Comparative analysis of sensors for climate check

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Abstract. Registration and monitoring of climatic conditions is an essential task in many manufacturing processes. These parameters are essential for storing certain types of materials or equipment and also play a significant role in the operation of the device. In this regard, the problem of using specialized recording devices becomes relevant. This paper considers such instruments for recording and monitoring climatic characteristics as testo 608-H1; testo 635; testo 645; TPM 201. Their technical characteristics and measurement ranges have been presented. Also the conclusions about the conditions under which it is better to use a particular device have been drawn. The study found that testo 608-H1 and testo 635 have limited functionality and are mainly used in accommodation units or small warehouses. The testo 645 and TPM 201 devices have more extensive functionality and are used in enterprises in test facilities, production lines, climate chambers, dryers, foundry furnaces, galvanic shops.

1. Introduction
The indoor control of temperature and humidity is an important task to maintain normal climate conditions, preventing the emergence of mold and various fungi, as well as buildings destruction. Today there are many means of climate control: ordinary thermometers, barometers, and modern automated digital devices. The latter is studied in this paper [1].

A lot of digital devices for recording and monitoring climate characteristics are presented on the market today. There are simple models for home use, as well as industrial zones, which are used on production lines in complex technological processes. Some devices simply record climate characteristics, and there are hardware complexes that allow controlling, register, and, if necessary, edit climate characteristics [2].

2. Overview of climate recorders
Let us compare the above-described devices from simpler to more complex ones. So the first device that is considered in this paper is testo 608-H1. Its technical specifications are presented in Table 1.
Table 1. Technical specifications of testo 608-H1

| Specifications          | Description                                                                 |
|------------------------|-----------------------------------------------------------------------------|
| Measured parameters    | Relative humidity; temperature (°C, °F); dew point                         |
| Sensors                | RH sensor; NTC                                                             |
| Measuring range        | 15…85% RH; 0…+50°C; -20…+50°C dp                                           |
| Accuracy of measurements | ±3% RH; ±0,5°C                                                             |
| Resolution             | 0,1% RH; 0,1°C                                                             |
| Display                | Two way LCD                                                                |
| Measurement cycle      | 18 sec.                                                                    |
| Operating temperature  | 0…+50°C                                                                   |
| Storage temperature    | -40…+70°C                                                                 |
| Power supply           | 9V brick battery                                                           |
| Battery life           | 1 year                                                                     |
| Housing                | ABC plastic                                                                |
| Dimensions             | 120x89x40 mm                                                               |
| Weight                 | 168 g.                                                                     |
| Warranty               | 2 years                                                                    |

As can be seen from table 1, this device has a simple design and control but limited functionality.

Figure 1. Testo 608-H1

This device is designed for recording indoor temperature and humidity and can be used both in industrial enterprises and at home. Currently, there is a whole line of testo devices; let's consider the following one [3].

The technical specifications of multifunctional testo 635 series thermohygrometer are presented in Table 2.
Table 2. Testo 635 technical specifications

| Specifications        | Description                                      |
|-----------------------|--------------------------------------------------|
| Plug-in probes        | 1 Omega TC socket; 1 Mini-DIN socket; radio module (option) |
| Memory                | 10000 readings                                   |
| Protection class      | IP 65                                            |
| Measurement cycle     | 2 sec.                                           |
| Operating temperature | -20…+50°C                                        |
| Storage temperature   | -30…+70°C                                        |
| Power supply          | 3 AA batteries                                   |
| Battery life          | 200 h.                                           |
| Housing               | ABC plastic; thermoelastolayer; metal            |
| Dimensions            | 225х74х46 mm                                     |
| The EU Directive      | 2004; 108; EU                                     |
| Warranty              | 2 years                                          |

Table 3. Testo 635 measurement cycles

| Specifications       | Measurement cycle | Inaccuracy of measurements | Resolution |
|----------------------|-------------------|----------------------------|------------|
| Temperature(K/T types)|                   |                            |            |
|                      | -200…+1370°C (K type) | ±0,3°C (-60…+60°C)        | 0,1°C      |
|                      | -200…+400°C (T type)  | ±0,2+0,5% of reading      |            |
|                      | -328…+2498°F (K type) | ±0,6°F (-76…+140°F)       | 0,1°F      |
|                      | -328…+752°F (T type)  | ±0,4°F+0,5% of reading    |            |
| Relative humidity    | 0…+100% RH        | Depends on the probe      | 0,1% RH    |
| Pressure             | 0…+2000 gPa       | Depends on the probe      | 0,1 gPa    |

Figure 2. Testo 635

After analyzing tables 2 and 3, we can conclude that the examined device has more functionality compared to testo 608 H1. The main distinguishing feature of this device compared to the previous model is that it allows saving the measured characteristics after a specific time interval that can be programmed [3]. The device’s internal memory is enough for 10,000 measurements. Also, this device
can be connected to a PC and transfer data directly to it. The thermohygrometer testo 635 is designed for use in industrial areas rather than at home. The latest advanced development of testo is the 645 series designed for industry. The technical specifications and measurement ranges of this device are presented in Tables 4 and 5.

**Table 4. Testo 645 technical specifications**

| Specifications                  | Description                                           |
|--------------------------------|-------------------------------------------------------|
| Measured parameters            | Air humidity (dp; g/m³; g/kg; J/g); temperature (°C, °F) |
| Inaccuracy of measurement      | ±1 unit at +22°C                                       |
| Display                        | Four line LCD;                                         |
| Operating temperature          | 0…+50°C                                               |
| Storage temperature            | -20…+70°C                                              |
| Power supply                   | 9V brick battery                                       |
| Battery life                   | 45h                                                    |
| Housing                        | ABC plastic                                            |
| Dimensions                     | 215x68x47 mm                                           |
| Weight                         | 255 g.                                                 |
| Warranty                       | 2 years                                                |

**Table 5. Testo 645 measurement range**

| Probe type       | Capacitive Testo humidity sensor | Pt100 | K type (NiCr-Ni) |
|------------------|----------------------------------|-------|------------------|
| Measurement range| 0…+100 % RH                      | -200…+800 °C | -200…+1370 °C    |
| Inaccuracy of measurement | ±0.1% of the measured value (+200…+800 °C) | ±0.5% of the measured value (+60…+1370 °C) |
| Resolution       | 0.1% RH                           | 0,1 °C | 0,1 °C           |
| Probe type       | S type (Pt10Rh-Pt)                |       | K type (Fe-CuNi) |
| Measurement range| -50…+1700 °C                     | -40…+750 °C | -50…+150 °C |

![Figure 3. Testo 645](image-url)
This device, like the previous ones, allows saving the measured characteristics in the internal memory and then transfer the received data to a PC [4].

All the devices described above have one serious drawback. They allow registering the measured climatic characteristics, but they cannot edit them if they do not meet the necessary standards [5]. Such a device as a ThermoData TPM can be used not only to record climatic characteristics but also, if necessary, edit them (turn on/off fans, heating). Its appearance is shown in Figure 4. The technical specifications and measurement ranges are presented in tables 6 and 7, respectively.

![Figure 4. TPM ThermoData](image)

Due to the use of various thermocouples, thermal resistance converters, this device allows recording temperature characteristics in broad ranges, as well as it can work both autonomously and be directly connected to a computer [5]. The main distinguishing feature of the TPM 201 from the previous models under consideration is the presence of a built-in control relay, due to which it is possible to regulate the climatic characteristics they do not meet the requirements. Figure 6 shows the full functional diagram of TPM 201.

### 3. Conclusion

There are a large number of various sensors for monitoring climatic characteristics that differ from each other both in technical data and in the price range at the moment. Thanks to this, the user can choose exactly the device that he needs for a specific use. So the testo 608-H1 and testo 635 devices are more suitable for use at home or in small warehouses. Individual entrepreneurs in their projects use these devices. The testo 645 and TPM 201 devices are more functional and intended primarily for industrial premises or direct use in manufacturing processes. These devices are usually used in production lines or test shops.
### Table 6. TPM technical specifications

| Name                        | Description                                |
|-----------------------------|--------------------------------------------|
| **Power supply**            |                                            |
| Supply voltage              | 90...245 V                                 |
| Power consumption           | 6 VA                                       |
| Frequency                   | 47...63 Hz                                  |
| **Inputs**                  |                                            |
| Input polling time no more  | 1с                                         |

The input resistance of the device when connecting a unified signal source:
- Current (when connecting an external precision resistor) 100 Ohm±0,1%
- voltage, not less than 100 kOhm

The limit of the main permissible reduced error measured by:
- resistance thermal converter 0,25%
- thermocouple 0,5%
- unified current and voltage signals 0,5%

| Output devices              |                                            |
|-----------------------------|--------------------------------------------|
| Transistor optocoupler     |                                            |
| Load current                | 200 mA                                     |
| Voltage                     | 40 V                                       |
| Triac optocoupler          |                                            |
| Load current                | 0,5 A                                      |
| Voltage                     | 240 В 50 Hz                                |
| Electromagnetic relay      |                                            |
| Load current                | 8 А                                        |
| Voltage                     | 220 V 50 G                                 |
| Analog output device        |                                            |
| For DAC (parameter-current) |                                            |
| DAC output signal           | 4...20 mA                                  |
| supply voltage              | 4...20 mA                                  |
| load resistance             | 10...30 V                                  |
| - limit of the main permissible reduced error | 0...1000 Ohm 0,5%                         |
| For DAC (parameter-voltage) |                                            |
| DAC output signal           | 0...10 V                                   |
| supply voltage              | 0...10                                     |
| load resistance             | 15...32 V                                  |
| - limit of the main permissible reduced error | 2 kOhm 0,5%                              |
| Output for controlling an external solid state relay |                     |
| Load current                | 4...6 V                                    |
| Voltage                     | 100 mA                                     |

| Communication interface    |                                            |
|-----------------------------|--------------------------------------------|
| Interface type              | RS-485                                     |
| Data transfer rate, kbit/s  | 2,4; 4,8; 9,6; 14,4; 19,6; 28,8; 38,4; 57,6; 115,2 |
| Cable type                  | Shielded twisted pair                       |
### Table 7 - TPM measurement ranges

| Sensor type | Measurement range   | Low significant bit value |
|-------------|---------------------|---------------------------|
| **Thermocouples (SOST standard 8.585-2001)** |                     |                           |
| L           | -200…+800 °C        |                           |
| K           | -200…+1300 °C       |                           |
| N           | -200…+1300 °C       |                           |
| J           | -200…+1200 °C       |                           |
| T           | -200…+400 °C        |                           |
| A-1         | 0…+2500 °C          | 0,1 °C                    |
| A-2         | 0…+1800 °C          |                           |
| A-3         | 0…+1800 °C          |                           |
| R           | 0…+1750 °C          |                           |
| S           | 0…+1750 °C          |                           |
| B           | +200…+1800 °C       |                           |
| **Thermal resistance converters (TC) (GOST standard 6651-94)** |                     |                           |
| TC (Cu50)   |                     |                           |
| W₁₀₀=1.4260 | -50…+200 °C         |                           |
| TC (50M)    |                     |                           |
| W₁₀₀=1.4280 | -200…+750 °C        |                           |
| TC (Pt50)   | -50…+200 °C         | 0,1 °C                    |
| W₁₀₀=1.3850 | -200…+750 °C        |                           |
| TC (Cu100)  |                     |                           |
| W₁₀₀=1.4260 | -200…+750 °C        |                           |
| TC (100M)   |                     |                           |
| W₁₀₀=1.4280 | -200…+750 °C        |                           |
| TC (100Pt)  |                     |                           |
| W₁₀₀=1.3850 | -200…+750 °C        |                           |
| **Non-standard thermal resistance converters (TC)** |                     |                           |
| TC (46Pt)   |                     |                           |
| W₁₀₀=1.3910 | -200…+750 °C        | 0,1 °C                    |
| TC (53Cu)   |                     |                           |
| W₁₀₀=1.4260 | -50…+200 °C         |                           |
| **Unified DC Signals** |                     |                           |
| 4…20 mA    | 0…100%              |                           |
| 0…20 mA    | 0…100%              | 0,1%                      |
| 0…5 mA     | 0…100%              |                           |
| **Unified DC Voltage Signals** |                 |                           |
| 0…1 V      | 0…100%              | 0,1%                      |
| -50…+50 mV | 0…100%              |                           |

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