperature T_1, Q_2 as the exchanged heat with the source at temperature T_2 and L as the input mechanical work done by the compressor.

Evaluating winter operation (civil application case) with the support of work L, the heat pump releases heat Q_2 to the body that has to be heated at temperature T_2. COP is defined as the ratio between the energy released and the imparted energy provided by the compressor and represents the performance of the heat engine is warming up phase. In other words, the COP is the ratio between the thermal power Pt made available and the consumed electric power Pe.

In winter situation we have: $COP_i = Q_2/L$

For summer operation (civil case application) we can similarly define a value of COP as a function of cooling. In this case, providing a quantity of work L, the temperature of the body concerned goes down, subtracting the heat Q_1 from the environment at temperature T_1.

In summer situation we have: $COP_e=Q_1/L$

Please note that the COP is not a thermodynamic efficiency (which would have values between 0 and 1) and, therefore, can take values higher than unity. The fact that this coefficient takes values even greater than unity, however, does not affect the first law of thermodynamics, so

$$|Q_2|=|Q_1|+|L|$$

The heat Q_2 released to serb2 at the highest temperature T_2 is equal to the sum of work L required to carry out the cycle and of the absorbed heat Q_1 by serb1 at temperature $T_1<T_2$.

On the base of the second principle of thermodynamic we have anyway a maximum value of COP, named COP_{carnot} achievable in a theoretic way by a heat engine operating between two tanks at temperature T_1 e T_2. According to Carnot's theorem, this limit is only function of temperature T1 e T2 *(see Tab1.2)* (absolute temperature espressed in Kelvin degree T[k]=T[°C] + 273.15).

In the case of heating mode (winter mode to civilian use) we have:

$COP_{i\_carnot}=T_2/(T_2-T_1)$

In the case of cooling mode (summer mode to civilian use) we have:

$COP_{e\_carnot}=T_1/(T_2-T_1)$

The analyzed $COP\__{carnot}$ with the above formula are purely theoretical, because the formula do not take into account the irreversibility characterizing the real cycle compared to the Carnot theoretic one *(se Tab1.1)* and to the technical inability to realize the cycle without heat sink (the cycle consists of two isotherms and two adiabatic transformations). The most significant internal irreversibility in the cycle are found in the actual process of rolling (completely irreversible transformation) during the compression phase and early stages of evaporation and condensation. The latter cannot be considered perfectly isobars because of the fluid losses due to friction within the components. In fact, the COP is approximately half of the theoretical value.

It 'important to highlight that, regardless of the system irreversibility, the energy efficiency of a heat pump is closely related to the two thermal reservoirs. The lower the temperature difference the greater the theoretical maximum obtainable and thus the real value of the COP too.

The performance of commercially available products, irrespective of the various civil applications or production, usually provide values of COP varying between 3.5 and 4.5, depending on the type of machine. These values tend to improve with time, as projects and products are refined in order to minimize energy dissipation during the cycle.

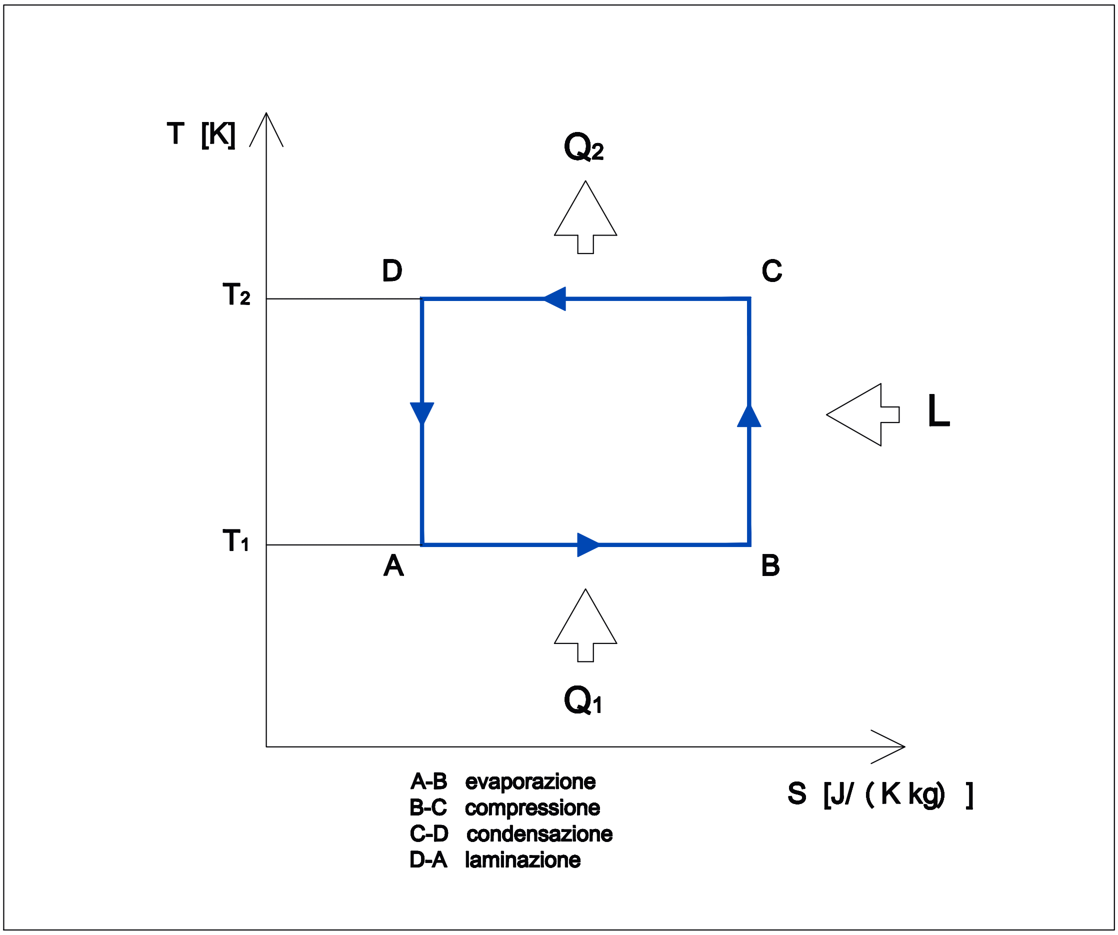


Fig. 1. Carnot Cycle

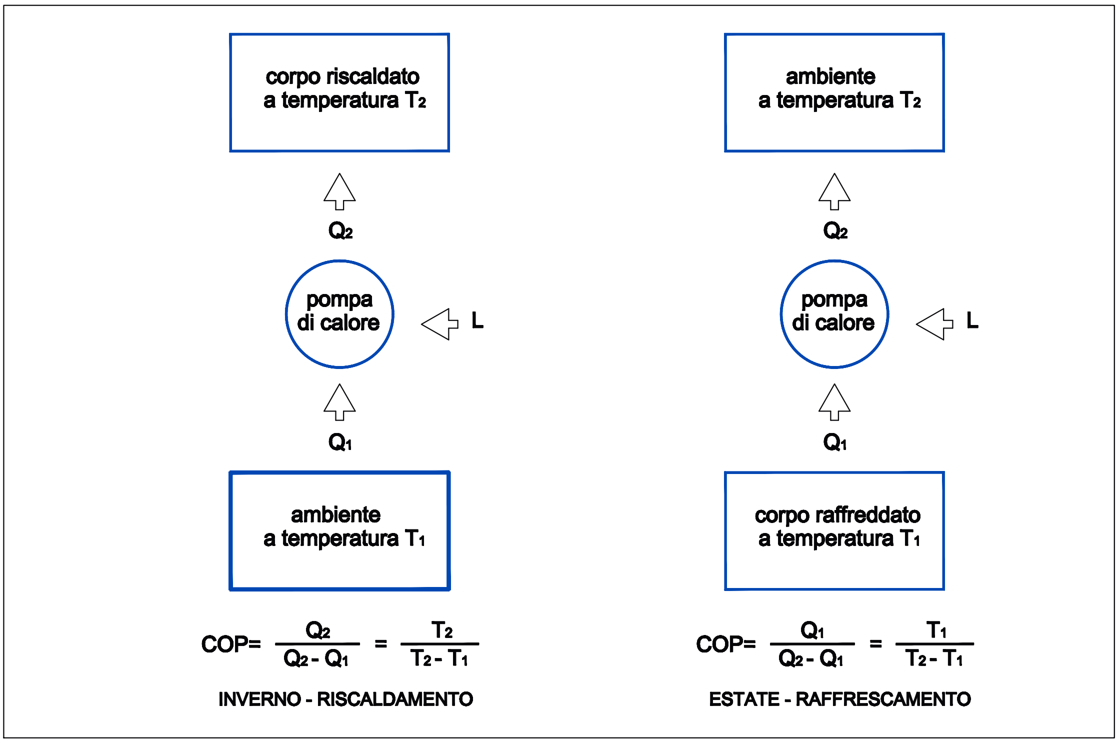


Fig. 2. Scheme of the production principle of heat/cool by PC

Tab 1.1

Carnot cycle

The Carnot cycle is a purely theoretical and its realization requires the study of a theoretical heat engine in which a theoretical gas also makes thermodynamic cycle. This statement suggests that it is impossible to create a real heat engine that can be applied to the Carnot cycle.
The stated theoretical machine that runs the cycle is called Carnot engine. It requires two sources, namely two heat sources at different temperatures that is summarized generally as a closed cylinder with a piston with adiabatically insulated walls containing gas which can only exchange heat through the bottom of the cylinder.

Four conversions:

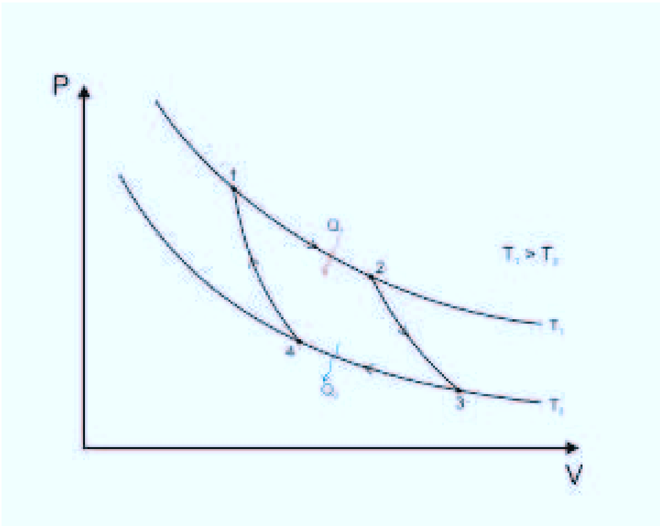


Fig. 3. Carnot cycle, diagram P-V.

Graph of the pressure as a function f the volume of the four transformation in Carnot cycle.

The Carnot cycle of a perfect gas is composed by two isotherms (1-2) and (3-4) at temperature respectively $T_1 > T_2$ and two adiabatic (2-3) and (4-1):

- *Isothermal expansion* (1-2), the gas picks up the amount of heat Q_1 from the source warmer T_1 and this causes the increase of gas volume and the decrease in pressure. The trend to lower the temperature of the gas is balanced, only in the first part of the raced by the effect of the heating (heat source). So it remains constant.

- *Adiabatic expansion* (2-3): When the gas ceases to collect thermal energy, it is maintained so that no energy exchange with the outside through an adiabatic, while continuing to expand, thus resulting in a lowering of the temperature.
- *Compression isotherm* (3-4): the gas is compressed at constant temperature and the heat generated by the work done at this stage, removed from contact with the source at a lower temperature $T_2 < T_1$. The amount of heat Q_2 is transferred from the gas to the source.
- *Adiabatic compression* (4-1): When the gas ends to transfer heat to the cooler, it continues to compress, but it is kept so that there is no energy exchange with the outside.

Tab 1.2

Output of a Carnot cycle

The key feature of the Carnot engine is that its performance does not depend on fluid used in the cycle, but only by the temperature of the sources with which exchanges the heat (or rather, more precisely, by the ratio between the two temperatures).
This very important result of thermodynamic theory goes under the name of Carnot's theorem.
The efficiency of a heat engine is, in general, the ratio of useful work that the machine can perform and the total heat absorbed by the system. If a cycle is executed *n* times, the performance of the machine will then be:

$$\eta = \frac{|L|}{|Q_1|}$$

where *L* is the total work done by the engine, and Q_1 the total heat absorbed by the latter.

In the Carnot cycle case, the output will be equal to

$$\eta = \frac{|Q_1| - |Q_2|}{|Q_1|}$$

From this last equation is possible to derive that the output depends only on the temperatures T_1 and T_2 given that the heat exchange occurs only during the isotherms (*Carnot output*):

$$\eta = \frac{|Q_1| - |Q_2|}{|Q_1|} = \frac{T_1 - T_2}{T_1}.$$

Soon, the output would be maximum (100%), only if T_2 = 0K (absolute zero), a value of temperature not reachable by any physical body. It follows that, independently of any detail, the output theoretically achievable with a Carnot cycle, is always less than one.
This result is obviously in agreement with the second law of thermodynamics, which prohibits the possibility to produce perpetual motion of the second kind.
So it is possible to summarize the statement of Carnot into two major parts:

1. No heat engine that uses the Carnot cycle is able to completely transform heat into work, because some (Q_2) of the heat originally supplied to the system (Q_1) is

transferred to the mean at a temperature lower than the T at which it was supplied and therefore the heat cannot be reused. From this it follows that the efficiency of a heat engine can never be equal to the unit since Q_2 can never be null.

2. The output of a heat engine do not depend on the nature of the used fluid but rather on the temperature lapse in which the engine operates.

An important consequence of the Carnot statement: heat is a kind of energy of second type because it cannot be converted entirely in other energy type.

Determination of theoretical output

The *Carnot efficiency* can be obtained either by applying the ideal gas law, or by the overall balance of entropy.

Overall balance of entropy

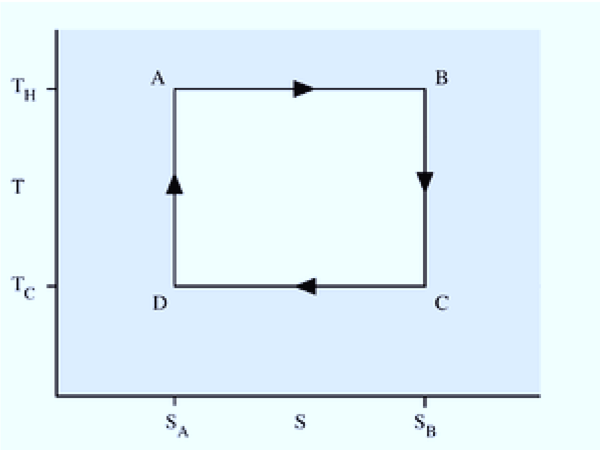


Fig. 4.Carnot cycle reppresented in the T-S graph (or entropic diagram)

The adiabatic transformations do not involve the exchange of heat. To draw their graph on a *T-S* plane would produce an isentropic, i.e. a vertical line, indicating no variation in entropy. For an isothermal transformation, the change in entropy is simply the ratio between the work done and the temperature (constant). Therefore

$$\Delta S = \frac{Q}{T} = \frac{nRT \ln\left(\frac{V_f}{V_1}\right)}{T} = nR \ln\left(\frac{V_f}{V_1}\right)$$

the heat (for the isothermal, the variation of internal energy is zero, so the heat is equivalent to the work) will be given by:

$$Q = nRT \ln\left(\frac{V_f}{V_i}\right)$$

The output η will become

$$\eta = \frac{nRT_1 \ln\left(\frac{V_2}{V_1}\right) + nRT_2 \ln\left(\frac{V_4}{V_3}\right)}{nRT_1 \ln\left(\frac{V_2}{V_1}\right)}$$

which coincides with the one previously calculated together with the application of the ideal gas law.

2. Geothermal energy

2.1 Preliminary remarks

Among the possible renewable energies, the geothermal one is perhaps the most interesting in terms of sustainable development, representing a form of alternative energy, that is clean, free, renewable and available everywhere.

In recent years, geothermal systems (heating and cooling in the civil field) represented the technology option that best optimizes the relationship between investment and operating costs.

The use of underground heat as reservoir has always been a great opportunity more or less exploited by man over time; due to the coupling with the heat pump system, such exploitation has reached a very good value for money.

With the term “geothermal”, we identify several technologies that are united by the use of subsoil for energy purposes and, by convention, refers to the exploitation of "hot", underground with temperatures above 40°C.

The exploitation of this form of energy takes place from immemorial time in the places where particular geo-lithological conditions allow to the carrier "water", in liquid or vapor phase, to "carry" the heat from deep underground to the surface. This is the case of spas and fumaroles (*geyser*). Such form of energy is used for example to produce electricity by exploiting the pressure of the steam contained in underground aquifers to drive a turbine (Rankine) coupled to a generator; such as in the Lardarello plant in Tuscany and those even more known in Iceland. Italy is now the fourth country in the world for the production of electricity from geothermal sources.

2.2 Low-enthalpy geothermal energy

The cases mentioned so far refer to particular geo-lithological substrate of the Earth. In most cases the subsoil retains an almost constant temperature from 10m to 100m depth. The layer of the first 10m, however, is affected by temperature day/night, summer/winter. For depths exceeding 100m, although not consistently, the average temperature gradient proceeds increasing at a rate of 3°C per 100m deep.

Excluding phenomena of hydrogeological anomalies, the temperature of the subsoil in Italy is between 12 and 14°C, with possible periodic oscillations contained within 4°C.

The temperature of the soil to a depth of 10m can be found with the value given by the arithmetic mean of the ambient air temperature along a calendar year.

Also for the basements that do not have any geo-lithological peculiar condition, an exploitation for energy purposes in the various fields (civil, industrial and general manufacturing) is possible. The depth of soil normally used for such purposes is ranging from a few meters up to 200m.

The expression "*low enthalpy geothermal energy* " (henceforth *geothermal energy*), generally refers to the type of technology that exploits the portions of subsurface without any hydrogeological anomaly, up to 200m deep. From now on, the term "*geothermal plant*" will be referred to that type of system that exploits the low enthalpy of the subsoil for the various purposes of environment heating and cooling, fluids and/or bodies.

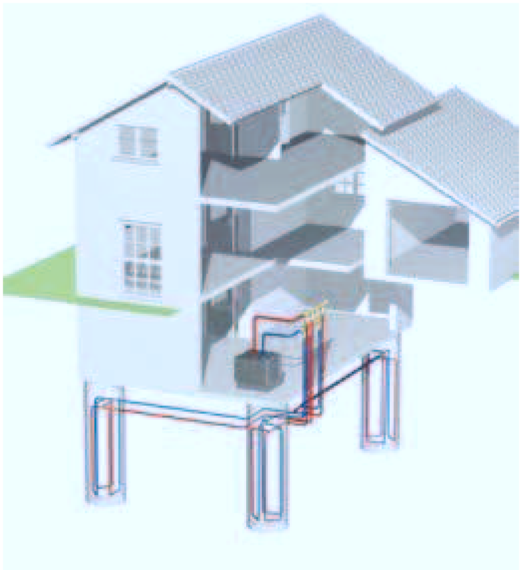


Fig. 5. Example of geostructure.

To entirely exploit thermal energy stocked in subsoil it is necessary to join an exchanger thermal system (geothermal probes) to a heat engine heat pump (see chapt. 1).

2.3 Geothermal applications

The function of a geothermal power plant is to produce water (or air) cold or hot depending on the needs. The main difference with a conventional heat pump system (PC) is in the different used heat source. Using air as a thermal source, even if extremely popular, has a non-negligible critic: the temperature of the outer environment is variable along the year and it is lower in periods of high heat demand and higher in periods of low demand . This leads to a deterioration in the PC performance.

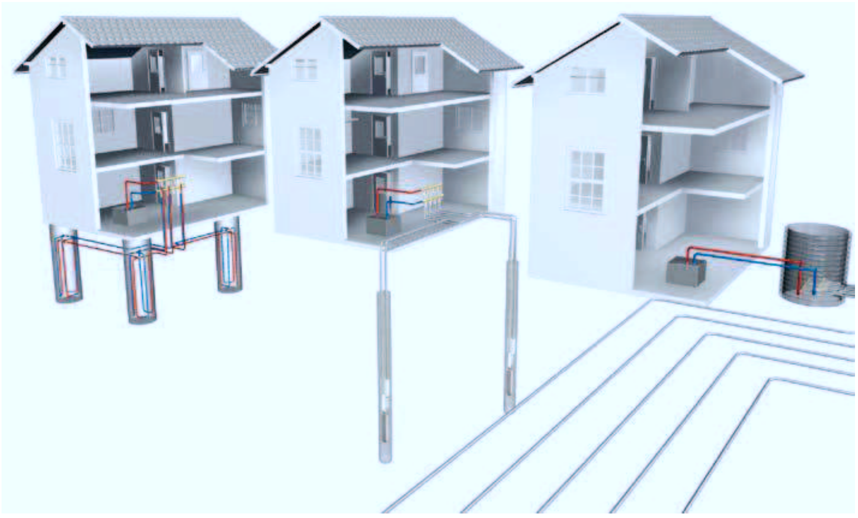


Fig. 6. Application of the several geothermal probes.

On the contrary, in the geothermal plant, the PC system can rely on a theoretically inexhaustible source of heat at an almost constant temperature (12-14°C).

The heat exchange between the source and PC can be made using the following techniques:

- vertical geothermal probes;
- horizontal geothermal probes;
- mixed exchanger;
- groundwater;
- Deep energetic foundations (geostructures).

Fig.7.Geostructure (foundation pile with probes)

Fig.8. Horizontal geothermical probes

The fields of application of these systems are very different, the geothermal energy is an excellent technology, suitable for heating and cooling, to produce hot water for some production processes and, not less, for coupling with other processes in various sectors. This study proposes the use of geothermal probes in zootechnical farms, especially for the dairy cows breeding, in order to achieve energy savings in the process of milk cooling and, simultaneously, to improve animal welfare. Only after a more detailed discussion of the geothermal plants, applied to civilian use, the case study will be introduced with the proposed use for livestock.

2.4 Vertical geothermal probes

For civil applications the system with vertical probes is certainly the technological solution more widespread in central Europe, occasionally alternating the horizontal probe system. Instead, the solution with vertical probes becomes the practice, considering the installations for public buildings of considerable size or for production activities.

Exchangers on the market are of two types: "U" exchangers, single or double type, and coaxial exchangers, simple or complex type, see fig. 9, p. 18.

Conventionally we take the "U" solutions, thanks to the high reliability that this installation provides.

In particular, the use of double "U" probes has the following advantages (Rohener 2001):

- At the same probe linear development, we have thermal well resistance lower than those occurring with the probe in a simple "U", through the use of smaller diameter tubes, with reduced thickness enabling the achievement of transfer higher coefficients of thermal exchange;
- In case of malfunctioning of one of the two “U" tubes, depending on the characteristics of the soil, the other tube can provide from 70 to 85% of original power;
- At the same capacity we can produce lower capacity drop.

On the contrary, probes with a single "U" are preferable in terms of reliability due to a simple design and the absence of the phenomena of thermal circulation and differences of capacity, typical of the double "U" probes, see fig. 10, p. 18.

Until now, the market has undoubtedly preferred "U" technology at the expense of coaxial heat exchangers. For the latter, there are research and testing work in progress of materials and geometries that, most likely, will guarantee a raise in the market. After the application of the first probes made of copper or galvanized steel (commercially known as "galvanized iron"), the experience led to exclude those materials which, while providing excellent heat exchange properties, revealed problems for the excessive cost of copper and for galvanized steel corrosion problems.

The material currently used for the probes is the high density polyethylene - PEAD type or HDPE, PE 100 PN 10/16- that, thanks to the combination of good heat transfer, low cost, good mechanical performance and best reliability in the implementation of joints, make this product ideal for application in the field of geothermal energy (*see Tab 2.1*). The letters "PN 16" (PN = nominal pressure) means that the tube is guaranteed in order to maintain its mechanical properties up to a pressure of 16 bar. These features must be chosen according to the depth of the probe. We have to consider that a pipe at 100 m depth is subjected to a pressure equal to the 100 m water column ≈ 10 bar.

2.4.1.Thickness and diameters of the probes. With the aim of heat exchange, a minimum thickness would be worthwhile, however this contrasts with the required mechanical performance, particularly with the terminal section that is subjected to higher pressures and increased stress during the phase of the probe insertion into the ground. The diameter should be sized according to the pumping power (not too small) and have values such as to ensure the turbulent regime of fluids.

The size most used for geothermal probes are:

- PE 100 SDR 11 PN 16 outer diameter 40.0 mm and thickness 3.7 mm;
- PE 100 SDR 11 PN 16 outer diameter 32.0 mm and thickness 2.9 mm;

For the jointing of high density polyethylene the thermal melt method is used, a technique widely diffused civilian use hydraulics.

2.4.2. Base of the exchanger. For a “U” or double “U” shaped system, the base of the exchanger, also called "*foot",* is the most critical point, as the fluid reverses its motion.

The methods most used are designed for pipe diameters ranging from 32 to 40 mm with the geometries shown in fig. 9 (pag.18).

2.4.3. Probes Insertion into the holes. The insertion techniques vary depending on the geolithological underground features. On the contrary to what one might imagine, the construction of geothermal probes on solid rock is beneficial either for the quality of heat transfer obtained or for the insertion mode of the tubes. These can be inserted into holes drilled with a superior diameter than probes size, that are sent down with a ballast, after filling the hole with water. For clay soils and / or sand, for the insertion of the probe we apply ballast of different sizes. In general, the techniques for the insertion of the probes are easily applied by companies that specialize in drilling small diameter (300 mm), such as the creation of foundation micropile or similar.

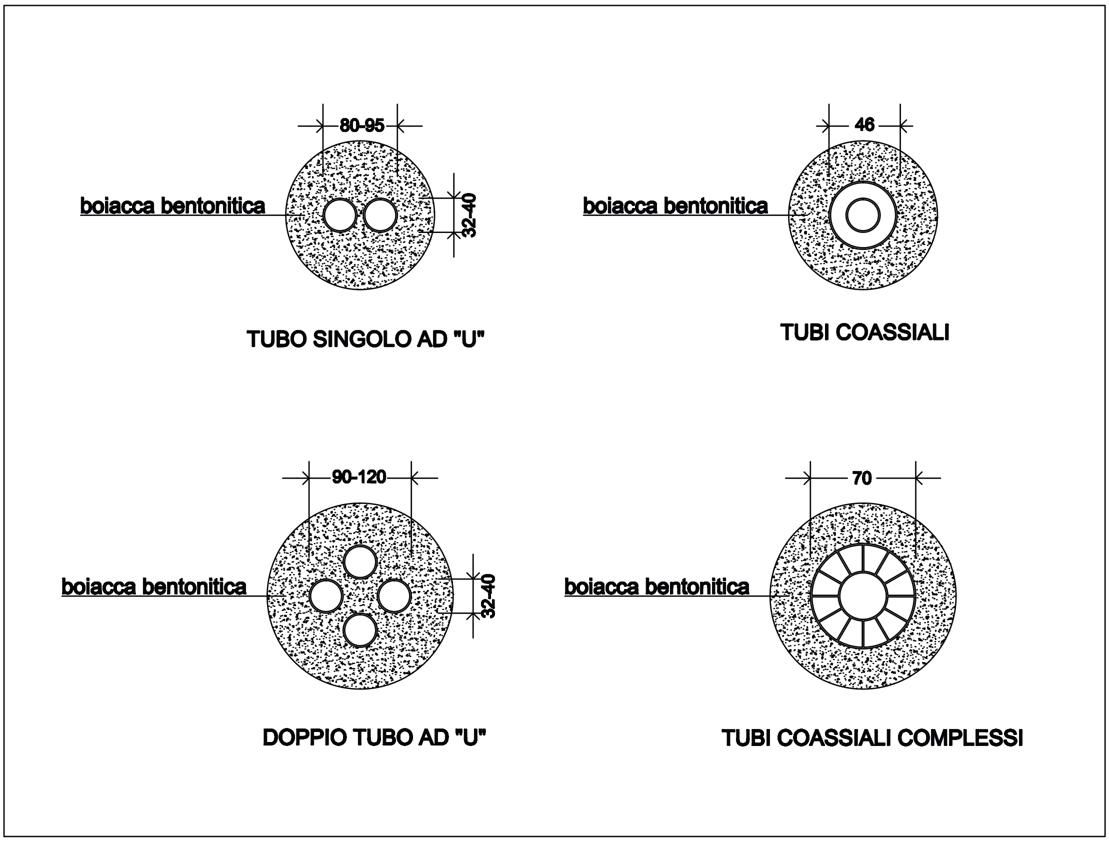


Fig. 9. Types of probe head

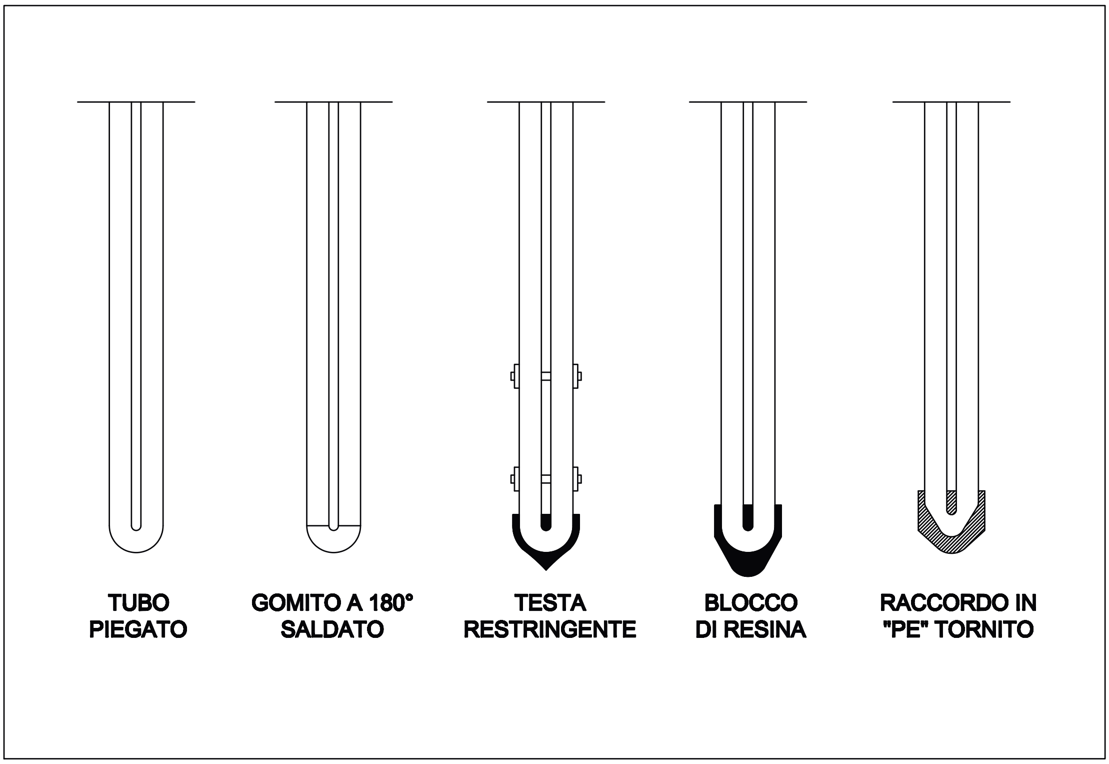


Fig. 10. Section of the several geothermal probes (see Tab 2.1)

Fig. 11. Drilling for vertical probes.

2.4.4. Cementing of the hole. After the probe is lowered into the hole, the latter must be sealed with cement-bentonite grout from the base of the probe. In so doing we must take particular care not to leave empty gaps, some of which would cause air pockets which drastically reduce the heat exchange with the surrounding soil. Several studies (Phetteplace, Kavanaugh, 2000) using the more correct fill hole brought to light the difficulties in order to balance the optimization of thermal performance with environmental considerations. The cement-bentonite grout, while not optimal for heat transfer, it is not soluble, however, is the material that provides protection against the pollution caused by contact between the upper stratum and lower stratum. Moreover, this material is pumped into an aqueous solution (ease of application) is slightly expanded (optimizes the effect sealant) and weakly elastic characteristics in order to prevent fractures in mild stress suffered by the ground (seismic movements).

After the probe was lowered into the hole, it must be sealed with cement-bentonite grout from the base of the probe. In doing so we must take particular care in not leaving empty gaps, some of which would cause air pockets which drastically reduce the heat exchange with the surrounding soil.
Several studies (Phetteplace, Kavanaugh, 2000) about the most correct material for filling the hole brought into light the difficulties in balancing the optimization of thermal

performance with environmental considerations. The cement-bentonite grout, even though it is not optimal for heat transfer but it is soluble, seems to be anyway the material that provides protection against the pollution caused by contact between the upper stratum and lower stratum. Moreover, this material can be pumped into an aqueous solution (easily applicable), it is slightly expanded (optimizes the sealant effect) and it has weakly elastic characteristics in order to prevent fractures in mild stress suffered by the ground (seismic movements).

Recent studies performed in collaboration between the Brookhaven National Laboratory and the University of Alabama led to define a new filler, called MIX111, that, thanks to the results of some tests carried out in specific conditions, has led to the reductions in the depth of the wells from 22 to 35% ,compared to traditional filling.

2.4.5. Used geothermal fluids. Mixtures of water and other fluids (contained by 20%) are used to ensure a freezing point near to 263 ° Kelvin. Among the most widely used fluids are included:

- Methanol;
- Ethanol;
- Sodium chloride;
- Potassium acetate;
- Ethylene glycol;

Regardless of the type of solution, an ideal fluid should be:

- Cheap;
- With excellent performance in relation to thermal fluctuations;
- Not flammable;
- Low viscosity;
- Non-toxic;
- Stable;
- Non-corrosive and not compatible with the materials that make up the whole system;

2.5 Non-technical summary of the geothermal plant operation with vertical probe for heating function for housing units with floor radianting panel

In order to extract heat from the underground through a geothermal vertical probe is sufficient to put water into the probe at a temperature of about 5°C lower than the subsoil,given that in the first 100 m depth, with a good approximation, the temperature of the subsoil is constant (about 13°C in the north-central Italian regions). Assuming we analyze the case study of a plant with a single geothermal probe inserted up to 100 m depth, the geothermal fluid (*fluid*), after covering the entire development of the probe (100 m descent + 100 m ascent), will return to the surface at a temperature higher than that at which it was entered and, therefore, will have acquired heat from the ground. Obviously, the temperature of the fluid after the cycle will not be equal to 13°C but it will be few degrees lower.

For the current case, from the data available in literature we know that the temperature at which the fluid flows from the subsoil is close to 10°C, while the inlet temperature is about 6°C.

When fully operational, the ΔT between the supply and return of the fluid in the probe with good approximation, remain constant. Such temperature difference (AT = 4°C) implies that each kg of water passed through the circuit has released to the heat pump 4 kcal, which are then transferred by the heat pump to the circuit of the heating plant.

The temperature of the fluid supply and return in the probes are a function of several parameters, some of which can be determined in the planning stages:

- Length probes;
- Temperature of the subsoil;
- Extent of circulation of a heat pump;
- Correct estimate of the working hours of the heat pump.

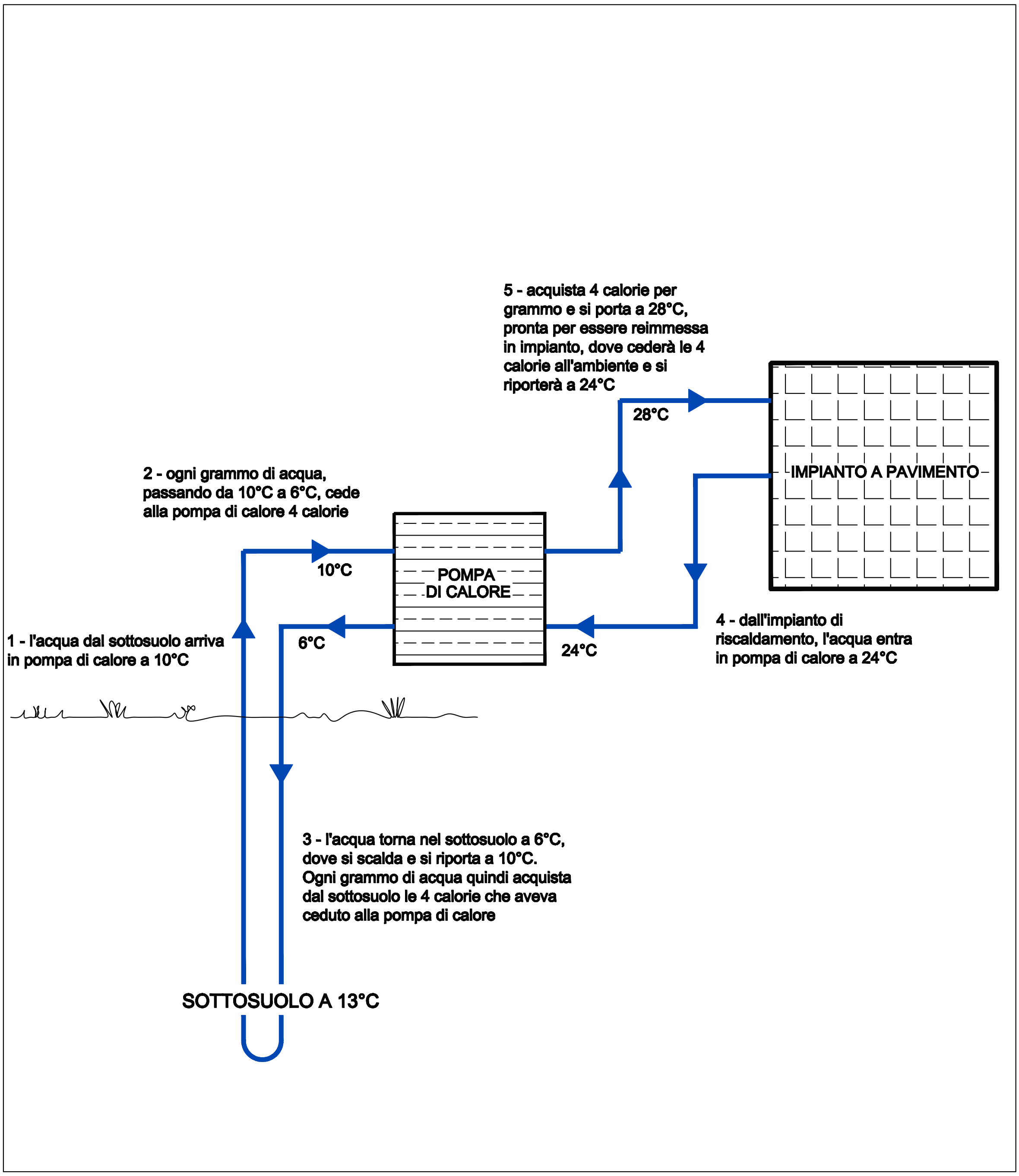


Fig 12. Diagram showing the operating temperatures of the geothermal plant.

2.6 Sizing of the vertical geothermal probes

2.6.1 General consideration. The required parameters for a correct sizigi of the geothermal probes can be divided into those concerning the subsoil and those concerning the plant.

Parameters concerning the subsoil:

1. lithology;
2. Relative moisture;
3. density;
4. porosity;
5. thermal gradient;
6. conductivity;
7. heat capacity;
8. material chosen to cement the hole;
9. used geothermal fluid;

Parameters concerning the plant:

1. temperatures of the evaporator / condenser heat pump;
2. thermal requirements;
3. summer refrigerator needs;
4. hours of plant operation.

Other parameters that have to be considered, even though they are difficult to determine, are: the probe geometry and the thermal resistance of the well (coupling probe - soil as a function of the thermal properties of the soil).

Because of the many involved parameters, the right modeling of the trend of the geothermal heat exchanger is not easy and this makes rather difficult the use of simplified methods concerning only plants of modest size.

The chart below shows the thermal conditions that are created around a running heat exchanger.

As you can see by reading the table, the heat exchanger creates a "thermal reservoir" in the ground similar to the cylindrically shaped, in the presence of groundwater an equilibrium is reached more easily.

During the sizing process, if the soil temperature is undisturbed between 10°C and 13°C, the geothermal fluid will not be always close and constant at that temperature: when the plant starts operating, the temperature distribution assumes a typical "funnel" trend. We must also consider thermal effects even in the long run.

In the sizing process, the key points have to be considered when:

• in case of winter operation, the fluid temperature entering the heat pump, without damaging the compressor, it is generally desirable that the inlet temperatures to the heat pump (project status) are at least close to 0°C or little below;
• in case of summer operation, especially if you plan to use a free-cooling, levels of the maximum temperature of the fluid;
• considerations on the above thermal levels cannot be verified only in the steady state but it is important also to check the achievement of a new heat balance for accumulation in the soil for the long term. If the plant is properly sized, the long-term impact (over 25 years of operation) must not lead to variations in temperature over 2°C compared to the temperature of the undisturbed soil.

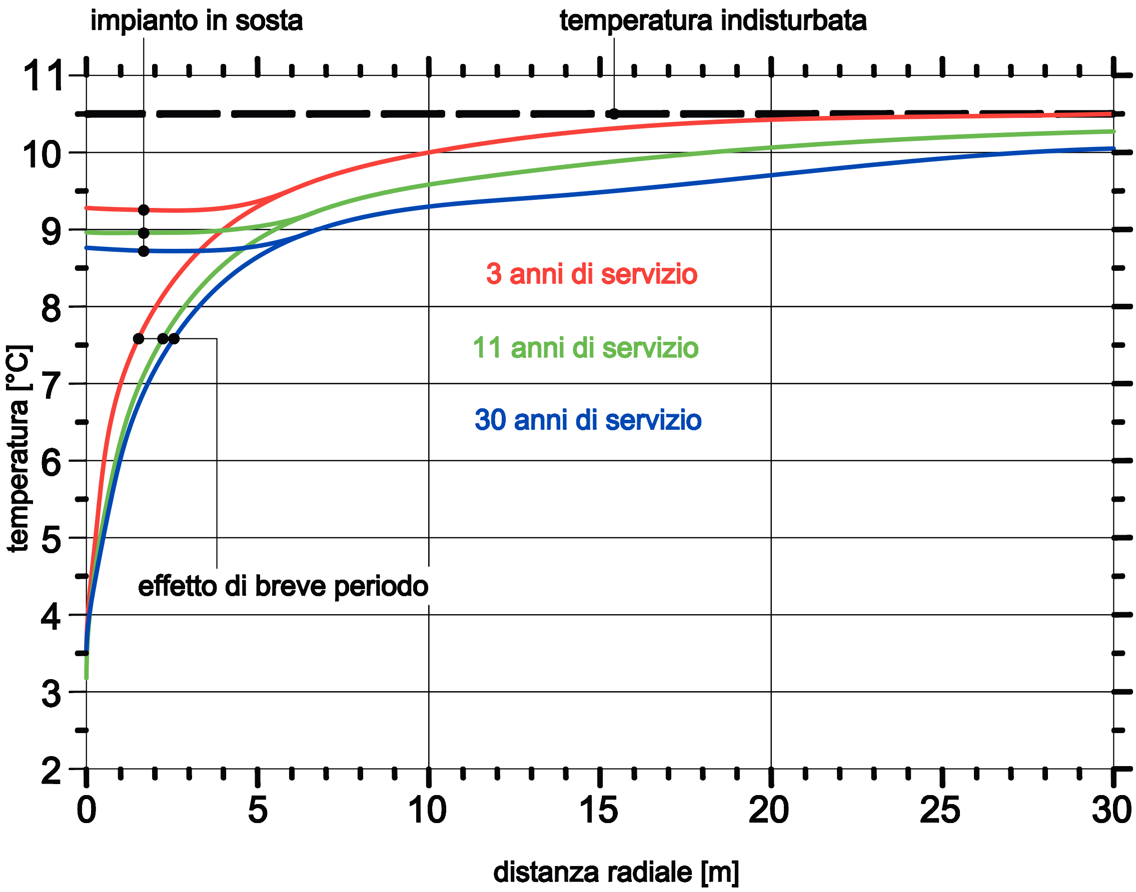


Fig. 13. Funnel temperature distribution around a vertical heat exchanger (Eugster, Rybach, 2000)

2.6.2 Design approaches. It is assumed that given the recent spread of this technology to date, UNI or CEN references (they are in preparation). do not still exist. Generally in Europe we refers to the German VDI 4640 standards developed round about 1998, although they are mainly geared to the needs of the thermal heating only. The only pieces of legislation that consider also the cooling methods are the "simplified" used in North America by ASHRAE and IGSHPA (*International Ground Heat Pump Association*).

All the rules have in common a method of approach: there is a level of thermal power of the plant (commonly 30kW) below which simplified methods for sizing of geothermal probes are applicable. Above this value accurate simulation and a thermal efficiency test performed on site are required.

• For systems with thermal power (Pt) <30 kW, tabulated values are used, on the basis of the average properties of the soil, to provide the correct relationship between installed capacity and total length of the wells, expressed in W/m (specific power extraction).

• For systems with Pt> 30 kW, commonly the Ground Response Test (GRT) is uesd, which allows to know the thermophysical properties of the subsurface exchange in order to obtain a correct sizing of the geothermal field, avoiding over-dimensioned costs of the system. The GRT provides, inter alia, the determination of equivalent thermal conductivity of the soil and the thermal resistance of the well.

To carry out a right sizing the following data in input have to be known:

- Thermal conductivity of soil (GRT);
- Equivalent thermal resistance of the well (GRT);
- Undisturbed soil temperature;
- Diameter, thickness and material of the probe;
- Diameter and fill material of the well;
- Thermal capacity of the well;
- Characteristics of the heat transfer fluid;
- Cooling and heating requirements by month;
- Peak heating load by month;
- Characteristics of the coupled heat pump;
- Monthly average COP of the heat pump (in order to calculate the energy injected or taken from the ground).

As it can be seen for plants with Pt above 30 kW, the design is quite complex and plays a key role for the good performance of geothermal probes.

2.6.3 Equivalent thermal resistence (R_b). The Rb of the well is the term that, in a simplified way, allows to determine the relationship between the soil temperature in a neighborhood of the exchanger and the temperature of the heat transfer fluid. The following formula expresses the relationship between the difference in temperature within soil and fluid and extracted heat flow:

$$\mathbf{T_b - T_f = q\ R_b}$$

Dove

q = Specific power of extraction [W/m];

T_b = Soil temperature around the well [K];

T_f = Fluid avarage temperature = $(T_{fin} + T_{fout})/2$ [K];

R_b = dimensionally [mK/W]; it is given by the tabular values briefly listed in tab. 1

Geometria	**Località**	**Tipo riempimento**	**R_b [mK/W]**
Single U	Germany, various	Bentonite	0.10 – 0.13
Single U	USA, various	Bentonite	0.06 – 0.08
Single U	Sweden, various	Water(heating)	0.06 – 0.08
Double U	Lulea	Water(heating)	0.03
Double U	Burgdof	Water(heating)	0.01
Triple U	Denamrk	Bentonite with spacers	0.09

Tab. 1. Rb values.

For example, if we consider a specific power of extraction of 50W/m and a conventional value of thermal resistance equal to 0:10 mK / W, the temperature difference ΔT between the fluid and surrounding soil is around 4-5 K (Pahud , 2002).

2.6.4. Tabular simplified methods (Pt< 30kW). The boundary conditions for this calculation are:

• depth of the probe in the range 40-100m;

• heat exchanger double "U" with diameters of 25 or 32 mm, single-tube U-shaped with a diameter of 60 mm.

• minimum distance between the probes between 5 and 6 m;

These conditions relate to residential applications, commercial or little productive activities with Pt <30kW.

The tabular sizing is based on three elements:

• definition of the power extraction at the heat pump evaporator Pev;

• determination of soil characteristics (conductivity) as data in input;

• determination of the equivalent hours of plant operation (relation between heat demand and nominal power).

The steps in the calculation procedure are listed below:

1. calculating the heating requirements and power project Pt;
2. definition of thermal levels of the plant;
3. choice of heat pump; with the use of technical specifications, location of the COP related to working conditions or B0/W35 W45: "B" means *brine* (antifreeze solution to the evaporator), and W *water* (condenser water) and the two numbers indicate the thermal levels of reference; conventionally this work is chosen given that it is considered that the minimum temperature at which the pump is operating is 0 ° C at the evaporator; for example the value of the COP may be 4 or 4.5 . A more precise reasoning would require the use of seasonal average COP (or SPF, Seasonal Performance Factor).
4. calculation of the power exchanged with the soil P_{ev}:

$$P_{ev} \quad —— \quad Pt$$

1. Tabular determination of the value of extraction specific power P_{ter} (expressed in W/m), depending on the *thermal conductivity of the soil* (it is required to know the nature of the soil) and the *equivalent hours of plant operation* (conventionally up to 2400 h) . For a rough calculation you can assume a value of 50 W/m

The overall length of the wells is:

$$L= P_{ev}/P_{ter}$$

Regarding the definition of the capacity required by the probe, as target range can be a good approximation to take the values between 1 and 3 m^3/h (Phaud, 2006). It is important to use a tube diameter of about 32 mm for probes within the 100-120 m depth and diameter of 40 mm to greater depths. In the case of multiple probes it should be oversized of about 15%.

From experiments carried out in Italy it was observed that the output of the underground remained stable between 35 and 70 W/m.

2.7 Others heat exchanger

2.7.1 Horizontal geothermal probes. Systems using horizontal probes have sizing problems similar to the vertical probe systems, having in common the particularity of the mean (the ground) with which it exchanges. The boundary conditions are very different because of the limited depth (usually within 2.50 m) that results in undisturbed soil temperature significantly affected by fluctuations in temperature and outer air and, however, heat is transferred mainly by the outer surface rather than the volume of the surrounding terrain.

Normally for excavation solutions, the assessments were made in terms of area of excavation, with coefficients of sizing in W/m2. In recent years, with the emergence of solutions in the trenches, the sizing parameter is related precisely to the length of the trench and is then expressed in W / m of trench.

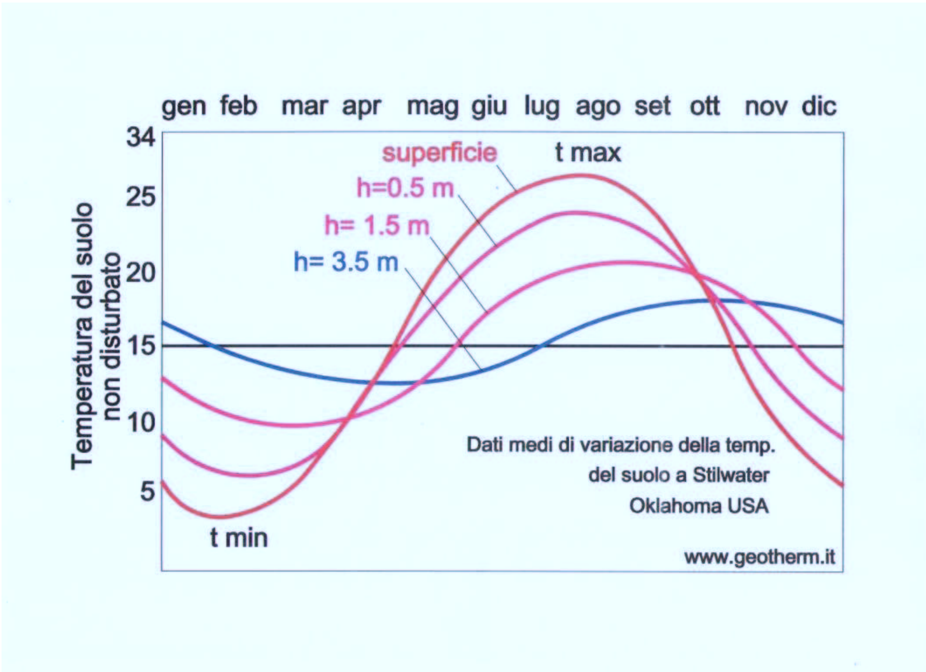


Fig. 14. Distribution of the underground temperatures.

Unlike systems with vertical probes, in this case, the temperature verification of heat transfer fluid is sufficient if done on an annual scale, and not on a long term, as is shown in the graph below (Fig. 14), given that the exchange is characterized by the annual cycle of the outside air temperature. As already seen for vertical systems, including the between the fundamental parameters for the sizing of geothermal plant there are the minimum winter temperatures and summer maximum of heat transfer fluid flowing into the heat pump.

The sizigi of a horizontal probe system depends on the following variables:

- local climate condition;
- features of the ground;
- choice of settling geometry;

In the systems for excavation there are some simple approaches that, depending on soil type, indicate the sizing parameters between 10 and 40 W/m2.

Nomograms are used for the sizing of the heat horizontal exchangers, even if they are related to colder weather than the Italian one. The terms of reference for the ground are availables in the bibliography:

- sandy and exposed moist soil, with regular irradiation, has an extraction ratio (ER) included between 20 and 30 W/m^2;

- loose and shady rocky terrain has a RE included between 8 and 12 W/m^2;

- water saturated with high solar radiation sandy soil has a RE between 35 and 40 W/m^2.

For systems in the trenches, there are many available parameters, the limited data available are from the North American bibliography. *Ret Screen International* takes as reference the double tube trench and provides a value of RE between 20 and 30 W/m^2 of installed thermal power, which assuming a value of COP = 3.5, corresponds to a value of thermal power exchanged between 21 and 36 W / m.

The computational procedure is quite similar to that seen for systems with vertical probes:

- Definition of the nominal thermal power of the PC, in relation to the thermo-cooling needs of the building;

- Selection of seasonal average COP;

- Calculation of power at the evaporator (which it exchanges with the ground);
- Choice of the value W/m area of Rorizz horizontal drilling;
- Sizing of the exchangers: total trench development L =Pevap / Rorizz

With regard to the spiral configuration (SLINKY systems), an avarage total length of the heat exchangers higher than the other systems is required, but the total length of the excavation is reduced.

2.7.2 Mixed exchangers. In order to avoid the deep drilling we can use a mixed system that comes from the conceptual fusion within horizontal probes and vertical probes: a sort of hybrid comb heat exchanger, produced by IVT (Swedish firm). It is made of a comb, about two meters tall, that is vertically placed in the trench; the latter reduces the installation costs by eliminating the drilling.

2.7.3 Groundwater. Even a water basin may be an appropriate thermal tank: streams, lakes and sea can easily accommodate different types of heat exchangers.
We have to use the same type of closed-loop system of horizontal or vertical probes, that, instead of exchanging heat with the soil, they exchange heat with another fluid. One of the most popular system used in lake waters consists of a polyethylene heat exchanger in PEHD 3408, wrapped in a spiral loop.
The wrapped pipe systems use real coils wound on the surface and then fixed using appropriate weights.

2.7.4 Deep energetic foundations (geostructures). Among the different foundations systems there are deep foundations that can develop with piles or foundation micropiles; the difference between the two types lies in diameter.
The use of such technique is widespread throughout the country. In contrast to the piles, the micropiles are also applied for static consolidation on structures already built. The stakes are nothing more than the energy integration of the geothermal structure of the piles or foundation micropiles. It is about to insert the heat exchanger within the different types of pile before concrete casting. This technique allows considerable savings for the application of geothermal energy in all those cases where deep foundations should be used in order to construct a new building or for the static consolidation.

2.7.5 Passive cooling (geocooling) and the applications to improve animal welfare.

Similarly in civil applications is proposed, in a early stage, the application study of passive cooling technology (geocooling) in livestock frames (milking parlor), in order to improve the microclimate in hot seasons.

This technique is usually applied with a air/air system (see Fig. 15 and 16) that, through the use of horizontal drill, can pipe, in the environment to be cooled, flows of air at temperatures much lower than those of the external environment. The diagram of figure 15 shows a air/air geothermal exchange system for passive cooling of a house. Through the external intake, the air is injected into the geothermal heat exchanger, is heated the temperature close to the ground. Following is directed into the volume to be cool. The term "passive" derives from the fact that there is not presence of a heat engine (heat pump) which is the air. Therefore the energy required for such a system is reduced to that consumed in order to ensure air circulation in the heat exchangers, from the suction fan.

Since there isn't heat pump, it's clear that the necessary condition for the functioning of this system is, that the room temperature by cooling is greater (at least 5-6°C) than, subsoil temperature compared to the depth of the insertion point of geothermal heat exchangers. Evaluate ambient temperatures (up to 34°C) of the milking parlor during the summer (see findings attached), taken note suffering of dairy cows at high temperatures, resulting in lower productivity, it's considered appropriate to propose the application of geothermal energy for cooling rooms milking.

That being stated, highlighting the proposal to study the subject of this thesis, in the application of vertical geothermal probes to the cooling milk process (see section 3), it is considered valid and reasonable the hypothesis of coupling of the probes with a simple air/water exchanger, to cool passively in the milking parlor.

Given the considerable difference in temperature between the “water probe” (16-18°C) and ambient air into the milking parlor during the summer (28-34°C), although considering humble output of a hypothetical air/water exchanger, it's considered that there may be successful in terms of temperature lowering inside the milking parlor.

This proposal is intended as a starting point for further study, contributing positively to optimize the installing cost of geothermal probes for cooling milk, proposed in next chapter 3.

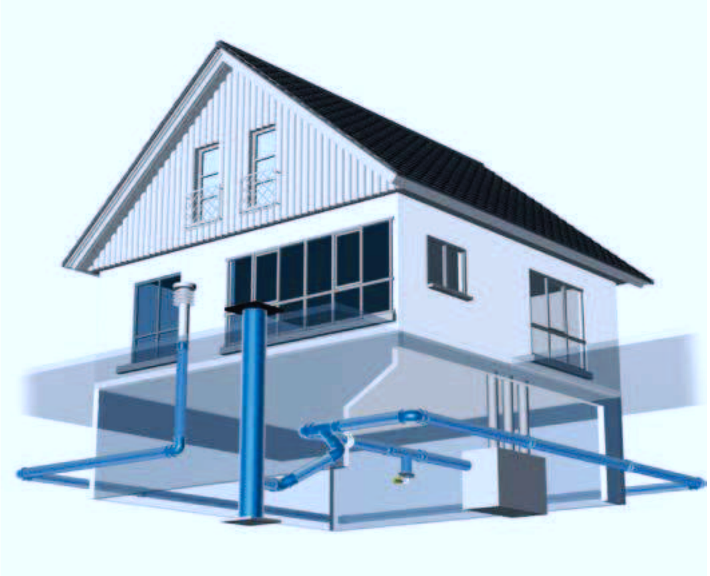


Fig. 15 e 16. Air-air probes schemes.

2.8 Environmental sustainability

A proper design of a geothermal system should primarily consider the environmental sustainability of the same system. A suitable definition "*for sustainable production from a single geothermal system*" may be as follows (Orkustofnun Working Group, 2001): *"For each geothermal system, and for each mode of production, there is a certain level of maximum production of energy, below which it is possible to maintain the production of energy from the system for a long time (100-300 years)".*

In designing a geothermal system, it must therefore be ensured that the interaction between plant and soil leads to the achievement of a thermodynamic equilibrium in the long run, without compromising too much the values of the temperature of the underground portion housing the probes (tolerable fluctuations are contained within 1.5°C in absolute value (1)).

It will therefore be important that, once abandoned the plant, the soil reaches, over the whole volume affected by the probes, including around the heat exchanger, temperature values that will deviate slightly from those of undisturbed soil before the application of the probes. In this regard it is important to consider that the type of horizontal geothermal probes, due to their installation in surface soil (within 3 m deep), will have no impact on soil temperature on medium to long term.

Note 1. On this topic the work of Eugster and Rybach (2000,2002) can be cited; Rybach ans Mongillo (2006); Signorelli, Kohl and Rybach (2004).

TABS CHAPT. 2

Tab 2.1

Technical features of some geothermal probes available on the market

Three versions produced by *Geo Therm*: polyethylene PE 100 black with high density, PE 100 RC (resistant to crack) PE 100 RT for high temperatures (up to 95°C).

The raw material is available in two versions: polyethylene PE 100 and PE 100 RC, "resistant to crack", with this reference and the specific geothermal rule SKZ stamped along the length of the probe. The PE 100 RC is characterized by a high resistance to the tension and concentrated load. Above 175m, the probes are only EP 100 RC. The PE100 RT is used in geothermal direct exchange. The production is done in black only, in line with U.S. directives relating to this sector.

Hereafter the data sheet specification of a PE 100 tube, supplied by the OPPO for hydraulic aims.

Polyethylene tubes **PE 100** with MRS minimum values (Minimum Required Strenght) of 10 MPa, **for disstribution of water** producted in accordante to **UNI EN 12201** of the 2004, and as required by **D.M. n. 174 del 06/04/2004 (it substitutes Circ. Min. Sanità n. 102 del 02/12/1978)**; must be marked with the brand **IIP** of the Istituto Italiano deiPlastici and/or equal to the euopean brand, as required by the "Regolamento di attuazione della legge quadro in materia di lavori pubblici 11 febbraio 1994, n. 109, e successive modifiche".

The pipes should be formed by extrusion, and can be supplied in roll bars.

Raw material For the tube prduction

The raw material to be used for the extrusion of the tube shall be produced and approved by leading European manufacturers and exclusively derived from the ethylene polymerization or copolymerization, stabilized and fortified by the manufacturer of the resin of suitable additives, uniformly dispersed in the granular mass .

These additives (antioxidants, lubricants, stabilizers, carbon black) are determined and added by the resin manufacturer to the polymer during formation of the compound, and are intended to improve the performance of drawing, injection, resistance to weathering and aging of the finished product .

These additives must be uniformly dispersed in the granular mass and, for carbon black, distribution and dispersion parameters defined by UNI standard reference and the contents (2 to 2.5% by weight) have to be respected.

The compounds, when released into the hopper of the extruder, shall have a maximum moisture content not exceeding 300 ppm.

The used raw materials will have to be in the list of those approved by IIP (Istituto Italiano dei Plastici).

Prova	**Reference value**	**Normative reference**
Density	³ 955-965 kg/m³	ISO 1183
Content in carbon black	2 ÷ 2,5 %	ISO 6964
Dispersion of carbon black	£ grado 3	ISO 18553
Oxidation induction time (OIT)	> 20 min at 210° C	EN 728
Fluidity index per 5 kg at 190°C per 10 min- MFI	0,2 ÷ 0,5 g/10 min	ISO 1133
Content in volatile substances	£ 350 mg/kg	EN 12099
Content in water	£ 300 mg/kg	EN 12118

Tab. 2. Requirements of the raw material

Tab 2.2

Probe foot patented and produced by *Geo Therm*.

During the installation and its functioning, this part is subject to the highest load. A special element with the following features has been developed:

• raw material: PE 100;

• monitoring control as required by HR 3.26 of SKZ;

• satisfy the demands on the pressure drop according to VDI 4640 less than 10 mbar, flow rate of 1 m/s;

• fastener through counterweights

• possibility of small diameter drilling :4-5-inch probe 25 and 32mm and 5-6 inches for the 40mm

• welding on site are not required, according to VDI 4640 and the certificate of quality issued by the geothermal "Fördergemeinschaft Wärmepumpen Schweiz (Switzerland Communities sponsoring heat pumps);

• patent CH 687 268, Euro Patent pending;

• duration of at least 100 years.

Fig.17 and 18. “U” head and ballast

Tab 2.3

Collectors and flow controllers.

The manifolds are designed to wire the different lines of heat exchange with the ground to the heat pump. The collectors are made of PE 100, with valves of interception in PVC. Each geothermal line is then controlled by flow control mechanism, so as to maximize the exchange of geothermal energy and reduce consumption of the pump system.

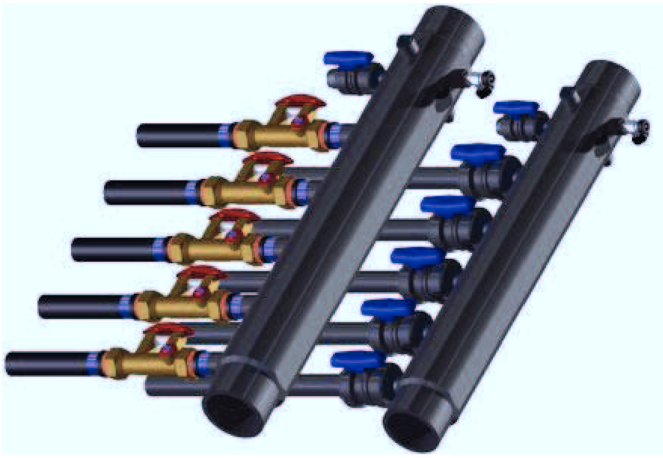


Fig. 19.Collectors.

Geothermal probes DeepBlue

The poluethylene geothermal probes DEEPBLUE PE100 are designed to be used in difficult and heterogeneous underground environment.

Many geographic areas of the alpine and mediterranean basin are characterized by heterogeneous ecological and stratigraphic conditions which frequently produce difficulties in drilling and insertion of the probe. The use of the geothermal probes DEEPBLUE PE100 <<NF>> reduces the operative difficulties allowing a rapid, safety and cheap installation,

The DEEPBLUE PE100 probe is a tubing system with single or double U-shaped circuit, made of the following elements:

· Tubing DEEPBLUE PE 100 PN 16 in pure polyethylene 100 %

· Head BLACKHEAD PE 100 with single or double U-shaped circuit, with high mechanical resistance to lateral push and crush.

The DEEPBLUE PE100 geothermal probe is produced in two types and can be used in every underground situation or in drilling core destruction.

Fig. 20.DEEPBLUE PE 100 probe

Scheda 2.4

Determination of thermal values of plant

It is common to size the probes so that the temperature difference within supply and return of the heat pump (ΔT_{pc}) is equal to 4°C, in order that each Kg of the flowing water in the circuit releases at the heat pump 4 Kcal, that will be then transferred to the circuit of the heating plant that works at higher temperature in the winter session; on the contrary, in the summer session, each Kg of the water flowing in the circuit subtract to the heat pump 4 Kcal, that will be then subtracted to the refrigerator group working at lower temperatures.

The temperature value of the housing-side unit must be set by the designer with the choice of the final user:

- heating fanconvector = 45 ° C;
- radiant floor heating = 35 ° C;
- cooling fanconvettor = 15 ° C;
- radiant floor cooling = 10 ° C;

Once determined the temperature value of the housing-side, the temperature of the heat pump probe-side depends on ΔT_{pc} chosen in the design phase and on the land temperature T_b in a neighborhood of the temperature probes.

To get the ΔT_{pc} of 4 ° C at some value of T_b is necessary that the temperature of liquid entering the probe is:

- in winter mode in $T_s - T_b = - 7$ ° C;
- in summer mode $T_s = T_b + 7$ ° C;

With $T_{s\text{-}in}$ = temperature of fluid entering the probe in winter mode, $T_{s\text{-}es}$ = temperature of fluid entering the probe in summer mode.

3. Application of the geothermal energy to the milk refrigeration system

3.1 Milk Refrigeration plant: remarks

The most widespread system to cool the milk is the compression refrigeration system. For all practical purposes is a cyclic heat engine whose components operate so as to achieve a transfer of thermal energy from a source at a lower temperature to a higher temperature (see chapt. 1)

For the cooling system are worth all the considerations and formulas already stated in chapter 1 with respect to the heat pump in summer mode.

Similar to the definition of efficiency based on the heat pump in summer operation, the efficiency of a refrigeration unit is as greater as higher the amount of heat extracted from the reservoir at lower temperature, used for equal work (see Fig. 21, pag. 61).

Q_1 subtracted from the heat source at temperature T_1, Q_2 given that the source temperature $T_2 > T_1$ and L is the mechanical work supplied to the system, the definition given in paragraph 1.2 of COP for the heat pump in summer operation, we had:

$$COP_e = \frac{Q_1}{L}$$

In this example COP_e is named also the *COP refrigerator* or *refrigerating effect* (henceforth COP_f), which we rewrite:

$$COP_f = \frac{Q_1}{L}$$

Considering the first law of thermodynamics: $|Q_2| = |Q_1| + |L|$

and considered that : $|Q_1| = |Q_2| - |L|$

It can write the COP_f according of the COP form the heat pump in winter mode ,

Already defined as $COP_i = Q_2/L$

$$OP_f = \frac{Q_2 - L}{L} = \frac{Q_2}{L} - 1$$

So:

$$COP_f = COP_i - 1$$

This parameter varies with the temperatures of condensation and evaporation of the refrigeration fluid and it is influenced by the dissipation of system energy (mechanical friction, turbulent motions of the refrigerant, heat exchange with the external environment).

For these reason, it usually gets $COP_{real} \approx 0.5\ COP_{carnot}$.

3.2 Refrigeration systems with direct or indirect expansion

Assuming that a milk cooler is in effect a cyclic heat engine with a compression refrigeration system, we can examine the components with the scheme in Fig. 22, p.61. Overall, the refrigeration unit can be compact, or assembled at some distance from the tank, as in systems of considerable ability. The cooling units are distinguished primarily by different expansion system: direct or indirect

3.2.1 Direct expansion refrigeration. In this system, the evaporator of the refrigeration unit is placed in direct contact with the outer wall of the tank containing the milk (see fig. 22). In this case the transfer of heat from the milk is directly on the evaporator refrigerant, and for that reason, the refrigeration compressor is contextual to the operation of the chiller. The compressor is controlled by a thermostat that turns on or off the operation in relation to the temperature of the milk inside the tank. In general, the work L to be administered to the compressor, calculated per unit time (power) must be sized so as to ensure the cooling of a predefined amount of milk within a set time depending on the class, as shown in the table below

Classes	Cooling time in hours for all milkings from 37 to 4°C
0	2.0
I	2.5
II	3.0
III	3.5

Tab.3. ISO Standard.

3.2.2 Indirect expansion refrigeration. This system, less widespread than the direct expansion system, consists of a tank with a hollow space where the water circulates. The water is cooled by the evaporator placed inside the hollow space, in adhesion to the bottom of the tank. The milk give off heat through a heat exchange with water. the water is brought to lower temperature and releases heat to the coolant, forming a layer of ice around the coil, which is considered a true "cold reserve". In newer models, there is a perfusion circuit that generates the constant circulation of water during the cooling.

3.2.3 Selection criteria. The fitted up electric power in the systems with direct expansion is lower by 40-50% compared to systems with direct expansion (*Pazzona* 1999). This is due to the different times of the compressor in the two systems: direct expansion, the compressor labor in a shorter time interval, together with the cooling of milk, while in the indirect operation of the compressor for the production of water supply and ice does not coincide with the time of milk cooling and can be extended for a longer period of time. By contrast, concerning a refrigeration cycle, the indirect expansion system involves higher electricity consumption, of about 25% per liter of milk, compared to the direct expansion system.

3.3 Current systems for energy savings in refrigeration: pre-cooler and heat recovery

3.3.1 Pre-cooling. It's a countercurrent heat exchanger that is applied to the milk circuit. Allows the heat exchange between the milk and water from wells or water mains, the result is a partial cooling of milk as a function of the water temperature input and of the relationship between the flows of two fluids. These heat exchangers are mainly of two types: plate and tubular. The use of pre-cooler doesn't require changes in the milking plant, it's mounted on the discharge of milk cooling tank. The performance of the pre-cooler depend on many factors, as discussed in more detail in paragraph 3.4.2

3.3.2 Heat recovery. The system involves the insertion of a heat exchanger in series with the capacitor in order to obtain a heat recovery for hot water, or dispersed, resulting in increased cooling efficiency and reduce power consumption of the refrigeration. The most widely solution used involves the insertion of the regenerator between the compressor and air condenser; the coolant releases heat to the water through the exchanger of heat regenerator plate, then move itself to the air condenser which removes the residual heat. The water tank, integrated or separated, has capacities ranging between 100 and 500 liters; the water final temperature, out of the heat regenerator plate, varies between 40 and 70 °C.

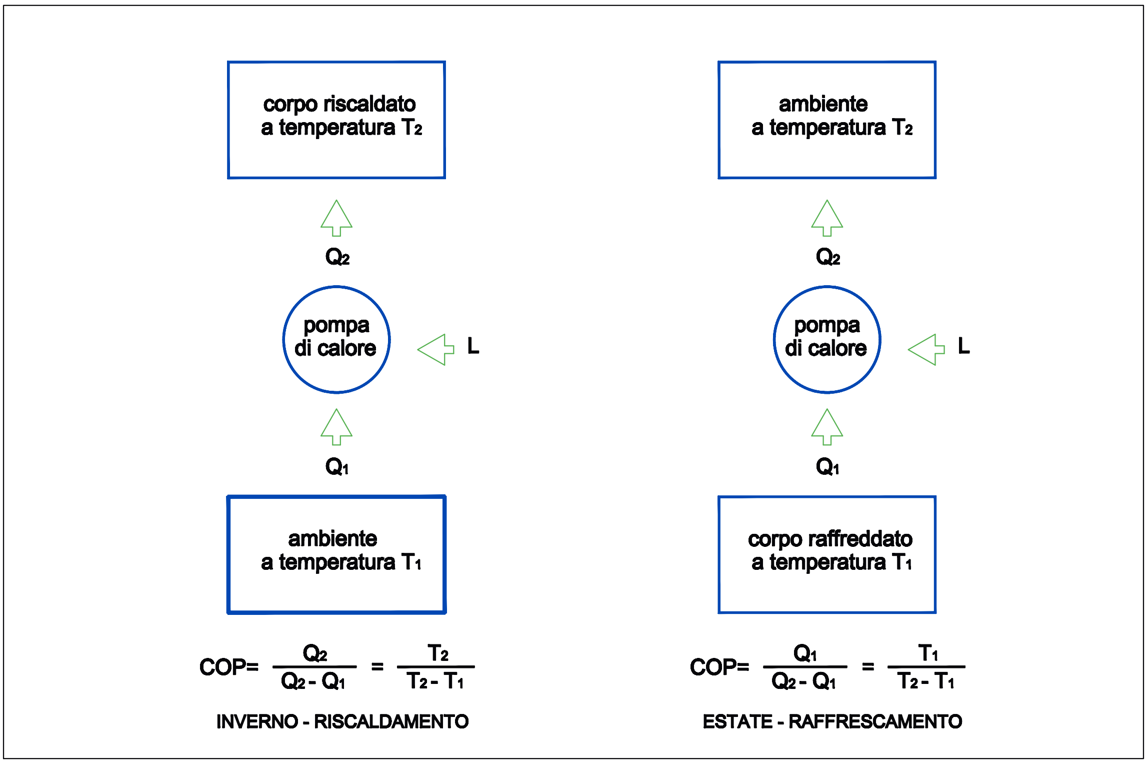


Fig. 21. Heat pump: summer and winter operation

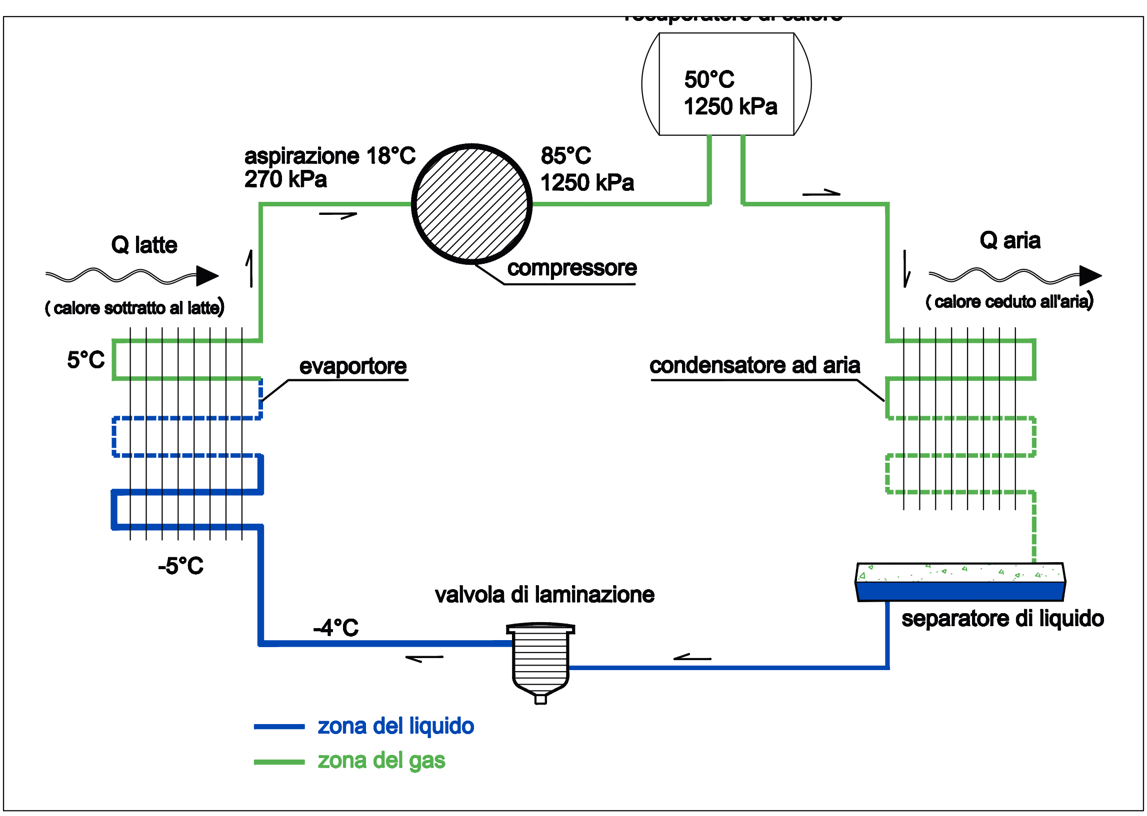


Fig. 22. Refrigeration cycle with heat recovery

3.4 Case study: assessment of energy savings in the process of milk cooling from the exploitation of geothermal energy

3.4.1 Introduction. As already said in chapter 2, in the last fifteen years, geothermal probes have been increasingly utilized for different uses: residential, industrial, productive. In Europe, Germany and Switzerland have been the main users, mostly in the civilian sector. Only more recently and even in this case mainly for the civil sector, the technology has been applied in Italy too.

It's important to note that at a recent conference - expo GEOENERGY 2010 - first exhibition of the geothermal industry for the Mediterranean, held in Rome in September, the number of conferences related case studies have dealt mainly in civil buildings, but providing input for the experimentation in other areas. It's in their search for potential applications offered by geothermal energy, that it is proposed the coupling with the building structures for the breeding of the dairy species, through the use of geothermal energy. The following paragraphs will analyze the coupling between the two proposals for geothermal power and cooling process of milk.

3.4.2 Application of geothermal probes to the pre-cooling process

As mentioned in the previous chapter, the precooling process occurs through a heat exchanger installed upstream of the *refrigeration system.*

The lowering of the milk temperature in the counter-current heat exchanger, as well as being related to the geometrical parameters of the heat exchanger is directly proportional to the ratio of water flow and the flow of milk. The literature has established that such relationship is conventionally set between 5 and 2; to increase this ratio may act by increasing the flow of water or by limiting the flow of milk. Given that it is not worthwhile to decrease the flow of milk, because it reduces the heat transfer capability, reducing or terminating the regime of turbulent flow, with increasing time of chilling milk, however, increase the flow of water implies too an excessive waste of the resource.

Assuming the following input data:

- temperature of milk in input T_{li} = 35°;
- temperature of water in input T_{ai} = 16°C;
- relationship between the flow of water and milk flow of 2;

A countercurrent heat exchanger with good geometric characteristics, is capable of lowering the temperature of the milk output (T_{lo}) of about 15-16 °C => T_{lo} = 21-22 °C, while providing water at T_{ao} = 22 - 23 °C.

The performance of the exchanger depends on the geometric characteristics (methods and exchange surface area, timing ...), the temperature and the input ports of the two fluids.

Analyzing in general terms, the average power of heat exchange (heat transferred per unit time) for a fluid we have:

$$P_s = \frac{\Delta Q}{\Delta t} = \frac{\Delta m}{\Delta t} c_s \Delta T$$

where:

$P_s = \frac{\Delta m}{\Delta t} c_s \Delta T$ = basic expression of heat transfer;

Δt = amount of time it takes for the fluid exchange through the heat exchanger;

c_s = specific heat of fluid;

ΔT = temperature difference between fluid input and output from the heat exchanger;

Defined f = fluid flow → $f = \frac{\Delta V}{\Delta t} = \frac{\Delta m}{\Delta t} \rho \rightarrow \Delta m = f \Delta t \rho^{-1}$

$$P_s = f \rho^{-1} c_s \Delta T$$

For the energy conservation principle, the amount of heat exchanged between the two fluids per unit of time must be equal and therefore:

$$P_{sl} = P_{sa} \rightarrow$$
$$\rightarrow f_l \rho_l^{-1} c_{sl} \Delta T_l = f_a \rho_a^{-1} c_{sa} \Delta T_a \rightarrow$$
$$\rightarrow \Delta T_l = f_a \rho_a^{-1} c_{sa} \Delta T_a f_l^{-1} \rho_l c_{sl}^{-1} \rightarrow$$
$$\rightarrow \Delta T_l = (f_a f_l^{-1} \rho_a^{-1} \rho_l c_{sa} c_{sl}^{-1}) \Delta T_a \qquad (1)$$

Thus the change in temperature of the milk ΔT_l depends linearly on the ratio between the flows of water and milk (r).

In standard conditions, whereas the density of milk ρl takes values ranging between 1029 and 1034 kg/dm3 that the density of water is 1,000 kg/dm^3; that the specific heat of milk csl is equal to 3.94 kJ / (kg • K), whereas the specific heat of water is equal to 4186 (kg • K);

the term ($\rho l\ \rho a^{-1} csa\ csl^{-1}$) = 1.03 · 1.00 · 1.00 · 0.94 = 0.97 ≅ 1.0
the (1) can be written:

$$\Delta T_l \cong f_a\, f_l^{-1}\, \Delta T_a$$

calling $f_a\, f_l^{-1} = r$, it is:

$$\Delta T_l \cong r\, \Delta T_a$$

The relationship between the difference in temperature of milk (Input/ Output) and the water is equal to the ratio between the flow of water on the milk. Data then the following values:

$T_{l\,i}$ = 35 °C;

T_{ai} ≈ 16 °C;

On the market there are heat exchangers such as to obtain benefits in the water outlet (T_{ao}) at a temperature of about 22 °C with an "r" between 2 and 2.5. Defined:

$$T_{l\,i} - T_{LO} = r\,(T_{ao} - T_{ai})$$

with r = 2.5, we have:

$$T_{li} - T_{lo} = 2.5(T_{ao} - T_{ai})$$
$$T_{lo} = 35° - 2.5(22° - 16°) = 20°C$$

instead r = 3.5, = 21 ° C and T_{ao}, we have:

$$T_{li} - T_{lo} = 3.5(T_{ao} - T_{ai})$$
$$T_{lo} = 35° - 3.5(21° - 16°) \cong 18°C$$

3.4.3 Analysis of the pre-cooling system with water well supply. In this case we have the advantage of having water at a temperature T_{ai} reasonably constant (about 16 °C) throughout the year and, by contrast, we have consumption in terms of ground water and electricity for extraction and pumping varying linearly with the change in the flow of water introduced in the heat exchanger: to improve the performance of the heat exchange should increase the ratio between the flows, which implies an increase in the consumption of water and energy.

Performance of the pre-cooler and quantification of consumption and costs, with the following data

Dati Input of the analyzed system

- T_{ai} = 16°C;
- T_{li} = 35°C;
- depth well = 100 m;
- amount of milk pre-cooler = 1.000 litres;
- water flow and milk flow ratio (2:1) r = $\frac{f\text{acqua}}{f\text{latte}}$ = 2;
- Data output to the countercurrent heat exchanger
- T_{ao} = 20-21°C;
- T_{lo} = 21-22 °C;
- Use of groundwater = 2.000 litres

Determination of the energy used to pump the necessary water to the exchanger, neglecting the mechanical friction and pressure loss:
since r = 2 → exchanger requires 2,000 litres of water

$$F = m\,g\ ; \rightarrow F = 2.000kg \cdot 9.8m\ s^{-2} = 19.600\ \text{N}$$

$L = F \cdot S$

$$L = 19.6 \cdot 10^{5}\ \text{J circa} = 2/3\ \text{kWh}$$

The pressure drop (see Tab 3.1) for a supply of about 100 with 5 to 90° curves are estimated to have ranged from 2000 and 3000%;
The efficiency of a pump (depending on the speed, extent, etc.) for a well about 100 m depth is estimated at η ≈ 0800;
The total return is equal to the product yield, so:
η_{tot} ≈ 0.980 · 0.800 = 0.784.

3.4.4. Analysis of the pre-cooling system with water main supply In this case there will be no pumping costs but costs of consumption. The temperature of the water supply inlet to the exchanger will vary depending on period of year and construction methods of the supply network**.** Normally, water supply networks are buried about 50-60 cm at that depth the soil suffers from strong temperature (see fig. 14, chapt. 2) and, in the curve of 0.5 m in depth, taking values of about 4 °C higher than the average minimum air temperatures in winter and about 3-4 °C lower than the average maximum air temperatures during the summer. Probably, the latitude of 42° parallel, can be expressed into an average range between 8-10 °C minimum temperature in winter and 24-25 °C maximum temperature in summer. For the same principle of geothermal energy (and thus heat transfer) such conduct has the effect of a horizontal borehole heat exchanger (with a length of the line), transferring the heat of the underground water supply. Therefore, in summer conditions (months from July to August), with burial of about 50 cm, the water network reaches an average value close to 22-23 ° C, with relaxations in the months from May to June and September-October, then arrive at about 15-16 ° C in April and November (see fig. 14, chapter 2).

It should be noted that in the event of mains water, the temperature rise due to heat exchange with the subsoil in summer is a main cause of the reduction in the efficiency of the pre-cooling (and consequently of refrigeration), just when the process would be more necessary for the refrigeration system, which already in itself is a thermally unfavorable external environment in the process of milk cooling.

Performance of the pre-cooler and amount of use and costs, with the following initial data:

- Data Input System
- T_{ai} = 22°C; Network water temperature during July and August
- T_{li} = 35°C;
- Pre-cooler Milk Amount = 1.000 litres;
- Ratio Water flow and Milk flow (2:1) r = $\frac{f\text{acqua}}{f\text{latte}}$ = 2;

Output data to the countercurrent heat exchanger

- T_{ao} = 25°C;
- T_{lo} = 25-26°C;
- Consumption of underground water = 2.000 litres

3.4.5. Application of probes to the refrigerator system: "geothermal condenser".

As seen in paragraph 3.3.2, the refrigeration systems can be equipped with heat recovery unit that is interposed the refrigeration system between compressor and condenser.

From extensive studies on the subject (Pazzona et al., 1999), we find that the ideal condition for the heat recovery would be achieved by replacing the air with a common condenser water, *so as to be able to transfer all the heat of coolant water*.

But in this way *in order to avoid the continuous rising of temperature inside the regenerator reduces the efficiency of the system and overload the compressor, it is necessary that the hot water is withdrawn continuously or that there is a source of permanent cooling*.

In practice, this condition is not easy to get around as it always should use during the milk cooling, hot water produced, or you should wasted large amounts of water (mains or wells) to ensure the supply of heat during condensation process.

It is no coincidence, that the most widely used solution involves the insertion of the heat exchanger between the compressor and the condenser, so that the refrigerant, after suffering a first cooling water supply of heat recovery, is further cooled thanks to the air condenser which removes the residual heat.

The proposed coupling with the geothermal probes, under study, is independent on the maintenance of heat recovery (to take advantage, however, the heat for hot water) and the replacement of air cooled condenser with a water that will exchange heat geothermal fluid with the geothermal probes. In this way you will get significantly improved the efficiency of the refrigeration unit that will work by transferring heat to the condenser at a level considerably more favorable than the thermal heat exchange with the air temperature that would. Even before going into the analytical tests, think of the benefit achieved in terms of efficiency of heat engine (COP) if, during the warmer months (meaning all those months in which the average daily temperature is above 14-15 °C ≈ the temperature of the probe, namely six months of the year from mid-April to mid October), the capacitor will be working at a constant temperature of about 16 ° C, rather than the air temperature that has a value average of 25 °C in July and August, and 20 °C in June and September.

If the comparison it should be done with a direct expansion cooler (the compressor operates at the same time the milk), then the above reasoning should be added that the temperatures at which it works the condenser in heat exchange with the atmosphere is not average temperature during the day time reference, but mainly (considering the work requirement for cooling and to maintain the temperature of 4 °C) are the temperatures at times when the milking is done, so you should take into account the temperature distribution in the intervals of time when you do the milking.

Finally we consider that the milk cooling room is normally located adjacent to the milking room and, if not well insulated, the temperature rise is affected during milking. In this respect the checks are to be observed (see chart 3.4-relief-) in the company during milking (h. 15:30 to 16:30 approx.) For 20 out of 22 surveys conducted from May 2008 to April 2009, the average values at the three stations "D", "E", "F", always indicate temperatures above 15 °C, only for the relief of 23 January March 25, the temperatures are below this value. In a first approximation, this datum indicates that, when coupled with geothermal probes, for most of the year, the condenser of the refrigeration machine would be to release heat at a temperature much more convenient (about 15 °C) than that of cell air cooling. If you consider that the average temperature Tm (average of averages between the different views "D", "E", "F") is approximately 23 °C, it appears that, at least for the milking of the 15:30 and 16:30, the advantage of having a lower temperature heat exchanger of the condenser is independent from the time of year. Regarding the first milking, for determining the months of the year for which the average daily temperature is above 14-15 °C, the values will be used instead of the historical average temperatures increased by a constant k equal to 3 °C. k consists of two factors: k_1 and k_2, where k_1 is ≈ 1.5 °C rise in temperature due to heat dissipated by the lactating cows (average of differences of variances - see table XX), while k_2 ≈ 1.5 °C rise in temperature due to heat dissipated by the condenser of the refrigeration and electric motors in the engine room.

The data of temperature distribution (see also fig.24) shows that,, the time of year when the minimum temperature plus the factor k is ≥ 15 °C, appears to be from mid April to early November ≈ 7 months of the year .

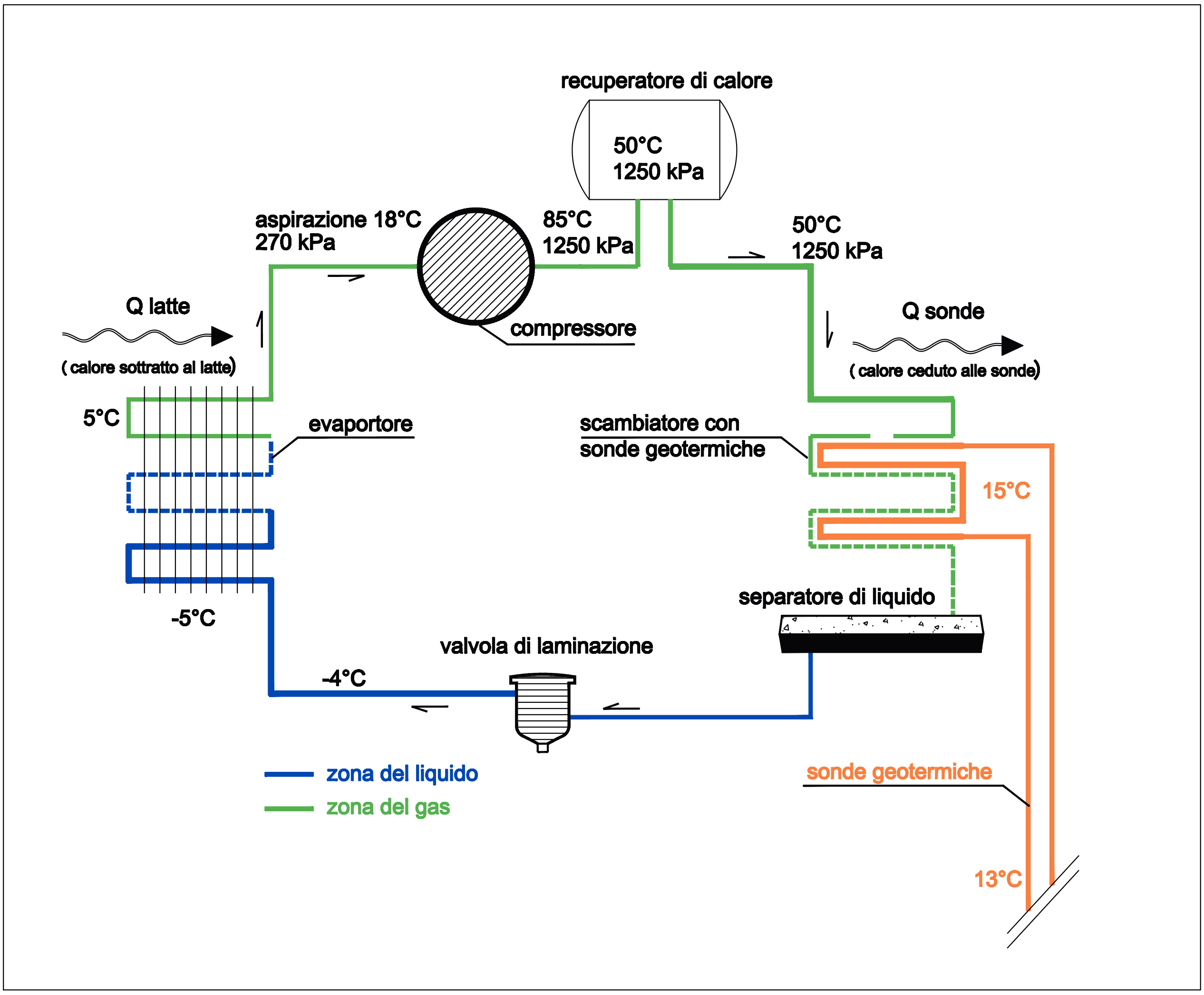
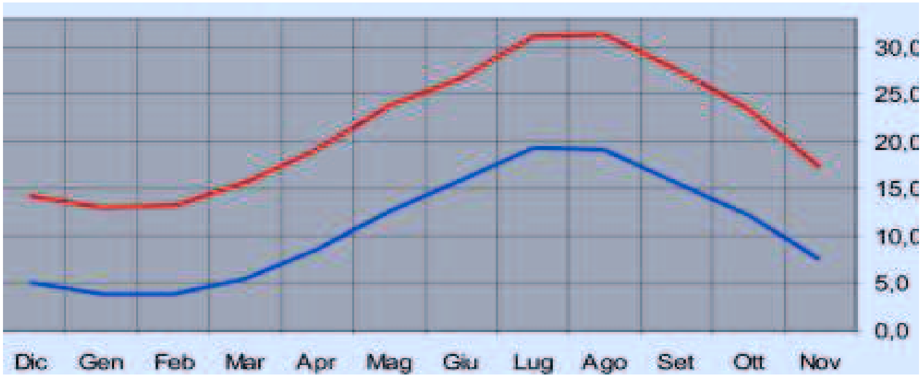


Fig. 23. Refrigeration coupled geothermal plant scheme



Tab.4. Distribution of atmospheric temperature - center Italy.

Therefore, from the above considerations and the measured values, we know that the use of an exchange with geothermal probes is beneficial thermal when:

- for the first milking of the day (early morning), the thermal cost (meaning the advantage in terms of heat transfer machine heat at lower temperatures) to the exchanger you have it for 7 months a year;
- for the second milking (h.15:00 – 16:30) there is convenience in heat all year round.

In the following section, we make the comparison between the power required for refrigeration of milk with a traditional cooling system (SFT) with pre-cooling system (with r = 2), without heat recovery, and that required for a geothermal cooling system (SFG), also with precooling (with r = 3) and without heat recovery. It is understood that the system of heat recovery can be equally applied without this resulting in changes to the comparison between the two systems.

3.5 Calculating the thermal power P_t required to cool a given volume of milk. Given the volume of milk to be refrigerated per each milking and known the class of performance of the system (for example, class 1), we calculate the quantity of heat Ql which is necessary to strip in order to cool the milk at a given temperature:

$$Q_l = V_l \cdot c_s \cdot (t_1 - t_2)\ \alpha$$

The power required at a given time T will be:

$$P = \frac{Ql}{T}$$

with:

V = quantity of milk;

c^1= milk specific heat (3.9 kJ/l°C);

t^s = milk initial temperature;

t^1 = milk final temperature;

α^2 = 1.15 increasing factor that takes into account the cooling of the cooler tank (5%) and loss of system efficiency (10%)

We now calculate the average power required 1000 liters of milk to refrigerate

V = 1.000 lt;

c^1= milk specific heat (3.9 kJ/l°C);

t^s = 35°C;

t^1 = 4°C;

α^2 = 1.15; $Q_l = 1000 \cdot 3.9 \cdot 31 \cdot 1.15 \approx 14 \cdot 10^7$ J

con T = 9000 sec (2.5h)

$$P_l = \frac{Ql}{T} = 14 \text{ kW}$$

The actual power required for refrigeration depends on the COP of the machine, so for a *traditional cooling system* (SFT) we have

$$P_{SFT} = \frac{Pl}{COP} = Q_l \cdot \frac{1}{T} \cdot \frac{1}{COP}$$

The average power required for the compressor of a conventional refrigeration system

(SFT) with COP = 4.5 and class I (T = 9000 seconds), is:

$$P_{SFT} = \frac{Pl}{CoP} = Q_l \cdot \frac{1}{T} \cdot \frac{1}{COP} = 14 \cdot 10^7 \text{ J} \cdot \frac{1}{9000s \cdot 4.5} = 14 \cdot 10^4 \text{ J} \cdot \frac{1}{9s \cdot 4.5} \approx$$

$$4 \cdot 10^3 \text{ W} = 3.5 \text{ kW}$$

3.6 Comparison between SFT and SFG

The second study proposal is to replace the air cooled condenser with a geothermal probes heat exchanger that generates the effect of a water tank of infinite volume and constant temperature (conservatively assumed to be 15 °C, about 2 °C higher than the temperature of the undisturbed soil). With this solution, the cooling machine will no longer have to exchange heat between the refrigeration temperature of milk (4 °C) and the air (temperature varies according to season, about 22 °C on average from early May to late September), but between the refrigeration temperature of milk (4 °C) and the temperature of the geothermal fluid ($T_{o\_sonda} \approx 15$ °C). The very definition of performance COP of a heat engine shows us how important it is to decrease the ΔT of labor between "hot source " and "cold source" in order to optimize machine performance and reduce the energy consumption.

Thanks to the coupling of geothermal probes we will achieve the following important advantages:

1. **energy savings due to the direct improvement of the COP**, due to the fact that the working temperature of the refrigeration for the seven warm months of the year (taken to be the warm months those months where the average daily temperature is> 15 °C) are more profitable;
2. **energy savings in the sizing of the compressor (in case of new plants) for operations between ΔT minor and constant**, there is no longer the need to oversize the compressor in anticipation of the high peak temperatures of the hottest months (June to September). The capacitor will no longer provide for the exchange of heat with temperatures up to 32 °C (July and August - see table), but the exchange will always be at a constant temperature of about 15 °C ± 2 °C.
3. reduction in the time of milk cooling

Please note that the coupling of the geothermal probes to the cooler does not constitute any change in the heat engine, just replace the air cooled condenser with one water condenser -in connection to the geothermal probes (see fig. 23).

3.6.1 Comparison between SFT e SFG throughout the COP_{carnot} calculation. Please note that the COP (coefficient of performance) for a refrigeration unit which exchanges heat between two temperatures T_1 and T_2 with $T_2 > T_1$, is defined as the ratio between the cooling effect Q1 (heat removed) and the equivalent thermal work compression L for which energy is spent:

$$\mathrm{COP} = \frac{\mathbf{Q1}}{\mathbf{L}}$$

$$COP = \frac{Q1}{Q2 - Q1}$$

For the Carnot cycle:

$$COP_{carnot} = \frac{T1}{T2 - T1}$$

Since the real COP is a variable proportion between 30% and 45% of COP_{carnot}, we calculate it for the two heating systems:

- ***SFT –*** *traditional cooling system with precooling* (r = 2-2.5), without heat recovery

Operating temperature of the heat engine:

T_1 = 277 K (4°C) milk refrigeration temperature;

T_2 = Variable depending on air temperatures in the engine room: for the first milking, during the period between mid-April to early November, the temperature varies between 15 °C (288 K) and 23 °C (306 K) for second milking the temperature varies throughout the year between 16 °C (289 K) and 35 °C (308 K) (see tab 3.4: mountains and table).

The following are the calculations on the average temperatures of the months for which the average temperature is ≥ 15 ° C.

- 1° Milking, month of April (assuming the average temperature of the month T_2 = 288 K, plus the factor k)

$$COP_{carnot} = \frac{277}{288 - 277} = 25.2$$

- 2° Milking, month of April (takes the average of readings T_2 = 296 K)

$$COP_{carnot} = \frac{277}{296 - 277} = 14.6$$

- 1° Milking, month of May (assuming the average temperature of the month T_2 = 289 K, plus the factor k)

$$COP_{carnot} = \frac{277}{289 - 277} = 23.1$$

- 2° Milking, month of May (takes the average of readings T_2 = 297 K)

$$COP_{carnot} = \frac{277}{297 - 277} = 13.8$$

- 1° Milking, month of June (assuming the average temperature of the month T_2 = 294 K, plus the factor k)

$$COP_{carnot} = \frac{277}{294 - 277} = 16.3$$

- 2° Milking, month of June (takes the average of readings T_2 = 307 K)

$$COP_{carnot} = \frac{277}{307 - 277} = 9.2$$

- 1° Milking, month of July (assuming the average temperature of the month T_2 = 300 K, plus the factor k)

$$COP_{carnot} = \frac{277}{300 - 277} = 12.0$$

- 2° Milking, month of July (takes the average of readings T_2 = 308 K)

$$COP_{carnot} = \frac{277}{308 - 277} = 8.9$$

Month	Milking	T1 [K]	T2 [K]	COPcarnot	COPcount
January	1°	277	283	46,2	27,7
	2°	277	287	27,7	27,7
February	1°	277	283	46,2	27,2
	2°	277	290	21,3	21,3
March	1°	277	284	39,6	27,7
	2°	277	293	17,3	17,3
April	1°	277	287	27,7	27,7
	2°	277	296	14,6	14,6
May	1°	277	289	23,1	23,1
	2°	277	297	13,9	13,9
June	1°	277	294	16,3	16,3
	2°	277	307	9,2	9,2
July	1°	277	295	15,4	15,4
	2°	277	308	8,9	8,9
August	1°	277	296	14,6	14,6
	2°	277	311	8,1	8,1

September	1°	277	291	19,8	19,8
	2°	277	298	13,2	13,2
October	1°	277	289	23,1	23,1
	2°	277	295	15,4	15,4
November	1°	277	287	27,7	27,7
	2°	277	291	19,8	19,8
December	1°	277	283	46,2	27,7
	2°	277	290	21,3	21,3

COP average alculation: 19,5

Note (1) when the value is greater than 27.7, COPg is used by default COP = 27.7

Tab. 4. Calculation COP_{carnot} and $COP_{average\_calculation}$.

- ***SFG* - *geothermal cooling system*** with precooling (r = 3), without heat recovery

  Operating temperature of the heat engine:

  T_1 = 277 K (4°C) Operating temperature of the heat engine;

  T_2 = 287 constant throughout the year;

$$COP_{carnot} = \frac{277}{287 - 277} = 27.7$$

With aim to avoid estimating the real COP relative to Carnot COP calculated, we perform the ratio of the powers of SFG and SFT;

Assumed:

Pt = *traditional cooling system power* (*SFT*);
Pg = *geothermal cooling system power* (*SFG*);
T1t = milk initial temperature in the *SFT;*
T2t = milk final temperature in the *SFT;*
T1g = milk initial temperature in the *SFG;*
T2g = milk final temperature in the *SFG;*

we have:

$$\frac{Pg}{Pt} = \frac{(T1g - T2g)}{(T1t - T2t)} \frac{COPt}{CoPg} \frac{Vl \cdot cs \cdot \alpha}{Vl \cdot cs \cdot \alpha}$$

$$\frac{Pg}{Pt} = \frac{(T1g - T2g)}{(T1t - T2t)} \frac{COPt}{CoPg}$$

Called the arguments made in paragraph 3.4 on the heat exchanger, we assume that both systems SFT and SFG are equipped with milk pre-cooler, respectively, with ratios r = 2.5 and r = 3.5, so:

T1t = 23° C = 295 K
T2t = 4° C = 277 K
T1g = 19℃ = 292 K
T2g = 4℃ = 277 K
COPt = COPt = 19.5 (tab.4)
COPg = $COPg_{carnot}^{count\_m}$ = = 27.7

$$\frac{Pg}{Pt} = \frac{(292 - 277)}{(296 - 277)} \frac{19.5}{27.7} = 0.55$$

$$Pg = 0.55\ Pt$$

$$Pg = crg \cdot Pt$$

With **crg** = Geothermal savings ratio.

This equation effectively summarizes the advantages in terms of power savings achieved by the use of geothermal probes. In conclusion, the power required for SFG is 55% of that required for SFT.

The use of the relationship between the powers has enabled us to achieve a coefficient of energy savings based on improved efficiency of pre-cooling prior to sending the milk to the chiller and optimization of the COP in relation to different seasonal temperatures.

Please note that the heat recovery unit, not considered in previous cases, it is equally applicable to both systems SFG and SFT, without this different results.

3.7 Forecast of the savings achievable through the application of the SFG to companies for which you know the energy consumption of the cooling process.

Based on previous studies (*Caria 2007*) is given below the simulation of the achievable savings in terms of electricity power (kWh).

The data refer to companies with the following features:

Companies	A	B	C	D
Breeding type	Free stalling	Free stalling	Free stalling	Free stalling
N° milking animals	250	90	22	20
Milk production (l/d)	9.000	2.800	500	490
Cooling Tank (l)	2 x 5.000 2M	1.200 + 2.100 4M	520 2M	1.000 4M
Plant	rotation 28 placed	comb 8+8 placed	Truck	Truck

Tabella 5. Extract: *Energetic consumption analysis in milk cattle farm – Caria 2007*

The table below shows the annual consumption of four dairy farms in Sardinia.

	Consumption process refrigeration			Estimated annual savings with *SFG*	Total Consumptions
	SFT Consumption		*SFG* Consumption		
Farm	kWh/year	Crg	kWh/year	euro	kWh/year
A	59.130,0	0,55	32.521,5	€ 5.321,70	102.770,0
B	20.367,0	0,55	11.201,9	€ 1.833,03	54.192,0
C	4.198,0	0,55	2.308,9	€ 377,82	10.422,0
D	4.568,0	0,55	2.512,4	€ 411,12	10.936,0

Crg= coeff. geothermal reduction. Energie cost≈ 0,20 €/kWh.

Scheme 6. Processing based on data extracted from: *Analisi dei consumi energetici in aziende bovine da latte – Caria 2007*

In order to standardize the data, for the dimensions and calculations, in the previous paragraphs, The savings achieved by projecting from the use of a SFG for a production of 1,000 liters of milk per day, it follows

- variable annual savings (kWh) among 680,00 and 790,00 euro/year depending on the size and technology company;
- Reduction time of milk cooling;
- for new installation, savings in term of size compressor with low power of about 45%;
- the possible exploitation of heat exchanger located between the compressor and condenser;
- In the presence of well, cost savings in terms of lifting and ground water resources of about 2,500 liters / day (ratio of water flow / milk ≈ 2.5);
- In case of mains water, saving on water costs about 2,500 liters / day (ratio of water flow / milk ≈ 2.5), saving on pre-cooling in this case would be less effective due to water temperatures network during the summer (see section 3.4.4).
- possibility of exploitation of geothermal probes (outside the hours of milking) for heating water for hygiene and breast implants, reducing energy costs;
- possibilities of using the probes (outside the hours of milking) for passive cooling of the milking parlor with improved animal welfare

3.8 Sizing of the geothermal probes and pricing.

3.8.1 Sizing of geothermal probes for direct expansion systems. Determined geothermal power (Pg), what share of the power of the traditional system (Pt), for powers below 30 kW size probes can, in first approximation, with the simplified tabular methods already expressed in chap. 2.

As mentioned in Chapter 2, you must have the stratigraphy of the subsurface to determine the power extraction for meter of probes, depending on the values of thermal conductivity of substrates.

Determined the value of power $P = \frac{QI}{T_{l}} = 16\ \mathrm{kW}$ (see paragraph 3.5), in order to dimension the length of the probes (table size), this EP the average power of extraction, is applied at the outset as follows:

$$\mathrm{Pe} = 50\ \mathrm{W/m}$$

$$L_{sonde} = 16\ \mathrm{kW}/50\mathrm{W} = 320\ \mathrm{m}$$

This result can be obtained with the three probes to a depth of about 100 or 160 m with two probes, the choices must be made according to the findings of stratigraphic and investigations conducted by the geologist.

Known the stratigraphy, it is possible to calculate the power of extraction with the following table:

Subsoil	Thermal conductivity	Power extraction
	[W/mK]	[W/m]
Poor quality subsoil (mobile dry rocks)	1.5	20
Rocks hardened or saturated mobile	1.5 – 3.0	50
Rocks hardened high thermal conductivity	>3.0	50
Gravel, sand, soil dry	0.4	< 20
Gravel, sand, soil aquifer	1.8 – 2.4	55 – 65
Clay, silt, wet soil	1.7	30 – 40
Calcare, massiccio	2.8	45 – 60
Sandstone	2.3	55 – 65
Granite	3.4	55 – 70
Basalt	1.7	35 – 55

Tab.7. Thermal conductivity values of the subsoil

It's important to highlight that, except for two situations unsuitable, depending on the substrate thermal conductivity of different materials can have values that determine the extraction capacities ranging from 30 to 70 W/m. Consequently, the length of the probe depth in pre-measurement as above, can take the following values:

$$L_{calculation} = 16\ \mathrm{kW}/70\mathrm{W} \approx 230\ \mathrm{m}$$

The tab 3.5 is an example of calculation of geothermal probe performed with a program developed by *ACCA Software of 2010* - 1st version.

3.8.2 Sizing of geothermal probes for indirect refrigeration systems The system with geothermal probes appears most appropriate for indirect refrigeration systems, because in this case the "time machine" is no longer dependent class of the cooler, so it is reasonable to assume:

$$\Delta t_{INdiretta}=24h\approx 10\cdot 2.5h=\Delta t_{Diretta} \rightarrow P_{Indiretta} \approx 10P_{Diretta}$$

That is, the average thermal power required is reduced to 1/10 and this has repercussions almost entirely on reducing costs previously stated (eg L_{onde_max}= kW/30W/ 10 = 16 = 53 m)

Only drawback is the need for thermal power necessary to maintain the same levels of exchange in the pre-cooler, but that problem is easily solved with a water storage tank to be filled immediately preceding the juncture use, (as is often already in many companies use of groundwater).

3.8.3 Pricing. The cost for installation of geothermal probes also varies depending on the characteristics of the substrate: if rock drilling must be performed with a rotary percussive drill, sand or clay will suffice if a rotary drilling.

Set out below the average market premium for the execution of drilling, inserting probes and sealing the hole with benthic material:

- building yard set up per body: € 500,00;
- drilling with a diameter 200 mm: € 30,00/m;
- supply and installation of probe: € 8,00/m
- sealing the hole: € 4,00/m
- tot. ≈ €42,00/ excluding building yard set up costs.

Depreciation of installation costs of geothermal to produce about 1,000 liters of milk day:

- Direct cost savings achievable: circa 735,00 euro/anno;
- saving water pre-cooling: circa 210,00 euro/year (in caso di acqua di rete);
- estimated cost of geothermal (estimated for n. 2 probes of 130 m – average power extraction probe = 60 W/m): € 42,00/m · 260m + € 500,00 = 10.920,00€;

- estimated cost change heat exchanger and hydraulic connections: 1.180,00€;

Given that the estimated total cost of plant amounts to € 12,100.00 and that it has been estimated annual savings achievable in the order of € 945.00, assuming greater caution, that if you were to exploit the potential offered by the probes counted for other applications, the timing of depreciation of plant would be approximately 13 -14 years. Given that the average lifetime of a geothermal plant is estimated at 30 years with limited maintenance costs and maintain good performance over time, it is believed that the investment would be of benefit.

Finally, it specifies that the installation costs could fall substantially in the following cases:

- If there was a possibility of installing geothermal horizontal depending on the characteristics of the subsoil in the first two meters deep, the establishment costs would be reduced by about 35%, whereas the CRG would experience an increase, with values between 0.60 and 0.65, with a consequent decrease in amortization periods for about 8 - 9 years;
- If there was a reservoir of surface water (lake or river), the geothermal probes could be replaced from heat exchangers by immersion in reduced installation costs as a function of distance from the basin of the milking room, but not predictable on average in a reduction of 50% equipment costs, in this case, the payback would be reduced to 6 - 7 years.

Tabs Chapt. 3.

Tabs 3.1

Determination of pressure loss in pipes

It is clearly of great importance to calculate estimates of the losses in a pipe, in order to define the hydraulic characteristics and the pressures placed on it. the concept of proportionality to the kinetic energy at the point is derived directly from Bernoulli's equation.

This is a method most used to calculate the loss of local pressure, namely, those arising from irregularities of the circuit (valves, bends, etc.). Whereas in practice a given section of the circuit, where the fluid has velocity v, the Y will drop to the water:

$$\Delta H = k \cdot \frac{v^2}{2g} \ [\mathrm{m}]$$

where g is the Earth's gravitational constant, conventionally equal to 9.80665 m/s^2, k a factor depending on the type of circuit at the point. For example, if we had a flow rate of 3 m^{3}s^{-1} water at 20 °C in a tube (full) internal diameter 1000 mm, and then an average speed of 3.82m • s^{-1}, we would have a kinetic energy equal to 0.744 m.

The factor k has been experimentally defined, and is such

- k = 1,25 Curve Corner
- k = 10 to check valve disc
- k = 0,5 for input in tank

So if you had it in sequence: elbow/check-valve/elbow/thank entry, this was function

$$\Delta H = (1{,}25 + 10 + 1{,}25 + 0{,}5) \cdot \frac{3{,}82^2}{(2 \cdot 9{,}81)} = 9{,}67 \ \mathrm{m}$$

Even in the case of an abrupt narrowing or widening of the pipeline will have some losses. In this case we consider the difference between the two speeds in two different sections of the pipeline in different diameters:

$$\Delta H = k \cdot \frac{(v_1 - v_2)^2}{2g}$$

In this case the coefficient k takes the value 0.4.

To this we must add of course the pressure drop due to friction in the connecting tubes. To determine this, various formulas have been proposed, but the most used is the *formula Fanning*:

$$\Delta H = f \cdot \frac{v^2}{2g} \cdot \frac{L}{D} = i\, L$$

where in addition to above, *L* is the length in meters of the tube, **D** its inner diameter in meters, *f* is a dimensionless coefficient, defined in various ways, which we define here the *friction coefficient*, depending on the Reynolds number (Re) and *i* is called the piezometric gradient (seems pointless but it is often convenient in project formulation as it changes very little if speed and diameter do not change the order of magnitude).

$$i = f \cdot \frac{v^2}{2g} \cdot \frac{1}{D}$$

The *coefficient of friction* can be plotted (scale bi-logarithmic) as a function of Reynolds number and parameterized over the roughness. This diagram, the characteristic shape, it is sometimes said *harp Nikuradse* by the name of the physicist who first traced by experimental measurements or, in the anglo-saxon world, Moody diagram (obtained from the Colebrook formula that was in pre-computer science, difficult to implement because it implied).

To calculate the coefficient of friction (dimensionless) have been proposed various formulas in case of laminar flow (Re <2100) there is an analytical solution (*Pouiseuille formula*):

$$f = \frac{64}{\mathrm{Re}}$$

while in case of turbulent flow (Re> 4000), we can use the *Churchill formula* (who has the advantage of being explicit):

$$f = \frac{1}{\left(-4 \cdot \log\left(\frac{0{,}27 \cdot R}{D} + \frac{7}{\mathrm{Re}}\right)^{0{,}9}\right)^2}$$

where R is the roughness of the pipe (always use a consistent unit of measurement):

- R = 0,0000547 m for steel
- R = 0,000259 m for cast iron
- R = 0,000122 m for surfaces coated
- R = 0,000152 m for galvanized surfaces
- R = 0,00165 m for the cement

or the above-mentioned *Colebrook* formula

$$\frac{1}{\sqrt{f}} = -2 \log\left(\frac{R}{3{,}71\, D} + \frac{2{,}51}{\mathrm{Re}\sqrt{f}}\right)$$

or the *Haaland* formula which is an approximation

$$\frac{1}{\sqrt{f}} = -1{,}8 \log \left[\left(\frac{R}{3{,}7\, D} \right)^{\frac{10}{9}} + \frac{6{,}9}{\mathrm{Re}} \right]$$

if 2100 < Re < 4000, using the maximum use of the two values.

In many cases it may be advantageous to apply the *Darcy* formula

$$i = \beta\, \frac{Q^2}{d^5}$$

That is

$$\Delta H = \beta\, \frac{Q^2}{d^5}\, L$$

where

$$\beta = f \cdot \frac{8}{\pi^2\, g} \simeq \frac{f}{12{,}1}$$

and also for the Reynolds number can be used

$$\mathrm{Re} = \frac{4}{\pi} \cdot \frac{Q}{D\,\nu} \simeq 1{,}27 \frac{Q}{D\,\nu}$$

In our case, since Re = 12,732, we can use the formula of Churchill and assuming that the tube is steel, we is obtain:

f = 0,0072839

and in conclusion, if you have a total of 80 m of pipe, we have

$$\Delta H = 0{,}43 + 9{,}67 = 10{,}1 \text{ m}$$

In other words, if we set the two surfaces to 10.1 m in altitude, we get exactly the circuit with a flow 3 m^3s^{-1}.

Tabs 3.2

Coolants

The refrigerant used in air conditioning, especially in refrigeration equipment, are the R22, R407C el'R410A. The symbol R was invented, starting with the chemical formula of fluid, by the American ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers), to identify a simple and immediate coolant. This classification of refrigerants is recognized worldwide.

Under the new European Regulation 2037/2000 issued by the EU's Official Journal 29/09/2000, entered into force on 1st October 2000, there are three dates to be considered for operators in the cold.

From 1st January, 2001 fire ban on the use of the refrigerant R22 in all refrigeration and air conditioning with cooling capacity greater than or equal to 100 kW, manufactured after 31/12/2000 with the exception of reversible heat pumps.

From the 1st July 2002 enters into force, prohibiting the use of R22 in all refrigeration and air conditioning cooling capacity of less than 100 kW, manufactured after June 30, 2002, with the exception of reversible (heat pumps).

Finally the 1st January 2004 the ban on the use of R22 is extended to all refrigeration and air conditioning reversible (heat pumps) produced after 31th December 2003

The gases used to replace the R22 are essentially two: the R407 and R410. R407C (ternary non-azeotropic mixture), has a high "temperatures - glide" that recommends caution, given the diversity of condensation and evaporation of the components of the mixture R410A (almost azeotropic binary mixture), close to thermodynamic R22, but it requires a pressure of use almost twice as R22

R22

This refrigerant is a gas component ("pure"), which is part of the family of HCFCs (hydro-chlorine-fluorine carbons), those that contain chlorine, ozone layer. For this reason, since 1st January 2004 it is prohibited in the newly built machines. Existing plants and machinery in the warehouse can still use R22, according to the European Regulation No. 2037/2000, entered into force on 1st October 2000, which prescribes the use of gas as a virgin until 31/12/2009 while gas as recycled or reclaimed will be used until 31 December 2014. From 1st January 2015 all HCFCs will be banned.

This regulation has forced manufacturers to make the switch to HFCs (hydro-fluorine carbons where there is no chlorine), in particular all'R407C, easiest solution, but with some problems, or to redesign the machines for the use of R410A that enables significant improvements in terms of cooling capacity, but with considerably higher pressures (see Table "A")

.

Tabella A

Comparison between the working gauge pressure R22 - R407C - R410A

Coolant	Temp. Evap. ℃	Press. Evap. bar	Temp. Cond. ℃	Press. Cond. bar
R22	+2°	4,31	+50°	18,42
R407C	+2°	4,91 (liq.)	+50°	21,24 (liq.)
R410A	+2°	7,57	+50°	30,75

In terms of features the new refrigerants are similar to their predecessor, R22, but not identical, which implies changes in the design phase, construction and maintenance of installations.

R407C

It is a mixture of refrigerants, belonging to the family of HFC, characterized by the lack of chlorine, then with ODP (ozone distribution power) equal to 0 and ecological consequences for the ozone. Unfortunately, these are not as environmentally friendly refrigerants in the greenhouse effect, however, as they give their contribution, albeit small compared to the most dangerous CFCs. For this reason there is in place a proposed EU regulation includes provisions relating to the use, containment, reporting and marketing of fluorinated greenhouse gases, including HFCs. L'R407C zeotropic refrigerant is a mixture consisting of R32 (23%), R125 (25%) and R134a (52%): Percentage in weight and a liquid at 25 ° C (Table "B"). The tolerance allowed for each component is ± 2%. To the gas phase composition is R32 (32.5%), R125 (31.4%) and R134a (36.1%). The mixture zoetrope is characterized by the fact that when the liquid and vapor are in equilibrium (saturation), the composition of the liquid differs from that of steam, resulting in different values of pressure-temperature saturated liquid and saturated vapor, which in turn cause a "slip" (glide), the saturation temperature, both evaporation and condensation in. Basically, the fluid begins its phase change of state at a temperature and ends in another, the temperature change was not constant, as is the case the gas pressure, as occurs in "pure" (R22, R134a, etc.).

Tabs B
Coolants Composition at 25℃

Refrigerante	**HFC 32**	**HFC 125**	**HFC 134a**
R407C Liquid	23%	25%	52%
R407C Steam	32,5%	31,4%	36,1%
R410A	50%	50%	-

It is also not flammable or explosive, has low toxicity (safety class A1, like the R22) and non-corrosive under normal conditions. The permissible exposure limit (Permissible Exposure Limit) for the R407C for 8 h per day / 40 hour per week is 1000 ppm. Exhibits and inhalation rates may cause irritation, cardiac arrhythmia or asphyxiation (like R22). The physical properties of R407C are very similar but not identical, to those of R22 pressures of work, on equal terms, are slightly higher than those of R22. The characteristics of R407C, it is a ternary blend, require procedures other than the pure gases, gas in the process of transferring, charging, leaks in the system itself and in the measures of operating parameters. Since the composition of the saturated vapor of R407C is different from that of the liquid, it's like using two different refrigerants, using only the vapor or liquid only.

Substantial differences between R22 and R407C

Although not identical to the R22 and R407C, no significant differences in pressure and cooling capacity (R407C makes about 5% less than R22 for the same machine) that would result in substantial differences in the choice of components. This has allowed manufacturers to use the machinery designs for use with R22 refrigerant R407C, without significant changes (except the oil in the compressor). In addition to an existing plant can replace R22 with R407C (retrofit) that there is always the possibility of changing the compressor oil.

R 410A

It is a chemically stable refrigerant, low toxicity and non-flammable, belonging to the family of HFC. The R410A is a blend refrigerant of R32 (50%) and R125 (50%), with properties very close to the azeotropy (it behaves almost like a pure gas), with a low temperature shift (glide), which can be considered negligible (about 0.2 ° C under normal working conditions of the split system). It is also not flammable or explosive, has low toxicity (safety class A1, like the R22) and non-corrosive under normal conditions. The permissible exposure limit is equal to that of R407C and R22.

Substantial differences between R22 and R410A

The working pressure is about 1.6 to 1.7 times higher than that of R22. In fact, with the evaporation temperature of 2 ° C, the manometric pressure in the low side is 7.5 bar to 4.3 bar of R22 and R410A, while in the high pressure side, with 50 ° C condensation you have 30.7 and 18.4 bar for R410A to R22. The great advantage of R410A is "high cooling capacity," which allows him than R22, to obtain the same cooling performance with a smaller compressor. The significant differences in pressure and cooling capacity between the R22 and R410A involve substantial differences in the choice of components, as those for R22 may not be used in installations for R410A

You cannot replace the R22 with R410A in an existing plant, not to compromise the integrity of the facility.

The high working pressure of R410A compared to R22, requires the use of suitable materials to withstand these pressure levels. First of all, you have to choose copper tubes suitable for refrigeration and air conditioning to a thickness of not less than 0.8 mm for pipes up to 1/2" in diameter. I arrived at this chart can be used for pipes with external diameter of 20 mm (3/4"). Besides solder joints should be used with appropriate minimum thickness. In carrying out the attacks, "in folder" should pay more attention to avoid losses or, worse, "tearing" of the folder, which is to be the weak point of the connection. In the case of pipelines already in place in the wall, during construction of the building, loaded with systems using R410A, check the thickness of the pipes themselves. If you do not have the minimum thickness that, to use those pipes, you should use the inserts to pre-compression flange, to be included in the final part of the existing copper pipe.

The tightening of the unions should be done preferably with a torque wrench set to the value provided by the manufacturer of the machine (Table C).

Tab C

Diameter	**External Diameter**	**Clamping Torque Nm (kgf cm)**	**Minimal thickness. x R410A**
1/4"	6,35 mm	14-18 (140-180)	0.80
3/8"	9,52 mm	33-42 (330-420)	0.80
1/2"	12,70 mm	50-62 (500-620)	0.80
5/8"	15,88 mm	63-77 (630-770)	1.00

Tab 3.3

Refrigeration cycle with refrigerant R407C

We examine below the operation of the various sections of the refrigeration cycle, highlighting the temperatures and pressures to which the refrigerant will have to work to cool the milk at 4 °C.

Since the European Regulation 2037/2000 issued by the European Union Official Journal, 29/09/2000, from 1st October, 2000 requires the gradual reduction of the use of refrigerant R22 (see Tab XX), with complete elimination from 1st January 2015, given the similarity and the possibility of exchange with the machines designed for the R22, it is suggested to use the refrigerant R407C, which reports the characteristics compared with the popular R22:

Coolant	Temp. evap. °C	Press. evap. bar	Temp. cond. °C	Press. cond. bar
R22	+2°	4.31	+50°	18.42
R407C	+2°	4.91 (liq.)	+50°	21.24 (liq.)

Input Data:

- Coolant Temperature Outlet Compressor: T_{comp} = 85°C;
- Coolant temperature entering the condenser, after heat exchange occurred with the heat recovery: T_{cond} = 50°C;
- Coolant temperature after the condensation process and lowering the pressure through rolling valve: T_{cond} = -5°C;

The evaporation temperature of the fluid is generally set to a value of about 10 °C lower than that of the fluid to be cooled, so the evaporator will operate at -6 °C. Fixed temperature, one can learn that the corresponding pressure for R407C is approximately 4.8 bar (Fig. XX). The gas reaches the compressor even with a temperature rise of about 10 °C: at the entrance will have a temperature of about 5 °C and maintains a constant pressure of 4.8 bar.

At this point, the compressor, through mechanical work, should raise the gas pressure up to a value which allows the condensation to the selected temperature, this depends on the temperature of the hot tank to which it wishes to transfer heat, in this case will be the temperature of air to which the capacitor is. For example, if you evaluate the operation in July and August, you can see from the tables of the findings that the air temperature inside the milking parlor is between 28 °C and 32 °C. The temperature of the medium used to condense the fluid is estimated to be lower by about 15-20 °C above the dew point, let's say about 50 °C.

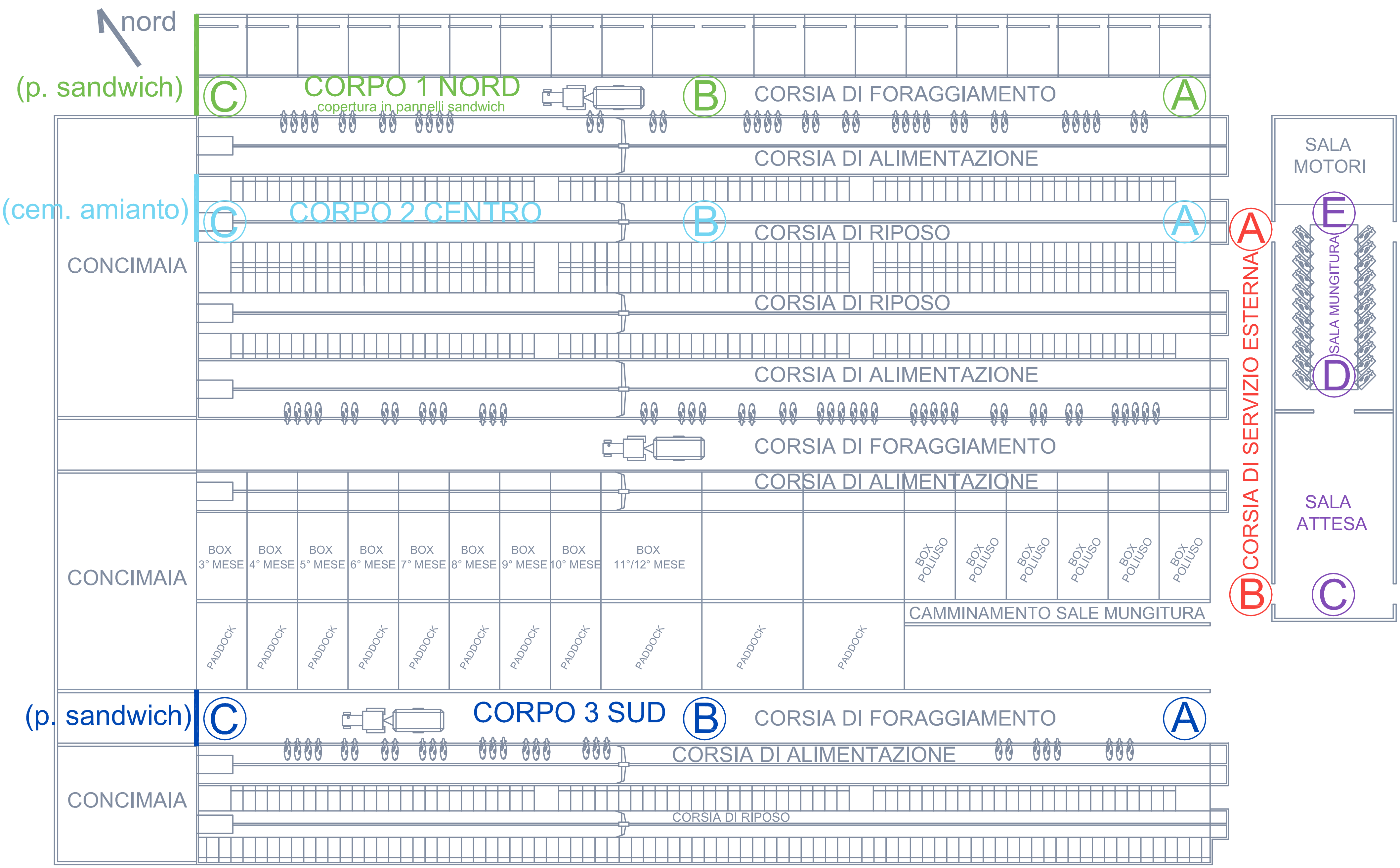
As the condensing pressure at this temperature is equal to 18.42 bar, the mechanical work to be performed by the compressor should be enough to raise the fluid pressure from 4.8 bar to bar 21.24. This work is transformed into heat, which causes an increase in gas temperature to about 85 °C.

Now may be the condensation process, the fluid exchanges heat with the refrigerant recovery unit that it cools the fluid and it heats the water tank. Probably the fluid comes out at about 50 °C. The waste heat must be removed with an air cooled condenser which will bring the gas in liquid state by lowering the temperature to about 20-25 °C. Due to the throttling valve, will lower temperature and pressure of the fluid to return the refrigerant to a temperature of -5 ° C and a pressure of 4.8 bar, ready for release in the evaporator for the start of the new cycle.

It is obvious that to make the cycle, the compressor had to work to compress the refrigerant gas from 4.8 bar up to about 21.0 bar.

Scheda 3.4

Surveys in the company and tables


nord
(p. sandwich)
C
CORPO 1 NORD
copertura in pannelli sandwich
B
CORSIA DI FORAGGIAMENTO
A
CORSIA DI ALIMENTAZIONE
(cem. amianto)
C
CORPO 2 CENTRO
B
CORSIA DI RIPOSO
A
CONCIMAIA
CORSIA DI RIPOSO
CORSIA DI ALIMENTAZIONE
CORSIA DI FORAGGIAMENTO
CORSIA DI ALIMENTAZIONE
BOX 3° MESE
BOX 4° MESE
BOX 5° MESE
BOX 6° MESE
BOX 7° MESE
BOX 8° MESE
BOX 9° MESE
BOX 10° MESE
BOX 11°/12° MESE
BOX POLIUSO
BOX POLIUSO
BOX POLIUSO
BOX POLIUSO
BOX POLIUSO
BOX POLIUSO
CONCIMAIA
CAMMINAMENTO SALE MUNGITURA
PADDOCK
PADDOCK
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(p. sandwich)
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CORSIA DI FORAGGIAMENTO
A
CORSIA DI ALIMENTAZIONE
CONCIMAIA
CORSIA DI RIPOSO
SALA MOTORI
E
SALA MUNGITURA
D
A
CORSIA DI SERVIZIO ESTERNA
B
SALA ATTESA
C

Azienda Calvia- dati microclimatici APRILE 2008

Foglio n° 1- Data: 30 aprile 2008 - Campionamento mensile n° 1

AREA CAMPIONATA	PUNTI CARATTERISTICI	TEMP. °c	UM.REL. %	V.ARIA m/s N/S	E/O	TEMP. °c	UM.REL. %	V.ARIA m/s N/S	E/O	TEMP. °c	UM.REL. %	V.ARIA m/s N/S	E/O	TEMP. °c	UM.REL. %	V.ARIA m/s N/S	E/O	TEMP. °c	UM.REL. %	V.ARIA m/s N/S	E/O
INTERNA Sala d'attesa + sala mungitura a 24 poste capi in mungitura= 240	STAZIONE	OSSERVAZIONE **1** (orario: 15,30) PRIMA della mungitura				OSSERVAZIONE **2** (orario: 15,45) DURANTE la mungitura				OSSERVAZIONE **3** (orario: 16,00) DURANTE la mungitura				OSSERVAZIONE **4** (orario:…………) DURANTE la mungitura				MEDIA OSSERVAZIONI **1+2+3+4**			
	punto **C** sala attesa	22,90	35,20	/	/													**22,90**	**35,20**	**/**	**/**
	punto **D** sala mung.	22,40	37,60	/	/	23,70	66,00	/	/	23,70	63,00	/	/	/	/	/	/	**23,27**	**55,53**	**/**	**/**
	punto **E** sala mung.	22,00	37,60	/	/	23,50	52,50	/	/	/	/	/	/	/	/	/	/	**22,75**	**45,05**	**/**	**/**
																		MEDIA TRA I PUNTI **C+D+E**			
																		22,97	**45,26**	**/**	**/**
ESTERNA Stalle + corsia servizio esterna	STAZIONE	stalla-corpo **1** Nord orario: ………………………………				stalla-corpo **2** Centro orario: ………………………………				stalla-corpo **3** Sud orario: ………………………………				corsia di servizio esterna orario: 15,20							
	punto **A**	/	/	/	/	/	/	/	/	/	/	/	/	23,30	31,00	4,00	1,50				
	punto **B**	/	/	/	/	/	/	/	/	/	/	/	/	23,90	30,00	/	/				
	punto **C**	/	/	/	/	/	/	/	/	/	/	/	/								
MEDIA TRA I PUNTI **A+B+C**		/	/	/	/	/	/	/	/	/	/	/	/	**23,60**	**30,50**	**/**	**/**				

NOTE: *Osservazioni:* I campionamenti sono eseguiti con le sonde degli strumenti a circa 2,0 mt. da terra; l'umidità dimininuisce sensibilmente con presenza di correnti d'aria e viceversa, aumenta sensibilmente durante la mungitura; la mungitura di ogni singolo animale dura circa 10 minuti, mentre il ciclo completo di mungitura pomeridiano inizia verso le 15,30 e finisce intorno alle 19 (il primo ciclo di mungitura della giornata viene effettuato intorno alle 5,30 della mattina); velocita max rilevata del vento: 4,0 m/s

Azienda Calvia- dati microclimatici MAGGIO 2008

Foglio n° 2 - Data: 09 maggio 2008 - Campionamento mensile n° 1

AREA CAMPIONATA	PUNTI CARATTERISTICI	TEMP. °c	UM.REL. %	V.ARIA m/s N/S	E/O	TEMP. °c	UM.REL. %	V.ARIA m/s N/S	E/O	TEMP. °c	UM.REL. %	V.ARIA m/s N/S	E/O	TEMP. °c	UM.REL. %	V.ARIA m/s N/S	E/O	TEMP. °c	UM.REL. %	V.ARIA m/s N/S	E/O
INTERNA Sala d'attesa + sala mungitura a 24 poste capi in mungitura= 240	STAZIONE	OSSERVAZIONE **1** (orario: 15,30) PRIMA della mungitura				OSSERVAZIONE **2** (orario: 15,45) DURANTE la mungitura				OSSERVAZIONE **3** (orario: 16,00) DURANTE la mungitura				OSSERVAZIONE **4** (orario:…………) DURANTE la mungitura				MEDIA OSSERVAZIONI **1+2+3+4**			
	punto **C** sala attesa	26,10	28,30	/	/													**26,10**	**28,30**	**/**	**/**
	punto **D** sala mung.	26,80	27,60	/	/	24,40	42,00	0,00	0,00	24,50	46,00	0,00	0,00	/	/	/	/	**25,23**	**38,53**	**0,00**	**0,00**
	punto **E** sala mung.	27,00	27,50	/	/	25,00	35,20	0,00	0,00	26,80	42,00	0,00	0,00	/	/	/	/	**26,27**	**34,90**	**0,00**	**0,00**
																		MEDIA TRA I PUNTI **C+D+E**			
																		25,87	**33,91**	**0,00**	**0,00**
ESTERNA Stalle + corsia servizio esterna	STAZIONE	stalla-corpo **1** Nord (cop. sandwich) orario: 16,30				stalla-corpo **2** Cent. (cop.sandwich) orario: 16,45				stalla-corpo **3** Sud (cop. sandwich) orario: 17,00				corsia di servizio esterna orario: 15,20							
	punto **A**	21,40	35,60	0,60	4,00	23,30	32,80	0,20	0,50	21,50	35,40	1,50	1,10	27,30	27,00	1,50	0,00				
	punto **B**	22,10	35,60	0,70	0,00	23,00	34,80	0,00	0,90	22,40	35,20	1,20	1,20	/	/	/	/				
	punto **C**	21,60	36,50	0,40	0,30	22,90	35,80	1,80	1,00	23,50	34,40	0,80	1,70								
MEDIA TRA I PUNTI **A+B+C**		**21,70**	**35,90**	**0,57**	**1,43**	**23,07**	**34,47**	**0,67**	**0,80**	**22,47**	**35,00**	**1,17**	**1,33**	**27,30**	**27,00**	**1,50**	**0,00**				
NOTE	*Osservazioni:* Per i vari corpi di stalla e la corsia di alimentazione l'osservazione è UNICA e viene effettuata indipendentemente dall'orario di mungitura. Durante la mungitura, abbiamo sul punto E la porta socchiusa e i vasistas aperti (da maggio in poi questi ultimi rimangono sempre aperti); la corsia di servizio esterna è sempre soleggiata nel pomeriggio; veolcità max rilevata del vento: 4,0 m/s																				

Azienda Calvia- dati microclimatici MAGGIO 2008

Foglio n° 3 - Data: 29 maggio 2008 - Campionamento mensile n° 2

AREA CAMPIONATA	PUNTI CARATTERISTICI	TEMP. °c	UM.REL. %	V.ARIA m/s N/S	E/O	TEMP. °c	UM.REL. %	V.ARIA m/s N/S	E/O	TEMP. °c	UM.REL. %	V.ARIA m/s N/S	E/O	TEMP. °c	UM.REL. %	V.ARIA m/s N/S	E/O	TEMP. °c	UM.REL. %	V.ARIA m/s N/S	E/O
INTERNA Sala d'attesa + sala mungitura a 24 poste capi in mungitura= 240	STAZIONE	OSSERVAZIONE **1** (orario: 15,20) PRIMA della mungitura				OSSERVAZIONE **2** (orario: 15,35) DURANTE la mungitura				OSSERVAZIONE **3** (orario: 15,50) DURANTE la mungitura				OSSERVAZIONE **4** (orario: 17,00) DURANTE la mungitura				MEDIA OSSERVAZIONI **1+2+3+4**			
	punto **C** sala attesa	16,20	85,20	0,70	1,20									15,70	88,50	0,60	0,60	**15,95**	**86,85**	**0,65**	**0,90**
	punto **D** sala mung.	17,20	83,30	0,00	0,00	18,70	89,50	0,00	0,00	18,70	88,50	0,00	0,00	/	/	/	/	**18,20**	**87,10**	**0,00**	**0,00**
	punto **E** sala mung.	17,70	83,50	0,00	0,00	17,80	88,00	0,00	0,00	17,50	81,00	0,40	0,20	/	/	/	/	**17,67**	**84,17**	**0,13**	**0,07**
																		MEDIA TRA I PUNTI **C+D+E**			
																		17,27	**86,04**	**0,26**	**0,32**
ESTERNA Stalle + corsia servizio esterna	STAZIONE	stalla-corpo **1** Nord (cop. sandwich) orario: 16,30				stalla-corpo **2** Cent. (cop. sandwich) orario: 16,45				stalla-corpo **3** Sud (cop. sandwich) orario: 17,00				corsia di servizio esterna orario: 16,30 (**A**)/17,30 (**B**)							
	punto **A**	14,80	88,00	0,90	0,90	16,40	85,70	0,80	1,00	14,90	89,00	0,50	1,00	18,20	78,50	0,30	1,20				
	punto **B**	14,70	89,00	1,50	1,50	15,80	85,00	0,50	1,50	14,60	89,00	1,70	1,70	15,60	87,00	1,20	0,60				
	punto **C**	14,20	90,50	3,50	2,50	14,50	90,00	1,50	3,00	14,20	89,80	2,00	3,00								
MEDIA TRA I PUNTI **A+B+C**		**14,57**	**89,17**	**1,97**	**1,63**	**15,57**	**86,90**	**0,93**	**1,83**	**14,57**	**89,27**	**1,40**	**1,90**	**16,90**	**82,75**	**0,75**	**0,90**				
NOTE	*Caratteristiche della giornata:* Giornata autunnale e piovosa, lievemente afosa; vento preminente E/O; velocita max rilevata del vento: 4,0 m/s *Osservazioni:* Primo ciclo di mungitura effettuato con porte aperte, le seguenti con porte chiuse; vasistas laterali aperti.																				

Foglio n° 4 - Data. 10 giugno 2008 - Campionamento mensile n° 1

Azienda Calvia- dati microclimatici GIUGNO 2008

AREA CAMPIONATA	PUNTI CARATTERISTICI	TEMP. °c	UM.REL. %	V.ARIA m/s N/S	E/O	TEMP. °c	UM.REL. %	V.ARIA m/s N/S	E/O	TEMP. °c	UM.REL. %	V.ARIA m/s N/S	E/O	TEMP. °c	UM.REL. %	V.ARIA m/s N/S	E/O	TEMP. °c	UM.REL. %	V.ARIA m/s N/S	E/O
INTERNA Sala d'attesa + sala mungitura a 24 poste (capi in mungitura= 240)	STAZIONE	OSSERVAZIONE **1** (orario: 15,30) PRIMA della mungitura				OSSERVAZIONE **2** (orario: 15,50) DURANTE la mungitura				OSSERVAZIONE **3** (orario: 16,10) DURANTE la mungitura				OSSERVAZIONE **4** (orario: 16,30) DURANTE la mungitura				MEDIA OSSERVAZIONI **1+2+3+4**			
	punto **C** sala attesa	25,40	55,00	0,50	0,70													**25,40**	**55,00**	**0,50**	**0,70**
	punto **D** sala mung.	25,90	54,00	0,00	0,00	26,30	61,50	0,00	0,00	28,10	52,00	0,00	0,00	26,50	57,00	0,00	0,00	**26,70**	**56,13**	**0,00**	**0,00**
	punto **E** sala mung.	26,50	50,00	0,00	0,00	27,20	57,00	0,00	0,00	27,50	50,00	0,00	0,00	26,30	51,00	0,00	0,00	**26,88**	**52,00**	**0,00**	**0,00**
																		MEDIA TRA I PUNTI **C+D+E**			
																		26,33	**54,38**	**0,17**	**0,23**
ESTERNA Stalle + corsia servizio esterna	STAZIONE	stalla-corpo **1** Nord (cop. sandwich) orario: 17,00				stalla-corpo **2** Centro (cop. eternit) orario: 16,45				stalla-corpo **3** Sud (cop. sandwich) orario: 17,15				corsia di servizio esterna orario: 16,35							
	punto **A**	24,80	53,00	0,90	0,90	24,80	55,00	0,70	0,90	24,20	53,00	2,50	3,00	31,20	41,00	0,50	1,20				
	punto **B**	25,20	53,00	1,00	1,60	25,80	49,00	0,50	0,50	24,30	53,00	2,40	2,00	27,30	47,50	0,80	1,00				
	punto **C**	25,00	52,00	4,00	3,00	24,70	51,00	0,70	1,60	24,50	50,00	4,50	4,50								
MEDIA TRA I PUNTI **A+B+C**		**25,00**	**52,67**	**1,97**	**1,83**	**25,10**	**51,67**	**0,63**	**1,00**	**24,33**	**52,00**	**3,13**	**3,17**	**29,25**	**44,25**	**0,65**	**1,10**				

NOTE

Caratteristiche della giornata: Giornata abbastanza calda, non afosa, lievemente ventilata, cielo limpido; velocita max rilevata del vento: 6,0 m/s

Osservazioni: A partire da oggi si rileva il corpo di stalla centrale con copertura in eternit; come sempre, nella sala di mungitura la temperatura si mantiene decisamente costante durante la misurazione, mentre l'umidità relativa varia continuamente con oscillazioni anche di 5/10 punti percentuali, in funzione delle correnti d'aria, della presenza di acqua sul pavimento e dell'altezza della sonda di campionamento (stabilita d'ora in poi sempre a 2 mt da terra). Nella stalla invece (ambiente esterno), l'umidità presenta meno sbalzi rispetto alla sala di mungitura (ambiente interno); al contrario, la velocità del vento subisce discontinue variazioni rendendo particolarmente complesso il metodo di misura da attuare: come criterio si è scelto di fare una media tra la max e min velocità rilevata.

Foglio n°5 - Data: 20 giugno 2008 - Campionamento mensile n° 2

Azienda Calvia- dati microclimatici GIUGNO 2008

AREA CAMPIONATA	PUNTI CARATTERISTICI	TEMP. °c	UM.REL. %	V.ARIA m/s N/S	E/O	TEMP. °c	UM.REL. %	V.ARIA m/s N/S	E/O	TEMP. °c	UM.REL. %	V.ARIA m/s N/S	E/O	TEMP. °c	UM.REL. %	V.ARIA m/s N/S	E/O	TEMP. °c	UM.REL. %	V.ARIA m/s N/S	E/O
INTERNA Sala d'attesa + sala mungitura a 24 poste (capi in mungitura= 240)	STAZIONE	OSSERVAZIONE **1** (orario: 15,30) PRIMA della mungitura				OSSERVAZIONE **2** (orario: 15,55) DURANTE la mungitura				OSSERVAZIONE **3** (orario: 16,15) DURANTE la mungitura				OSSERVAZIONE **4** (orario: 16,40) DURANTE la mungitura				MEDIA OSSERVAZIONI **1+2+3+4**			
	punto **C** sala attesa	28,50	45,00	0,60	0,50													**28,50**	**45,00**	**0,60**	**0,50**
	punto **D** sala mung.	28,60	53,00	0,00	0,00	29,30	56,00	0,00	0,00	29,20	56,00	0,00	0,00	29,30	53,00	0,00	0,00	**29,10**	**54,50**	**0,00**	**0,00**
	punto **E** sala mung.	28,40	50,00	0,00	0,00	30,50	48,00	0,00	0,00	30,00	44,00	0,00	0,00	28,80	49,00	0,00	0,00	**29,43**	**47,75**	**0,00**	**0,00**
																		MEDIA TRA I PUNTI **C+D+E**			
																		29,01	**49,08**	**0,20**	**0,17**
ESTERNA Stalle + corsia servizio esterna	STAZIONE	stalla-corpo **1** Nord (cop. sandwich) orario: 16,00				stalla-corpo **2** Centro (cop. eternit) orario: 16,25				stalla-corpo **3** Sud (cop. sandwich) orario: 16,45				corsia di servizio esterna orario: 15,40							
	punto **A**	29,30	43,00	0,00	0,00	29,50	39,00	0,30	0,20	29,30	42,00	0,90	1,50	32,00	40,00	/	/				
	punto **B**	29,50	42,00	0,60	1,00	29,30	41,00	0,20	0,20	28,50	42,00	0,50	1,20	32,20	38,00	/	/				
	punto **C**	29,60	40,00	2,50	2,00	28,50	41,00	0,20	2,00	29,00	40,00	1,50	1,30								
MEDIA TRA I PUNTI **A+B+C**		**29,47**	**41,67**	**1,03**	**1,00**	**29,10**	**40,33**	**0,23**	**0,80**	**28,93**	**41,33**	**0,97**	**1,33**	**32,10**	**39,00**	**/**	**/**				

NOTE

Caratteristiche della giornata: Giornata calda, non afosa, brezza leggera, cielo limpido; velocita max rilevata del vento: 3,0 m/s.

Osservazioni: Non sono sono rilevate differenze apprezzabili di dati tra le coperture con pannelli sandwich (poliutretano rivestito di plastica) e la vecchia copertura in eternit presente nel blocco di stalla centrale.

Azienda Calvia- dati microclimatici GIUGNO 2008

Foglio n° 6 - Data: 30 giugno 2008 - Campionamento mensile n° 3

AREA CAMPIONATA	PUNTI CARATTERISTICI	TEMP. °c	UM.REL. %	V.ARIA m/s N/S	E/O	TEMP. °c	UM.REL. %	V.ARIA m/s N/S	E/O	TEMP. °c	UM.REL. %	V.ARIA m/s N/S	E/O	TEMP. °c	UM.REL. %	V.ARIA m/s N/S	E/O	TEMP. °c	UM.REL. %	V.ARIA m/s N/S	E/O
INTERNA Sala d'attesa + sala mungitura a 24 poste capi in mungitura= 240	STAZIONE	OSSERVAZIONE **1** (orario: 15,30) PRIMA della mungitura				OSSERVAZIONE **2** (orario: 15,50) DURANTE la mungitura				OSSERVAZIONE **3** (orario: 16,10) DURANTE la mungitura				OSSERVAZIONE **4** (orario: 16,40) DURANTE la mungitura				MEDIA OSSERVAZIONI **1+2+3+4**			
	punto **C** sala attesa	32,50	43,00	0,00	0,00													**32,50**	**43,00**	**0,00**	**0,00**
	punto **D** sala mung.	34,50	44,00	0,00	0,00	33,50	50,00	0,00	0,00	31,20	66,00	0,00	0,00	27,80	70,00	0,00	0,00	**31,75**	**57,50**	**0,00**	**0,00**
	punto **E** sala mung.	34,60	42,00	0,00	0,00	34,50	47,00	0,00	0,00	28,50	64,00	0,20	0,50	27,20	62,00	0,00	0,00	**31,20**	**53,75**	**0,05**	**0,13**
																		MEDIA TRA I PUNTI **C+D+E**			
																		31,82	**51,42**	**0,02**	**0,04**
ESTERNA Stalle + corsia servizio esterna	STAZIONE	stalla-corpo **1** Nord (cop. sandwich) orario: 16,00				stalla-corpo **2** Centro (cop. eternit) orario: 16,30				stalla-corpo **3** Sud (cop. sandwich) orario: 16,45				corsia di servizio esterna orario: 15,40							
	punto **A**	31,50	42,00	0,00	0,00	26,60	63,00	0,80	1,20	26,70	58,00	0,00	0,60	35,50	37,00	1,30	1,50				
	punto **B**	31,20	42,00	0,00	0,00	26,20	64,00	0,80	1,50	26,10	61,00	0,00	0,30	35,00	39,00	1,00	1,00				
	punto **C**	31,20	43,00	0,00	0,00	25,70	62,00	0,70	1,50	26,20	60,00	0,00	0,20								
MEDIA TRA I PUNTI **A+B+C**		**31,30**	**42,33**	**0,00**	**0,00**	**26,17**	**63,00**	**0,77**	**1,40**	**26,33**	**59,67**	**0,00**	**0,37**	**35,25**	**38,00**	**1,15**	**1,25**				

NOTE

Caratteristiche della giornata: Giornata molto calda, cielo coperto, brezza leggera, velocita max rilevata del vento: 2,0 m/s; verso le 16 il tempo è cambiato repentinamente e minaccia pioggia.
Osservazioni: Nell'arco di 30 minuti la temperatura è scesa di quasi 10°; come sempre, durante la mungitura le porte vengono tenute leggermente aperte e ad ogni turno di essa gli operatori usano la pompa dell'acqua all'interno della fossa; nelle stalle sono accesi i ventilatori elettrici; le stalle sono invase dalle mosche, che peraltro disturbano molto gli animali; nel corpo di stalla 2, i campionamenti sono stati fatti durante il cospargimento di acqua nebulizzata, la quale influenza sensibilmente i dati del rilievo.

Azienda Calvia- dati microclimatici LUGLIO 2008

Foglio n° 7- Data: 10 luglio 2008- Campionamento mensile n° 1

AREA CAMPIONATA	PUNTI DI CAMPIONAMENTO	TEMP. °c	UM.REL.% min.	UM.REL.% max.	UM.REL.% media	V.ARIA m/s N/S	E/O	TEMP. °c	UM.REL.% min.	UM.REL.% max.	UM.REL.% media	V.ARIA m/s N/S	E/O	TEMP. °c	UM.REL.% min.	UM.REL.% max.	UM.REL.% media	V.ARIA m/s N/S	E/O	TEMP. °c	UM.REL.% min.	UM.REL.% max.	UM.REL.% media	V.ARIA m/s N/S	E/O	TEMP. °c	UM.REL.% media	V.ARIA m/s N/S	E/O
INTERNA Sala d'attesa + fossa di mungitura + sala mungitura (24 poste- spina di pesce) capi in mungitura= 240	STAZIONE	OSSERVAZIONE **1** (orario: 15,15) PRIMA della mungitura						OSSERVAZIONE **2** (orario: 15,50) DURANTE la mungitura						OSSERVAZIONE **3** (orario: 16,10) DURANTE la mungitura						OSSERVAZIONE **4** (orario: 16,35) DURANTE la mungitura						MEDIA OSSERVAZIONI **1+2+3+4** *(punto **C** solo osservaz. **1**)*			
	punto **C** sala attesa	32,40	31,84	37,70	34,77	0,20	0,70																			**32,40**	**34,77**	**0,20**	**0,70**
	punto **D** fossa mung.	31,40	34,48	36,86	35,67	0,00	0,00	32,40	42,78	57,40	50,09	0,00	0,00	31,60	52,36	66,08	59,22	0,00	0,00	32,00	45,91	53,71	49,81	0,00	0,00	**31,85**	**48,70**	**0,00**	**0,00**
	punto **E** sala mung.	31,10	33,99	34,08	34,04	0,00	0,00	33,00	34,18	37,09	35,64	0,00	0,00	31,50	42,57	47,29	44,93	0,00	0,00	32,00	36,77	42,63	39,70	0,00	1,00	**31,90**	**38,58**	**0,00**	**0,25**
																										MEDIA TRA I PUNTI **C+D+E**			
																										32,05	**40,68**	**0,07**	**0,32**
ESTERNA Stalle (3 punti di camp.) + corsia di servizio esterna (2 punti di camp.)	STAZIONE	stalla-corpo **1** Nord (cop. sandwich) orario: 15,35						stalla-corpo **2** Centro (cop. eternit) orario: 16,50						stalla-corpo **3** Sud (cop. sandwich) orario: 17,10						corsia di servizio esterna orario: 15,25									
	punto **A**	34,20	25,26	26,45	25,86	0,00	0,00	32,00	33,36	35,36	34,36	0,80	0,40	32,60	32,49	33,01	32,75	1,50	0,40	34,10	29,28	30,56	29,92	0,80	1,80				
	punto **B**	32,70	30,15	30,92	30,54	0,20	2,00	32,00	33,47	34,24	33,86	0,20	0,00	32,20	32,52	33,56	33,04	0,00	0,00	33,00	29,63	30,33	29,98	0,20	1,00				
	punto **C**	33,20	31,83	33,82	32,83	0,00	0,00	31,90	32,90	33,48	33,19	0,70	0,50	32,70	31,55	33,43	32,49	0,00	1,00										
MEDIA TRA I PUNTI **A+B+C** *(solo punti **A+ B** per corsia serv. est.)*		**33,37**	**29,08**	**30,40**	**29,74**	**0,07**	**0,67**	**31,97**	**33,24**	**34,36**	**33,80**	**0,57**	**0,30**	**32,50**	**32,19**	**33,33**	**32,76**	**0,50**	**0,47**	**33,55**	**29,46**	**30,45**	**29,95**	**0,50**	**1,40**				

NOTE

Caratteristiche della giornata: Giornata calda, non afosa, cielo limpido, brezza leggera; velocita max rilevata del vento: 2,5 m/s

Osservazioni: D'ora in avanti si riporteranno in tabella l'umidita min. e max rilevata per ogni campionamento, quindi si farà media matematica dei due dati rilevati; vento assente anche sul punto E (durante i campionamenti), nonostante le porte d'ingresso aperte entrambe; i ventilatori elettrici nelle stalle non sono in funzione .

Foglio n° 8- Data: 22 luglio 2008- Campionamento mensile n° 2

Azienda Calvia- dati microclimatici LUGLIO 2008

AREA CAMPIONATA	PUNTI DI CAMPIONAMENTO	TEMP. °c	UM.REL.% min.	UM.REL.% max.	UM.REL.% media	V.ARIA m/s N/S	E/O	TEMP. °c	UM.REL.% min.	UM.REL.% max.	UM.REL.% media	V.ARIA m/s N/S	E/O	TEMP. °c	UM.REL.% min.	UM.REL.% max.	UM.REL.% media	V.ARIA m/s N/S	E/O	TEMP. °c	UM.REL.% min.	UM.REL.% max.	UM.REL.% media	V.ARIA m/s N/S	E/O	TEMP. °c	UM.REL.% media	V.ARIA m/s N/S	E/O
INTERNA Sala d'attesa + fossa di mungitura + sala mungitura (24 poste- spina di pesce) capi in mungitura= 240	STAZIONE	OSSERVAZIONE **1** (orario: 15,30) PRIMA della mungitura						OSSERVAZIONE **2** (orario: 16,00) DURANTE la mungitura						OSSERVAZIONE **3** (orario: 16,35) DURANTE la mungitura						OSSERVAZIONE **4** (orario: 17,10) DURANTE la mungitura						MEDIA OSSERVAZIONI **1+2+3+4** *(punto **C** solo osservaz. **1**)*			
	punto **C** sala attesa	27,00	45,44	48,81	47,13	0,80	1,10																			**27,00**	**47,13**	**0,80**	**1,10**
	punto **D** fossa mung.	27,50	49,38	51,25	50,32	0,00	0,00	28,20	59,67	63,92	61,80	0,00	0,00	27,00	59,64	61,32	60,48	0,00	0,00	27,40	62,07	65,77	63,92	0,00	0,00	**27,53**	**59,13**	**0,00**	**0,00**
	punto **E** sala mung.	27,10	50,30	50,93	50,62	0,00	0,00	27,10	52,42	54,22	53,32	0,00	0,45	27,30	54,52	58,24	56,38	0,00	1,30	26,60	56,26	59,47	57,87	0,00	0,70	**27,03**	**54,55**	**0,00**	**0,61**
																										MEDIA TRA I PUNTI **C+D+E**			
																										27,18	**53,60**	**0,27**	**0,57**
ESTERNA Stalle (3 punti di camp.) + corsia di servizio esterna (2 punti di camp.)	STAZIONE	stalla-corpo **1** Nord (cop. sandwich) orario: 15,40						stalla-corpo **2** Centro (cop. eternit) orario: 16,20						stalla-corpo **3** Sud (cop. sandwich) orario: 16,50						corsia di servizio esterna orario: 16,10									
	punto **A**	27,60	46,65	49,37	48,01	1,05	0,30	28,20	42,48	48,24	45,36	0,30	1,35	26,90	48,82	50,11	49,47	0,50	1,30	27,80	45,63	48,19	46,91	2,05	2,40				
	punto **B**	27,20	48,73	49,09	48,91	0,00	1,35	27,00	49,45	51,94	50,70	1,30	2,25	27,30	47,24	49,80	48,52	0,00	0,00	30,70	42,97	44,29	43,63	0,50	1,60				
	punto **C**	27,80	45,83	46,32	46,08	1,95	1,20	27,20	50,41	51,08	50,75	3,65	2,65	27,50	44,92	45,70	45,31	2,60	1,40										
MEDIA TRA I PUNTI **A+B+C** *(solo punti **A+B** per corsia serv. est.)*		**27,53**	**47,07**	**48,26**	**47,67**	**1,00**	**0,95**	**27,47**	**47,45**	**50,42**	**48,93**	**1,75**	**2,08**	**27,23**	**46,99**	**48,54**	**47,77**	**1,03**	**0,90**	**29,25**	**44,30**	**46,24**	**45,27**	**1,28**	**2,00**				
NOTE	*Caratteristiche della giornata:* Giornata temperata e abbastanza ventilata, cielo limpido; velocita max rilevata del vento: 5,0 m/s *Osservazioni:* Il campionamento verrà effettuato, d'ora in poi, facendo stabilizzare lo strumento per circa 30 secondi prima di iniziare la registrazione dei dati riferiti all'umidità relativa, ottenendo così due valori più precisi di max e min, dai quali poi si estrapolerà il valore di umidità relativa MEDIA; sono accese le ventole elettriche e inebulizzatori d'acqua sono in funzione afiancoal corpo 1 e 2																												

Azienda Calvia- dati microclimatici AGOSTO 2008

Foglio n° 9- Data: 04 agosto 2008 Campionamento mensile n° 1

AREA CAMPIONATA	PUNTI DI CAMPIONAMENTO	TEMP. °c	UM.REL.% min.	UM.REL.% max.	UM.REL.% media	V.ARIA m/s N/S	E/O	TEMP. °c	UM.REL.% min.	UM.REL.% max.	UM.REL.% media	V.ARIA m/s N/S	E/O	TEMP. °c	UM.REL.% min.	UM.REL.% max.	UM.REL.% media	V.ARIA m/s N/S	E/O	TEMP. °c	UM.REL.% min.	UM.REL.% max.	UM.REL.% media	V.ARIA m/s N/S	E/O	TEMP. °c	UM.REL.% media	V.ARIA m/s N/S	E/O
INTERNA Sala d'attesa + fossa di mungitura + sala mungitura (24 poste- spina di pesce) capi in mungitura= 240	STAZIONE	OSSERVAZIONE **1** (orario: 15,20) PRIMA della mungitura						OSSERVAZIONE **2** (orario: 15,50) DURANTE la mungitura						OSSERVAZIONE **3** (orario: 16,30) DURANTE la mungitura						OSSERVAZIONE **4** (orario: 16,50) DURANTE la mungitura						MEDIA OSSERVAZIONI **1+2+3+4** *(punto **C** solo osservaz. **1**)*			
	punto **C** sala attesa	34,50	37,70	38,12	37,91	0,00	0,00																			**34,50**	**37,91**	**0,00**	**0,00**
	punto **D** fossa mung.	34,00	38,26	39,80	39,03	0,00	0,00	33,10	50,65	55,70	53,18	0,00	0,00	32,60	49,28	54,48	51,88	0,00	0,00	32,00	46,59	49,33	47,96	0,00	0,00	**32,93**	**48,01**	**0,00**	**0,00**
	punto **E** sala mung.	33,20	39,96	40,13	40,05	0,00	0,00	33,30	40,35	42,25	41,30	0,85	1,40	32,60	38,91	44,11	41,51	0,40	1,20	32,40	41,32	43,57	42,45	0,00	1,05	**32,88**	**41,33**	**0,31**	**0,91**
																										MEDIA TRA I PUNTI **C+D+E**			
																										33,43	**42,42**	**0,10**	**0,30**
ESTERNA Stalle (3 punti di camp.) + corsia di servizio esterna (2 punti di camp.)	STAZIONE	stalla-corpo **1** Nord (cop. sandwich) orario: 15,40						stalla-corpo **2** Centro (cop. eternit) orario: 16,10						stalla-corpo **3** Sud (cop. sandwich) orario: 16,00						corsia di servizio esterna orario: 15,30									
	punto **A**	34,80	34,66	35,85	35,26	1,50	2,00	32,90	37,38	40,48	38,93	1,00	2,10	32,80	38,54	39,64	39,09	1,60	2,00	36,20	36,97	38,04	37,51	2,75	3,30				
	punto **B**	33,70	36,94	37,42	37,18	1,10	1,00	32,50	38,12	38,75	38,44	1,50	2,30	32,80	37,75	39,10	38,43	2,75	3,15	36,50	33,72	35,74	34,73	3,10	3,75				
	punto **C**	34,30	35,84	37,28	36,56	2,00	3,25	32,50	37,76	38,88	38,32	1,70	3,25	33,10	36,67	37,55	37,11	4,00	5,65										
MEDIA TRA I PUNTI **A+B+C** *(solo punti **A+B** per corsia serv. est.)*		**34,27**	**35,81**	**36,85**	**36,33**	**1,53**	**2,08**	**32,63**	**37,75**	**39,37**	**38,56**	**1,40**	**2,55**	**32,90**	**37,65**	**38,76**	**38,21**	**2,78**	**3,60**	**36,35**	**35,35**	**36,89**	**36,12**	**2,93**	**3,53**				
NOTE	*Caratteristiche della giornata:* Giornata molto calda, non afosa, ventilata, cielo limpido; velocità max rilevata del vento: 6,0 m/s *Osservazioni:* Ventole elettriche accese nelle stalle; sono presenti meno mosche rispetto alle precedenti visite; l'acqua nebulizzata che viene distribuita nel paddock, viene utilizzata per bagnare il letame affinchè questo non si secchi e permettendo quindi ai raschiatoi di lavorare agevolmente e senza esser danneggiati: ovviamente gli animali approfittano di questa condizione e tendono a farsi bagnare per trovare refrigerio.																												

Azienda Calvia- dati microclimatici SETTEMBRE 2008

Foglio n° 10- Data: 30 settembre 2008- Campionamento mensile n° 1

AREA CAMPIONATA	PUNTI DI CAMPIONAMENTO	TEMP. °c	UM.REL.% min.	UM.REL.% max.	UM.REL.% media	V.ARIA m/s N/S	E/O	TEMP. °c	UM.REL.% min.	UM.REL.% max.	UM.REL.% media	V.ARIA m/s N/S	E/O	TEMP. °c	UM.REL.% min.	UM.REL.% max.	UM.REL.% media	V.ARIA m/s N/S	E/O	TEMP. °c	UM.REL.% min.	UM.REL.% max.	UM.REL.% media	V.ARIA m/s N/S	E/O	TEMP. °c	UM.REL.% media	V.ARIA m/s N/S	E/O
INTERNA Sala d'attesa + fossa di mungitura + sala mungitura (24 poste- spina di pesce) capi in mungitura= 240	STAZIONE	OSSERVAZIONE **1** (orario:15,00) PRIMA della mungitura						OSSERVAZIONE **2** (orario:15,45) DURANTE la mungitura						OSSERVAZIONE **3** (orario:16,15) DURANTE la mungitura						OSSERVAZIONE **4** (orario:16,45) DURANTE la mungitura						MEDIA OSSERVAZIONI **1+2+3+4** *(punto **C** solo osservaz. **1**)*			
	punto **C** sala attesa	21,90	51,89	52,36	52,13	0,85	0,95																			**21,90**	**52,13**	**0,85**	**0,95**
	punto **D** fossa mung.	21,80	50,47	51,15	50,81	0,00	0,00	21,80	61,57	63,26	62,42	0,00	0,00	22,00	67,31	71,10	69,21	0,00	0,00	21,30	69,88	72,60	71,24	0,00	0,00	**21,73**	**63,42**	**0,00**	**0,00**
	punto **E** sala mung.	21,40	52,06	52,39	52,23	0,00	0,00	21,90	60,32	60,93	60,63	0,00	0,00	21,80	65,18	65,42	65,30	0,00	0,00	20,90	61,93	72,75	67,34	0,00	0,40	**21,50**	**61,37**	**0,00**	**0,10**
																										MEDIA TRA I PUNTI **C+D+E**			
																										21,71	**58,97**	**0,28**	**0,35**
ESTERNA Stalle (3 punti di camp.) + corsia di servizio esterna (2 punti di camp.)	STAZIONE	stalla-corpo **1** Nord (cop. sandwich) orario: 15,30						stalla-corpo **2** Centro (cop. eternit) orario: 15,50						stalla-corpo **3** Sud (cop. sandwich) orario: 16,15						corsia di servizio esterna orario: 15,15									
	punto **A**	22,30	51,62	52,80	52,21	0,55	0,60	20,60	54,67	56,50	55,59	0,60	1,90	19,90	58,77	59,36	59,07	1,75	0,80	22,90	47,57	49,60	48,59	1,60	3,35				
	punto **B**	21,40	51,10	51,76	51,43	1,40	1,70	20,20	51,55	54,35	52,95	0,80	0,65	19,50	57,80	58,58	58,19	0,50	1,80	23,50	46,35	49,68	48,02	0,80	2,80				
	punto **C**	20,70	51,52	52,22	51,87	0,65	3,60	20,70	54,53	54,86	54,70	2,25	0,95	19,70	58,01	58,44	58,23	3,35	4,10										
MEDIA TRA I PUNTI **A+B+C** *(solo punti **A+B** per corsia serv. est.)*		**21,47**	**51,41**	**52,26**	**51,84**	**0,87**	**1,97**	**20,50**	**53,58**	**55,24**	**54,41**	**1,22**	**1,17**	**19,70**	**58,19**	**58,79**	**58,49**	**1,87**	**2,23**	**23,20**	**46,96**	**49,64**	**48,30**	**1,20**	**3,08**				

NOTE

Caratteristiche della giornata: Giornata tiepida, cielo coperto, brezza moderata; velocita max rilevata del vento: 4,5 m/s
Osservazioni: S ono presenti meno mosche rispetto ai precedenti campionamenti estivi.

Azienda Calvia- dati microclimatici OTTOBRE 2008

Foglio n° 11- Data: 22 ottobre 2008 - Campionamento mensile n° 1

AREA CAMPIONATA	PUNTI DI CAMPIONAMENTO	TEMP. °c	UM.REL.% min.	UM.REL.% max.	UM.REL.% media	V.ARIA m/s N/S	E/O	TEMP. °c	UM.REL.% min.	UM.REL.% max.	UM.REL.% media	V.ARIA m/s N/S	E/O	TEMP. °c	UM.REL.% min.	UM.REL.% max.	UM.REL.% media	V.ARIA m/s N/S	E/O	TEMP. °c	UM.REL.% min.	UM.REL.% max.	UM.REL.% media	V.ARIA m/s N/S	E/O	TEMP. °c	UM.REL.% media	V.ARIA m/s N/S	E/O
INTERNA Sala d'attesa + fossa di mungitura + sala mungitura (24 poste- spina di pesce) capi in mungitura= 240	STAZIONE	OSSERVAZIONE **1** (orario: 15,15) PRIMA della mungitura						OSSERVAZIONE **2** (orario: 16,00) DURANTE la mungitura						OSSERVAZIONE **3** (orario: 16,20) DURANTE la mungitura						OSSERVAZIONE **4** (orario: 16,40) DURANTE la mungitura						MEDIA OSSERVAZIONI **1+2+3+4** *(punto **C** solo osservaz. **1**)*			
	punto **C** sala attesa	22,40	63,55	63,78	63,67	0,00	0,00																			**22,40**	**63,67**	**0,00**	**0,00**
	punto **D** fossa mung.	20,90	70,61	70,86	70,74	0,00	0,00	21,90	82,54	87,55	85,05	0,00	0,00	22,20	83,35	87,08	85,22	0,00	0,00	22,40	85,79	87,69	86,74	0,00	0,00	**21,85**	**81,93**	**0,00**	**0,00**
	punto **E** sala mung.	20,30	73,03	74,22	73,63	0,00	0,00	21,40	88,32	90,30	89,31	0,00	0,00	21,60	91,00	91,55	91,28	0,00	0,00	21,90	90,37	90,64	90,51	0,00	0,00	**21,30**	**86,18**	**0,00**	**0,00**
																										MEDIA TRA I PUNTI **C+D+E**			
																										21,85	**77,26**	**0,00**	**0,00**
ESTERNA Stalle (3 punti di camp.) + corsia di servizio esterna (2 punti di camp.)	STAZIONE	stalla-corpo **1** Nord (cop. sandwich) orario: 15,45						stalla-corpo **2** Centro (cop. eternit) orario: 16,10						stalla-corpo **3** Sud (cop. sandwich) orario: 16,30						corsia di servizio esterna orario: 15,30									
	punto **A**	21,40	65,92	66,84	66,38	0,00	0,25	19,70	71,56	74,69	73,13	0,00	0,00	19,50	74,22	74,61	74,42	0,60	1,00	21,09	67,85	69,33	68,59	0,00	0,00				
	punto **B**	20,00	71,26	71,80	71,53	0,00	0,00	20,00	72,51	73,35	72,93	0,00	0,00	19,70	74,91	75,17	75,04	0,00	0,00	21,60	67,87	70,85	69,36	0,00	0,00				
	punto **C**	19,70	72,77	73,05	72,91	0,00	0,00	19,40	74,04	74,16	74,10	0,25	0,60	19,70	72,66	73,52	73,09	0,00	0,00										
MEDIA TRA I PUNTI **A+B+C** *(solo punti **A+B** per corsia serv. est.)*		**20,37**	**69,98**	**70,56**	**70,27**	**0,00**	**0,08**	**19,70**	**72,70**	**74,07**	**73,39**	**0,08**	**0,20**	**19,63**	**73,93**	**74,43**	**74,18**	**0,20**	**0,33**	**21,35**	**67,86**	**70,09**	**68,98**	**0,00**	**0,00**				
NOTE	*Caratteristiche della giornata:* Giornata tiepida con leggera pioggia, vento quasi assente, cielo coperto; velocità max rilevate del vento: 1,2 m/s *Osservazioni:*																												

Azienda Calvia- dati microclimatici NOVEMBRE 2008

AREA CAMPIONATA	PUNTI DI CAMPIONAMENTO	TEMP. °c	UM.REL.% min.	UM.REL.% max.	UM.REL.% media	V.ARIA m/s N/S	E/O	TEMP. °c	UM.REL.% min.	UM.REL.% max.	UM.REL.% media	V.ARIA m/s N/S	E/O	TEMP. °c	UM.REL.% min.	UM.REL.% max.	UM.REL.% media	V.ARIA m/s N/S	E/O	TEMP. °c	UM.REL.% min.	UM.REL.% max.	UM.REL.% media	V.ARIA m/s N/S	E/O	TEMP. °c	UM.REL.% media	V.ARIA m/s N/S	E/O
INTERNA Sala d'attesa + fossa di mungitura + sala mungitura (24 poste- spina di pesce) capi in mungitura= 240	STAZIONE	OSSERVAZIONE **1** (orario: 15,20) PRIMA della mungitura						OSSERVAZIONE **2** (orario: 15,45) DURANTE la mungitura						OSSERVAZIONE **3** (orario: 16,05) DURANTE la mungitura						OSSERVAZIONE **4** (orario: 16,30) DURANTE la mungitura						MEDIA OSSERVAZIONI **1+2+3+4** *(punto **C** solo osservaz. **1**)*			
	punto **C** sala attesa	17,50	71,02	72,55	71,79	0,00	0,00																			**17,50**	**71,79**	**0,00**	**0,00**
	punto **D** fossa mung.	17,20	71,08	72,00	71,54	0,00	0,00	18,00	67,23	70,07	68,65	0,00	0,00	17,80	78,48	79,03	78,76	0,00	0,00	18,70	89,32	90,22	89,77	0,00	0,00	**17,93**	**77,18**	**0,00**	**0,00**
	punto **E** sala mung.	16,70	73,70	73,84	73,77	0,00	0,00	19,40	72,02	73,59	72,81	0,00	0,00	18,10	78,30	80,95	79,63	0,00	0,00	18,40	91,00	92,76	91,88	0,00	0,00	**18,15**	**79,52**	**0,00**	**0,00**
																										MEDIA TRA I PUNTI **C+D+E**			
																										17,86	**76,16**	**0,00**	**0,00**
ESTERNA Stalle (3 punti di camp.) + corsia di servizio esterna (2 punti di camp.)	STAZIONE	stalla-corpo **1** Nord (cop. sandwich) orario: 16,00						stalla-corpo **2** Centro (cop. eternit) orario: 16,10						stalla-corpo **3** Sud (cop. sandwich) orario: 16,20						corsia di servizio esterna orario: 15,15									
	punto **A**	16,70	62,53	64,12	63,33	0,00	0,00	16,00	69,12	70,80	69,96	0,00	0,00	15,40	67,82	69,68	68,75	0,00	0,00	19,30	56,32	56,76	56,54	0,00	0,00				
	punto **B**	15,50	65,11	67,84	66,48	0,00	0,00	15,80	68,44	68,90	68,67	0,00	0,00	15,10	69,94	71,74	70,84	0,00	0,00	19,50	56,01	55,88	55,95	0,00	0,00				
	punto **C**	15,40	69,72	70,65	70,19	0,00	0,00	15,50	69,26	71,00	70,13	0,00	0,00	15,60	69,83	71,41	70,62	0,00	0,00										
MEDIA TRA I PUNTI **A+B+C** *(solo punti **A+B** per corsia serv. est.)*		**15,87**	**65,79**	**67,54**	**66,66**	0,00	0,00	**15,77**	**68,94**	**70,23**	**69,59**	0,00	0,00	**15,37**	**69,20**	**70,94**	**70,07**	0,00	0,00	**19,40**	**56,17**	**56,32**	**56,24**	0,00	0,00				

NOTE

Caratteristiche della giornata: Giornata tiepida, quasi vento assente, cielo nuvoloso con sporadiche schiarite; velocita max rilevata del vento: 0,8 m/s

Osservazioni: Ai lati delle stalle (nei punti di campionamento A e C), le temperature sono mediamente più alte rispetto ai punti centrali di campionamento B: probabilmente per via della diversa esposizione ai raggi solari. Spesso si nota anche una sensibile differenza di temperatura aanche tra la fossa di mungitura (punto D) e la sala di mungitura (punto E).

Azienda Calvia- dati microclimatici DICEMBRE 2008

Foglio n° 13- Data: 23 dicembre 2008- Campionamento mensile n° 1

AREA CAMPIONATA	PUNTI DI CAMPIONAMENTO	TEMP. °c	UM.REL.% min.	UM.REL.% max.	UM.REL.% media	V.ARIA m/s N/S	E/O	TEMP. °c	UM.REL.% min.	UM.REL.% max.	UM.REL.% media	V.ARIA m/s N/S	E/O	TEMP. °c	UM.REL.% min.	UM.REL.% max.	UM.REL.% media	V.ARIA m/s N/S	E/O	TEMP. °c	UM.REL.% min.	UM.REL.% max.	UM.REL.% media	V.ARIA m/s N/S	E/O	TEMP. °c	UM.REL.% media	V.ARIA m/s N/S	E/O
INTERNA Sala d'attesa + fossa di mungitura + sala mungitura (24 poste- spina di pesce) capi in mungitura= 240	STAZIONE	OSSERVAZIONE **1** (orario: 15,20) PRIMA della mungitura						OSSERVAZIONE **2** (orario: 15,50) DURANTE la mungitura						OSSERVAZIONE **3** (orario: 16,30) DURANTE la mungitura						OSSERVAZIONE **4** (orario: 16,50) DURANTE la mungitura						MEDIA OSSERVAZIONI **1+2+3+4** *(punto **C** solo osservaz. **1**)*			
	punto **C** sala attesa	15,80	75,82	76,16	75,99	0,00	0,00																			**15,80**	**75,99**	**0,00**	**0,00**
	punto **D** fossa mung.	15,00	76,04	77,80	76,92	0,00	0,00	16,90	74,19	76,42	75,31	0,00	0,00	17,00	78,82	84,19	81,51	0,00	0,00	17,80	85,05	87,32	86,19	0,00	0,00	**16,68**	**79,98**	**0,00**	**0,00**
	punto **E** sala mung.	16,20	75,80	76,29	76,05	0,00	0,00	17,20	77,28	79,33	78,31	0,00	0,00	17,60	79,06	86,62	82,84	0,00	0,00	18,10	86,90	87,80	87,35	0,00	0,00	**17,28**	**81,14**	**0,00**	**0,00**
																										MEDIA TRA I PUNTI **C+D+E**			
																										16,58	**79,03**	**0,00**	**0,00**
ESTERNA Stalle (3 punti di camp.) + corsia di servizio esterna (2 punti di camp.)	STAZIONE	stalla-corpo **1** Nord (cop. sandwich) orario: 15,40						stalla-corpo **2** Centro (cop. eternit) orario: 16,10						stalla-corpo **3** Sud (cop. sandwich) orario: 16,00						corsia di servizio esterna orario: 15,30									
	punto **A**	16,20	74,12	74,90	74,51	0,00	0,00	15,80	80,14	82,00	81,07	0,00	0,00	15,20	77,82	78,12	77,97	0,00	0,00	17,20	70,38	73,80	72,09	0,00	0,00				
	punto **B**	16,00	74,90	75,15	75,03	0,00	0,00	15,60	82,44	83,14	82,79	0,00	0,00	16,00	74,34	78,26	76,30	0,00	0,00	17,30	74,52	80,00	77,26	0,00	0,00				
	punto **C**	15,40	73,62	75,22	74,42	0,00	0,00	16,70	79,26	82,30	80,78	0,00	0,00	15,60	75,66	77,13	76,40	0,00	0,00										
MEDIA TRA I PUNTI **A+B+C** *(solo punti **A+ B** per corsia serv. est.)*		**15,87**	**74,21**	**75,09**	**74,65**	0,00	0,00	**16,03**	**80,61**	**82,48**	**81,55**	0,00	0,00	**15,60**	**75,94**	**77,84**	**76,89**	0,00	0,00	**17,25**	**72,45**	**76,90**	**74,68**	0,00	0,00				

NOTE

Caratteristiche della giornata: Giornata tiepida, cielo coperto, vento molto debole; velocita max rilevata del vento: 1,8 m/s

Osservazioni: Non sono stati rilevati i dati relativi al vento nei punti assegnati; solo qialche misura a casuale sulla corsia di servizio

Azienda Calvia- dati microclimatici GENNAIO 2009

Foglio n° 14- Data: 23 gennaio 2009- Campionamento mensile n° 1

AREA CAMPIONATA	PUNTI DI CAMPIONAMENTO	TEMP. °c	UM.REL.% min.	UM.REL.% max.	UM.REL.% media	V.ARIA m/s N/S	V.ARIA m/s E/O	TEMP. °c	UM.REL.% min.	UM.REL.% max.	UM.REL.% media	V.ARIA m/s N/S	V.ARIA m/s E/O	TEMP. °c	UM.REL.% min.	UM.REL.% max.	UM.REL.% media	V.ARIA m/s N/S	V.ARIA m/s E/O	TEMP. °c	UM.REL.% min.	UM.REL.% max.	UM.REL.% media	V.ARIA m/s N/S	V.ARIA m/s E/O	TEMP. °c	UM.REL.% media	V.ARIA m/s N/S	V.ARIA m/s E/O
INTERNA Sala d'attesa + fossa di mungitura + sala mungitura (24 poste- spina di pesce) capi in mungitura= 240	STAZIONE	OSSERVAZIONE **1** (orario: 15,15) PRIMA della mungitura						OSSERVAZIONE **2** (orario: 15,55) DURANTE la mungitura						OSSERVAZIONE **3** (orario: 16,10) DURANTE la mungitura						OSSERVAZIONE **4** (orario: 16,30) DURANTE la mungitura						MEDIA OSSERVAZIONI **1+2+3+4** *(punto **C** solo osservaz. **1**)*			
	punto **C** sala attesa	11,80	84,77	85,26	85,02	0,00	0,00																			**11,80**	**85,02**	**0,00**	**0,00**
	punto **D** fossa mung.	12,10	85,21	85,42	85,32	0,00	0,00	13,90	91,80	91,91	91,86	0,00	0,00	15,30	92,10	92,24	92,17	0,00	0,00	15,80	89,18	90,43	89,81	0,00	0,00	**14,28**	**89,79**	**0,00**	**0,00**
	punto **E** sala mung.	12,00	71,56	80,86	76,21	0,00	0,00	13,40	90,64	91,23	90,94	0,00	0,00	14,20	91,79	92,04	91,92	0,00	0,00	15,20	87,48	89,65	88,57	0,00	0,00	**13,70**	**86,91**	**0,00**	**0,00**
																										MEDIA TRA I PUNTI **C+D+E**			
																										13,26	**87,24**	**0,00**	**0,00**
ESTERNA Stalle (3 punti di camp.) + corsia di servizio esterna (2 punti di camp.)	STAZIONE	stalla-corpo **1** Nord (cop. sandwich) orario: 15,25						stalla-corpo **2** Centro (cop. eternit) orario: 15,50						stalla-corpo **3** Sud (cop. sandwich) orario: 15,40						corsia di servizio esterna orario: 15,10									
	punto **A**	12,30	83,90	84,26	84,08	0,60	1,20	12,10	83,48	85,24	84,36	1,80	1,40	11,80	85,49	85,55	85,52	2,40	2,00	11,80	71,56	75,82	73,69	1,80	3,20				
	punto **B**	12,00	83,52	84,19	83,86	0,80	1,00	12,10	82,15	85,00	83,58	1,20	1,20	11,80	85,30	85,34	85,32	0,20	0,20	11,70	84,77	85,62	85,20	1,80	3,00				
	punto **C**	12,00	83,12	85,07	84,10	0,80	1,20	11,90	83,41	85,20	84,31	1,90	1,20	11,70	84,14	85,82	84,98	1,60	3,00										
MEDIA TRA I PUNTI **A+B+C** *(solo punti **A+B** per corsia serv. est.)*		**12,10**	**83,51**	**84,51**	**84,01**	**0,73**	**1,13**	**12,03**	**83,01**	**85,15**	**84,08**	**1,63**	**1,27**	**11,77**	**84,98**	**85,57**	**85,27**	**1,40**	**1,73**	**11,75**	**78,17**	**80,72**	**79,44**	**1,80**	**3,10**				

NOTE

Caratteristiche della giornata: Giornata piovosa, fredda, cielo coperto, vento moderato molto freddo; velocita max rilevata del vento: 4,2 m/s

Osservazioni: Porte della sala mungitura sempre chiuse.

Foglio n° 15- Data: 27 febbraio 2009- Campionamento mensile n° 1

Azienda Calvia- dati microclimatici FEBBRAIO 2009

AREA CAMPIONATA	PUNTI DI CAMPIONAMENTO	TEMP. °c	UM.REL.% min.	UM.REL.% max.	UM.REL.% media	V.ARIA m/s N/S	V.ARIA m/s E/O	TEMP. °c	UM.REL.% min.	UM.REL.% max.	UM.REL.% media	V.ARIA m/s N/S	V.ARIA m/s E/O	TEMP. °c	UM.REL.% min.	UM.REL.% max.	UM.REL.% media	V.ARIA m/s N/S	V.ARIA m/s E/O	TEMP. °c	UM.REL.% min.	UM.REL.% max.	UM.REL.% media	V.ARIA m/s N/S	V.ARIA m/s E/O	TEMP. °c	UM.REL.% media	V.ARIA m/s N/S	V.ARIA m/s E/O
INTERNA Sala d'attesa + fossa di mungitura + sala mungitura (24 poste- spina di pesce) capi in mungitura= 240	STAZIONE	OSSERVAZIONE **1** (orario: 15,05) PRIMA della mungitura						OSSERVAZIONE **2** (orario: 15,50) DURANTE la mungitura						OSSERVAZIONE **3** (orario: 16,10) DURANTE la mungitura						OSSERVAZIONE **4** (orario: 16,30) DURANTE la mungitura						MEDIA OSSERVAZIONI **1+2+3+4** *(punto **C** solo osservaz. **1**)*			
	punto **C** sala attesa	17,30	53,72	54,21	53,97	0,00	0,00																			**17,30**	**53,97**	**0,00**	**0,00**
	punto **D** fossa mung.	16,60	55,47	56,87	56,17	0,00	0,00	15,70	80,10	80,62	80,36	0,00	0,00	15,70	87,54	90,34	88,94	0,00	0,00	17,40	87,76	90,54	89,15	0,00	0,00	**16,35**	**78,66**	**0,00**	**0,00**
	punto **E** sala mung.	15,80	57,01	57,73	57,37	0,00	0,00	15,00	75,69	78,95	77,32	0,00	0,00	15,30	91,02	92,03	91,53	0,00	0,00	17,00	90,96	92,13	91,55	0,00	0,00	**15,78**	**79,44**	**0,00**	**0,00**
																										MEDIA TRA I PUNTI **C+D+E**			
																										16,48	**70,69**	**0,00**	**0,00**
ESTERNA Stalle (3 punti di camp.) + corsia di servizio esterna (2 punti di camp.)	STAZIONE	stalla-corpo **1** Nord (cop. sandwich) orario: 15,30						stalla-corpo **2** Centro (cop. eternit) orario: 15,20						stalla-corpo **3** Sud (cop. sandwich) orario: 15,40						corsia di servizio esterna orario: 14,55									
	punto **A**	15,50	55,19	58,03	56,61	0,00	0,00	14,80	60,82	61,88	61,35	0,00	0,00	13,60	67,50	69,91	68,71	0,30	0,00	16,40	48,01	51,02	49,52	1,50	2,10				
	punto **B**	14,60	59,15	60,91	60,03	0,00	0,00	14,60	59,84	62,12	60,98	0,00	0,00	13,70	68,39	69,04	68,72	0,00	0,00	16,60	51,00	56,02	53,51	0,00	0,00				
	punto **C**	14,50	61,01	62,66	61,84	1,80	0,00	13,90	62,00	63,41	62,71	0,00	0,00	14,20	66,44	69,03	67,74	1,00	0,40										
MEDIA TRA I PUNTI **A+B+C** *(solo punti **A+B** per corsia serv. est.)*		**14,87**	**58,45**	**60,53**	**59,49**	**0,60**	**0,00**	**14,43**	**60,89**	**62,47**	**61,68**	**0,00**	**0,00**	**13,83**	**67,44**	**69,33**	**68,39**	**0,43**	**0,13**	**16,50**	**49,51**	**53,52**	**51,51**	**0,75**	**1,05**				
NOTE	*Caratteristiche della giornata:* Giornata tiepida, cielo coperto, vento quasi assente; velocita max rilevata del vento: 2,1 m/s *Osservazioni: /*																												

Azienda Calvia- dati microclimatici MARZO 2009

Foglio n° 16- Data: 25 marzo 2009- Campionamento mensile n° 1

AREA CAMPIONATA	PUNTI DI CAMPIONAMENTO	TEMP. °c	UM.REL.% min.	UM.REL.% max.	UM.REL.% media	V.ARIA m/s N/S	E/O	TEMP. °c	UM.REL.% min.	UM.REL.% max.	UM.REL.% media	V.ARIA m/s N/S	E/O	TEMP. °c	UM.REL.% min.	UM.REL.% max.	UM.REL.% media	V.ARIA m/s N/S	E/O	TEMP. °c	UM.REL.% min.	UM.REL.% max.	UM.REL.% media	V.ARIA m/s N/S	E/O	TEMP. °c	UM.REL.% media	V.ARIA m/s N/S	E/O
INTERNA Sala d'attesa + fossa di mungitura + sala mungitura (24 poste- spina di pesce) capi in mungitura= 240	STAZIONE	OSSERVAZIONE **1** (orario: 15,30) PRIMA della mungitura						OSSERVAZIONE **2** (orario: 15,50) DURANTE la mungitura						OSSERVAZIONE **3** (orario: 16,20) DURANTE la mungitura						OSSERVAZIONE **4** (orario: 16,50) DURANTE la mungitura						MEDIA OSSERVAZIONI **1+2+3+4** *(punto **C** solo osservaz. **1**)*			
	punto **C** sala attesa	11,80	48,47	51,63	50,05	0,20	0,60																			**11,80**	**50,50**	**0,20**	**0,60**
	punto **D** fossa mung.	11,80	50,65	51,53	51,09	0,00	0,00	12,60	66,05	67,79	66,92	0,00	0,00	12,60	62,03	63,43	62,73	0,00	0,00	12,10	65,74	66,43	66,09	0,00	0,00	**12,28**	**61,71**	**0,00**	**0,00**
	punto **E** sala mung.	11,80	53,24	53,53	53,39	0,00	0,00	12,60	59,23	63,13	61,18	0,00	0,00	12,20	58,37	70,51	64,44	0,00	0,00	11,50	64,36	72,38	68,37	0,00	0,00	**12,03**	**61,84**	**0,00**	**0,00**
																										MEDIA TRA I PUNTI **C+D+E**			
																										12,03	**58,02**	**0,07**	**0,20**
ESTERNA Stalle (3 punti di camp.) + corsia di servizio esterna (2 punti di camp.)	STAZIONE	stalla-corpo **1** Nord (cop. sandwich) orario: 16,00						stalla-corpo **2** Centro (cop. eternit) orario: 16,10						stalla-corpo **3** Sud (cop. sandwich) orario: 16,30						corsia di servizio esterna orario: 15,20									
	punto **A**	11,00	53,28	53,96	53,62	1,80	1,60	10,20	55,02	56,15	55,59	2,40	2,00	9,70	56,99	57,61	57,30	1,50	2,00	11,50	50,69	52,78	51,74	3,80	4,00				
	punto **B**	10,20	54,71	55,08	54,90	0,00	0,00	10,00	54,80	56,00	55,40	0,20	0,40	9,50	56,51	56,86	56,69	0,40	0,40	10,60	51,15	54,09	52,62	2,00	3,50				
	punto **C**	9,80	54,67	56,68	55,68	0,80	1,80	9,60	54,22	55,62	54,92	1,80	1,60	9,80	54,88	56,33	55,61	2,80	2,20										
MEDIA TRA I PUNTI **A+B+C** *(solo punti **A+ B** per corsia serv. est.)*		**10,33**	**54,22**	**55,24**	**54,73**	**0,87**	**1,13**	**9,93**	**54,68**	**55,92**	**55,30**	**1,47**	**1,33**	**9,67**	**56,13**	**56,93**	**56,53**	**1,57**	**1,53**	**11,05**	**50,92**	**53,44**	**52,18**	**2,90**	**3,75**				

NOTE

Caratteristiche della giornata: Giornata abbastanza fredda, cielo coperto, vento moderato; velocita max rilevata del vento: 6,0 m/s

Osservazioni: /

Azienda Calvia- dati microclimatici APRILE 2009

Foglio n° 17- Data: 23 aprile 2009 Campionamento mensile n° 1

AREA CAMPIONATA	PUNTI DI CAMPIONAMENTO	TEMP. °c	UM.REL.% min.	UM.REL.% max.	UM.REL.% media	V.ARIA m/s N/S	V.ARIA m/s E/O	TEMP. °c	UM.REL.% min.	UM.REL.% max.	UM.REL.% media	V.ARIA m/s N/S	V.ARIA m/s E/O	TEMP. °c	UM.REL.% min.	UM.REL.% max.	UM.REL.% media	V.ARIA m/s N/S	V.ARIA m/s E/O	TEMP. °c	UM.REL.% min.	UM.REL.% max.	UM.REL.% media	V.ARIA m/s N/S	V.ARIA m/s E/O	TEMP. °c	UM.REL.% media	V.ARIA m/s N/S	V.ARIA m/s E/O
INTERNA Sala d'attesa + fossa di mungitura + sala mungitura (24 poste- spina di pesce) capi in mungitura= 240	STAZIONE	OSSERVAZIONE **1** (orario: 15,20) PRIMA della mungitura						OSSERVAZIONE **2** (orario: 15,40) DURANTE la mungitura						OSSERVAZIONE **3** (orario: 16,10) DURANTE la mungitura						OSSERVAZIONE **4** (orario: 16,40) DURANTE la mungitura						MEDIA OSSERVAZIONI **1+2+3+4** *(punto **C** solo osservaz. **1**)*			
	punto **C** sala attesa	24,80	43,92	44,55	44,24	0,00	0,00																			**24,80**	**44,24**	**0,00**	**0,00**
	punto **D** fossa mung.	22,80	49,31	49,95	49,63	0,00	0,00	22,80	61,08	67,61	64,35	0,00	0,00	22,80	58,32	61,93	60,13	0,00	0,00	22,80	55,00	59,51	57,26	0,00	0,00	**22,80**	**57,84**	**0,00**	**0,00**
	punto **E** sala mung.	22,40	50,23	51,35	50,79	0,00	0,00	22,60	55,29	64,82	60,06	0,00	0,00	22,70	50,43	59,98	55,21	0,00	0,00	23,00	45,90	48,52	47,21	0,00	0,00	**22,68**	**53,32**	**0,00**	**0,00**
																										MEDIA TRA I PUNTI **C+D+E**			
																										23,43	**51,80**	**0,00**	**0,00**
ESTERNA Stalle (3 punti di camp.) + corsia di servizio esterna (2 punti di camp.)	STAZIONE	stalla-corpo **1** Nord (cop. sandwich) orario: 15,50						stalla-corpo **2** Centro (cop. eternit) orario: 16,00						stalla-corpo **3** Sud (cop. sandwich) orario: 16,20						corsia di servizio esterna orario: 15,10									
	punto **A**	22,70	45,83	47,04	46,44	0,00	0,00	21,80	46,80	50,67	48,74	0,00	0,00	21,90	49,53	54,33	51,93	0,00	0,00	25,20	38,41	41,96	40,19	1,70	2,20				
	punto **B**	21,50	48,81	51,04	49,93	0,00	0,00	21,00	46,95	50,55	48,75	0,00	0,00	21,30	52,07	53,37	52,72	0,00	0,00	24,60	42,54	49,81	46,18	0,40	1,00				
	punto **C**	21,40	50,09	51,19	50,64	2,05	2,10	22,60	47,77	49,57	48,67	1,40	1,50	20,00	44,44	50,46	47,45	2,00	2,95										
MEDIA TRA I PUNTI **A+B+C** *(solo punti **A+B** per corsia serv. est.)*		**21,87**	**48,24**	**49,76**	**49,00**	**0,68**	**0,70**	**21,80**	**47,17**	**50,26**	**48,72**	**0,47**	**0,50**	**21,07**	**48,68**	**52,72**	**50,70**	**0,67**	**0,98**	**24,90**	**40,48**	**45,89**	**43,18**	**1,05**	**1,60**				

NOTE

Caratteristiche della giornata: Giornata abbastanza calda, soleggiata, cielo limpido, vento debole; velocita max rilevata del vento: 3,5 m/s

Osservazioni: Con l'arrivo della primavera, inizia ad esserci la presenza di mosche; le porte sono tenute aperte durante la mungitura.

Foglio n° 18- Data: 29 maggio 2009 Campionamento mensile n° 1

Azienda Calvia- dati microclimatici MAGGIO 2009																													
AREA CAMPIONATA	PUNTI DI CAMPIONAMENTO	TEMP. °c	UM.REL.% min.	UM.REL.% max.	UM.REL.% media	V.ARIA m/s N/S	E/O	TEMP. °c	UM.REL.% min.	UM.REL.% max.	UM.REL.% media	V.ARIA m/s N/S	E/O	TEMP. °c	UM.REL.% min.	UM.REL.% max.	UM.REL.% media	V.ARIA m/s N/S	E/O	TEMP. °c	UM.REL.% min.	UM.REL.% max.	UM.REL.% media	V.ARIA m/s N/S	E/O	TEMP. °c	UM.REL.% media	V.ARIA m/s N/S	E/O
INTERNA Sala d'attesa + fossa di mungitura + sala mungitura (24 poste- spina di pesce) capi in mungitura= 240	STAZIONE	OSSERVAZIONE **1** (orario: 15,10) PRIMA della mungitura						OSSERVAZIONE **2** (orario: 15,55) DURANTE la mungitura						OSSERVAZIONE **3** (orario: 16,20) DURANTE la mungitura						OSSERVAZIONE **4** (orario: 16,40) DURANTE la mungitura						MEDIA OSSERVAZIONI **1+2+3+4** *(punto **C** solo osservaz. **1**)*			
	punto **C** sala attesa	22,80	35,90	36,50	36,20	/	/																			**22,80**	**36,20**	**/**	**/**
	punto **D** fossa mung.	23,00	34,44	37,00	35,72	/	/	23,20	40,86	44,09	42,48	/	/	24,00	44,24	45,48	44,86	/	/	24,50	47,29	47,58	47,44	/	/	**23,68**	**42,62**	**/**	**/**
	punto **E** sala mung.	23,50	32,15	34,27	33,21	/	/	23,50	38,16	40,02	39,09	/	/	23,90	41,82	42,45	42,14	/	/	24,20	48,00	49,70	48,85	/	/	**23,78**	**40,82**	**/**	**/**
																										MEDIA TRA I PUNTI **C+D+E**			
																										23,42	**39,88**	**/**	**/**
ESTERNA Stalle (3 punti di camp.) + corsia di servizio esterna (2 punti di camp.)	STAZIONE	stalla-corpo **1** Nord (cop. sandwich) orario: 15,20						stalla-corpo **2** Centro (cop. eternit) orario: 15,30						stalla-corpo **3** Sud (cop. sandwich) orario: 16,10						corsia di servizio esterna orario: 15,00									
	punto **A**	22,00	31,80	33,25	32,53	/	/	23,30	34,80	35,12	34,96	/	/	24,00	31,15	33,00	32,08	/	/	25,00	30,00	31,15	30,58	/	/				
	punto **B**	22,80	32,12	33,08	32,60	**/**	**/**	23,50	35,40	35,68	35,54	**/**	**/**	24,00	32,67	33,90	33,29	**/**	**/**	24,70	30,77	32,00	31,39	/	/				
	punto **C**	21,80	34,60	36,30	35,45	/	/	22,90	32,86	35,02	33,94	/	/	24,30	31,70	32,60	32,15	/	/										
MEDIA TRA I PUNTI **A+B+C** *(solo punti **A+B** per corsia serv. est.)*		**22,20**	**32,84**	**34,21**	**33,53**	**/**	**/**	**23,23**	**34,35**	**35,27**	**34,81**	**/**	**/**	**24,10**	**31,84**	**33,17**	**32,50**	**/**	**/**	**24,85**	**30,39**	**31,58**	**30,98**	**/**	**/**				
NOTE	*Osservazioni:* Non rileviamo più la VELOCITA' dell'aria: risulta un campionamento piuttosto aleatorio in funzione della metodologia usata.																												

Foglio n° 19- Data: 29 giugno 2009 Campionamento mensile n° 1

Azienda Calvia- dati microclimatici GIUGNO 2009

AREA CAMPIONATA	PUNTI DI CAMPIONAMENTO	TEMP. °c	UM.REL.% min.	UM.REL.% max.	UM.REL.% media	V.ARIA m/s N/S	E/O	TEMP. °c	UM.REL.% min.	UM.REL.% max.	UM.REL.% media	V.ARIA m/s N/S	E/O	TEMP. °c	UM.REL.% min.	UM.REL.% max.	UM.REL.% media	V.ARIA m/s N/S	E/O	TEMP. °c	UM.REL.% min.	UM.REL.% max.	UM.REL.% media	V.ARIA m/s N/S	E/O	TEMP. °c	UM.REL.% media	V.ARIA m/s N/S	E/O
INTERNA Sala d'attesa + fossa di mungitura + sala mungitura (24 poste- spina di pesce) capi in mungitura= 240	STAZIONE	OSSERVAZIONE **1** (orario: 15,30) PRIMA della mungitura						OSSERVAZIONE **2** (orario: 15,50) DURANTE la mungitura						OSSERVAZIONE **3** (orario: 16,10) DURANTE la mungitura						OSSERVAZIONE **4** (orario: 16,30) DURANTE la mungitura						MEDIA OSSERVAZIONI **1+2+3+4** *(punto **C** solo osservaz. **1**)*			
	punto **C** sala attesa	26,20	56,12	56,77	56,45	/	/																			**26,20**	**56,45**	**/**	**/**
	punto **D** fossa mung.	26,80	53,40	54,15	53,78	/	/	27,00	45,20	47,18	46,19	/	/	27,50	47,30	47,70	47,50	/	/	27,80	49,40	49,82	49,61	/	/	**27,28**	**49,27**	**/**	**/**
	punto **E** sala mung.	26,60	50,80	51,22	51,01	/	/	27,30	1,84	45,00	23,42	/	/	27,50	45,24	46,29	45,77	/	/	28,00	48,12	49,00	48,56	/	/	**27,35**	**42,19**	**/**	**/**
																										MEDIA TRA I PUNTI **C+D+E**			
																										26,94	**49,30**	**/**	**/**
ESTERNA Stalle (3 punti di camp.) + corsia di servizio esterna (2 punti di camp.)	STAZIONE	stalla-corpo **1** Nord (cop. sandwich) orario: 15,40						stalla-corpo **2** Centro (cop. eternit) orario: 15,45						stalla-corpo **3** Sud (cop. sandwich) orario: 16,00						corsia di servizio esterna orario: 16,40									
	punto **A**	27,50	45,50	45,82	45,66	/	/	28,00	43,40	43,82	43,61	/	/	29,50	45,70	46,00	45,85	/	/	31,70	32,28	32,90	32,59	/	/				
	punto **B**	27,80	44,60	44,90	44,75	**/**	**/**	28,20	44,50	45,10	44,80	**/**	**/**	29,00	45,32	45,71	45,52	**/**	**/**	32,00	32,75	33,36	33,06	/	/				
	punto **C**	27,80	41,12	41,74	41,43	/	/	28,50	44,00	45,00	44,50	/	/	29,20	44,65	44,82	44,74	/	/										
MEDIA TRA I PUNTI **A+B+C** *(solo punti **A+B** per corsia serv. est.)*		**27,70**	**43,74**	**44,15**	**43,95**	**/**	**/**	**28,23**	**43,97**	**44,64**	**44,30**	**/**	**/**	**29,23**	**45,22**	**45,51**	**45,37**	**/**	**/**	**31,85**	**32,52**	**33,13**	**32,82**	**/**	**/**				
NOTE	*Osservazioni:* Non rileviamo più la VELOCITA' dell'aria: risulta un campionamento piuttosto aleatorio in funzione della metodologia usata.																												

Azienda Calvia- dati microclimatici LUGLIO 2009

Foglio n° 20- Data: 15 luglio 2009 Campionamento mensile n° 1

AREA CAMPIONATA	PUNTI DI CAMPIONAMENTO	TEMP. °c	UM.REL.% min.	UM.REL.% max.	UM.REL.% media	V.ARIA m/s N/S	E/O	TEMP. °c	UM.REL.% min.	UM.REL.% max.	UM.REL.% media	V.ARIA m/s N/S	E/O	TEMP. °c	UM.REL.% min.	UM.REL.% max.	UM.REL.% media	V.ARIA m/s N/S	E/O	TEMP. °c	UM.REL.% min.	UM.REL.% max.	UM.REL.% media	V.ARIA m/s N/S	E/O	TEMP. °c	UM.REL.% media	V.ARIA m/s N/S	E/O
INTERNA Sala d'attesa + fossa di mungitura + sala mungitura (24 poste- spina di pesce) capi in mungitura= 240	STAZIONE	OSSERVAZIONE **1** (orario: 15,30) PRIMA della mungitura						OSSERVAZIONE **2** (orario: 15,50) DURANTE la mungitura						OSSERVAZIONE **3** (orario: 16,10) DURANTE la mungitura						OSSERVAZIONE **4** (orario: 16,30) DURANTE la mungitura						MEDIA OSSERVAZIONI **1+2+3+4** *(punto **C** solo osservaz. **1**)*			
	punto **C** sala attesa	33,20	31,72	32,85	32,29	/	/																			**33,20**	**32,29**	**/**	**/**
	punto **D** fossa mung.	32,50	32,64	33,00	32,82	/	/	33,00	40,40	42,90	41,65	/	/	33,40	45,51	47,70	46,61	/	/	33,80	46,80	52,84	49,82	/	/	**33,18**	**42,72**	**/**	**/**
	punto **E** sala mung.	32,40	32,10	32,71	32,41	/	/	32,60	34,15	37,84	36,00	/	/	32,80	44,12	46,60	45,36	/	/	33,90	46,45	48,15	47,30	/	/	**32,93**	**40,27**	**/**	**/**
																										MEDIA TRA I PUNTI **C+D+E**			
																										33,10	**38,43**	**/**	**/**
ESTERNA Stalle (3 punti di camp.) + corsia di servizio esterna (2 punti di camp.)	STAZIONE	stalla-corpo **1** Nord (cop. sandwich) orario: 16,00						stalla-corpo **2** Centro (cop. eternit) orario: 16,30						stalla-corpo **3** Sud (cop. sandwich) orario: 16,45						corsia di servizio esterna orario: 15,45									
	punto **A**	34,80	26,26	26,81	26,54	/	/	34,00	28,49	29,60	29,05	/	/	34,60	34,24	35,67	34,96	/	/	36,80	28,28	28,50	28,39	/	/				
	punto **B**	33,90	27,15	28,22	27,69	/	/	34,20	32,52	33,01	32,77	/	/	34,60	35,40	35,88	35,64	/	/	37,00	29,10	29,67	29,39	/	/				
	punto **C**	33,60	28,54	29,00	28,77	/	/	34,30	33,42	33,70	33,56	/	/	34,80	32,62	32,90	32,76	/	/										
MEDIA TRA I PUNTI **A+B+C** *(solo punti **A+B** per corsia serv. est.)*		**34,10**	**27,32**	**28,01**	**27,66**	**/**	**/**	**34,17**	**31,48**	**32,10**	**31,79**	**/**	**/**	**34,67**	**34,09**	**34,82**	**34,45**	**/**	**/**	**36,90**	**28,69**	**29,09**	**28,89**	**/**	**/**				
NOTE	*Osservazioni:* Non rileviamo più la VELOCITA' dell'aria: risulta un campionamento piuttosto aleatorio in funzione della metodologia usata.																												

Foglio n° 21- Data: 04 agosto 2009 Campionamento mensile n° 1

Azienda Calvia- dati microclimatici AGOSTO 2009

AREA CAMPIONATA	PUNTI DI CAMPIONAMENTO	TEMP. °c	UM.REL.% min.	UM.REL.% max.	UM.REL.% media	V.ARIA m/s N/S	E/O	TEMP. °c	UM.REL.% min.	UM.REL.% max.	UM.REL.% media	V.ARIA m/s N/S	E/O	TEMP. °c	UM.REL.% min.	UM.REL.% max.	UM.REL.% media	V.ARIA m/s N/S	E/O	TEMP. °c	UM.REL.% min.	UM.REL.% max.	UM.REL.% media	V.ARIA m/s N/S	E/O	TEMP. °c	UM.REL.% media	V.ARIA m/s N/S	E/O
INTERNA Sala d'attesa + fossa di mungitura + sala mungitura (24 poste- spina di pesce) capi in mungitura= 240	STAZIONE	OSSERVAZIONE **1** (orario: 15,25) PRIMA della mungitura						OSSERVAZIONE **2** (orario: 16,00) DURANTE la mungitura						OSSERVAZIONE **3** (orario: 16,20) DURANTE la mungitura						OSSERVAZIONE **4** (orario: 16,40) DURANTE la mungitura						MEDIA OSSERVAZIONI **1+2+3+4** *(punto **C** solo osservaz. **1**)*			
	punto **C** sala attesa	35,80	38,25	37,15	37,70	/	/																			**35,80**	**37,70**	**/**	**/**
	punto **D** fossa mung.	35,50	39,82	40,12	39,97	/	/	34,80	51,65	54,67	53,16	/	/	35,20	50,15	53,66	51,91	/	/	35,80	49,64	52,29	50,97	/	/	**35,33**	**49,00**	**/**	**/**
	punto **E** sala mung.	35,40	36,60	36,98	36,79	/	/	34,20	48,28	50,57	49,43	/	/	35,30	52,32	54,11	53,22	/	/	36,00	48,70	49,92	49,31	/	/	**35,23**	**47,19**	**/**	**/**
																										MEDIA TRA I PUNTI **C+D+E**			
																										35,45	**44,63**	**/**	**/**
ESTERNA Stalle (3 punti di camp.) + corsia di servizio esterna (2 punti di camp.)	STAZIONE	stalla-corpo **1** Nord (cop. sandwich) orario: 15,40						stalla-corpo **2** Centro (cop. eternit) orario: 15,50						stalla-corpo **3** Sud (cop. sandwich) orario: 16,10						corsia di servizio esterna orario: 15,35									
	punto **A**	34,80	35,84	35,98	35,91	/	/	33,80	36,66	39,05	37,86	/	/	33,70	39,64	40,12	39,88	/	/	36,80	35,72	37,08	36,40	/	/				
	punto **B**	33,90	36,40	38,75	37,58	**/**	**/**	34,20	36,02	38,55	37,29	**/**	**/**	33,80	37,54	38,26	37,90	**/**	**/**	36,60	34,81	35,25	35,03	/	/				
	punto **C**	33,80	37,71	37,90	37,81	/	/	34,00	35,74	36,04	35,89	/	/	34,00	39,10	40,67	39,89	/	/										
MEDIA TRA I PUNTI **A+B+C** *(solo punti **A+B** per corsia serv. est.)*		**34,17**	**36,65**	**37,54**	**37,10**	**/**	**/**	**34,00**	**36,14**	**37,88**	**37,01**	**/**	**/**	**33,83**	**38,76**	**39,68**	**39,22**	**/**	**/**	**36,70**	**35,27**	**36,17**	**35,72**	**/**	**/**				
NOTE	*Osservazioni:* Non rileviamo più la VELOCITA' dell'aria: risulta un campionamento piuttosto aleatorio in funzione della metodologia usata.																												

Azienda Calvia- dati microclimatici SETTEMBRE 2009

Foglio n° 22- Data: 28 settembre 2009 Campionamento mensile n° 1

AREA CAMPIONATA	PUNTI DI CAMPIONAMENTO	TEMP. °c	UM.REL.% min.	UM.REL.% max.	UM.REL.% media	V.ARIA m/s N/S	V.ARIA m/s E/O	TEMP. °c	UM.REL.% min.	UM.REL.% max.	UM.REL.% media	V.ARIA m/s N/S	V.ARIA m/s E/O	TEMP. °c	UM.REL.% min.	UM.REL.% max.	UM.REL.% media	V.ARIA m/s N/S	V.ARIA m/s E/O	TEMP. °c	UM.REL.% min.	UM.REL.% max.	UM.REL.% media	V.ARIA m/s N/S	V.ARIA m/s E/O	TEMP. °c	UM.REL.% media	V.ARIA m/s N/S	V.ARIA m/s E/O
INTERNA Sala d'attesa + fossa di mungitura + sala mungitura (24 poste- spina di pesce) capi in mungitura= 240	STAZIONE	OSSERVAZIONE **1** (orario: 15,10) PRIMA della mungitura						OSSERVAZIONE **2** (orario: 15,20) DURANTE la mungitura						OSSERVAZIONE **3** (orario: 15,50) DURANTE la mungitura						OSSERVAZIONE **4** (orario: 16,20) DURANTE la mungitura						MEDIA OSSERVAZIONI **1+2+3+4** *(punto **C** solo osservaz. **1**)*			
	punto **C** sala attesa	27,40	45,58	46,02	45,80	/	/																			**27,40**	**45,80**	**/**	**/**
	punto **D** fossa mung.	27,10	47,55	47,94	47,75	/	/	27,40	60,18	64,48	62,33	/	/	27,80	57,99	63,71	60,85	/	/	26,20	68,11	76,05	72,08	/	/	**27,13**	**60,75**	**/**	**/**
	punto **E** sala mung.	26,50	49,71	50,38	50,05	/	/	27,50	63,79	66,04	64,92	/	/	27,50	66,34	67,26	66,80	/	/	25,50	60,56	68,68	64,62	/	/	**26,75**	**61,60**	**/**	**/**
																										MEDIA TRA I PUNTI **C+D+E**			
																										27,09	**56,05**	**/**	**/**
ESTERNA Stalle (3 punti di camp.) + corsia di servizio esterna (2 punti di camp.)	STAZIONE	stalla-corpo **1** Nord (cop. sandwich) orario: 15,30						stalla-corpo **2** Centro (cop. eternit) orario: 15,40						stalla-corpo **3** Sud (cop. sandwich) orario: 16,30						corsia di servizio esterna orario: 15,00									
	punto **A**	27,30	46,78	47,48	47,13	/	/	26,40	48,19	48,68	48,44	/	/	26,00	49,05	50,69	49,87	/	/	26,70	48,55	49,89	49,22	/	/				
	punto **B**	26,50	48,99	49,56	49,28	**/**	**/**	26,30	49,09	50,24	49,67	**/**	**/**	26,30	49,03	49,33	49,18	**/**	**/**	28,00	43,94	45,55	44,75	/	/				
	punto **C**	26,30	51,02	51,17	51,10	/	/	26,60	50,59	51,04	50,82	/	/	26,80	47,42	48,03	47,73	/	/										
MEDIA TRA I PUNTI **A+B+C** *(solo punti **A+B** per corsia serv. est.)*		**26,70**	**48,93**	**49,40**	**49,17**	**/**	**/**	**26,43**	**49,29**	**49,99**	**49,64**	**/**	**/**	**26,37**	**48,50**	**49,35**	**48,93**	**/**	**/**	**27,35**	**46,25**	**47,72**	**46,98**	**/**	**/**				
NOTE	*Osservazioni:* Non rileviamo più la VELOCITA' dell'aria: risulta un campionamento piuttosto aleatorio in funzione della metodologia usata.																												

Azienda Calvia- dati microclimatici OTTOBRE 2009

Foglio n° 23- Data: 28 ottobre 2009 Campionamento mensile n° 1

AREA CAMPIONATA	PUNTI DI CAMPIONAMENTO	TEMP. °c	UM.REL.% min.	UM.REL.% max.	UM.REL.% media	V.ARIA m/s N/S	V.ARIA m/s E/O	TEMP. °c	UM.REL.% min.	UM.REL.% max.	UM.REL.% media	V.ARIA m/s N/S	V.ARIA m/s E/O
INTERNA Sala d'attesa + fossa di mungitura + sala mungitura (24 poste- spina di pesce) capi in mungitura= 240	STAZIONE	OSSERVAZIONE **1** (orario: 15,20) PRIMA della mungitura						OSSERVAZIONE **2** (orario: 16,00) DURANTE la mungitura					
	punto **C** sala attesa	21,40	52,92	55,03	53,98	/	/						
	punto **D** fossa mung.	21,20	57,92	59,57	58,75	/	/	20,20	75,67	79,32	77,50	/	/
	punto **E** sala mung.	20,80	58,29	58,74	58,52	/	/	20,20	64,41	69,92	67,17	/	/
ESTERNA Stalle (3 punti di camp.) + corsia di servizio esterna (2 punti di camp.)	STAZIONE	stalla-corpo **1** Nord (cop. sandwich) orario: 15,40						stalla-corpo **2** Centro (cop. eternit) orario: 16,10					
	punto **A**	20,90	56,98	57,56	57,27	/	/	20,90	56,97	57,85	57,41	/	/
	punto **B**	20,30	58,24	58,78	58,51	/	/	20,00	59,99	60,89	60,44	/	/
	punto **C**	19,90	57,49	58,85	58,17	/	/	19,50	60,80	62,04	61,42	/	/
MEDIA TRA I PUNTI **A+B+C** *(solo punti **A+B** per corsia serv. est.)*		**20,37**	**57,57**	**58,40**	**57,98**	**/**	**/**	**20,13**	**59,25**	**60,26**	**59,76**	**/**	**/**

AREA CAMPIONATA	PUNTI DI CAMPIONAMENTO	TEMP. °c	UM.REL.% min.	UM.REL.% max.	UM.REL.% media	V.ARIA m/s N/S	V.ARIA m/s E/O	TEMP. °c	UM.REL.% min.	UM.REL.% max.	UM.REL.% media	V.ARIA m/s N/S	V.ARIA m/s E/O	TEMP. °c	UM.REL.% media	V.ARIA m/s N/S	V.ARIA m/s E/O
INTERNA	STAZIONE	OSSERVAZIONE **3** (orario: 16,20) DURANTE la mungitura						OSSERVAZIONE **4** (orario: 16,40) DURANTE la mungitura						MEDIA OSSERVAZIONI **1+2+3+4** *(punto **C** solo osservaz. **1**)*			
	punto **C** sala attesa													**21,40**	**53,98**	**/**	**/**
	punto **D** fossa mung.	20,40	75,42	76,13	75,78	/	/	21,10	73,34	75,62	74,48	/	/	**20,73**	**71,62**	**/**	**/**
	punto **E** sala mung.	20,10	73,16	77,43	75,30	/	/	21,10	73,14	78,61	75,88	/	/	**20,55**	**69,21**	**/**	**/**
														MEDIA TRA I PUNTI **C+D+E**			
														20,89	**64,94**	**/**	**/**
ESTERNA	STAZIONE	stalla-corpo **3** Sud (cop. sandwich) orario: 15,50						corsia di servizio esterna orario: 15,30									
	punto **A**	19,50	60,20	61,03	60,62	/	/	23,20	53,85	59,89	56,87	/	/				
	punto **B**	19,70	59,37	60,60	59,99	/	/	21,30	54,50	55,70	55,10	/	/				
	punto **C**	20,50	57,63	58,37	58,00	/	/										
MEDIA TRA I PUNTI **A+B+C** *(solo punti **A+B** per corsia serv. est.)*		**19,90**	**59,07**	**60,00**	**59,53**	**/**	**/**	**22,25**	**54,18**	**57,80**	**55,99**	**/**	**/**				

NOTE

Osservazioni: Non rileviamo più la VELOCITA' dell'aria: risulta un campionamento piuttosto aleatorio in funzione della metodologia usata.

N.B. Ricordare che la sonda percepisce sensibilmente le variazioni della corrente,cosicchè anche la misura della temperatura può essere influenzata dal fatto che ci sia vento oppure no.

Results and conclusions

After checking the technical feasibility for the proposed use of geothermal energy in the process of cooling the milk in (zoo technical) farms, the study confirmed the positive results achieved at EU level in civil applications

In both case studies (coupled with geothermal pre-cooling process, coupled with geothermal cooling cycle) occurred dependence between exchange geothermal cooling and the *cooling coefficient of performance* (COP).

In particular, it has demonstrated a clear improvement of the COP (COP geothermal) with reduction of the necessary power to the compressor of the refrigeration unit in the order of 45% (crg ≈ 0.55).

Based on data collected in part, and partly derived, the projections obtained for a production of 1,000 liters of milk per day have led to the following analytical results:

- annual savings in terms of electricity for refrigeration of milk varies between 680.00 and 790.00 euro per year, depending on the size and information technology company (the reported savings of 1,000 liters is not preserved in a strictly linear to the change on farm size);
- in a new installation of the refrigeration unit, saving in term of size reduction of the compressor with a capacity of approximately 45%;
- The use of geothermal seems more appropriate for indirect refrigeration systems, because in this case the "time machine" is no longer dependent class of the cooler, so we have that the average thermal power required is reduced to 1 / 10; this reduction has repercussions on the costs determined almost entirely (eg L is sonde_max kW/30W/10 = 16 = 53 m). Only drawback is the need for thermal power necessary to maintain the same levels of exchange in the pre-cooler, but that problem could be easily remedied with a water storage tank to be filled immediately preceding the juncture use.
- however, the possibility of including the heat exchanger in series between the compressor and condenser geothermal;
- In the case of the presence of a well, saving on the costs of lifting water resources and in terms of groundwater for 2,500 liters / day (ratio of water flow / milk ≈ 2.5);

- in the event of mains water, saving on water costs about 2,500 liters / day (ratio of water flow / milk ≈ 2.5) and savings on precooling that, if obtained with tap water, is less effective due to higher temperatures in summer (see paragraph 3.4.4);
- possibility of exploitation of geothermal probes (outside the hours of milking) for heating water for hygiene and breast and plants, with lower energy costs by reducing coefficients approaching 0.60 (equal to crg);
- possibilities of using the probes (outside the hours of milking) for passive cooling of the milking parlor with improved animal welfare.

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