Technical Support
Bulletin Nr. 3 – Heating

Contents

Introduction

The aim of this bulletin is to discuss new products for "space" heating (ECH 985, IC915D) and specific industrial applications (including food storage: IC974, ID915D).

Heating – Traditional applications for Eliwell products

In the same way as refrigeration and air conditioning processes, heating also requires temperature control. This leads to specific requirements for inputs, outputs and control methods:

- probes that are suitable, with regard to material and type of sensor, for high temperatures (e.g. thermocouples and Pt100s).
- outputs for different uses: switching on of electric heaters, enabling of combustion systems, valve control (water, oil), also with modulating signal, and control of the compressor (heat pump).
- control based on one or more steps with on-off control but also of the proportional-integral-(derivative) type with different types of actuation (modulating signal, on-off output with duty cycle...).

Some Eliwell controllers have been used and valued for some time because of their more straightforward control with one or two steps (for example: IC912 and 915, with their EWPC predecessors). These controls cover several different applications:

- ovens (for cooking food and other uses);
- moulding or material processing machinery;
- treatment of fluids in industrial processes;
- thermostatic control of laboratory equipment and incubators;
- control of cooking of food;
- heating of rooms for seasoning, drying, ripening...

The range of controllers in question can be defined as "universal" since, in addition to what has already been stated, they can be used for the control of very low temperatures (with Pt100 input), humidity, (V-I instruments with EWHS probes), pressure, etc.

Another line of development concerns the control of ambient air that is usually (but not always) linked to air conditioning systems; this is achieved using more complex controllers (e.g.: ECHs, ERTs) that are capable of integrating different controls with a high number of inputs and outputs.

"Space" heating:

this is obtained using:

- gas or other fuel burners: with intuitive operating, widely used and easy to control; they use fossil fuels with obvious environmental implications (renewability, emissions...).
- heat pumps (hereon referred to as HP): consisting of refrigerators that usually operate with a compression cycle; in this case ("reverse" cycle) the "cool" exchange occurs towards the outside and "heat" exchange towards the ambient under special conditions; the cycle may or may not allow reversal: the first case is more frequent and also allows summer cooling (reversible HP with 4-way valve, for example, on refrigerant); the second case is however relevant to climates that do not require cooling.

In the compression cycle, electrical energy is usually used (1 electrical kW can be used to exchange 2.5-5 thermal kW) and is affected by the quality of the external exchange; the different options for the type of external exchange and carrier fluids will be examined below.

- electric heaters: with intuitive operating; not widely used except when integrated with other methods (unlike the previous case, 1 electrical kW produces 1 thermal kW).

the above methods can direct the heat in the ambient air:

- directly (air)
- indirectly (water as carrier fluid: hydronic systems).

there is also another source of energy used for heating:

- solar energy exploited using water circuits (photovoltaic technology is not dealt with here); the increasing spread of solar energy systems is encouraged with financial incentives in several countries due to their low running costs and environmental compatibility.

Hydronic systems can easily integrate several modes among those listed in a single system; the control must therefore be able to handle the most convenient mode in terms of efficiency, comfort, etc.

For the above cases, accessory loads are also used (fan or water pump) with relative protections (on air filter, on motor thermal as well as flow switch, anti-freeze...)

If heat has to be distributed to several areas, each one with its own specific temperature and operating characteristics (e.g. valve, fan or damper...), several controllers are installed: one per area with simple control and one for the central heating unit (essential in hydronic systems).

A typical example in hydronic systems (with fan coils) consists of several FanCoilBasic controllers or similar and an ECH (200 or 400) controller.

Heat pumps

Let's take a detailed look at some concepts:

- energy efficiency: the relationship between the electrical and thermal power is explained by the fact that the HP simply moves the heat from one spot to another.
- The "subtracted" heat can be compensated for in different ways by solar (air, soil...) radiation or industrial processes (low temperature energy).
- the HP usually uses electricity, the cost of which varies considerably from country to country; we must also consider the efficiency and environmental impact of the electrical energy that depends on the sources used. Moreover, the energy efficiency of the HP may be affected in a number of ways by the climate since heat exchange with outside is necessary.

HP consumption/performance are affected by:

- heating requirements and seasonal variations,
- exchange temperature, in particular:

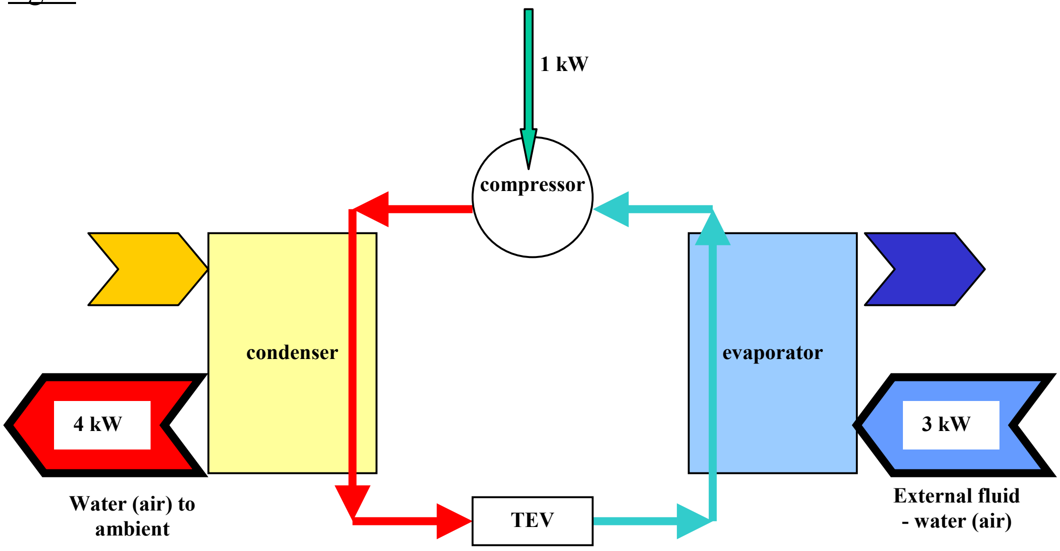
- the exchange of heat inside depends on the relative carrier fluid (air or water) and the method of distribution (e.g. fan-coil, floor system...)
- the exchange of heat outside is also linked to the medium that the heat is extracted from as will be explained below; this medium may undergo considerable temperature swings,

➢ consumption of auxiliary equipment (pumps, fans...)

Types of heat pump machine

➢ **Compression cycle** (mechanical energy is used that acts on the refrigerant fluid and latent heat of evaporation/condensation)

fig. 1



- (other less common methods: gas absorption cycle – similar to above but without phase transition – in which thermal energy and liquid solution are used...)

➢ the mechanical energy supplied to the compressor comes from the **electric motor** (energy efficiency is therefore based on the electrical absorption of the machine)

- (other less common methods: gas-powered combustion engine...)

the most common cases concerning the possibility of changing operating mode (summer, winter), exchange fluids and relative controllers are listed below:

➢ change of mode allowed (reversible HP)
- temperature control: **air**, outside: **air** --> ERT; reversal with 4-way valve (on refrigerant),
- temperature control: **water**, outside: **air** --> ECH; reversal as above
  - recovery in summer mode is sometimes used (partial use of machine as water to water)
- temperature control: **water**, outside: **water** --> ECH; reversal with:
  - 4-way valve (on refrigerant circuit),
  - 3-way valve (on water circuit),

➢ change of mode not allowed (non-reversible HP)
- temperature control: **air**, outside: **air** --> ERT,
- temperature control: **water**, outside: **air** --> ECH,
- temperature control: **water**, outside: **water** --> **ECH (also 985).**

➢ Defrosting, typical of the winter mode and with the exchange of external air, enables the HP to operate in harsh conditions (cold and humid external air); however, frequent defrosting reduces the HP's energy performance and makes it uneconomical; this can be overcome with alternative forms of heating (boiler) handled by the controller.

Water to water machines

Another heat exchange medium can be used as well as external air such as water to water machines (closed or open circuit).

Obviously, these do not require fan control; in summer mode, heat recovery is possible (useful in hotel installations...) and in winter mode, they do not require defrost control (restrictions for anti-freeze diagnostics remain however).

the "external" water circuit can then exchange with:

- industrial flows,
- the earth (**geothermal** machines),
- groundwater and basin water (allowed in some countries)

The use of water in an open circuit is typical of the summer mode with evaporative condensers.

Geothermal heat pump

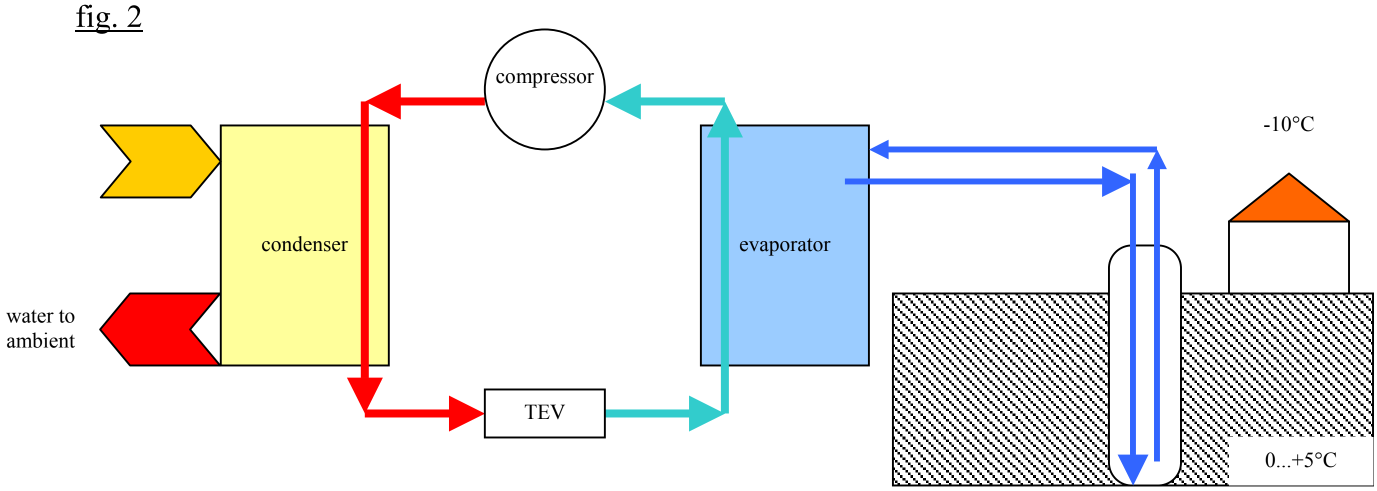
Geothermal machines are interesting especially in winter mode; the earth, with which low temperature heat is exchanged, is not subject to temperature changes and this is evident the further underground you go;

Exchange usually takes place through a pipe buried underground; the water in this absorbs heat from the earth thus balancing the evaporator load.

Here is a brief summary of the advantages and disadvantages of this technology that is very common in residential applications in America/Northern Europe.

- use of the HP in all conditions without the energy burden of defrosting; the COP (coefficient of performance) for the entire season is still advantageous (even if the heat exchange between the pipe and the earth is less beneficial than with other types)
- higher system costs must be considered (e.g. excavation work)

fig. 2



Applications for heat pumps

In addition to residential use (space heating and domestic water) there are other possibilities:

- buildings for services / commercial sector (space heating and water),
- thermostatic control of process fluids in industry,
- other industrial processes (heat for drying, steam production, distillation...),
- heating of greenhouses.

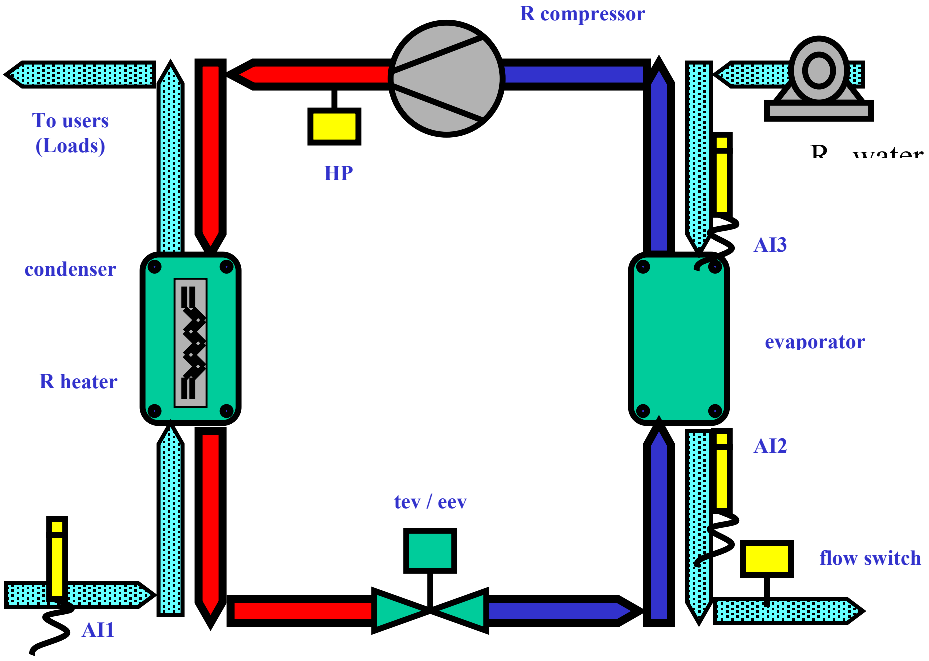
ECH985

If we consider a non-reversible, water to water HP with auxiliary heating (fig. 3), this can be controlled using ECH200-400s and the new ECH985 that features a weekly clock and straightforward configuration and wiring.

Main characteristics

- 24Vac/dc power supply,
- 3 NTC analogue inputs,
- 2 digital inputs (clean contact),
- 4 outputs on relay,
- all connections on screw connector,
- same casing, front keypad (IP65) as IC/ID family,
- same keys and display with same operating as IC/ID family,
- serial connector (5 pole TTL) for configuration tools and CopyCard,
- buzzers and relays can be used for alarm signalling,
- the compressor, pump and auxiliary heating operating times are calculated (with 100 hour resolution and a reset option),
- the presence of an onboard clock is very important and permits daily or weekly programming of set point modification (the start-up time and duration of status are established).

fig. 3



- the instrument heats the water (“boiler probe” temperature) with a heat pump cycle (compressor relay activated),
- the compressor is controlled by the usual safety times and high pressure digital input diagnostics,
- if alarms are present that inhibit the compressor, auxiliary heating is provided (e.g. electric heater or fuel system) that meets heating needs,
- the auxiliary load is also controlled in specific time bands in order to observe a set point that is higher than the “control” set point; this set point is useful for removing micro-organisms in the water (e.g. legionella),

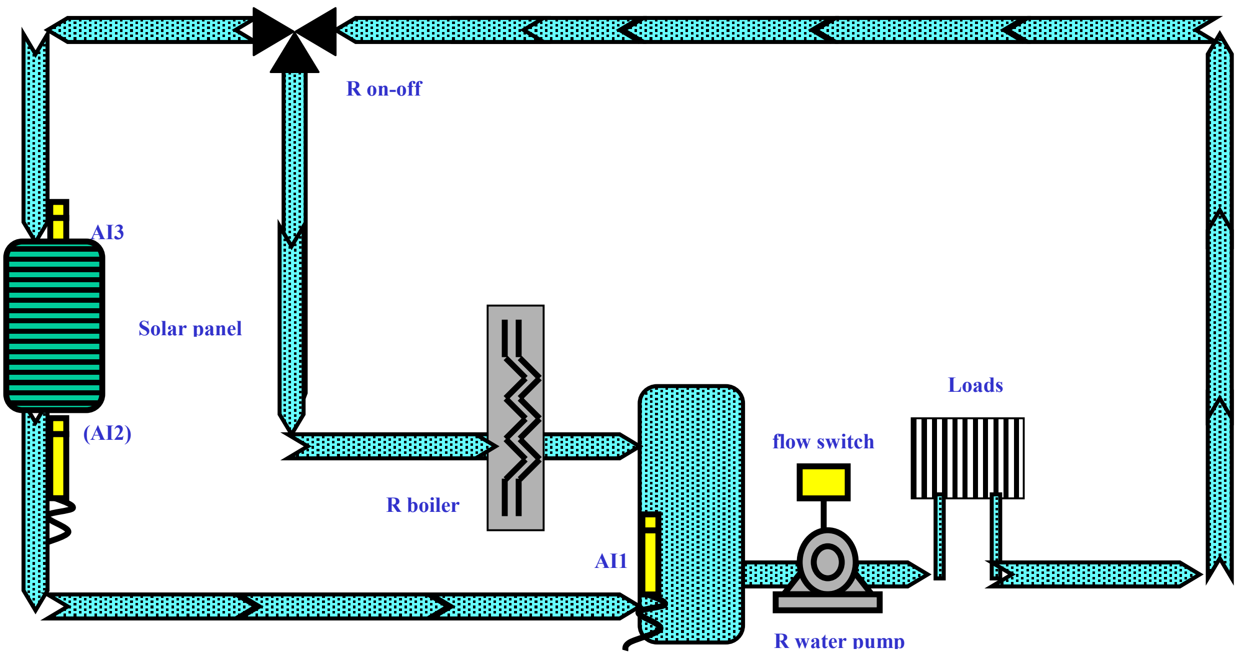
- there is also a relay for the water pump with relative diagnostic (flow switch) and timers for the control request,
- in addition to the high pressure and flow switch alarms, the diagnostic controls errors in the three probes, anti-freeze protection (based on the evaporator temperature) and low temperature of the inlet water; depending on the type of alarm, the conditions for passing from automatic to manual reset or by-pass conditions or the enabling/disabling temperature threshold can be configured; it also controls the clock resetting alarm.

ECH985 applications

Other relevant applications include:

- general two-step space heating one of which is preferential (more efficient); it can be linked to the economy set point (e.g. water temperature lower at nights and weekends),
- integration between solar and traditional heating: solar energy can be established as a preferential source of energy and automatically excluded when the temperature of the solar panels is too low. (see fig. 4); the "traditional" source can consist of boilers, heaters ... the considerations made concerning the economy set point set on a weekly basis remain valid,

fig. 4



- simultaneous control of cooling and heating (e.g. ambient air + swimming pool in summer...).

IC974

This instrument combines the characteristics of the ID and IC ranges.

The name of the product indicates that it includes ID974 (thermostat control, defrosting, fan...) and IC ("cool" and "warn" control) functions. Let's take a detailed look at the IC974LX. Main characteristics

- 24Vac/dc power supply
- 2 analogue inputs configurable as NTC or PTC,
- 1 digital input (clean contact),
- 4 outputs on relay,
- all connections on screw connector,
- same IP65 front keypad, keys and display with same operating as IC/ID family,
- serial connector (5 pole TTL) for CopyCard (Televis and Param Manager subject to availability),
- the relays can be configured for: cooling, heating, defrosting, ventilation, auxiliary control and alarms (for typical applications, see below),
- the digital input and three buttons can be configured for: defrosting, "economy" set point, auxiliary control, door switch, mode limitation (only "heat" or only "cool" is enabled); the single input can be configured as "external" alarm whereas the buttons can also be used for disabling control (stand-by),
- two set points can be used that are separate or interlinked (e.g. for controlling two steps in the same mode) or only one set point (neutral zone); the "economy" set point is set separately for each set point,
- the operating hours are counted ("heat" or "cool" mode) and can be displayed and reset,
- the diagnostic (controlled from a menu, relay, buzzer (if present), supervision system...) can be applied to the usual alarms (high/low temperature, door open...) as well as an "external" alarm that can be selected.

IC974 applications

- food storage in neutral zone (with heating, if necessary) at 0°C (with defrost request): useful in cold rooms (seasoning, ripening, storage; especially for food that is sensitive to temperature changes, unwanted freezing...); example of relay configuration: cool-heat-defrost-fan, or ...-alarm,
- thermostatic control plus alarm management (with particularly sensitive temperature alarms in cold rooms and industrial applications); examples: cool1-cool2-alarm, cool-heat-alarm...
- thermostat control (heat and/or cool) with consensus on the air outlet temperature (probe no. 2 / fan),
- control of dual compressor machines (each one with its own set point and suitable protection delays); examples: cool1-cool2-defrost-fan,
- flexible control of stored product (adjustment of set point with button or switch; temporary disabling of one of control modes...).

IC915D

This instrument is an advanced version of the IC915: in addition to the usual uses, specific controls can be enabled (parameter-enabled) so that two temperatures can be read,

Probe no. 2 can therefore be used for the external air temperature or the outlet temperature. Let's take a detailed look at the IC915D LX. Main characteristics

- power supply 230Vac (other voltages subject to availability),
- 2 analogue inputs configurable as NTC or PTC,
- 1 digital input (clean contact),
- 2 outputs on relay,

- all connections on screw connector,
- same IP65 front key pad, keys, display as other ICs,
- serial connector (5 pole TTL) for CopyCard (Televis and Param Manager subject to availability),
- the relays can be configured for: cooling, heating, alarm, duty-cycle, auxiliary control, instrument status repetition (on-off) (for typical applications, see below),
- the digital input and three buttons can be configured for: soft start (in heating mode), “economy” set point , auxiliary control, control disabled (stand-by), duty cycle activated; the single input can also be configured as an “external” alarm,

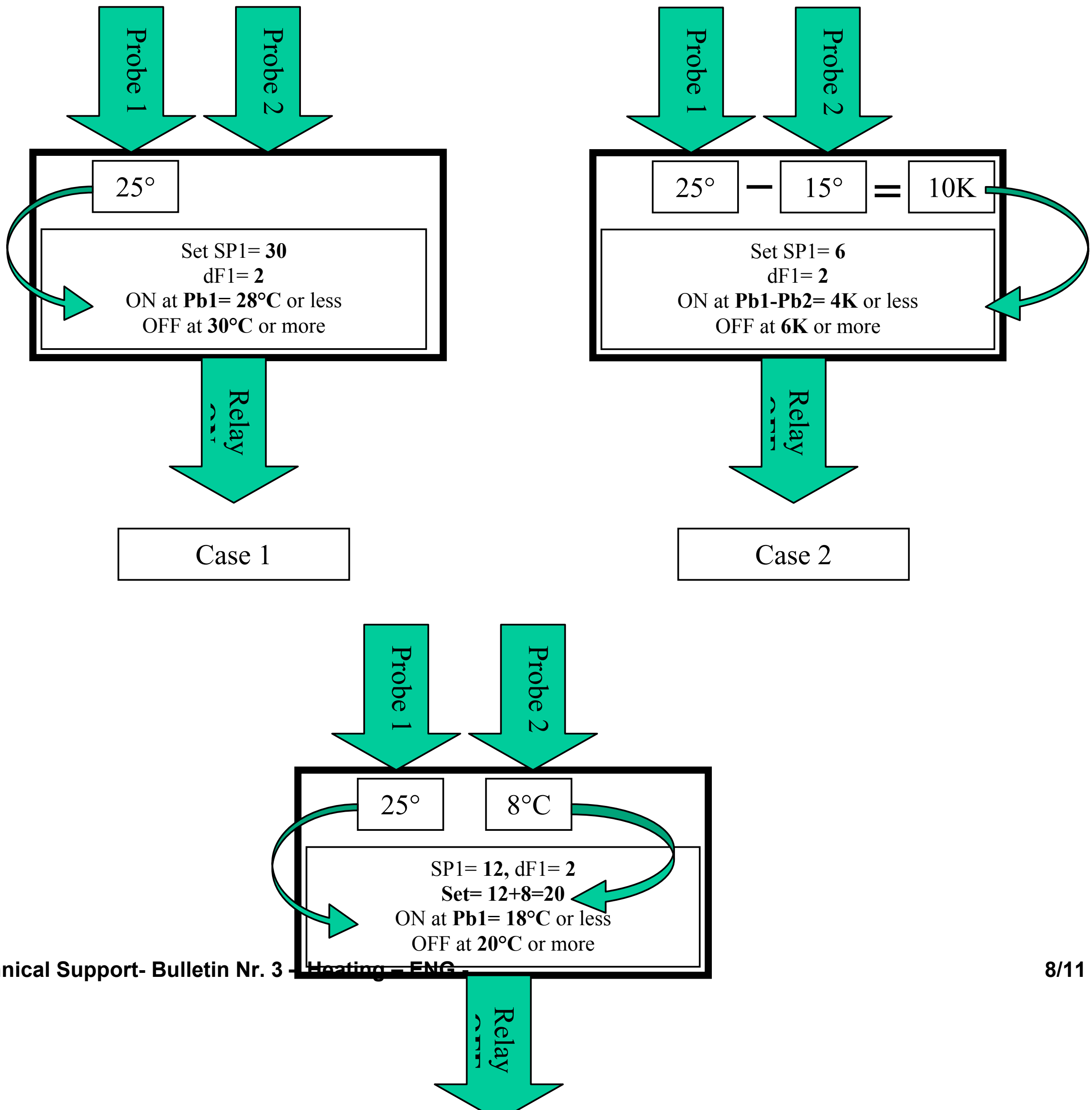
Two set points can be used that are separate or interlinked (e.g. when controlling two steps in the same mode) or only one set point (neutral zone); the “economy” set point is set separately for each set point.

The set point and start-up/shut-down temperatures of the load are linked to values set using the keyboard but also special conditions determined by the two probes; examples are illustrated below (for simplicity’s sake, one-step heat control is considered).

The three cases described are parameter-defined; the first is simple and applies to all IC models; with regard to the other two:

- case 2 adopts a “dynamically calculated” value as control input with a keyboard-set set point

fig. 5 (1-2-3)



- case 3 uses a "dynamically calculated" set point whereas the input value corresponds to probe no. 1; the actual set point (20°C in the example) may vary considerably because of variations on probe no. 2 (consider if it used as an "external air" probe): limits can therefore be imposed on the actual set point to obtain a fixed "winter" set point (when the external temperature is low), a fixed "summer" set point (external temperature is high) and a "dynamic" set point for intermediate external conditions.
- The displayed value can be selected (usually probe no. 1 or probe no. 2 or the "keyboard" set point; the "dynamic" value in cases 2 and 3 is not displayed).
- The diagnostic is the same as in other ICs and therefore has high/low temperature, digital input alarms...
  - the high/low temperature alarms can be detected on: probe 1 and/or probe 2 or the differential value ("probe 1" – "probe 2"), irrespective of the selected control (refer to the three cases described above).
- Cases 2 and 3 can also be controlled using the ECH products (200 and some 400s).

IC915D applications

- Case 2 – differential thermostat control:
  - Assignment of a preset temperature rise to the fluid, in heating or cooling mode, with two steps or in neutral zone: useful in some industrial applications.
  - Enabling of circulation of a fluid (valve, pump control) if the difference between temperatures is sufficient: relevant to solar panel systems.
  - Control of destratifiers, agitators... especially in association with a duty-cycle configured relay.
  - By-pass valve control to optimize exchanger operating parameters (e.g. DTML).
- Case 3 – set point compensation:
  - ambient control with set point compensation (based on external temperature). Compensation is used for comfort (for forcing heating in winter and reaching full power more quickly, for example) or energy saving (reduce the demand in order to reduce the stress of a compressor system or reduce the external-internal thermal gradient, for example)
  - decalibration of set point in order to control the temperature gradient for the direction of flow (taking the cold room area or its contents, furthest from the air outlet point, as a reference point).
- the above cases can be easily combined with the possibility of adjusting the set point ("economy" set point) for example, at night or at the end of a season
- use of alarm relay for abnormal inlet and/or outlet temperatures or poor performance of exchanger (due to fouling, insufficient flow...)

Appendix: solar panel heating

Financial incentives are currently being offered for this simple and relatively widely used technology. It is mainly used for heating domestic water.

It consists of glass panels in which water circulates (mixed with antifreeze), a tank that usually has two exchange elements (one for the solar circuit and one for integration purposes), a circulation pump and other components (valves, expansion tank).

Below reference is made to forced circulation systems (with circulation pump), that can also be used for space heating due to the increased capacity of the storage tank.

The solar panels can be integrated with space heating , not exceeding 1/3 of requirements, and require the use of a radiant floor and a suitably sized tank with two separate temperatures. Another field of application concerns the heating of swimming pools.

The control consists of comparing the temperature of the water in the tank with the solar liquid in the panels. If the temperature of the collectors is higher than the temperature of the tank, thermal energy is present and can be used; the circulation pump is switched on to force the solar liquid into a thermally insulated circuit until it reaches the cooling coil in the tank,

If the energy supply from the solar circuit is not sufficient (bad weather) or consumption of hot water is high, the temperature in the upper part of the accumulator drops below a certain level. The auxiliary heating system must then be switched on.

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