

# Temperature cutoffs (Thermal-links) for coffeemakers

## Extended Holding Temperature $T_{H-100}$ rated TCOs

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### 1. What is $T_{H-100}$ and why was it established?

As a result of several coffeemaker fires reported around 1990, Underwriter Laboratories had discussions with drip-type coffeemaker manufacturers regarding the cause of the failures. It was postulated that the cause of these fires was certain types of TCOs failing to open in older coffeemakers when the thermostat failed in the closed contact position. It was believed that certain TCO mechanisms failed due to age and the contact force was reduced until the pressure between the contacts was equal to zero. In some instances when the contacts moved very slowly from a closed to an open position and near-zero contact pressure was reached this condition could have resulted in the contacts failing to open.

In order to resolve the issues regarding these fires, in 1991 UL finally introduced a  $T_{H-100}$  rating for TCOs used in drip-type coffeemakers.

The  $T_{H-100}$  rating established a TCO holding temperature representing 100 weeks of use under normal load. During that time the TCO should not open prematurely and must still function at the end of the period of conditioning.

The 100 weeks (2 years !) of continuous operation correspond to approx. 6 years of operation for 8 hours a day. 6 years is considered to be the average life of a drip-type coffeemaker.

Besides the  $T_{H-100}$  rating for use in coffeemakers, UL also introduced a further test for all TCOs rated above 175°C.

This new method of testing was designated "Conductive Heat Ageing test" (CHAT) which represented slow ageing of the TCOs under load, while mounted directly to a heated surface. The proposed requirements in the UL 1082 Standard for "Household Electric Coffee Makers and Brewing-Type Appliances" became effective in 1993 and 1994.

The CH and  $T_{H-100}$  ratings stated by the manufacturer are to be considered by the OEM for design and specification of the end product.

### 2. What do the standards require?

#### a) Extended holding temperature conditioning test (UL1020)

According to UL 1020,  $T_{H-100}$  rating is defined as "Extended Holding Temperature".

25 devices have to be conditioned in a static- air oven for a period of 100 weeks.

During this time the rated load current and rated voltage is applied to the TCOs, the oven is heated and maintained at the specific  $T_{H-100}$  temperature value within given tolerances.

The TCOs must not open at the conclusion of the conditioning period. All samples except two are subjected to a load current interrupt test after the conditioning period and the remaining two samples are subjected to a calibration verification test.

#### b) Conductive Heat Ageing test "CHAT" (UL1020)

30 TCOs in three sample groups each made up of 10 samples are subjected to this test. The TCOs are securely mounted on an aluminum plate which is placed on a static-air oven as a cover.

The test oven applies heat to the plate and by conduction also to the TCO body.

The TCOs are connected to a load current of 10 A at 120 V during the ageing period and this period is set at 8 weeks plus one day.

The ageing consists of several steps beginning at 35°C below functioning temperature  $T_F$  for two weeks, then 25°C below  $T_F$  for two weeks and then increasing the temperature each week in 5°C steps up to  $T_F$  plus 5°C. To pass this test all TCOs have to operate as intended without a dielectric breakdown.

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### c) Limiting-Type devices (UL1082)

UL 1082 (Par. SA11.3.1) Standard for "Household Electric Coffee Makers and Brewing-Type Appliances" refers to the use of limiting devices. Such devices shall conform to one of the following specifications:

- A) A single thermal cutoff with an established  $T_{H-100}$  rating including a CH (conductive heat) rating
- B) Two thermal cutoffs under certain conditions specified by this standard
- C) A single operation device (SOD)
- D) A manual-reset thermostat which is inaccessible to the user without the use of tools.

When using a single thermal cutoff with  $T_{H-100}$  rating the temperature applied to the sensing surface of the TCO shall not exceed 90% of its established  $T_{H-100}$  temperature during normal operation of the coffeemaker.

### 3. TCOs made by INTER CONTROL

#### a) How to categorize TCOs made by INTER CONTROL?

INTER CONTROL adapted the TCO Types 155031 and 155431 to the required  $T_{H-100}$  rating very early in 1995.

Due to the special design of the TCO and the feature of its combination with a thermostat into a single mounting unit, the aim was to have an established  $T_{H-100}$  rating for this single TCO and it passed the 100 week conditioning test and the conductive heat ageing test in 1997. Since that time TCOs "Minimelt" Type 155431 alone or in combination with the thermostat "Discomelt" Type 161491 from INTER CONTROL have been used in drip-type coffeemakers in many European and UL-listed coffeemaker applications. Millions of these controls are sold.

#### b) How is the Minimelt designed?

The construction of the TCO is basically similar to a thermostat using a thermal element as a sensor instead of a snap disc type bimetal.

The switch system consists of a contact spring made of a very highly conductive material which is capable of carrying load current up to 13.5 A at 120 V for 100000 cycles or being used in a TCO to withstand 22.5 A at 120 V current interrupt test.

The movement to open the contacts is reinforced by a separate leafspring actuating the contact spring when relaxation due to ageing occurs.

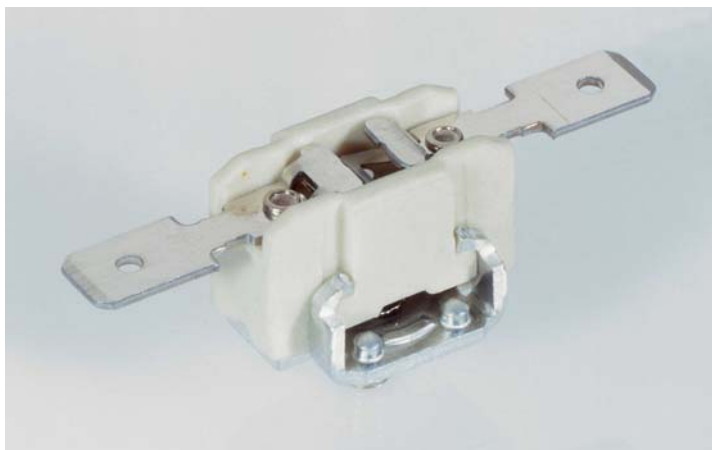
The actuating sensor which senses the temperature (thermal element) is electrically insulated from other live parts such as terminals and contact system.

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The thermal element consists of an aluminum cup containing an eutectic solder alloy with a very tight range in its melting transition. An insulating pin made of aluminum oxide ceramic is drops into the bushing and ejects the eutectic solder when the melting point is reached. By this action the contacts open permanently.



#### c) Ratings of TCO Minimelt™ Type 155431

Temperature ratings for thermal cutoffs “Minimelt” Type 155431

Code	Rated functioning temperature	Holding temperature					Max. temp. limit
		$T_H$	$T_{H-100}$	Baseplate 90%	$T_{H-100}$	Switchhead 90%	
	$T_f$						$T_m$
I	206°C	170°C	170°C	153°C	170°C	153°C	500 °C
K	229°C	195°C	195°C	175°C	195°C	175°C	“
L	260°C	220°C	220°C	198°C	220°C	198°C	“
V	298°C	250°C	250°C	225°C	220°C	198°C	“
N	318°C	270°C	250°C	225°C	220°C	198°C	“
Tolerance for $T_f$ is -10°C as per UL 1020							
The temperature indications for $T_f$ and $T_H$ refer to the temperature of the baseplate, measured near to the thermal element under working conditions.							
Electrical rating: $T_H$ : 15A 120V AC NI., $T_{H-100}$ : 13.5 A 120 V AC NI.							

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#### d) Advantage of TCOs Type 155431 and combination Type 161491

The main aspect in using this type of TCOs is the advantage when assembling the component into a coffeemaker or electrical appliance. As the sensor element is electrically insulated from live parts there is no need for extra insulation when the device is mounted to the surface of a heating element.

This results in a very low time constant as the heat is transmitted directly from the heating element to the TCO sensing plate and then to the thermal element itself by metal to metal contact.

Another aspect is the rated functioning temperature which can be chosen up to 318°C and its assigned holding temperatures. Considering the fast reaction of the TCO the functioning and holding temperatures are suitable for high temperature overshoots as they might occur in new high-powered coffeemakers i.e. above 1100 W especially with dry run operations or during descaling of the heater element.(see table of temperature ratings).

INTER CONTROL has introduced a system of combinations of thermostats with TCOs on a common baseplate made of aluminum.

The thermostat-TCO combination "Discomelt" consists of two similar switch sockets mounted side by side on an aluminum plate. This provides a one piece assembly unit which is easy to fit on a heating element. Due to the rectangular shape of the combination it is even suitable for handling with pick and place equipment for automated assembly directly to a surface without extra insulation.

The terminals can be provided in different versions, like quickconnects, crimp or welding terminals or combinations of these. If desired, both components - thermostat and TCO - can be delivered internally wired in series or each with separate terminals as is required for European applications.

An interesting technical aspect of the combination is the common location of both components on the surface to be monitored. As the TCO is fitted very closely to the thermostat, it senses temperatures almost identical to those to which the thermostat is exposed and the temperature gradient at both units is nearly the same. The time constant of the thermostat side is approx. 7 seconds and of the TCO approx. 4 seconds depending of the method of mounting.

This enables the manufacturer of the appliance to achieve a very accurate and tight tuning of the temperature limits between thermostat and TCO.



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