Self-operated Temperature Regulators
Type 1 to Type 9

PN 16 to 40 · Class 125 to 300
DN 15 to 250 · NPS ½ to 10
G ½ to 1 · Up to 350 °C · Up to 660 °F
### Self-operated temperature regulators

<table>
<thead>
<tr>
<th>Applications with</th>
<th>Steam</th>
<th>Water and other liquids</th>
<th>Air and non-flammable gases</th>
<th>Heating</th>
<th>Cooling</th>
<th>Mixing/diverting</th>
</tr>
</thead>
</table>

| Globe valve | · | · | · | · | · |
| Three-way valve | · | · | · | · | · |
| Pressure-balanced | · | · | · | · | · |
| Not balanced | · | · | · | · | · |

| Control thermostats | Adjustable set point | Optionally available with double adapter | · | · | · | · |

| Safety thermostats | · | · | · | · | · | · |

| Type 2231 and Type 2232 | · | · | · | · | · | · |
| Type 2233 and Type 2234 | · | · | · | · | · | · |
| Type 2235 | · | · | · | · | · | · |

<table>
<thead>
<tr>
<th>For details, refer to Data Sheet</th>
<th>T 2111 EN</th>
<th>T 2112 EN</th>
<th>T 2113 EN</th>
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</thead>
</table>

| Fig. 1 | · Control thermostats with set point adjustment at the sensor | Fig. 2 | · Control thermostats with separate set point adjustment |

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1) Only with extension piece  
2) DN 15 only 25: EN-JS1049 only  
3) ANSI version on request  
4) Pressure balancing in DN 32 to 50

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**Type 2231** - Set point adjustment at the sensor - Set points from –10 to +150 °C (15 to 300 °F) - Suitable for liquids and steam - Suitable for installation in pipelines, tanks and other heating and cooling installations  
**Type 2232** - Separate set point adjustment - Set points from –10 to +250 °C (15 to 480 °F) - Application same as Type 2231  
**Type 2233** - Set point adjustment at the sensor - Set points from –10 to +150 °C (15 to 300 °F) - Suitable for liquids, air and gases - Suitable for installation in air ducts, tanks, pipelines and other heating and cooling installations - Regulation of liquids with short response times  
**Type 2234** - Separate set point adjustment - Set points from –10 to +250 °C (15 to 480 °F) - Application same as Type 2233  
**Type 2235** - Separate set point adjustment - Set points from –10 to +250 °C (15 to 480 °F) - Sensor tube to be installed on site for measuring different temperature layers - Suitable for installation in air-heated storage rooms, drying, climatic and heating cabinets - Suitable for air and gases
Typetested safety thermostats

For the control, limitation, safety monitoring and safety limitation of energy supplied to heating generating systems and heat exchangers which must be equipped with typetested devices, the following typetested equipment is available:

- Temperature regulator (TR)
- Safety temperature monitors (STM)
- Safety temperature limiters (STB) and
- Combination with these devices

Refer to Information Sheet T 2040 EN as well as Data Sheets T 2043 EN and T 2046 EN for more details.

Fig. 3 · Safety thermostats

1) DN 15 to 25: not balanced  ·  2) ANSI version on request
Dynamic behavior of thermostats

The regulator’s dynamics basically depends on the response behavior and the characteristic time constant of the sensor used. Table 1 shows the time response of SAMSON control thermostats suitable for Type 1 to Type 9 Temperature Regulators working according to various operating principles measured with water.

### Table 1 - Time response of SAMSON thermostats

<table>
<thead>
<tr>
<th>Operating principle</th>
<th>Type ... Control Thermostat</th>
<th>Time constant in s</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Without thermowell</td>
<td>With thermowell</td>
</tr>
<tr>
<td>Liquid expansion</td>
<td>2231</td>
<td>70</td>
</tr>
<tr>
<td></td>
<td>2232</td>
<td>65</td>
</tr>
<tr>
<td></td>
<td>2233</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>2234</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>2235</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>2213</td>
<td>70</td>
</tr>
<tr>
<td>Adsorption</td>
<td>2212</td>
<td>_1)</td>
</tr>
</tbody>
</table>

1) Not permissible
Conversion factors

**K\textsubscript{VS} and C\textsubscript{V} coefficients**

The valve flow coefficients can be determined accurately using IEC 60534, Part 2-1 and Part 2-2. In addition, the equations specified in the ISA-S75.01-1-1985 standard and the VDI/VDE Guideline 2173 can be used for this purpose. Calculating the K\textsubscript{V} coefficient according to the methods provided by the VDI/VDE guideline is sufficiently accurate in most cases. The equations can be found in SAMSON’s AB 04 EN Calculation Sheet.

\[ K_{VS} = 0.86 \times C_V \]
\[ C_V = 1.17 \times K_{VS} \]

**Pressure**

1 pound/square inch [lbs/in\(^2\) = psi] = 0.06895 bar
1 bar = 14.5 psi

**Area**

1 square inch [sq.in; in\(^2\)] = 6.452 cm\(^2\) • 1 cm\(^2\) = 0.155 in\(^2\)

**Mass**

1 pound [lb] = 0.4536 kg • 1 kg = 2.2046 lb

**Mass flow**

1 pound per second [lb/s] = 0.4536 kg/s • 1 kg/s = 2.2046 lb/s

**Flow rate**

1 U.S. gallon per min [US gal/min] = 0.227 m\(^3\)/h
1 m\(^3\)/h = 4.4 US gal/min

**Temperature**

\[ ^\circ F = \frac{9}{5} \times ^\circ C + 32 \]
\[ ^\circ C = \frac{5}{9} \times (^\circ F - 32) \]
Principle of operation
Self-operated temperature regulators are control devices which extract the energy required to position the valve from the temperature of the process medium.
The temperature regulators shown in Figs. 5.1, 5.2 and 5.3 operate according to the liquid expansion principle.
They consist of a valve and a control thermostat.
The control thermostat comprises a temperature sensor (11), set point adjuster (13), capillary tube (10) and a hydraulic actuator termed the operating element (7). The sensor is filled with an expansion liquid which acts via the positioning bellows (9) and the positioning pin (8) upon the valve plug (3) attached to the plug stem (6). The temperature-dependent change in volume of the liquid contained in the sensor and the displacement of the piston (12) located in the set point adjuster cause the bellows and the plug to move.
The hydraulic actuator and the valve which does not contain a packing ensure high operating reliability of the regulators. Since the regulators operate on the liquid expansion principle, the temperature sensor and the control thermostat can be adapted to different operating conditions.
Therefore, the easy-to-install versions shown in Figs. 5.1 and 5.2 are used in most cases. The version illustrated in Fig. 5.3 is used for temperatures exceeding 150 °C (300 °F) and in applications where separate installation of the sensor and the set point adjuster is appropriate. The selection of a Type 2231, 2232, 2233, 2234 or 2235 Temperature Sensor depends on the medium, required time constant and installation situation.
The regulators are proportional devices operated by the process medium.
Each time the temperature measured deviates from the adjusted set point, the valve plug position changes. The accuracy and stability of the control process depend on the disturbances occurring in the controlled systems, such as changes in the upstream pressure and flow rate. The regulators are designed to keep the effect of these disturbances small: they can be equipped with a balancing bellows or a balancing plug to eliminate the disturbing forces that are produced by the differential pressure across the valve and act on the valve plug. In unbalanced versions (Fig. 5.1), the disturbing forces result from the cross-sectional seat area and the differential pressure across the seat orifice. The valves shown in Figs. 5.2 and 5.3 are equipped with a balancing bellows.
The pressure upstream of the valve plug \(p_1\) acts through a bore in the plug stem on the outer bellows surface, whereas the pressure downstream of the valve plug \(p_2\) acts on the inner surface of the bellows. In this way, the forces acting on the valve plug are balanced. By using these fully balanced valves, self-operated regulators can be designed in nominal sizes up to DN 250 (valves up to NPS 10 on request).

Legends for Figs. 5.1 to 5.3
Valve
1 Valve body 5 Balancing bellows
2 Seat 6 Plug stem
3 Plug 6.1 Plug stem with hole
4 Bellows housing for pressure balancing
Control thermostat
7 Operating element 11 Temperature sensor
8 Positioning pin 12 Piston
9 Positioning bellows 13 Set point adjustment
10 Capillary tube 14 Set point dial

Fig. 5.1 · Temperature regulator with unbalanced valve and compact thermostat
Fig. 5.2 · Temperature regulator with balanced valve and compact thermostat
Fig. 5.3 · Temperature regulator with balanced valve and a thermostat with separate set point adjustment

Fig. 5 · Schematic diagrams of Type 1 to Type 9 Temperature Regulators
Type 1 to Type 9 Temperature Regulators
The temperature regulators consist of a valve (globe or three-way valve) and a Type 2231, 2232, 2233, 2234 or 2235 Control Thermostat including temperature sensor, set point adjuster, capillary tube and operating element

Special features
• Low-maintenance P-regulators requiring no auxiliary energy
• Globe or three-way valve for liquids, gases and vapors, especially for the heat transfer media of water, oil and steam or for coolants, for example cooling water or brine
• Valve body material optionally available as cast iron, spheroidal graphite iron (DIN version only), cast steel, cast stainless steel or red brass
• DIN and ANSI versions available

Regulators with globe valves
• Regulators for heating installations

Type 1 Temperature Regulator · Flange connections
With unbalanced Type 2111 Single-seated Globe Valve · Body made of either cast iron, spheroidal graphite iron, cast steel or cast stainless steel · The valve closes as the temperature rises · Type 2231 to Type 2235 Control Thermostats

Technical data Data Sheet T 2111 EN · T 2115 EN
Set points –10 to +250 °C · 15 to 480 °F
Nominal size DN 15 to 50 · NPS ½ to 2
Nominal pressure PN 16 to 40 · Class 125 to 300
Temperatures Up to 350 °C · Up to 660 °F

Type 1 Temperature Regulator · Screwed ends
With unbalanced Type 2111 Single-seated Globe Valve · Red brass body · The valve closes as the temperature rises · Type 2231 to Type 2235 Control Thermostats

Technical data Data Sheet T 2112 EN
Set points –10 to +250 °C
Nominal size G ½ to 1
Nominal pressure PN 25
Temperatures Gas · Up to 80 °C
Liquids, vapors · Up to 220 °C

Type 4 Temperature Regulator · Flange connections
With balanced Type 2114 Single-seated Globe Valve · Body made of either cast iron, spheroidal graphite iron (DIN version only), cast steel or cast stainless steel · The valve closes as the temperature rises · Type 2231 to Type 2235 Control Thermostats

Technical data Data Sheet T 2121 EN/T 2650 EN · T 2025 EN
Set points –10 to +250 °C · 15 to 480 °F
Nominal size DN 15 to 250 · NPS ½ to 10
Nominal pressure PN 16 to 40 · Class 125 to 300
Temperatures Up to 350 °C · Up to 660 °F

Regulators with three-way valves for temperatures of max. 350 °C when used in mixing or flow diverting services
• Regulators for heating or cooling installations

Type 8 Temperature Regulator · Flange connections
With unbalanced Type 2118 Three-way Valve · Cast iron body · For mixing or diverting liquids · Type 2231 to Type 2235 Control Thermostats

Technical data Data Sheet T 2131 EN
Set points –10 to +250 °C
Nominal size DN 15 to 50
Nominal pressure PN 16
Temperature Up to 150 °C

Type 9 Temperature Regulator · Flange connections
With balanced Type 2119 Three-way Valve · Body made of either cast iron, cast steel or cast stainless steel · For mixing or diverting liquids · Type 2231 to Type 2235 Control Thermostats

Technical data Data Sheet T 2133 EN · T 2134 EN
Set points –10 to +250 °C · 15 to 480 °F
Nominal size DN 15 to 25 · NPS ½ to 6
Nominal pressure PN 16 to 40 · Class 150 and 300
Temperatures Up to 350 °C · Up to 660 °F

Regulators with three-way valve for temperatures of max. 350 °C when used in mixing or flow diverting services
• Regulators for heating or cooling installations

Type 1 · Flanged body version
Body EN-JL1040/A126B
Type 2231 Control Thermostat

Type 8 · Three-way valve
Type 2231 Control Thermostat

Fig. 6 · Various temperature regulator versions
Regulators for cooling installations

Type 4u · Flange connections
Same as Type 4, but equipped with a reversing device. The valve opens as the temperature rises.

Technical data Data Sheets T 2123 EN/T 2650 EN
See Type 4

Type 1u Temperature Regulator · Screwed ends/flange connections
With unbalanced Type 2121 Single-seated Globe Valve · DIN version: body made of either red brass or spheroidal graphite iron, ANSI version: body made of either cast steel or cast iron. The valve opens as the temperature rises. Type 2231 to Type 2235 Control Thermostats

Technical data Data Sheets T 2113 EN · T 2114 EN
Set points
-10 to +250 °C · 15 to 480 °F
Screwed ends
Female thread G ½ to G 1
Flange connections
Nominal size DN 15 to 50 · NPS ½ to 2
Nominal pressure PN 25 · Class 125, 150 and 300
Temperatures
Gases Up to 80 °C · Up to 175 °F
Liquids Up to 150 °C · Up to 300 °F

Combined devices
Type 1, Type 4, Type 8 and Type 9 Regulators allow a manual adjuster or a double adapter to be installed between the thermostat and the valve. The double adapter allows a second thermostat to be attached to the valve. For details, see Data Sheet T 2036 EN.

Type tested temperature regulators (TR), safety temperature monitors (STM), safety temperature limiters (STL) and combinations of these devices (e.g. TR+STM) for sizes DN 15 to 150 (NPS ½ to 6) and limit signals up to max. 170 °C (340 °F) are used as safety equipment in heat generating systems. All versions can be used with a three-way valve in place of the globe valve.

For details, refer to Information Sheet T 2040 EN and the Data Sheets T 2043 EN and T 2046 EN.

Thermowells and fastening elements
For Type 2231 and Type 2232 Control Thermostats and Type 2212 and Type 2213 Safety Thermostats, thermowells with threaded connections or flanges are available. For Type 2233 and Type 2234 Control Thermostats, flanges, clamps and perforated covers are available for wall mounting.

Accessories
If the operating conditions affect the reliability of the operating element, an extension piece and/or separating piece can be mounted between the valve and the operating element.

The extension piece is needed for valves in nominal sizes DN 15 to 100 (NPS ½ to 4) when temperatures above 220 °C (430 °F) occur.

The separating piece in the stainless steel version isolates the non-ferrous metal parts of the operating element from the medium flowing through the valve. In addition, it prevents medium leakage while the thermostat is being replaced. The double adapters are especially suited for the attachment of a second control thermostat to the regulator. For details, see Data Sheet T 2036 EN.

Fig. 9 · Type 1u and Type 4u Temperature Regulators as well as combined devices
Temperature control for different services
T1 Heating or cooling with a globe valve
T2 Heating with a three-way valve (mixing valve)
T3 Control of a water-heated air duct
T4 Control of a steam-heated drying cabinet, drying room or storage room

Temperature control for boilers, heat generators and heat transfer devices
T5 Control of a water-heated boiler
T6 Control of a steam-heated boiler
T7 Control at a heat generator or heat exchanger
T8 Temperature control safeguarded by a safety temperature monitor on a heat generator or water-heated heat exchanger

Temperature control in district heat supply systems and cooling systems
T9 Return flow temperature limitation
T10 Return flow temperature increase in a boiler system

T11 Temperature control of a condenser
T12 Control of the coolant circuit in motors and compressors

Legend for the examples of application
1 Types 1, 1u, 4, 4u
2 Types 8, 9
3 Types 1, 4 with Type 2233 or Type 2234 Thermostat
4 Types 1, 4 with Type 2235 Thermostat
5 Types 1, 4 with Type 2231 Thermostat and Type 2212 Safety Thermostat
6 Types 1, 4
8 Types 1u, 4u
9 SAMSON strainer
10 SAMSON steam trap

For other examples of application of typetested devices, refer to Information Sheet T 2040 EN