DOMESTIC HEATING CONTROLS ARE EASY
PART 3 - THERMOSTATS

Energy efficient heating/DHW requires close control of both *time* and *temperature*. **Thermostats** limit fuel consumption and enhance comfort by controlling the temperatures of air within dwellings, and their stored domestic hot water (DHW), at desired levels.

TYPES

Room, Cylinder and **Radiator thermostats** (TRVs) are 'Minimum Set' recommendations in the Government's new domestic heating controls Good Practice Guide (GPG) 302. Their use is essential to complying with the revised (2002) Building Regulations, Part L, which apply to all new dwellings and to existing ones undergoing major heating upgrades. **Programmable Room thermostats** are listed as 'Best Practice' controls in GPG302 and provide extra energy saving benefits.

Frost and **Pipe thermostats** are often required in 'wet' central heating installations. Built-in **Boiler thermostats** are primary safety controls outside the scope of this article.

Room and cylinder thermostats	On/Off temperature controls for living areas and DHW, effective during system's timed operating periods. User settable to desired temperatures.
Radiator thermostats (TRVs)	Modulating, self-acting radiator controls (non-electric). Do not cycle On and Off like room thermostats. Provide individual room control. Enable 'free heat' advantage from extraneous sources, i.e. sunlight, appliances.
Programmable Room thermostats	Combined electronic time controls/room thermostats that enable users to set several daily periods at different room temperatures to suit household activities. Some models provide additional timed DHW feature.
Programmable Cylinder thermostats	Combined electronic programmers/cylinder thermostats that enable users to set different DHW temperatures at different daily periods.
Frost thermostats	Needed day and night to prevent heating systems or boilers freezing during exceptionally cold snaps; override time controls.
Pipe thermostats	Control boiler return (oil-fired systems) or work with frost thermostats.

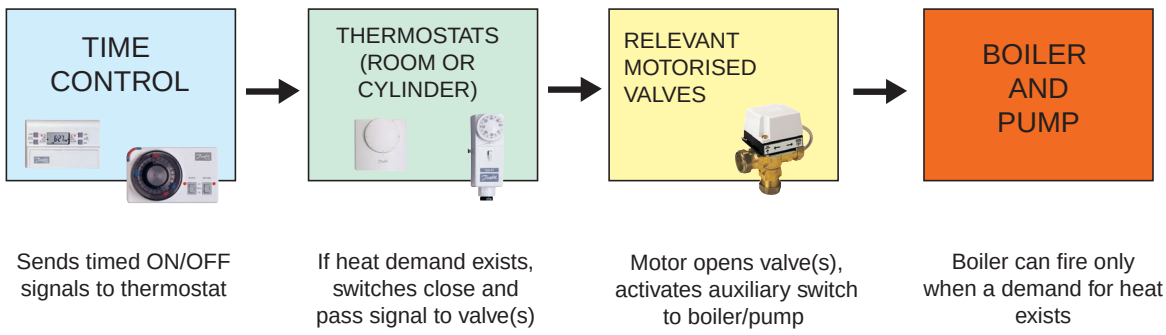


Fig. 1. Typical controls operating sequence for 'wet' domestic central heating system.

Thermostats are second in line to time controls in the controls 'chain of command', allowing the timed 'On' signal to go forward to valve and boiler *only when heat is needed*. They can be self-acting, electro-mechanical or electronic.

Generally, electronic units provide greater sensing accuracy and faster response to temperature changes. Most electronic thermostats are battery powered, allowing simple two-core output wiring and no neutral connection. RF (wireless) models transmit radio signal commands to other control system components via adjacently sited receiver/switching units. They simplify installation, eliminate long wiring runs and avoid much 'making good'.

OPERATION

General. Most thermostats (not TRVs) switch Off the heat source when rising temperature reaches set point, and On when it falls below. Having once switched off, there must then be a slight cooling off - typically less than 1°C - before a thermostat can switch on again. This is known as the thermostat's *switching differential* or *hysteresis*.

A simple unassisted electro-mechanical thermostat (Fig. 2) uses expansion/contraction movement of a temperature sensitive vapour capsule or bimetal strip to operate its output switch or relay. As such, it is just a temperature-operated On/Off switch, consuming no power and requiring no neutral wiring connection.

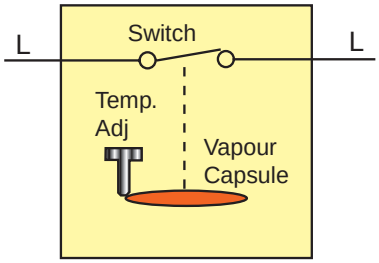


Fig. 2. Schematic of simple, unassisted vapour capsule type room thermostat.

Bimetal and vapour capsule temperature sensors can take time to warm up and cool down, resulting in 'temperature overshoot' and lengthy cycling (see Fig. 3). Temperature overshoot occurs when the residual heat already injected into the system before switch-off is enough to raise the room or DHW temperature several more degrees above the set temperature. Cooling down again can take some time and the result is significant heat wastage.

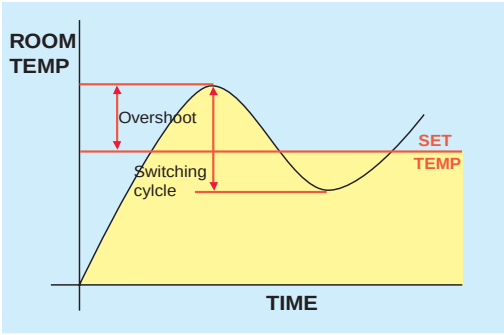


Fig. 3. Temperature overshoot and switching cycle

Room thermostats. A domestic central heating system requires a room thermostat for each heating zone, i.e. living and sleeping areas, as specified in Building Regulations. Each thermostat will switch a separate valve controlling the flow to those radiators within its zone. Strictly speaking, these thermostats monitor and control the temperature in just the room where they are fitted but, because the dwelling's other radiators are sized and balanced to suit their rooms' individual heat losses, the entire zone will be controlled as required.

To overcome temperature overshoot, most bi-metal/vapour capsule room thermostats are fitted with anticipators (accelerator heaters), small electrical resistors wired close to the sensing element. These anticipators warm up

the sensor when the thermostat switch closes (Fig.4), causing it to re-open the switch. Their effect is to sequentially open and close the switch, stepping up room temperature gradually to avoid overshoot and prolonged cooling (Fig.5). Although anticipators consume small amounts of electricity, they help save heating fuel. (NB. The anticipator requires a neutral connection)

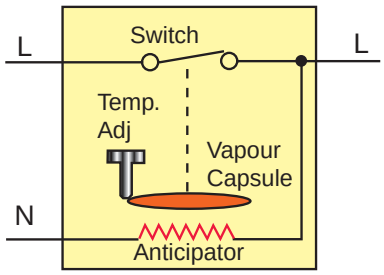


Fig. 4. Schematic of vapour capsule type room thermostat with anticipator

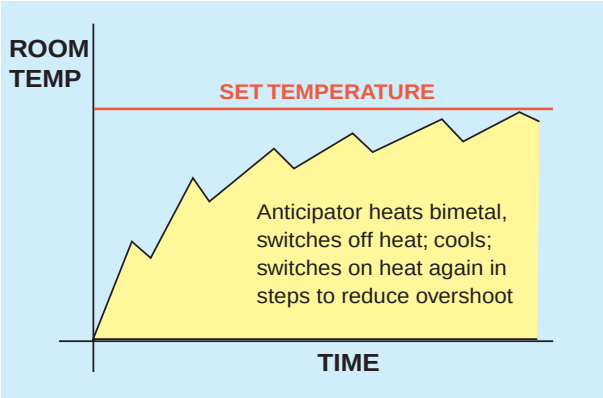


Fig. 5. The step-up heating action of a room thermostat's anticipator.

Electronic room thermostats react very rapidly to temperature change and do not need anticipators. They do not rely on mechanical linkages to operate their output relays.

Frost thermostats, similar to room thermostats, are usually set at 6°-8°C to switch on the heating, and prevent water within the system freezing, should air temperatures become exceptionally low.

Pipe thermostats can be used additionally to protect exposed pipes that might freeze before the frost thermostat can take effect; or to maintain essential boiler return temperatures (above dew point) with oil-fired boilers. Also, they can act as high limit thermostats to activate a cooling pumped flow in solid fuel systems.

Cylinder thermostats monitor cooler temperatures at the lower half of the tank to maintain hotter water at the top (see Fig. 5). Usually, because of temperature stratification within the storage cylinder, electro-mechanical types are calibrated to switch some 15°C below their dial settings. Thus, such a thermostat positioned one-third of the way up a typical domestic DHW cylinder, and set at the 60°C marking, will enable water at this temperature to be drawn off the top – even though the bimetal is operating at 45°C. The higher up the tank the thermostat is placed; the cooler will be the draw-off temperature for any given setting

To prevent 'hunting' (frequent On/Off switching), cylinder thermostats do not have anticipators. Operating over a wider temperature differential, they can be less precise than room thermostats because the heat they control is stored in insulated tanks and energy losses are minimal.

Electronic cylinder controls are available also. The Danfoss Randall WP75H programmable hot water thermostat is a noteworthy example. Comprising a programmable control unit and a separate strap-on sensor, this 7 day or 5/

2 day control provides up to 3 different hot water settings a day, convenient user overrides including a ‘one-shot’ boost and a hot water status indicator.

Also, Danfoss Randall’s range includes the self-acting (TRV type) RAVI thermostatic cylinder controls.

Radiator thermostats (TRVs) consist of two parts – a valve body and a sensor head. The head contains a wax, liquid or gas filled sensing element that expands and contracts with changes in room temperature to move the valve stem against a spring, positioning the valve seat to control flow through the radiator. Setting is simply carried out by rotating the sensor head cover to the desired marked position. Other setting positions can include frost protection and positive off.

Unlike most other thermostats, TRVs do not need to traverse through On/Off switching cycles and, installed correctly, can maintain extremely close temperature control. Their control action is modulating, i.e. it throttles up or down according to sensed room temperature changes. Accurate control depends upon the sensor monitoring a truly representative room temperature and not being influenced by heat from the radiators, pipes or other sources (see INSTALLATION).

Energy-saving advantages provided by TRVs are the accurate temperature control of individual rooms and that ‘free heat’ from extraneous sources such as sunlight, appliances and people is taken into account and not permitted to overheat the room.

TRV’s are self-acting and consume no electricity. They do not provide an electrical interlock to switch off the boiler when room temperatures are satisfied. This can be provided either by a ‘master’ room thermostat, a flow switch device or by using TRVs in conjunction with a Danfoss Randall BEM5000 Boiler Energy Manager.

Danfoss Randall, the UK’s market leader for radiator thermostats, can supply TRVs in popular sizes for all domestic and commercial two-pipe and one-pipe systems. A full range of accessories is available. Installers and specifiers would benefit from obtaining the company’s literature and data sheets on the entire range.

Programmable Room thermostats provide far more flexible control than conventional room thermostats and, as they are combined programmers/room thermostats, installers only have to fit and wire-up one unit instead of two. Available as 24-hour, 5/2 day or 7-day units, they are simple to install and operate. They are particularly suitable for use with combination boiler systems.

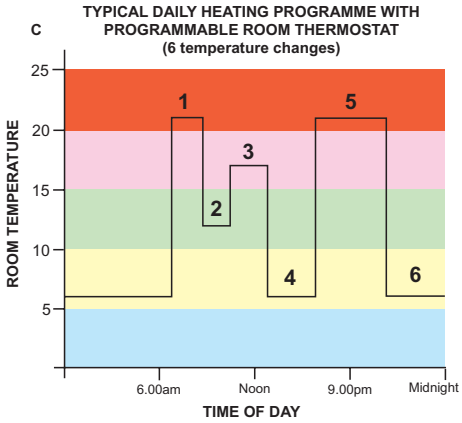


Fig. 6. Typical automatic temperature changes possible with programmable room thermostat

Ordinary room thermostats control at a single set temperature. By the time the user has realised that the room is over-hot and turned down the temperature setting, fuel has already been wasted.

The great advantage of programmable room thermostats is that they allow home temperatures to change automatically several times a day, or night, to suit regular household needs – see Fig. 6. This means that desired

comfort levels are achieved throughout the day with minimum fuel consumption. Fig. 6 illustrates a system running with nighttime frost protection; it is just as easy to switch the heating off altogether whenever required.

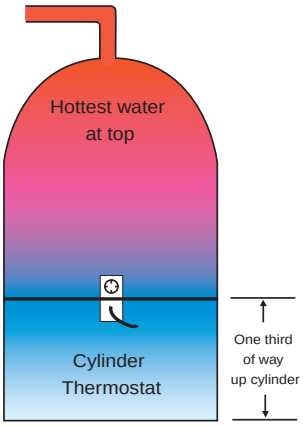
Most programmable room thermostats have in-built switching programmes that users can easily adapt to suit their individual needs. They are battery powered and do not require neutral wiring. Installers need only to fit them, often in place of the existing thermostat, using the same output wiring, hand the user instructions over and walk away. Job done! And a good job at that - because the Government's new Good Practice Guide 302 lists Programmable room thermostats as 'Best Practice' controls.

Danfoss Randall's range includes a model with timed DHW control, and RF (wireless) versions that greatly speed up and simplify installation.

INSTALLATION

All domestic heating controls come with manufacturers' detailed installation instructions that should be carefully followed. Basic guidance is given below for various types.

Room Thermostats. Initial installation of electro-mechanical, electronic and programmable room thermostats usually involves simply fitting a standard single-gang wall wiring box (probably flush mounting); running electrical connections to the control system's wiring centre (often in the airing cupboard); and fixing the thermostat unit to the wall box. Replacements or upgrade units usually fit on existing boxes and require little wiring modification.
Room thermostats should be positioned approximately 1.5m above the floor where they can monitor representative air temperatures. Locations to avoid are above radiators, near hot pipes, in direct sunlight, behind curtains and furnishings, away from electrical appliances or where there is any draught.



Frost thermostats. Installed like room thermostats, these should be sited in the coldest spots of the areas to be kept frost-free. When used to protect boilers in unheated areas, they should be fitted within 2m from the boiler.
Cylinder thermostats (Fig. 7). These are clamped tightly against the copper surface of the DHW cylinder, approximately one-third of the way up, by means of an expanding spring wire or metal strap. With pre-insulated cylinders, this means carefully removing an appropriately sized piece of insulation. Simple wiring connections are made to a wiring centre.

Fig.7. Positioning of cylinder thermostat.

Pipe thermostats. Strapped directly to pipes, typically from ½" to 2" diameter.

Radiator Thermostats (TRVs). Before fitting, installers should check whether valve bodies are flow direction dependent. An arrow on the valve casting indicates this usually. Fitting a one-directional valve the wrong way round will impair control performance and probably generate noise (banging) in the system. Using modern bi-directional TRVs, like the Danfoss Randall RAS-D, will overcome uncertainty.
Room temperature control will be impaired if sensors are fitted directly above hot valves or pipes. For best results, TRVs should be installed horizontally at the flow inlet (see Fig. 8); vertical installation in the return provides control that is less accurate, but usually acceptable.
Space restrictions and furnishings are factors that can influence the positioning of TRVs. Sometimes, it may be necessary to use models with remote sensors and adjusters. TRVs should not be installed in rooms controlled by conventional room thermostats.

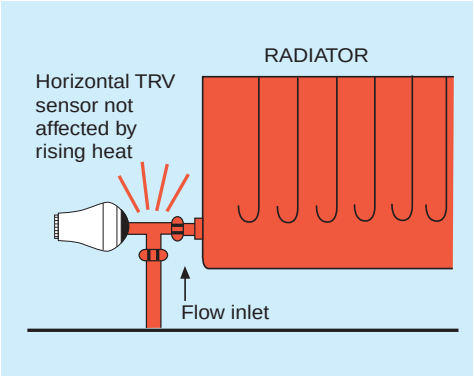


Fig.8. TRV fitted horizontally in flow is unaffected by rising heat from valve or pipes.

Having decided which end of the radiator the TRV is to be fitted, valve installation is a simple plumbing job. First, the removable tailpiece, with its threads wrapped with PTFE sealing tape, is screwed into the radiator tapping. The appropriate valve inlet/outlet is then connected to this using the tailpiece compression fitting. Connecting the other valve inlet/outlet to the flow/return pipe with the compression fitting provided completes valve body installation.

The sensing head can then be attached, following the manufacturer's instructions carefully. No wiring is necessary and control becomes effective as soon as the system is filled and turned on.

DANFOSS RANDALL THERMOSTATS (Domestic)

Operation	Type	Model	Set. Range	Remarks
Self-Acting	Radiator	**RAS-D**	8-28°C	2-pipe TRV, snap-lock sensor, bi-directional
	Radiator	**RAS-C**	8-28°C	2-pipe TRV, snap-lock sensor, bi-directional
	Full range of options and accessories for RAS-D/RAS-C² – refer to data sheets.			
	Cylinder	**RAVI**	43-65°C	Select 15mm or 22mm, pumped or gravity
	Cylinder	**RAVK**	26-65°C	Sensing element with 2m capillary tube.
Electro-Mech.	Room	**RMT230***	8-30°C	230Vac, no anticipator
	Room	**RMT230**	8-30°C	230Vac, with anticipator
	Room	**RMT230T**	8-30°C	230Vac, anticipator, thermometer, set-back
	Room	**RMT24**	8-30°C	24Vac, with anticipator
	Room	**RMT24T**	8-30°C	24Vac, anticipator, thermometer, set-back
	Room	**TW Range**	5-30°C	Thermostats with supplementary functions
	Cylinder	**ATC**	30-90°C	with fitting strap
	Pipe	**ATP**	30-90°C	with fitting strap
Electronic				
Single Setting	Room	**RT51**	5-30°C	Manually selected Day/Night operation
	Room	**RT52**	5-30°C	Programmable return to Day mode
	Room	**RT51-RF**	5-30°C	as RT1, RF operation
	Room	**RT52-RF**	5-30°C	as RT2, RF operation
Programmable	Room	**TP4**	5-30°C	24 hr., up to 6 temp. changes daily
	Room	**TP5**	5-30°C	5/2 day, up to 6 temp. changes daily
	Room	**TP5000**	5-30°C	5/2 day, up to 6 temp. changes daily, Off
	Room	**TP5000-RF**	5-30°C	as above, RF operation
	Room	**TP7000**	5-30°C	7 day and 5/2 day, 3 temp. changes daily
	Room	**TP75H**	5-30°C	as above, high current 16(4)A contacts
	Room	**TP7000M**	5-30°C	as TP75, mains powered
	Room	**TP7000-RF**	5-30°C	as TP75, RF operation
	Room/Cyl.	**TP9**	5-30°C	24 hr and 5/2 day, with timed DHW control
	Cylinder	**WP75H**	35-65°C	7 day and 5/2 day, 3 temp. changes daily

The above listing shows Danfoss Randall's popular domestic central heating thermostats. For further detail on these products, please refer to the company's Product Selection Guide, its various Data Sheets or contact the Sales Help Desk.