BS EN 12098-1:2013

BSI Standards Publication

Controls for heating systems

Part 1: Control equipment for hot water heating systems

...making excellence a habit.™

National foreword

This British Standard is the UK implementation of EN 12098-1:2013. It supersedes BS EN 12098-1:1997 and BS EN 12098-2:2001 which are withdrawn.

The UK participation in its preparation was entrusted to Technical Committee RHE/16, Performance requirements for control systems.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

ISBN 978 0 580 73039 9

ICS 91.140.10; 97.120

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 August 2013.

Amendments issued since publication

Date	Text affected

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 12098-1

August 2013

ICS 91.140.10; 97.120

Supersedes EN 12098-1:1996, EN 12098-2:2001

English Version

Controls for heating systems - Part 1: Control equipment for hot water heating systems

Régulation pour les systèmes de chauffage - Partie 1: Equipement de régulation pour les systèmes de chauffage à eau chaude

Mess-, Steuer- und Regeleinrichtungen für Heizungen - Teil 1: Regeleinrichtungen für Warmwasserheizungen

This European Standard was approved by CEN on 8 June 2013.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and United Kingdom.

EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

CEN-CENELEC Management Centre: Avenue Marnix 17, B-1000 Brussels

Ref. No. EN 12098-1:2013: E

Contents

Page

Foreword

This document (EN 12098-1:2013) has been prepared by Technical Committee CEN/TC 247 “Building Automation, Controls and Building Management”, the secretariat of which is held by SNV.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by February 2014, and conflicting national standards shall be withdrawn at the latest by February 2014.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN 12098-1:1996 and EN 12098-2:2001.

EN 12098, *Controls for heating systems*, currently consists of the following parts:

— *Part 1: Control equipment for hot water heating systems* (the present document);

— *Part 3: Outside temperature compensated control equipment for electrical heating systems*;

— *Part 4: Optimum start-stop control equipment for electrical systems*[1];

— *Part 5: Start-stop schedulers for heating systems*.

This standard is for products for Outside Temperature Compensated Controls for mechanical building services and covers Outside Temperature Compensated Controls in residential and non-residential buildings. This standard is part of a series of European Standards for Control for HVAC Applications. This standard, therefore, contributes to the general European policy for energy saving, particularly in the fields of the Construction Products Directive (89/106/EEC) Essential Requirements n°6 'Energy economy and heat retention' (and its interpretative document) and of the Energy Performance of Building Directive (2002/91/CE).

This standard covers also controllers which contain an integrated optimum start or an optimum start-stop control function.

According to the CEN-CENELEC Internal Regulations, the national standards organisations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

1) EN 12098-4:2005 is bound to be superseded in the future by an upcoming new edition of EN 12098-3.

Introduction

Equipment which controls the heating supply in buildings according to outside temperature and time is necessary to reduce the energy consumption of heating plants. This equipment can bring about improved comfort and energy savings.

For this purpose, an outside temperature compensated controller (OTC) is necessary.

This standard describes the main equipment characteristics and functions for reaching energy saving and comfort objectives.

1 Scope

This European Standard applies to electronic control equipment for heating systems with water as the heating medium and a flow water temperature up to 120 °C.

This control equipment controls and regulates the distribution and/or the generation of heat in relation to the outside temperature and time and other reference variables.

This standard covers also controllers which contain an integrated optimum start or an optimum start-stop control function.

Safety requirements on heating systems remain unaffected by this standard. The dynamic behaviour of the valves and actuators are not covered in this standard.

A multi-distribution and/or multi-generation system needs a coordinated solution to prevent undesired interaction and is not part of this standard.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

CEN/TS 15810, *Graphical symbols for use on integrated building automation equipment*

EN 60038, *CENELEC standard voltages (IEC 60038)*

EN 60529, *Degrees of protection provided by enclosures (IP Code) (IEC 60529)*

EN 60730-1, *Automatic electrical controls for household and similar use — Part 1: General requirements (IEC 60730-1)*

3 Terms and definitions

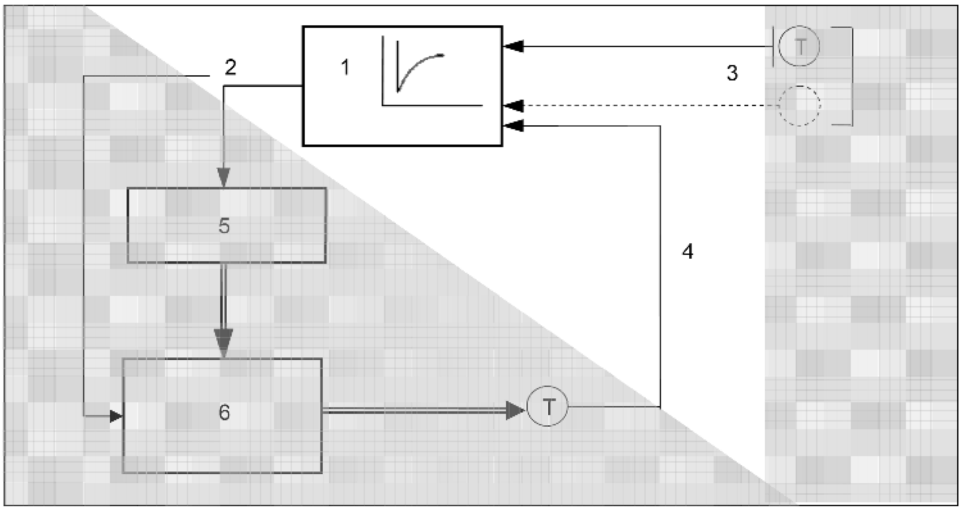
For the purposes of this document, the following terms and definitions apply.

3.1
Outside Temperature Compensated Controller
OTC
instrument that controls and regulates the distribution and/or the generation of heat in relation to the outside temperature and time and other reference variables

Note 1 to entry: The **O**utside **T**emperature **C**ompensated function calculates the flow (supply) temperature in relation to the outside temperature, based on the heating curve.

3.2
control equipment
equipment which consists of the OTC, sensor input signals and output signals, but does not include the sensors and actuating equipment

Note 1 to entry: See Figure 1.



Key

1 OTC
2 output signals
3 input signals: reference variables
4 input signal: controlled variable
5 actuating equipment
6 heat generation & distribution

Figure 1 — Control equipment for heating systems

3.3
actuating equipment
equipment by which the controller affects the controlled variable

3.4
controlled variable (input signal)
supply water temperature and/or boiler water temperature as a result of the heating curve in accordance to the reference variables

3.5
output signals
signals generated by the OTC controller for operating the actuating equipment

3.6
reference variables (input signal)
outside temperature with or without other influences or variables (e.g. room temperature) used to determine the setpoint of the controlled variable

3.7
outside temperature
reference variable that is measured with a sensor fitted outside the building, mainly intended to measure the ambient air temperature

3.8
room temperature
resulting room temperature in the building that arises in comfort, economy or building protection operation mode of the OTC controller and that can be different for individual rooms

3.9
characteristic heating curve
relation between the setpoint value of the controlled variable (e.g. flow water temperature) and the reference variables (outside temperature) defined by two or more parameters and depending on operation mode and additional variables

Note 1 to entry: The flow water temperature is a function of the outside temperature and the present room temperature setpoint. The supply water temperature as function of the outside temperature is graphically represented by the heating curve.

3.10
comfort operation mode
operating period between the switch-on time and the switch-off time for normally occupied rooms

3.11
economy operation mode (reduced mode)
operating period between the switch-off time and the switch-on time, maintaining a reduced room temperature compared to the comfort room temperature

3.12
building protection operation mode (reduced mode)
operating period between the switch-off time and the switch-on time, maintaining a room temperature required for building protection

3.13
automatic operation
mode of operation of equipment when significant control functions are not overridden by the user

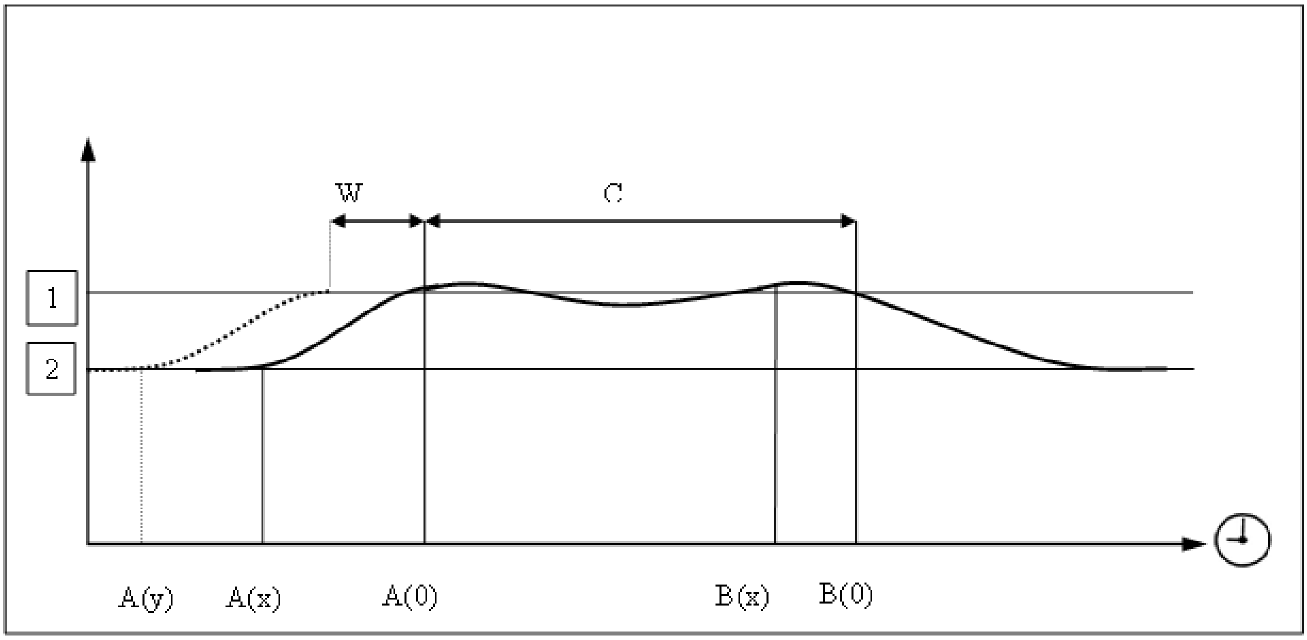
Note 1 to entry: The operation mode is selected automatically according to the scheduler, actual date and time.

3.14
summer/winter switch function
summer/winter switch is used to seasonal switch on/off the heating depending on a function of the outside temperature

3.15
set back function
function to switch off heat generation when the operation mode changes from comfort to economy or building protection until the calculated or measured room temperature drops below the economy or building protection set point, the operation mode switches back to comfort mode or the calculated switch-on time of the optimisation start function is reached

3.16
optimum start function
function that calculates the optimum pre-heat time to reach the comfort temperature level at the beginning of the comfort time period

Note 1 to entry: See Figure 2.

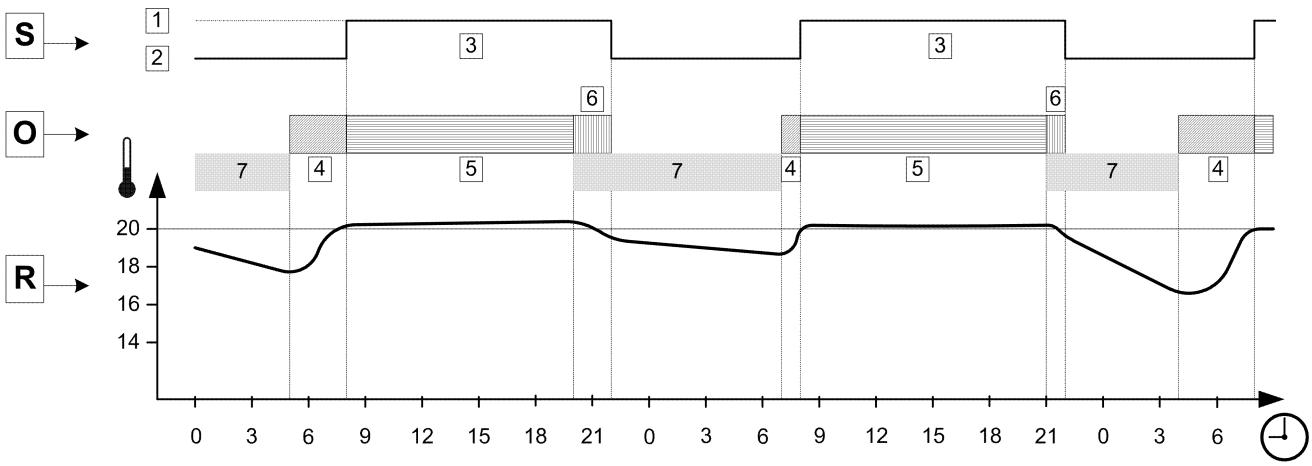


Key

1	comfort room temperature
2	reduced room temperature
A(0)	beginning of comfort occupation period
A(x)	switch-on time with start optimisation (variable start)
A(y)	switch-on time without start optimisation (fixed start)
B(0)	end of comfort occupation period without stop optimisation (fixed stop)
B(x)	switch-off time with stop optimisation (variable stop)
C = A(0) - B(0)	comfort occupation period
A(x) - A(0)	optimum start period
B(x) - B(0)	optimum stop period
W	time period of wasted heat (energy saving potential with start optimisation)

Figure 2 — Temperature time curve with optimiser function

The optimum start and the optimum stop functions are illustrated by Figure 3. Heating periods are different from scheduled occupation periods. These differences, due to thermal inertia, depend mainly on heating loads (or temperatures differences). A start and/or stop optimiser controls these switching points, using outside and/or room temperatures or their differences in relation to setpoints.



Key

S schedule occupation period
O heating operation status
R room temperature profile
1 comfort room temperature
2 reduced room temperature
3 comfort occupation period
4 optimum start period
5 main controller function
6 optimum stop period
7 set back period

Figure 3 — Example Optimum start and stop function

3.17
adaptive optimum start function
added function to optimum start function, which recalculates the parameters used to determine the switch-on time, based on measured room temperature

3.18
optimum stop function
switches off or reduces the heat generation at the earliest possible point in time so that the room temperature will drop max. 0,5 K below the comfort setpoint when the operation mode changes from comfort mode to economy or building protection mode

Note 1 to entry: See Figure 2.

3.19
adaptive optimum stop function
added function to optimum stop function, which recalculates the parameters used to determine the switch-off time, based on measured room temperature

3.20
scheduler
function which switches heating modes affecting the heating control system (see Figure 3) according to a program which includes memorised switch times, reproducing periods or periodic cycles, daily, weekly or yearly, and may also include periods of derogation

3.21
switch points and time periods

3.21.1
switch on time
point in time at which the controller increase the setpoint for boiler/flow temperature in order to reach the comfort room temperature

Note 1 to entry: If the optimum start function is applied the switch on time is automatically determined by the controller otherwise it is determined by the scheduler.

3.21.2
optimum start period
optimal pre heat period between the switch on time and the beginning of comfort occupation period

3.21.3
beginning of comfort occupation period
user programmed switch point when the comfort room temperature is bound to be reached

3.21.4
comfort occupation period
operating period during which comfort room temperature is bound to be maintained

3.21.5
end of comfort occupation period
user programmed switch point when the room temperature is allowed to decrease under the comfort room temperature and for which the room temperature setpoint is switched to Economy and/or Building Protection setpoint

3.21.6
switch off time
point in time at which the controller decreases the setpoint for boiler/flow water temperature

Note 1 to entry: If the optimum stop function is applied the switch off time is automatically determined by the controller otherwise it is determined by the scheduler.

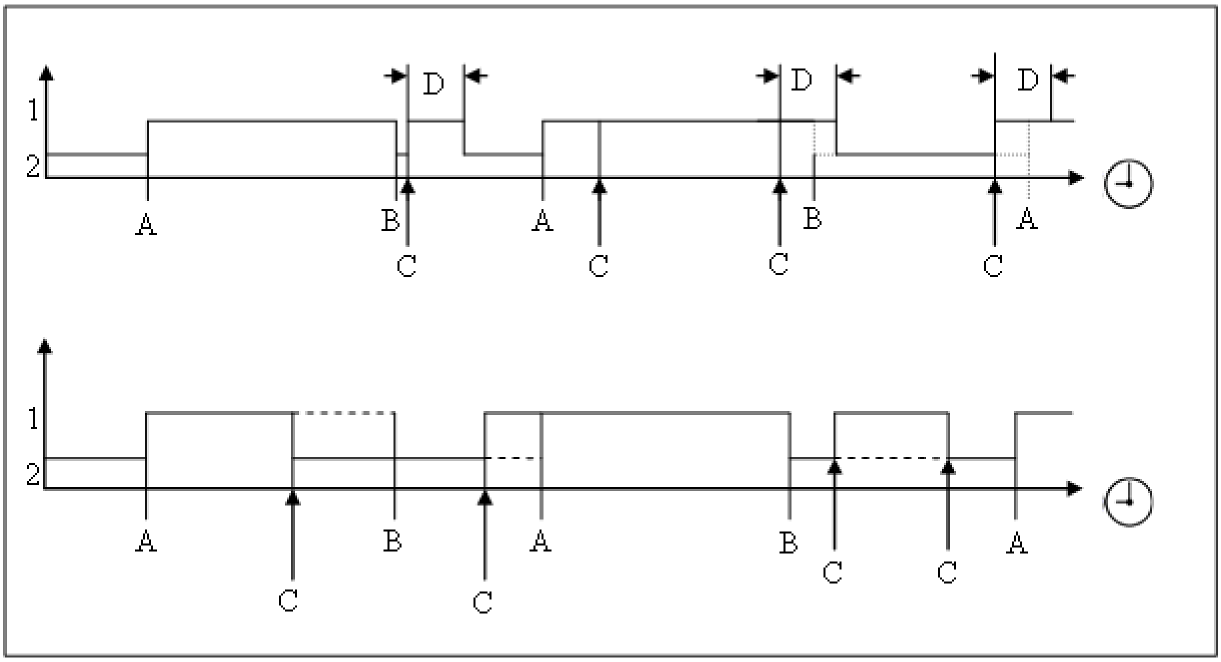
3.21.7
optimum stop period
operating period between the optimal switch off time and the end of comfort occupation period

3.21.8
derogation
function or set of functions for user interaction to temporary override the operation mode

Note 1 to entry: There are different possibilities for derogation functions. Two examples of temporary override of the program by derogation and recovery of the periodic program are shown in Figure 4:

- Upper Diagram: “derogation manual start” initiates a predefined timer which switches the mode to comfort. After the timer is elapsed, the mode defined by the scheduler is applied.

- Lower Diagram: “derogation manual start” changes the mode until the next programmed switch time.



Key

1	comfort room temperature
A and B	programmed switch times
2	reduced room temperature
C	derogation manual start
D	programmable duration

Figure 4 — Examples of derogation

3.22
valve protection function (valve exercise function)
anti-jamming function for valves in which the valves should be moved periodically during longer off periods

3.23
pump protection function (pump exercise function)
anti-jamming function for pump in which the pumps should be switched on during longer off periods

3.24
frost protection function
function in all operation modes (except manual emergency operation) to prevent the heating system from freezing by providing specific output signals

3.25
Manual Emergency Operation Mode
MEOM
mode in which the controller is inactive and the actuating equipment is manipulated manually

4 Functionality

4.1 Functional objective

The objective of outside temperature compensated control equipment is to save energy by reducing waste potential and supply losses performing these main functions:

a) to control supply temperature so that the room temperature can be maintained at the desired level, as determined by comfort and energy optimisation criteria, estimating the heat demand from measurements of the outside temperature with or without other reference variables;

b) to alter the heat supply to follow a scheduled change in order to match occupancy patterns.

OTC control equipment also incorporates a frost protection function and a manual emergency operation mode.

4.2 Control equipment functionality

See Figure 5:

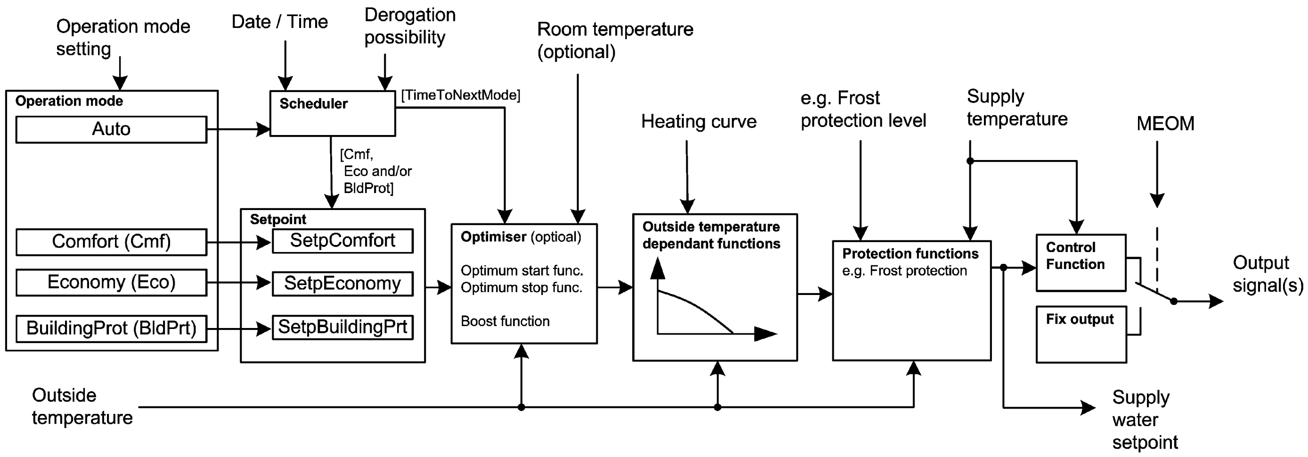


Figure 5 — Block-scheme of control equipment

5 Graphical symbols

Graphical symbols are described in CEN/TS 15810. Plain language can be used instead of, or in conjunction with, graphical symbols.

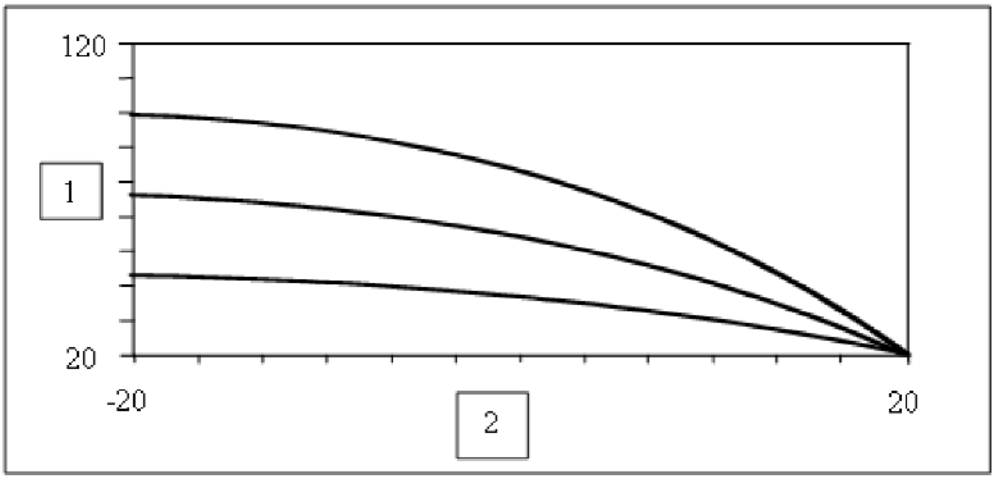
6 Requirements

6.1 Data protection

Actual time and date shall be retained for at least 12 h on failure of the power supply. All other data input on commissioning shall be retained.

6.2 Characteristic heating curve

The range of characteristic heating curve(s) shall be displayed graphically by the manufacturer on the unit and/or in the technical documents e.g. as shown in Figure 6.



Key

1 boiler / supply-water temperature (°C)
2 outside temperature (°C)

NOTE The graphical representation using a reversed temperature axis is also often used.

Figure 6 — Example of characteristic heating curves

The relations between the adjustable setting parameters and the characteristic heating curves shall be shown.

The average flow water temperature shall not deviate from the set temperature points on the characteristic heating curve by more than ± 3 K.

Characteristic heating curves are defined for different temperature ranges:

— heating system for high temperature as oil/gas burners or district heating and flow/return temperatures of 90 °C/70 °C;

— heating system for medium temperature as oil/gas burners with flow/return temperatures of 70 °C/50 °C;

— heating system for low temperature heat generation systems as renewable energies (solar/heat pump) with flow/return temperatures of 55 °C/45 °C;

— heating system for floor heating applications with flow/return temperatures of 35 °C/28 °C.

At least one of this temperature ranges shall be provided by the controller. The characteristic heating curves shall be adaptable to the related building.

6.3 Input signal – Sensors

The tolerances in Table 1 are required from sensors in the indicated ranges:

Table 1 — Sensor accuracy

	Temperature range	**Sensor accuracy**
Room temperature	+ 15 °C to + 25 °C	± 0,8 K
Boiler water temp. or Flow water temperature	0 °C to + 60 °C	± 1,0 K
Outside temperature	- 10 °C to + 18 °C	± 1,0 K

Outside these temperature ranges no sensor accuracy is specified in this standard.

6.4 Controller operation modes

6.4.1 General

Controllers shall facilitate at least automatic operation mode, comfort operation mode and one reduced operation mode (economy / building protection). The current operation mode shall be displayed.

The following operation modes shall be available by switching manually:

— comfort;

— economy and/or building protection;

— automatic.

6.4.2 Comfort operation mode

Operation mode of occupied rooms. The flow water temperature is a function of the heating curve, based on the outside temperature and the comfort room temperature setpoint.

6.4.3 Economy operation mode

Operation mode for rooms which do not need to be in the comfort operation mode for an extended period of time for energy saving.

The flow water temperature is a function of the heating curve, based on the outside temperature and the economy room temperature setpoint.

For the change from comfort to economy operation mode , the controller shall allow a reduction of the boiler/flow water temperature of at least 20 % of the difference between the water temperature during comfort operation and the comfort room temperature (e.g. 20 °C).

$$T_{W,R} <= T_{W,C} - 0,2(T_{W,C} – T_{R,C})$$

where

$T_{W,R}$ is the economy flow water temperature;

$T_{W,C}$ is the comfort flow water temperature;

$T_{R,C}$ is the comfort room temperature.

6.4.4 Building protection operation mode

Mode of operation to protect the building from damages caused by low temperatures and humidity.

The flow water temperature is a function of the heating curve, based on the outside temperature and the building protection room temperature setpoint. The building protection setpoint temperature is below the economy setpoint temperature.

6.4.5 Automatic operation mode

The operation mode (Comfort, Economy and/or Building Protection) is selected automatically according to the scheduler, actual date and time.

6.5 Frost protection

In all operating modes (except for manual emergency operation mode operation) a frost protection function shall be effective if the boiler flow water temperature falls to minimum of 5 °C or the outdoor temperature falls below 2 °C (can be lower for system with fluid frost protection (e.g. Glycol)). The pump operates, the valve opens. If the flow water temperature drops below 5 °C the heat generation shall be switched on.

6.6 Additional functions

6.6.1 General

These functions are optional. If implemented the requirements of the corresponding function in this subclause have to be fulfilled.

6.6.2 Summer/Winter switch function

When the attenuated outside temperature exceeds the summer/winter heating limit a change to summer operation will take place. When the attenuated outside temperature falls below the summer/winter heating limit a change to winter operation will take place. The summer/winter heating limit shall be adjustable.

In summer operation mode the summer/winter switch function switches off the heat generation and the pump and closes the valves.

6.6.3 Set back function

During set back period the reduced room temperature setpoint is valid. The function switches off the heat generation and the pump and closes the valves until the calculated or measured room temperature drops below the reduced setpoint.

6.6.4 Optimum start function

The optimum start function calculates the pre-heat time to reach the comfort temperature level at the beginning of the comfort time period within a limit of +/- 30 min. Once the comfort level is reached the room temperature shall stay within +/- 0,5 K around the comfort room temperature.

6.6.5 Optimum stop function

The optimum stop function calculates the optimum switch-off time so that the room temperature at the end of the comfort period is within the allowable temperature decrease of -0,5 K of the comfort temperature level.

6.7 Switching times

A time switching function is required for changing operating modes. Setting and accuracy requirements for the switching times and clock are shown in Table 2.

Table 2 — Switching time and clock

	SWITCHING TIMES			CLOCK	
	Minimum No. of settings	Resolution of settings	Accuracy	Resolution of setting	Accuracy
Digital clock	4/day	≤ 0,5 h	± 1 min	≤ 1 min	± 30 min/ year
Analogue clock	4/day for a clock 24-h 2/day for a weekly clock	≤ 0,5 h for a day clock ≤ 2 h for a [a] weekly clock	± 10 min	≤ 10 min	± 30 min/ year

[a] The minimum switching period shall be no longer than 4 h.

6.8 Manual Emergency Operation Mode (MEOM)

Due to a failure of the connected hardware like a sensor error or an abnormal operation of the control equipment the heat flow may be interrupted.

For such abnormal situation the control equipment shall have a MEOM providing a possibility to restart the heat distribution.

This MEOM shall be activated in a user-friendly way like a switch or an easy available parameter.

If an independent control function of the heat generator is available and functional, the MEOM shall:

— turn on flow water pump;

— switch off the control function regarding the motor drive or define a fix value for the valve;

— enable heat generation.

6.9 Parameter settings

The following setting facilities shall be provided for the user:

Actual time, switching times, characteristic heating curve parameters (e.g. gradient, offset, temperature setpoints).

NOTE A method for adjusting manually the parameters of the characteristic heating curve can be found in the paper of J. Tödtli listed in the Bibliography.

6.10 Factory settings / Default values

6.10.1 Characteristic heating curve

A factory setting of the heating curve has to be implemented in the OTC and described in the technical documentation.

6.10.2 Switching times / Operating condition

The default time for a reduced temperature shall be a minimum of 8 h per day (e.g. 10 pm to 6 am). The default setting shall be described in the technical documents.

6.11 Switching relays

The ratings of the relay contacts are to be declared in the technical documents and shall be designed for the following minimum number of switching operations in Table 3.

Table 3 — Switching operations

Actuating equipment	Number of switching Operations
Motor-Drive	800 000
Burner	300 000
Pump	30 000

6.12 Electrical requirements

6.12.1 Electrical connections

The electrical connections to the main power supply and external cables shall be designed according to EN 60730-1.

6.12.2 Supply voltage

EN 60038 shall be applied for the selection of the nominal voltage of the controller.

6.12.3 Electrical safety

The controller shall be designed to comply with one of the following protective classes to EN 60730-1:

— Protective class I;

— Protective class II;

— Protective class III.

6.12.4 Electro magnetic compatibility

The emissions of and immunity to electro magnetic interference shall satisfy the requirements of EMC Directive.

6.13 Degree of protection

The degree of protection of the controller shall comply with EN 60529. The OTC shall fulfil at least IP 20.

6.14 Environmentally induced stress due to temperature

The OTC controller shall withstand the stress due to temperature according to Table 4.

Table 4 — Ambient temperatures

Product	Ambient temperature in operation	Ambient temperature transport and storage
Controller	+ 5 °C to + 50 °C	- 20 to + 60 °C

6.15 Materials

The heat and fire resistance, creeping current and corrosion resistance shall correspond with the requirements of EN 60730-1.

6.16 Use of graphical symbols

Used graphical symbols shall be in accordance with CEN/TS 15810.

7 Test methods

7.1 Data protection

The control unit shall be supplied with nominal voltage and put into operation. The data shall be set according to the manufacturer information. In case of control units with a re-chargeable power storage, the minimum charging time shall be completed before testing. The supply voltage shall be switched off for 12 h. It shall then be switched on again and tested for correct retention of data as time, date and parameters of heating curve.

7.2 Controller operation modes

Check if automatic, comfort and at least one reduced operation mode is provided by the controller.

To check the reduced operation mode test points should be selected of the highest and lowest heating curve at an outside temperature of – 10 °C. The reduction in the boiler / flow water temperature shall meet the requirements of 6.5.

7.3 Controller characteristic heating curve

This test will check the ability to adapt the controller to the building types and heating systems and confirms the accuracy of the equipment in controlling the manipulated variable to a selected manufacturer's curve.

The ability to adapt the controller to the building types and heating systems is tested using reference characteristic heating curves. Four reference characteristic heating curves were defined to represent the demand for heating energy of a reference building in relation to the temperature ranges defined in 6.2. They were derived from a thermal building simulation.

For each heating system to which the manufacturer claims support the test has to be performed with the corresponding reference characteristic heating curve. For each of these references characteristic heating curves a heating curve of the controller has to be selected. The heating curve in the controller has to be higher or equal to the corresponding reference characteristic heating curve.

The conformance of the implemented heating curve with the reference characteristic heating curve is tested for four load scenarios (outside temperatures). All test conditions are listed in Table 5.

Table 5 — Flow water temperatures on the reference heating curves for the 4 outside temperatures

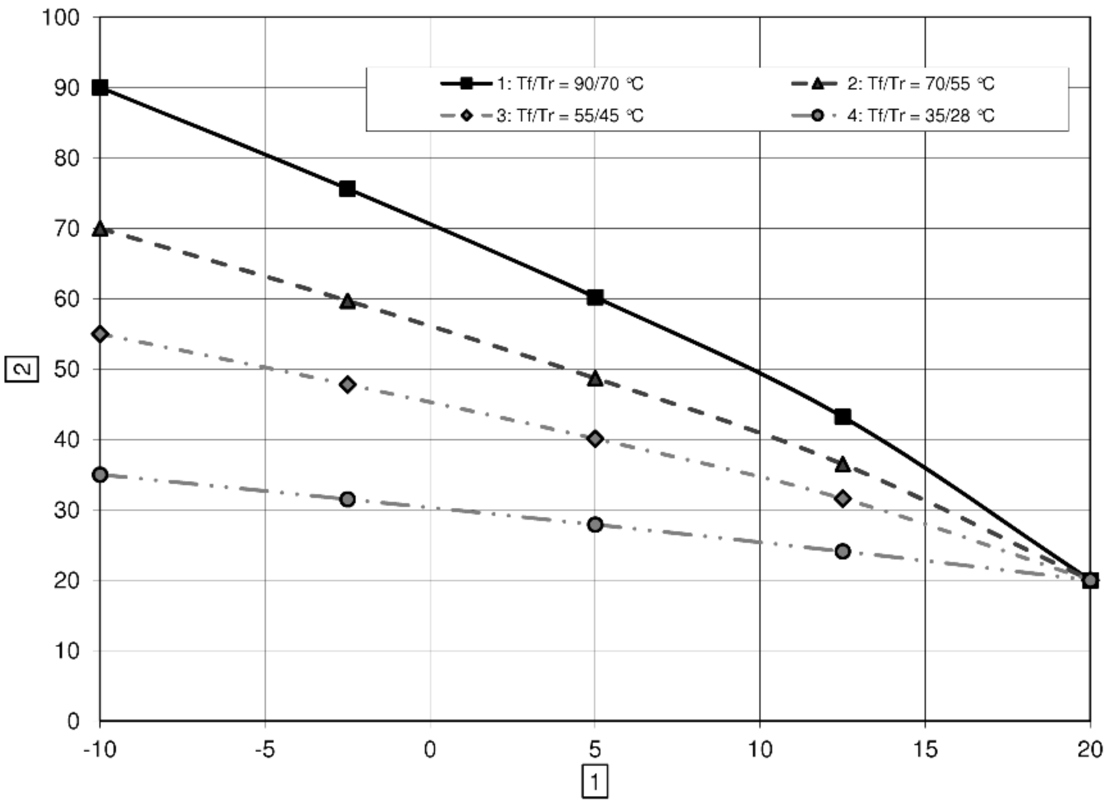
Outside temperature	**Temperatures setpoints on the reference heating curves for heating system (T_f/ T_r) [°C]**			
(T_O) [°C]	(90/70)	(70/55)	(55/45)	(35/28)
- 10	90,0	70,0	55,0	35,0
- 2,5	75,6	59,7	47,8	31,5
5	60,2	48,7	40,1	27,9
12,5	43,2	36,5	31,6	24,1

Key

T_f = design flow temperature

T_r = design return temperature

T_O = outside temperature



Key

1 outside temperature (°C)
2 boiler / supply-water temperature (°C)

Figure 7 — Graphical representation of the reference characteristic hearting curves

The controller is connected to an outside temperature simulator which can either be a signal directly connected to the sensor input or a sensor placed in a controlled liquid bath.

NOTE In case of attenuated outside temperature it is essential that the tester makes sure that the outside temperature value used to control the controlled variable is the required one.

For all of the selected scenarios of Table 5, the deviation of the setpoint of the controlled variable to the reference temperature is calculated:

$$\Delta T\ (HC, T_0) = T\ (HC, T_0) - T_{Ref}(HC, T_0)$$

where

$T(HC, T_0)$ is the temperature setpoint of heating curve at outside temperature;

$T_{Ref}(HC, T_0)$ is the temperature on the reference heating curve at the outside temperature;

$\Delta T\ (HC, T_0)$ is the difference of the temperature setpoint of heating curve and the temperature of the reference heating curve at the outside temperature;

HC: is the the index for the heating curve and corresponding reference heating curve (1: (90/70), 2: (70/55), 3: (55/45), 4: (35/28));

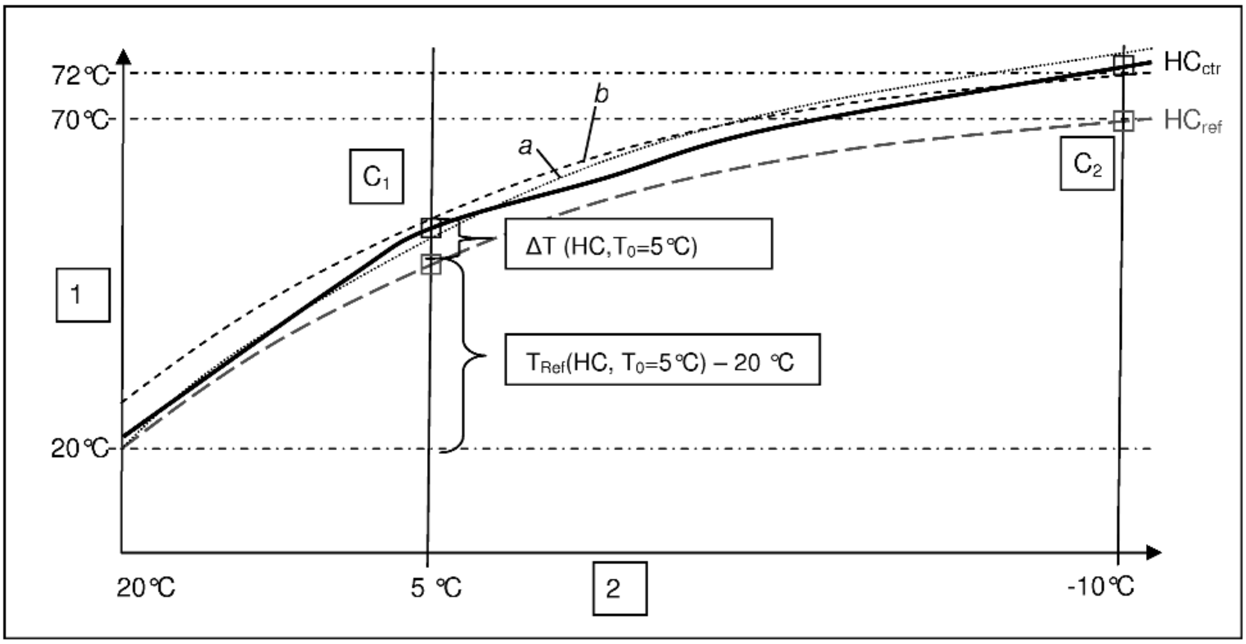
T_0 is the outside temperature.

The ability to adapt the heating curves to building types and heating systems is given, when the following criteria are met.

— 1 $\Delta T\ (HC, T_0) \geq 0$

— 2 $\Delta T\ (HC, T_0) < 4\ \%$ of $(T_{Ref}\ (HC, T_0) - 20\ °C)$ or

$\Delta T\ (HC, T_0) < 2K$



Key

1 flow water temperature setpoint
2 outside temperature
C_1, C_2 examples for Test cases (case 1, 2)
HC_{ctr} —— heating curve of the controller
HC_{ref} – – reference heating curve
a —— criteria: 4 % of (HC, T_0) – 20 °C
b - - - criteria: ΔT (HC,T_0) < 2K

Figure 8 — Example of the test of the accuracy of the heating curve

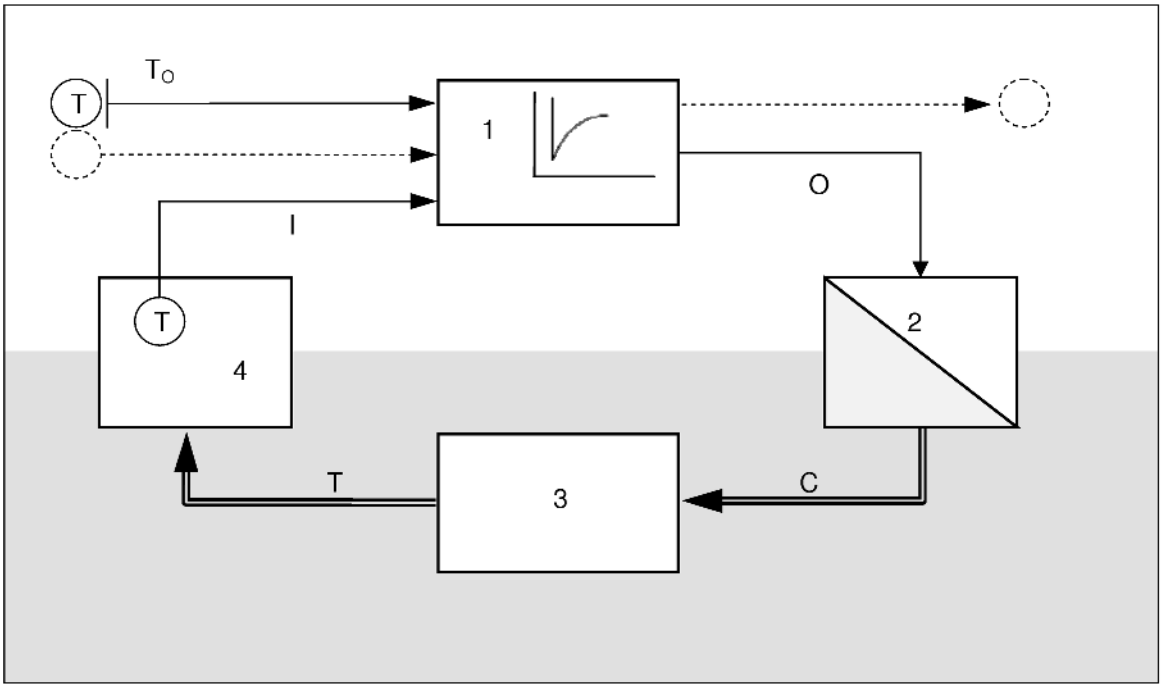
Figure 8 shows an example with two test cases (C_1 and C_2) of the accuracy of the selected heating curve in the controller compared to the reference heating curve. In both cases the controller heating curve meets the requirements:

— Case C1: $\Delta T(HC,T_0=5\ °C) > 0$, $\Delta T(HC,T_0=5\ °C) > 4\ \%$ of ($T_{Ref}(HC,\ T_0=5\ °C) – 20\ °C$), but < 2 K

  Test passed successfully

— Case C2: $\Delta T(HC,T_0=-10\ °C) > 0$, $\Delta T(HC,T_0=-10\ °C) > 2$ K, but < 4 % of ($T_{Ref}(HC,\ T_0=-10\ °C) – 20\ °C$)

  Test passed successfully



Key

1 OTC control device (device under test)

2 device for signal transformation of the analogue sensor output to a normalised digital control variable (C)

3 calculation of the flow water temperature

4 device for signal transformation of the simulated flow water temperature to an analogue sensor input signal of the controller (e.g. liquid bath, programmable resistor)

O output signal of OTC control device to control the flow water temperature (analogue)

I input signal to the OTC control device for the flow water temperature

C normalised control variable

T simulated flow water temperature variable

T_O outside temperature

Figure 9 — Test system block diagram

The accuracy of the equipment in controlling the manipulated variable to a selected manufacturer's curve is tested at least at one of the selected test points of Table 5.

A closed loop test system will be used to test the controller performance. The outside temperature shall be simulated e.g. by a fixed precision resistor or by other appropriate means, with an accuracy of ± 0,1K. The controlled variable (boiler / flow water temperature) shall also be simulated with an accuracy of ± 0,1K, e.g. by a variable precision resistor or by an associated sensor immersed in a liquid bath.

The tests should be performed so that the dynamic components of the sensor, the controller and the test equipment do not influence the results. A suitable test system is shown in Figure 9.

The actual value of the controlled variable T should be changed according to the following procedure:

1) Measure the controller output and produce a normalised value (C):

- C = 0 or 1 : for an on/off output signal.
- C = 0 or 0,5 or 1 : for a tri-state output signal.

- C = 0 .. 1 : for an analogue output signal

  (measured with an accuracy of ± 1 %)

2) Setpoint calculation: Calculate the value of the manipulated variable T [°C] using the formula below, and change the manipulated variable to this value.

$$T_{(t)} = T_{(t-\Delta t)} + (2 * C - 1) \cdot F \cdot \Delta t$$

where

$T_{(t)}$ is the manipulated variable at time t;

Δt is the time step, i.e. how often the test system updates the value T [sec];

F is a constant representing the response of the closed loop system.

It is recommended that Δt = 1 s and that F = 10K/3 600s (corresponding to 10 K/h).

The test should be run until the controlled variable reaches a steady state value or in case of periodic variation until three full cycles have been completed. The final value of the controlled variable is the steady state value or the mean value calculated over three full cycles in the case of periodic variation. This final value shall then be recorded and compared against the corresponding point on the characteristic heating curve as stated by the manufacturer.

The recorded temperature T shall not deviate by more then +/- 3K from the setpoint calculated by the controller based on the characteristic heating curve. The test result includes the accuracy of the sensors and test equipment.

7.4 Frost protection

Test by reducing boiler / flow water temperature below + 5 °C and check pump, valve and burner outputs.

All relevant signals shall be on or fully open in all operating modes, except in manual emergency operation.

7.5 Switching times

The number of switching times per day and per week and their switching resolution and accuracy shall be visually checked to be conform with the requirements of Table 2 in 6.7.

The accuracy of the switching times is to be confirmed by switching from comfort mode to a reduced mode and reverse (complete cycle) by observing relevant output(s).

The resolution of settings and the accuracy of the clock have to be checked against the requirements of Table 2 in 6.7.

7.6 Manual Emergency Operation Mode

When the OTC is set to manual emergency operation mode the outputs of the system has to be checked against the requirement in 6.8.

7.7 Optimum start-stop function

7.7.1 General

This test checks if the controller is able to optimise the switch on and switch off times for the heating system.

If the optimum start/stop function is based on adaptive learning, the controller might be pre-adjusted or the test can be run the number of days declared by the manufacturer in order to let the adaptive start and stop function learn the thermal dynamics of the room and heating system.

The optimum start-stop function test is done in a simulation environment. The real controller is connected to a simulated environment of the heating system and the building (represented by one single room). The simulation setup is illustrated in Figure 10.

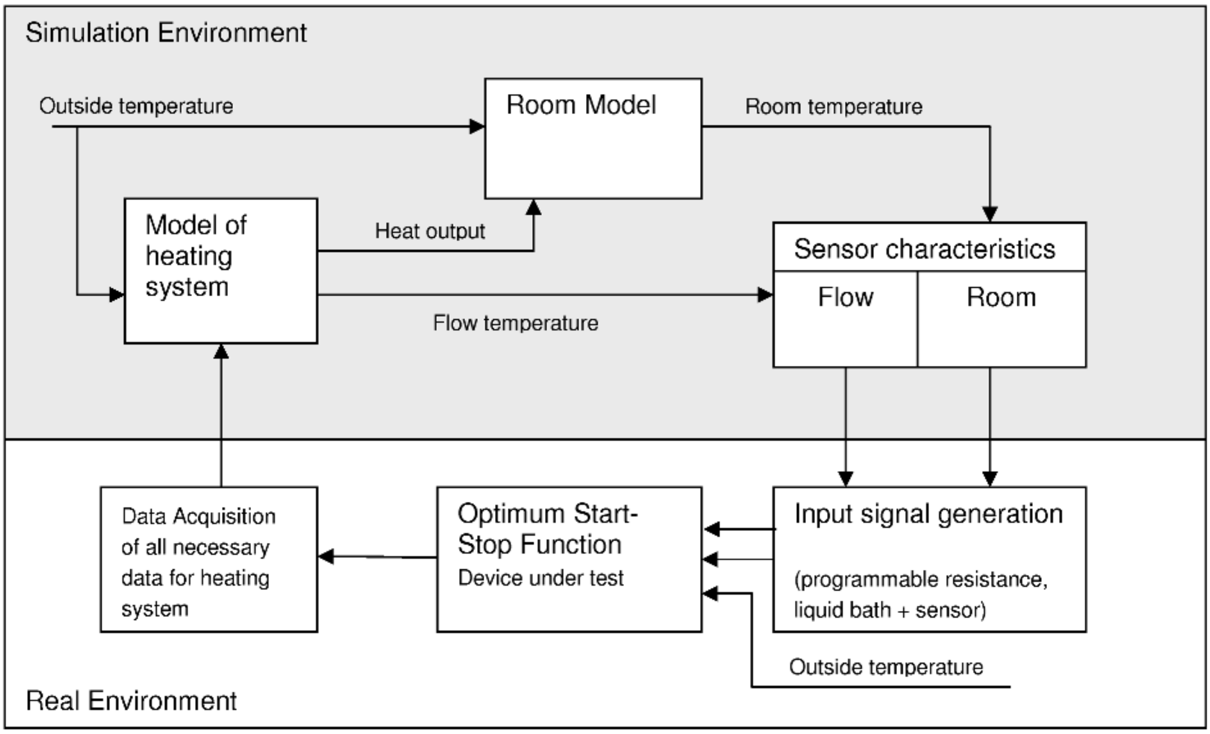


Figure 10 — Concept of the optimum start-stop simulation test

The block “Model of heating system” consist of the heat generation, distribution and heat emission. The heat emission shall be done by a radiator model.

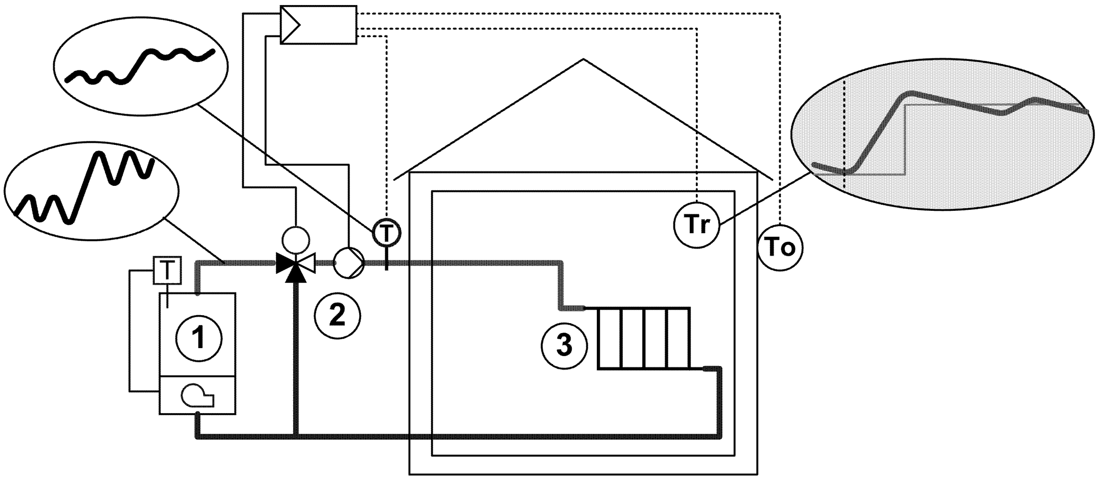
— The heat generation is modelled in a simplified manner. The output of the heat generation is the maximum flow water temperature. The dynamic behaviour is determined by the following calculation model using the return temperature:

$$T_{\mathrm{f}} = \frac{P}{\dot{m} \cdot c_{\mathrm{W}}} - T_{\mathrm{r}}$$

where

$\dot{m}$	is the massflow
c_{W}	is the heat capacity of water
T_{r}	is the return temperature calculated from the heating system model
T_{f}	is the flow water temperature
P	is the power of the heat generator in dependence on the system and the demand of the room model P_{Model} (Boiler: 2 P_{Model}, Heat pump: 1,1 P_{Model}, District heating: 5 P_{Model})

— The model of the heat distribution shall include the mixing valve and the pump. The valve position is based on the controller output. It can be done by on/off, on/off/stop or analogue signals. A model of the actuator (time for opening and closing) has to be integrated. The pump can only be switched on (maximum water flow) or off (no water flow).



Key

T_r room temperature
T_o outside temperature
T water temperature
1 heat generation
2 heat distribution
3 heat emission

Figure 11 — Model of the heating system

7.7.2 Test conditions

The test is performed for two different outside temperatures of + 5 °C and – 5 °C. The outside temperature is constant during a test run. The test shall be possible for controllers with and without a room temperature input. The test shall be done at least with one of the 3 heat generators (Boiler, Heat pump, District heating).

7.7.3 Test run

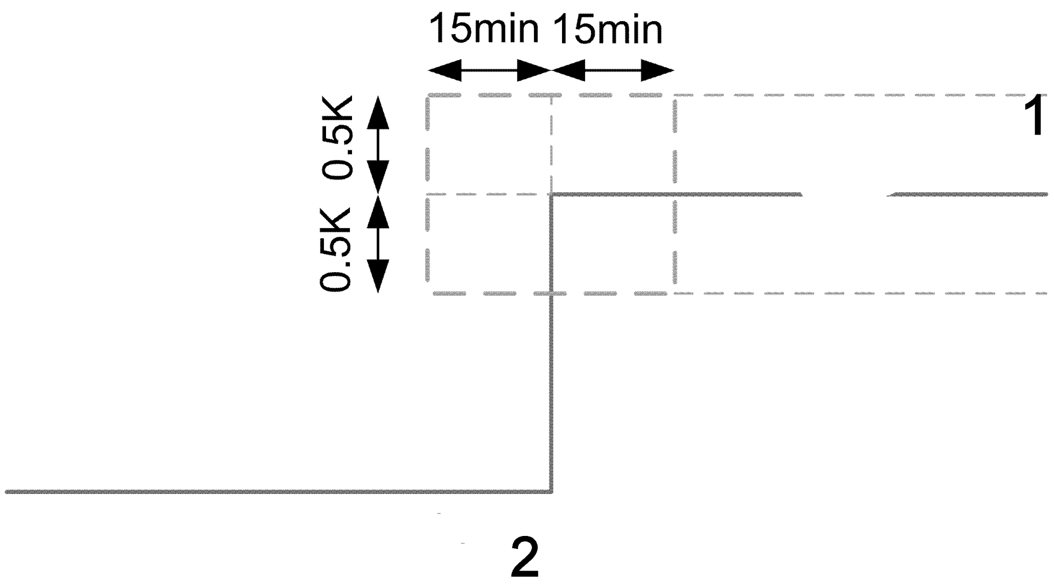
The same constant outside temperature is applied to the controller and the simulation environment. The test starts in comfort operation mode. The test runs in real time. During an initialisation phase the controller and the simulation model shall be harmonised and the controller shall control the flow water temperature according to the selected heating curve and outside temperature. The model calculates the flow water temperature, the return temperature and the room temperature. The test is performed according to the time table in Table 6.

Table 6 — Time table of optimisation test

17:00	Test start – Comfort mode
22:00	Start of economic mode
7:00	Start of comfort mode
9:00	Test end – Comfort mode

7.7.4 Test results start optimisation

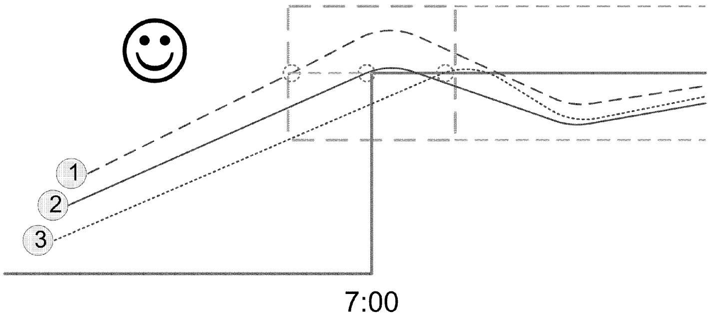
The test result is the verification if the function is working properly. The time difference between the comfort temperature level is reached and the start of the comfort period shall be within +/- 30 min. Once the comfort level is reached the room temperature shall stay within +/- 0,5 K around the comfort room temperature. The interpretation of the test results is illustrated in the following Figure 12 and Figure 13.



Key

1 comfort temperature level
2 beginning of the comfort time period

Figure 12 — Tolerances for time and temperature at the beginning of the comfort time period for an optimum start function



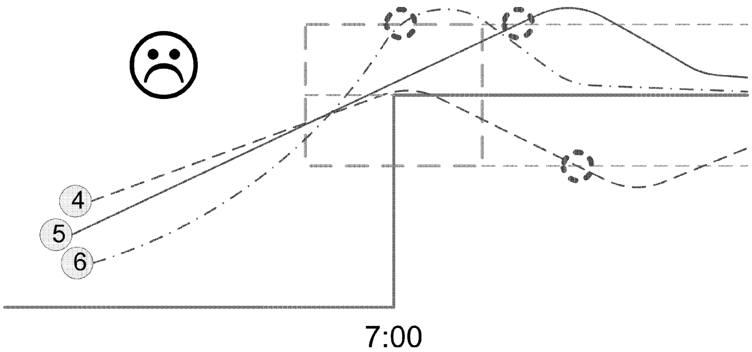
a)

Key

1 The comfort level is reached before the beginning of the comfort period within the time tolerance. The room temperature exceeds the setpoint and remains within the temperature tolerance.

2 The comfort level is reached at the beginning of comfort period. The room temperature falls below the comfort setpoint and remains within the tolerances.

3 The comfort level is reached after the beginning of the comfort period within the time tolerance. The room temperature remains within the tolerances.



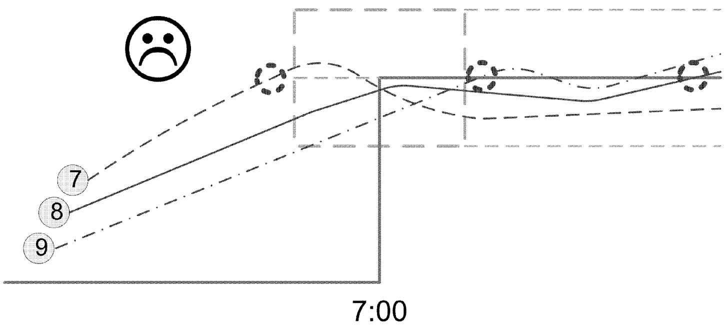
b)

Key

4 The comfort level is reached at the beginning of the comfort period, but the room temperature sinks below the lower limit of the temperature after the time tolerance period.

5 The comfort level is reached before the beginning of the comfort period within the time tolerance, but the room temperature exceeds the temperature tolerance after the time tolerance period.

6 The comfort level is reached before beginning of the comfort period within the time tolerance, but the room temperature exceeds the temperature tolerance within the time tolerance period.



c)

Key

7 The comfort level is reached too early.

8 The comfort level is reached too late.

9 The comfort level is reached too late.

Figure 13 — Interpretation of the results of the optimum start tests

7.7.5 Test results stop optimisation

The test result is the verification that the function is working properly. The function is working properly when:

- the switch-off time is before the end of the comfort period;
- the room temperature at the end of the comfort period is below the temperature setpoint in comfort mode but not more than the defined value of the acceptable temperature reduction (-0,5 K);
- the switch-off time is not identical for the simulation at - 5 °C and 5 °C.

7.7.6 Summer/Winter-switch

The outside temperature is changed from 15 °C to 20 °C and vice versa. The manufacturer declares the time needed to switch between summer and winter mode and vice versa. During the test, the controller shall be in comfort mode. If the controller operates with a room temperature sensor, the room temperature shall be 20 °C.

The test result is the verification that the function is working properly. This means the controller switches the heating off in summer time and on in winter time.

7.8 Set back

The set back test is performed during the optimum start-stop function test for an outside temperature of + 5 °C.

The test checks the pump/boiler signal of the controller. The switch off time is recorded. The room temperature when the pump/boiler switches on is detected.

The test result is the verification that the function is working properly.

The requirements of the function are fulfilled, when:

- the pump/boiler is switched off within 15 min after the start of the reduced period;
- the pump/boiler is switched on again when the room temperature reaches the reduced temperature setpoint (+/- 1 K).

7.9 Parameter settings

The setting facilities as described in 6.9 have to be checked if they are available and clearly indicated.

7.10 Factory settings

The default settings described in the technical document shall be checked against the minimum settings described in 6.10.

7.11 Switching relays

The technical documentation has to be checked against the requirements in 6.11.

7.12 Electrical test

The technical documentation has to be checked against the requirements in 6.12.

7.13 Degrees of protection

The technical documentation has to be checked against the requirements in 6.13.

7.14 Environmental individual stress due to temperature

The technical documentation has to be checked against the requirements in 6.14.

8 Marking

Controllers shall be marked, at least, with the following data:

- manufacturers' name / Trade mark or Product identification;
- reference or type designation;
- power supply (voltage and consumption);
- frequency;
- terminal blocks: each terminal clearly designated.

9 Documentation

9.1 Technical documents

The following information shall be provided in the technical documents:

- technical specifications;
- instructions for installation;
- users guidelines.

This information shall be referenced to the marking on the equipment.

9.2 Technical specifications

9.2.1 Controller

- Dimension [mm]
- Power supply voltage (AC or DC) [V]
- Frequency [Hz]
- Power consumption [W]
- Electrical protection class
- Degree of protection (IP)
- Range of Ambient conditions (operation and storage temperature [°C] and humidity [%])

- Max. Clock: cycle per day
- Clock: setting switch resolution [min]

9.2.2 Output signals

- Type and Specification of Output signal (Transistor Output) [A], [V]
- Type and Specification of Output signal (Relay Output)
- maximum rating, for resistive and inductive load [A], [V]
- Specification of Output signal (0 V – 10 V)

9.2.3 Input signals (Sensors)

Specifications for outside temperature sensor, flow water temperature sensor, other applied compensating sensors.

- Type e.g.: variable resistance sensors, thermistor, corresponding standard...
- Range (minimum-maximum) [°C]

9.3 Instruction installation

- Application and purpose of the controller: heat generators, emitters
- Mounting instructions
- Wiring plan
- Wire cross section, minimum / maximum for external wiring [mm^2] Complete instruction concerning control parameters and information on manual adjustment possibilities

9.4 User guideline

- Indications of temperatures, date and time
- Default program settings and adjustments
- Selection of operating modes
- Instruction for setting temperatures, date, time, on-off scheduling, derogation function
- Relation between the adjustable setting parameters and the heating curve
- Graphical representation of heating curve
- Indication of failure states and how to react
- Meaning of graphical symbols

Bibliography

[1] Jürg Tödtli, "Manual adjusting and self-adaptation of heating curves", CLIMA 2000, the second World Congress on Heating, Ventilation, Refrigerating and Air-Conditioning, Sarajevo, August 27 – September 1, 1989, pp. 329-336 vol II

This page deliberately left blank

British Standards Institution (BSI)

BSI is the national body responsible for preparing British Standards and other standards-related publications, information and services.

BSI is incorporated by Royal Charter. British Standards and other standardization products are published by BSI Standards Limited.

About us

We bring together business, industry, government, consumers, innovators and others to shape their combined experience and expertise into standards -based solutions.

The knowledge embodied in our standards has been carefully assembled in a dependable format and refined through our open consultation process. Organizations of all sizes and across all sectors choose standards to help them achieve their goals.

Information on standards

We can provide you with the knowledge that your organization needs to succeed. Find out more about British Standards by visiting our website at bsigroup.com/standards or contacting our Customer Services team or Knowledge Centre.

Buying standards

You can buy and download PDF versions of BSI publications, including British and adopted European and international standards, through our website at bsigroup.com/shop, where hard copies can also be purchased.

If you need international and foreign standards from other Standards Development Organizations, hard copies can be ordered from our Customer Services team.

Subscriptions

Our range of subscription services are designed to make using standards easier for you. For further information on our subscription products go to bsigroup.com/subscriptions.

With **British Standards Online (BSOL)** you'll have instant access to over 55,000 British and adopted European and international standards from your desktop. It's available 24/7 and is refreshed daily so you'll always be up to date.

You can keep in touch with standards developments and receive substantial discounts on the purchase price of standards, both in single copy and subscription format, by becoming a **BSI Subscribing Member**.

PLUS is an updating service exclusive to BSI Subscribing Members. You will automatically receive the latest hard copy of your standards when they're revised or replaced.

To find out more about becoming a BSI Subscribing Member and the benefits of membership, please visit bsigroup.com/shop.

With a **Multi-User Network Licence (MUNL)** you are able to host standards publications on your intranet. Licences can cover as few or as many users as you wish. With updates supplied as soon as they're available, you can be sure your documentation is current. For further information, email bsmusales@bsigroup.com.

Revisions

Our British Standards and other publications are updated by amendment or revision.

We continually improve the quality of our products and services to benefit your business. If you find an inaccuracy or ambiguity within a British Standard or other BSI publication please inform the Knowledge Centre.

Copyright

Useful Contacts:

Customer Services
Tel: +44 845 086 9001
Email (orders): orders@bsigroup.com
Email (enquiries): cservices@bsigroup.com

Subscriptions
Tel: +44 845 086 9001
Email: subscriptions@bsigroup.com

Knowledge Centre
Tel: +44 20 8996 7004
Email: knowledgecentre@bsigroup.com

Copyright & Licensing
Tel: +44 20 8996 7070
Email: copyright@bsigroup.com

BSI Group Headquarters

389 Chiswick High Road London W4 4AL UK

...making excellence a habit.™