TRNSYS Type 888 „Controller for Space Heating and Storage Charging by a Heat Source“

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1 Summary

This describes TRNSYS Type 888 „Controller for Space Heating and Storage Charging by a Heat Source“, programmed in FORTRAN 90. This TYPE simulates an electronic controller for heat source operation and space heat supply.

Possibilities offered include an outdoor temperature (or average outdoor temperature) controlled heating season, individual warm-water and room heating setpoints, warm water preference, room heating setpoint calculated depending on (average) outdoor temperature, minimum setpoint for the heat source during its operation, and more.

This type does not include the handling of startup time, minimum burning time, minimum off time and time needed to stop a boiler / burner. It is assumed that these tasks are done by the boiler/burner itself.

2 Parameter-List

Nr.	*short*	*explanation*	*unit*	*range*
Heating season				
1	$T_{start,HS}$	Reference outdoor temperature, below which heating season starts	°C	[-inf;+inf]
2	$T_{db,HS}$	Dead-band temperature for hysteresis. Heating season will stop when the outdoor temperature rises above Tstart+Tdb	°C	[0;+inf]
3	--	Unused		
Warm water and/or room heating preferences				
6	MoWW	Warm water Mode: 0 = room heating and Warm water heating may be done at the same time by the same heat source 1 = Warm water heating disables room heating use of heat source	--	0,1
7	MoRH	Room heating Mode: 1 = ON if Heating Season is on and not blocked by WW-Mode 2 = Additional criterion of store temperature based on absolute values 3 = additional criterion of store temperature based on values relative to the flow temperature setpoint of the heating system	--	1,2,3
8-10	--	Not used		
Heating curve				
11	MoHCcalc	Calculation mode for the heating curve: 1 = very simple 2 = simplified 3 = detailed	--	1,2,3
12	m	Radiator exponent	--	[-inf;+inf]
13	S	Slope of heating curve (for mode 1+2, not in use for mode 3)	--	[0;+inf]
14	$T_{amb,N}$	Outdoor reference temperature (for mode 2+3, not in use for mode1)	°C	[-inf;+inf]
15	$T_{Fl,N}$	Flow temperature at reference conditions (for mode 3, not in use for mode 1+2)	°C	[-inf;+inf]
16	$T_{Rt,N}$	Return temperature at reference conditions (for mode 3, not in use for mode 1+2)	°C	[-inf;+inf]
17-20	--			
Heat-Source Setpoint				
21	Tmin	Minimum setpoint temperature for heat source	°C	[-inf;+inf]
22	$T_{max,WW}$	Maximum setpoint temperature for heat source in warm water Mode	°C	[-inf;+inf]
23	$T_{max,RH}$	Maximum setpoint temperature for heat source in room heating Mode	°C	[-inf;+inf]
24	MoScOn	Mode for heat source on: Strategy to determine whether heat source shall be enabled (heating to setpoint at least) or	--	1,2,3

		off / disabled. This does not necessarily coincide with flow of water through the heat source: 1 = heat at least to minimum setpoint whenever heat-season is on or WW-Mode is on 2 = heat at least to minimum setpoint only when RH-Mode is on or WW-Mode is on 3 = always heat to minimum setpoint at least		
25	MoTww	Mode of temperature setpoint for warm water heating: 1 = absolute 2 = relative to TwwOFF 3 = relative to TwwON	--	1,2,3
26	MoTrh	Mode of temperature setpoint for room heating: 1 = absolute 2 = relative to flow temperature setpoint of the heating system 3 = relative ot TrhOFF 4 = relative to TrhON	--	1,2,3,4

3 Input-List

Nr.	*short*	*explanation*	*unit*	*range*
heating season				
1	$T_{amb,HS}$	Outdoor temperature used for the determination of the heating season	°C	[-inf;+inf]
2-5	--	Unused		
Warm water and/or room heating preferences				
6	$T_{WW,St,up}$	Upper temperature in the store that serves as a criterion to turn WW preparation by heat source on	°C	[-inf;+inf]
7	$T_{WW,St,lo}$	Lower temperature in the store that serves as a criterion to turn WW preparation by heat source off	°C	[-inf;+inf]
8	$T_{WW,ON}$	WW preparation will be turned on whenever Tww-store up drops below TwwON	°C	[-inf;+inf]
9	$T_{WW,OFF}$	WW preparation will be turned off whenever Tww-store low rises above TwwOFF	°C	[-inf;+inf]
10	$T_{RH,St,up}$	Trh-store up, Upper temperature in the store that serves as a criterion to turn heat source for room heating on	°C	[-inf;+inf]
11	$T_{RH,St,lo}$	Trh-store low, Lower temperature in the store that serves as a criterion to turn heat source for room heating off	°C	[-inf;+inf]
12	$T_{RH,ON}$	Heat source will be turned on for room heating whenever Trh-store up drops below TrhON (or TsetRH+TrhON if room heating mode MoRH = 3)	°C	[-inf;+inf]
13	$T_{RH,OFF}$	Heat source will be turned off for room heating whenever Trh-store low rises above TrhOFF (or TsetRH+TrhOFF if room heating mode MoRH = 3)	°C	[-inf;+inf]
14-15	--	Not used		
Heating Curve (mode 1)				
16	$T_{room,set}$	Room (indoorI setpoint temperature	°C	[-inf;+inf]
17	T_{amb}	(average) Outdoor Temperature	°C	[-inf;+inf]

18	dT_N	Value for nighttime reduction of room temperature setpoint. This negative value will be added to Ti,set to get the room temperature setpoint at night-time (connect the result of a time dependent forcing function to this input in order to use night-time reduction of setpoint)	K	[-inf;0]
19-20	--	not in use		
Heat-Source Setpoint				
21	$T_{Sc,set,ww}$	Setpoint temperature for the heat source in warm water mode. Absolute value in °C if temperature setpoint mode for warm water MoTww = 1, relative value in K if MoTww = 2 or 3	°C	[-inf;+inf]
22	$T_{Sc,set,rh}$	Setpoint temperature for the heat source in room heating mode. Absolute value in °C if temperature setpoint mode for room heating MoTrh = 1, relative value if MoTrh = 2, 3 or 4	°C	[-inf;+inf]

4 Output-List

Nr.	***short***	***explanation***	***unit***	***range***
Heating season				
1	BoHs	Boolean for heating season on	°C	[-inf;+inf]
2-5	--	Unused		
Warm water and/or room heating preferences				
6	BoWW	Boolean for Warm-Water Heating On (1) or Off (0)	--	0,1
7	BoRH	Boolean for Heat Source use for Room Heating On (1) or Off (0)	--	0,1
8-10	--	Unused		
Heating curve				
11	T_V	Flow setpoint temperature	°C	[-inf;inf]
12-15	--	Unused		
Heat-Source Setpoint				
16	$T_{Sc,set}$	Setpoint temperature for the heat source. If no preference for WW is set in section “warm water and/or room heating preferences” warm water mode MoWW =0, the higher value of TaWWset and TaRHset will be taken if BoWW AND BoRH are both On (both = 1).	°C	[-inf;+inf]
17	$T_{Sc,ww}$	Setpoint for source in warm water mode (independent of Par6 and Par7)	°C	[-inf;+inf]
18	$T_{Sc,rh}$	Setpoint for source in room heating mode (independent of Par6 and Par7)	°C	[-inf;+inf]
19	BoScOn	Boolean for heat source enabled / disabled according to the settings chosen by “mode for heat source on” MoScOn	--	0,1

5 Heating season

Usually the heating season is determined by the comparison of an average outdoor temperature over a certain time with a reference value. If the average outdoor temperature drops below this reference temperature, the heating season starts, if the average outdoor temperature rises above the reference temperature plus a dead-band temperature, then the heating season stops.

6 Warm-Water and/or Room Heating Preferences

If a specified reference temperature (e.g. in a warm water store) drops below a certain level, Warm-Water Mode will be turned on, if the same or another temperature measured in the store rises above a certain level, Warm-Water Mode will be turned off.

Room Heating may be turned on whenever the heating season is on, regardless of WW-Mode, or only if WW-Mode is not on (WW preference). Another restriction may be made to room heating mode by allowing it only to be on whenever the temperature in a store is below a certain level, and once it has shut off to let it start again only when the same (or another) temperature in the store has dropped below another level.

7 Flow temperature setpoint of the heating system (heating curve)

7.1 Detailed calculation (MoHCcalc=3)

In theory, there are two ways of calculating the temperature setpoint for the flow line of a heating system dependent on the radiator exponent m, the outdoor temperature t_a and the room temperature setpoint t_i. The first way uses the arithmetic mean of the flow and return temperature to calculate the average radiator temperature, the second uses the logarithmic mean. Acording to [Recknagel, Sprenger, 1997], the criterion to use the logarithmic mean is:

$$\left(\frac{t_R - t_i}{t_V - t_i}\right) < 0.7$$

However, since the formula for the calculation of the flow setpoint temperature that is based on the logarithmic mean can only be solved with iterations, and the exactness of the calculation will be overriden by heat losses and inexactness of temperature measurements and control in a real system anyway, only the arithmetic mean will be used here. The exact solution for the flow setpoint temperature tV based on the arithmetic mean temperature of the radiator is:

$$t_V = t_i + \frac{t_{V_N} - t_{R_N}}{2} \cdot \frac{t_i - t_a}{t_i - t_{a_N}} + \left(\frac{t_{V_N} + t_{R_N}}{2} - t_i\right) \cdot \left(\frac{t_i - t_a}{t_i - t_{a_N}}\right)^{\frac{1}{m}}$$

To include night-time temperature setpoint reduction, a formula corresponding to a previous TRNSYS type by Sulzer and Wetter [Sulzer, Wetter, 1996] will be used:

$$t_V = t_i + dT_N + \frac{t_{V_N} - t_{R_N}}{2} \cdot \frac{t_i + dT_N - t_a}{t_i - t_{a_N}} + \left(\frac{t_{V_N} + t_{R_N}}{2} - t_i \right) \cdot \left(\frac{t_i + dT_N - t_a}{t_i - t_{a_N}} \right)^{\frac{1}{m}}$$

The expected return temperature is:

$$t_R = t_i + dT_N - \frac{t_{V_N} - t_{R_N}}{2} \cdot \frac{t_i + dT_N - t_a}{t_i - t_{a_N}} + \left(\frac{t_{V_N} + t_{R_N}}{2} - t_i \right) \cdot \left(\frac{t_i + dT_N - t_a}{t_i - t_{a_N}} \right)^{\frac{1}{m}}$$

Where:

t_V = Temp. of flow (calculated), °C

t_R = Temp. of return (calculated), °C

t_i = setpoint indoor temperature (daytime), °C

dT_N = nighttime-reduction (a negative value), °C

t_{V_N} = Temp. of flow at norm conditions, °C

t_{R_N} = Temp. of return at norm conditions, °C

t_a = Current (or average) outdoor temperature, °C

t_{a_N} = Outdoor Temp. at norm-conditions, °C

7.2 Simplified (MoHCcalc = 2)

In a simplified version, t_V can be approximated by:

$$t_V = t_i + dT_N + S \cdot \left(t_i - t_{a,N} \right) \cdot \left(\frac{t_i + dT_N - t_a}{t_i - t_{a_N}} \right)^{\frac{1}{m}}$$

with S = slope of the heating curve that corresponds to:

$$S = \left(\frac{t_{V_N} - t_i}{t_i - t_{a_N}} \right)$$

The slope S will be taken directly from the input S (slope), and not calculated in this mode.

7.3 Very simple (MoHCcalc = 1)

Or even more simplified:

$$t_V = t_i + dT_N + S \cdot 20 \left(\frac{t_i + dT_N - t_a}{20} \right)^{\frac{1}{m}}$$

This simplification is based on the assumption that reference ambient temperature is 0 °C and room heating setpoint is 20 °C.

7.4 Reduced room temperature setpoints during the night

A common way to consider a shift in room-setpoint for the night is to subtract the difference between room-setpoint of the day and room-setpoint of the night from t_V. However, we propose here to just substitute t_i, which usually is the setpoint of the day, with the setpoint for the night.

7.5 Examples and further explanation

Independent of the mode of calculation chosen, the flow setpoint temperature for the heating system will be set to $t_i + dT_N$ whenever $t_i + dT_N - t_a < 0$. Examples for heating curves for a heating system with 35/30 °C and radiator exponents of 1.0 and 1.4 are given in *Figure 1*.

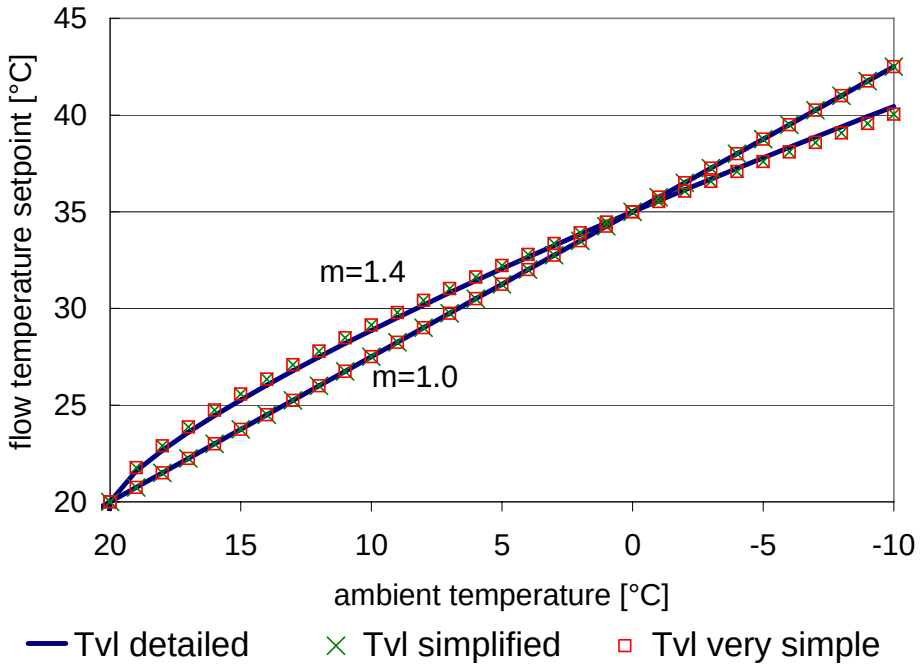

Figure 1: *Example for a heating system with T_{VN}=35, T_{RN}=30, T_{aN}=0, T_i=20, dTn=0, and m=1.0 and 1.4 respectively. These values correspond to a slope of S=0.75.*

8 Temperature Setpoint for the heat source

The temperature setpoint of the boiler may be different in WW-Mode and in RH-mode. In both modes, the setpoint may or may not be related to temperatures setpoints for the heat store or the flow of the heating distribution system.

At the same time, it may be necessary to narrow the range of possible setpoints with a T_{min} (e.g. boilers that have to avoid condensation in flue gas) and a T_{max} (for material reasons or to avoid steam).

9 References

Sulzer M., Wetter M.; TRNSYS Type “Aussentemperatureabhängiger Vor-/Rücklauftemperatursollwert” Modellbeschreibung und Implementation in TRNSYS, 7. Oktober 1996, Zentralschweizerisches Technikum Luzern, Ingenieurschule HTL, Technikumstrasse, 6048 Horw

Recknagel, Sprenger, Schramek; Taschenbuch für Heizung und Klimatechnik – einschliesslich Warmwasser- und Kältetechnik 97/98, 68. Auflage, 1997, R. Oldenbourg Verlag