Understanding the Technology

# New JTM standards for temperature test chambers - Methods of testing and indicating performance

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**Japan Testing Machinery Association (JTM) has established standards for environmental test equipment.**
**JTM has issued a new standard for environmental test chambers called JTM K 07, "Temperature chambers-Test and indication method for performance". This standard conforms to standards established by IEC (International Electrotechnical Commission) and JIS (the Japanese Standards Association), and has major changes from previous methods of testing and indicating performance for environmental test equipment. As a result, we would like to present the background leading to the establishment of this standard as well as its principal contents. In addition, we would like to discuss the coming trends in methods of testing and indicating performance for temperature and humidity test chambers.**

## 1 Trends in standards for environmental test equipment

Efforts to standardize environmental test equipment have been under way continuously since the "Engineering industry standardization project" of 1975. In 1976, MITI (the Ministry of International Trade and Industry) organized special committees to promote standardization, including the Japan Machinery Federation (JMF), Japan Testing Machinery Association (JTM), and related organizations, and investigations began on means of standardization. Following that, investigative research from those committees began accumulating, and JTM established standards related to performance and safety. Below is a list of the establishment and revision of some of the major performance standards.

1985: JTM K 01, Temperature and humidity chambers - Test and indication method for performance (Established)

1988: JTM K 03, Environmental temperature and humidity rooms - Test and indication method for performance (Established)

1991: JTM K 05, High temperature chambers - Test and indication method for performance (Established)

1998: JTM K 01 (Revised)

2000: JTM K 05 (Revised)

2001: JTM K 03 (Revised)

The driving force for promoting environmental testing software has included the United States military standards (MIL) and the IEC and JIS standardization of electrical, automotive, and maritime standards. JTM has been at the forefront for promoting the standardization of hardware. These industrial standards have been established for the purpose of contributing to the improvement and maintenance of product quality and to international standardization.

The IEC standards and JIS standards for environmental test equipment have been established as follows.

2001: IEC 60068-3-5, Environmental testing - Part 3-5: Supporting documentation and guidance - Confirmation of the performance of temperature chambers

2006: JIS C 60068-3-5, Environmental testing - Part 3-5: Supporting documentation and guidance - Confirmation of the performance of temperature chambers

The contents of this JIS standard matches the contents of the above IEC standard. The IEC and JIS standards for temperature test chambers are utilized for all equipment used in environmental testing and are provided for the general use of the ***user*** to confirm the performance of test chambers. Since these standards constitute ***guidance***, there is a danger that when put into practice they may be subject to a number of interpretations. Because of that, JTM has taken a proper understanding of the contents of these standards, and including portions that are unclear or not stipulated in the standards as well as contents that made up the previous JTM standards has developed new JTM standards.

The new JTM standards target the "temperature test chambers" and have changed the contents of JTM K 01 (Temperature and humidity chambers - Test and indication method for performance), JTM K 03 (Environmental temperature and humidity rooms - Test and indication method for performance), and JTM K 05 (High temperature chambers - Test and indication method for performance) to create the new JTM standards. However, the new standards will be phased in over the course of 5 years following their publication.

In addition, JTM is planning to publish new standards targeting "temperature and humidity test chambers" as well.

## 2 New test and indication methods for performance

Table 1 presents an overview of the major revisions to the standards.

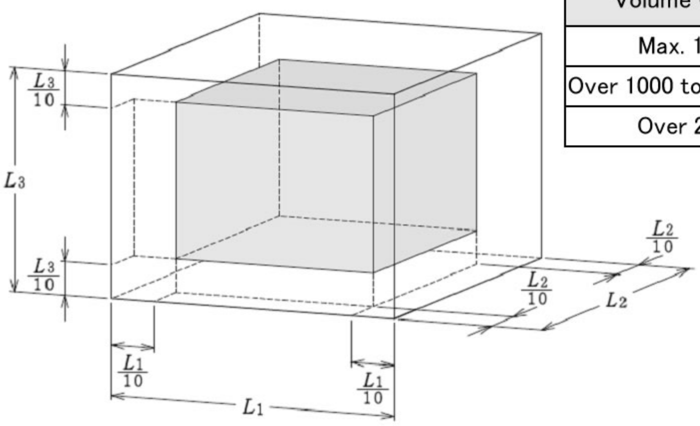
**Table 1 Principal changes in the new JTM standards**

| | | Current standards | New standards | Comments |
|---|---|---|---|---|
| Method of indicating performance | | Range of temp. fluctuation | Temp. fluctuation | Method of confirming performance also changed |
| | | Temp. uniformity | Temp. gradient, Temp. variation in space | Method of confirming performance also changed |
| | | Heating/cooling time | Temp. rate of change | Method of confirming performance also changed |
| Method of confirming performance | Distance of working space | Space excluding 1/6 of distance from inner walls | Space excluding 1/10 of distance from inner walls | Minimum values specified for different test chamber volumes |
| | Range of temp. fluctuation | Measurement point: single point at center of chamber<br>Calculation method: take the difference between average high and average low temps, divide by two, and express as ± value | Measurement points: 9 points (chamber center and 8 corners)<br>Calculation method: take the highest value of the standard deviation among all of the measurement points, double it, and express as ± value. | |
| | Temp. uniformity | Concept: Difference between center of chamber and 8 corner points | Concept: Difference between center of chamber and 8 corner points, and difference among corners | |
| | Heating/cooling time | Definition: Time required to reach max/min temp. from ambient temp.<br>Expression: n1℃ to n2℃, x minutes | Definition: Rate of temp. change during one minute for specified times<br>Expression:K/minute or ℃/minute | ***Time to reach temp. extreme*** conforms to prior ***heating/cooling time*** |

Let's consider the major points of the new standards.

## 2-1 Working space

The working space is a test chamber area that can maintain specified temperature conditions within an allowable range. The test chamber generally takes the shape of a rectangular box, and the working space is composed of the area surrounded by the shaded surface shown in Fig.1. The distance from each of the wall surfaces surrounding the working space to the next corresponding chamber surface shall be termed as $L_1$, $L_2$, and $L_3$, respectively. Current standards define the working space as the space between the surrounding walls excluding the area adjacent to the walls composed of a distance divided by 6 from the total surface distance, expressed as $L_1/6$, $L_2/6$, and $L_3/6$. The new standards define the working space as the space between the surrounding walls excluding the area adjacent to the walls composed of a distance divided by 10 from the total surface distance, expressed as $L_1/10$, $L_2/10$, and $L_3/10$. However, since it is necessary to consider the effect of thermal emissions in the space between the inner walls of the test chamber and the test specimens, the distance from the inner walls must be specified as a minimum value according to the volume of each test chamber.




| Volume (liters) | Minimum distance (mm) |
|---|---|
| Max. 1000 | 50 |
| Over 1000 to max. 2000 | 100 |
| Over 2000 | 150 |

**Fig.1 Working space**

## 2-2 Range of temperature fluctuation

The range of temperature fluctuation in the current standards is defined as the difference between the average high temperature and the average low temperature at the center of the test chamber. The new standards refer to ***temperature fluctuation***, which is defined as the difference between the maximum and minimum temperatures at discretionary points in the working space measured at specified time intervals after the temperature has stabilized. The new standards have set the discretionary points as being at the center and at the corners of the working space. As can be seen in Fig.2, to find the range of fluctuation according to current standards, average temperatures are first calculated for a measured point in the center of the chamber. Then, the average temperatures are separated into high and low temperatures and the average high and low temperatures are calculated, and the fluctuation is defined as the difference between these high and low averages. This difference is divided by two, and then that result is displayed as a ± value.

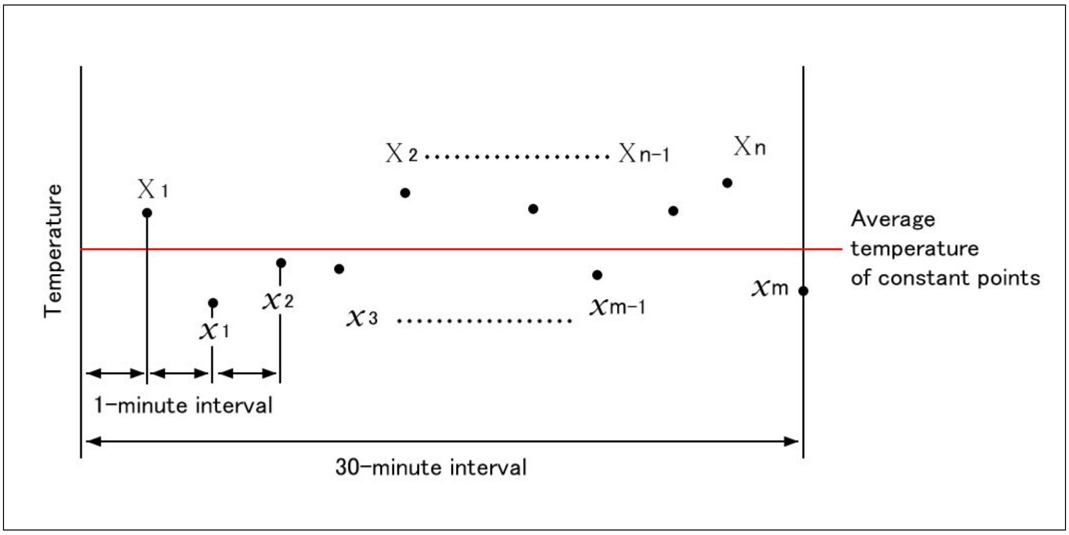



**Fig.2 Temperature fluctuation in current standards**

The calculation method used by the current standards is as follows.

$$\text{Average temp.} = \frac{X_1 + X_2 + \cdots + X_{n-1} + X_n + x_1 + x_2 + \cdots + x_{m-1} + x_m}{n+m}$$

$$\text{Average high temp.} = \frac{X_1 + X_2 + \cdots + X_{n-1} + X_n}{n}$$

$$\text{Average low temp.} = \frac{x_1 + x_2 + \cdots + x_{m-1} + x_m}{m}$$

Range of temperature fluctuation = ±(average high temp. - average low temp.)/2

No specific measurement procedures are presented in JIS C 60068-3-5 (IEC 60068-3-5). Actual measurements are performed at user-selected sampling intervals, and so one cannot say that the data has necessarily captured the peak temperatures.

The new standards call for statistical estimation of temperature fluctuation. After the temperature has stabilized, the temperature is measured at regular intervals at the specific measurement points, a minimum of 10 times for 30 minutes, and is represented as $X_1$,$X_2$, …$X_i$… $X_n$ (n ≧10). XAve represents the average value of X, and in $X_i$, the i represents a number from 1 to n. Using these, the $\sigma_{n-1}$ specimen standard deviation is defined as follows.

$$\sigma_{n-1} = \sqrt{\{[\Sigma(X_i - XAve)^2]/(n-1)\}}$$

Temperature fluctuation is found by taking $\pm 2\sigma_{n-1}$ for each of the 9 measurement points inside the working space and notating the greatest of these values as the temperature fluctuation. Units are represented in K (Kelvin, absolute temperature) or ℃ (Celsius).

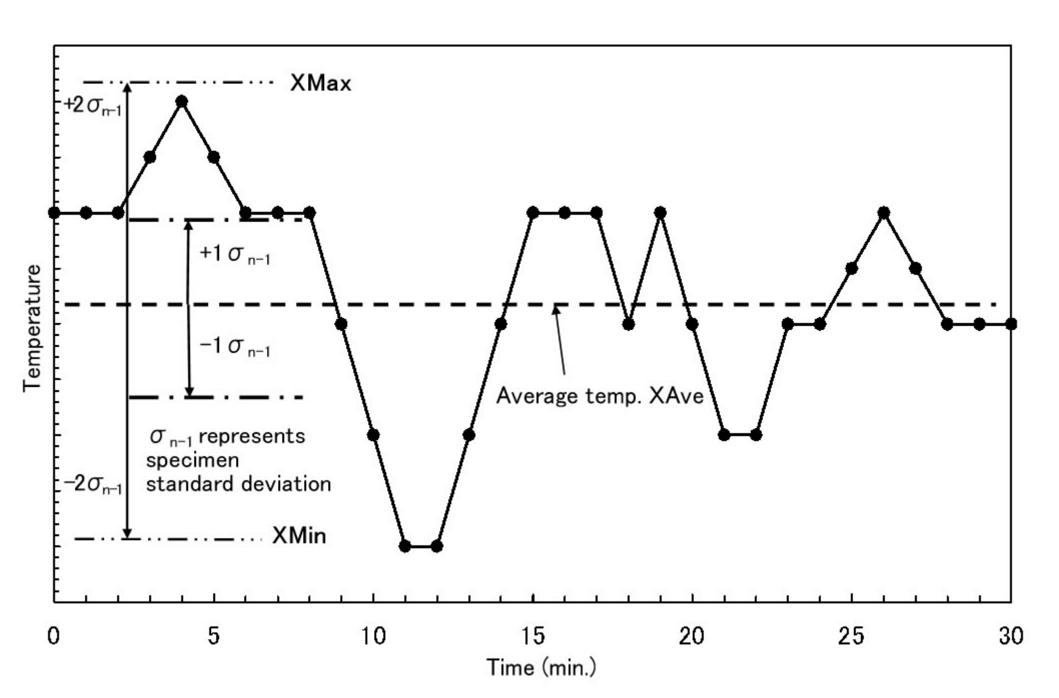



**Fig.3 Temperature fluctuation in new standards**

## 2-3 Temperature uniformity

In the current standards, temperature uniformity is defined as the temperature differential between the temperature at the center of the chamber and discretionary points in the working space. For the high temperature chamber or the temperature and humidity chamber, measurements are taken at a minimum of five points, which include the center of the chamber and at selected symmetrical points around the center, four of which are as far from the center as possible. For the temperature and humidity chamber, measurements are taken at nine points, which include at the center of the chamber and at each of the eight apices. First the average temperatures are calculated for each point, and then the average temperature at the center point is divided by the high and low temperatures. Next, the average temperatures are found for the high-temperature and low-temperature points. The temperature uniformity is the difference between the high and low average temperatures. This value is displayed as a ± value divided by 2.

The new standards, however, do not use the expression temperature uniformity, opting instead for the two terms ***temperature variation in space*** and ***temperature gradient.***

Temperature variation in space refers to the difference in average temperature between the center of the working space and separate discretionary points at some point in time after the temperature has stabilized. Measurements are taken at nine points: at the center of the working space and at the eight apices.

Temperature variation in space is defined as the maximum average difference between the average temperature at the center of the working space and the average temperatures at each of the other measurement points. This difference is expressed as an absolute value.

Average temperature at the center of the working space: XCenterAve
Average temperature at each of the working space apices: XCornerAve(j); j = 1 to 8
Temperature variation in space = |Max(XCornerAve(j) - XCenterAve)|

The temperature gradient is the greatest average difference between the average temperatures at two separate points within the working space at discretionary points in time after the temperature has stabilized. The nine measurement points are specified as at the center of the working space and at the eight apices. The temperature gradient is defined as the maximum difference in average temperature among the measurement points.

Maximum average temperature at each measurement point: XAveMax
Minimum average temperature at each measurement point: XAveMin
Temperature gradient = XAveMax - XAveMin

To sum up, temperature variation in space indicates how great a difference exists between the center of the working space and the rest of the working space. *Temperature gradient* indicates how great a difference exists among each of the various points in the working space. The two terms together express the concept of ***temperature uniformity.***

## 2-4 Heating and cooling time

In the current standards, heating and cooling time refers to the time required to reach the maximum or minimum temperature of the temperature control range from the ambient temperature under standard conditions at the center of the chamber. In the new standards, this term has been replaced with ***time to reach temperature extremes.*** The new standards have also added the term ***temperature rate of change.*** The temperature rate of change indicates the temperature for one minute, and refers to measuring the rate of temperature change between two specified points in time at the center of the working space. Fig.4 shows rate of change for an interval ten percent prior to both the maximum and minimum temperatures.

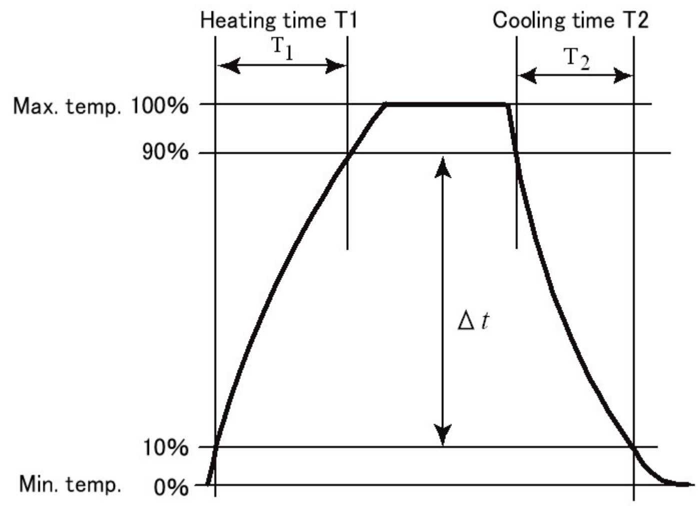



**Fig.4 Temperature rate of change for heating and cooling a test chamber**

The temperature rate of change is found using the following formula.

Temperature heating rate = $\Delta t/T_1$
Temperature cooling rate = $\Delta t/T_2$

The closer the temperature comes to the maximum or minimum temperature, the slower the rate of change, and so the *temperature rate of change* excludes that portion just prior to reaching maximum or minimum temperature. Because of this, it is not possible to know the actual time at which the maximum or minimum temperature is reached. Therefore, the heating and cooling time of the previous standard has changed only in its expression as *time to reach temperature extremes,* but the content adheres to the current concept with no change. The time to reach temperature extremes refers to the time to reach or pass through the temperature extreme from the ambient temperature under standard conditions at the center of the working space.

## 3 Current standards and the activation of new standards

The current standards will expire five years after the publication of the new standards. The new standards are for the ***temperature test chamber***. At the current stage JIS has not yet published new standards for the temperature and humidity test chamber, and so the new standards for the temperature test chamber will precede those for the temperature and humidity test chamber. As a result, current standards will continue to apply to the temperature and humidity test chamber, and only those contents concerning the temperature test chamber will proceed to application of the new standards.

**Table 2 Test chambers and standards subject to transition to new standards**

| Current standard number | Name of test chamber subject to current standard | Details of transition | Comments |
|---|---|---|---|
| JTM K01 | Temperature chamber | Transition to K07 as temperature test chamber | Measure expires 5 years after transition |
| | Temperature and humidity chamber | Current standard K01 stays in effect | Enactment of newer standard already planned |
| JTM K03 | Temperature room | Transition to K07 as temperature test chamber | Measure expires 5 years after transition |
| | Temperature and humidity room | Current standard K01 stays in effect | Enactment of newer standard already planned |
| JTM K05 | High temperature chamber | Full transition to K07 as temperature test chamber | Measure expires 5 years after transition |

## 4 Coming standards

The current standards have been established over a long period of time utilizing both domestic and foreign investigations as JTM has worked to standardize environmental testing equipment. The current standards are used not only in Japan but also around the world.

IEC 60068-3-5, enacted in 2001, has finally become a global standard. Five years have elapsed since its enactment as an international standard, and yet this standard is still not widely accepted throughout the world. In Europe there are wide variations in how this standard is applied. In America and Asia, even the contents are not well known.

JIS C 60068-3-5 was enacted in 2006, and so there has been a lot of discussion in Japan as to whether new JTM standards are necessary. The new JTM standards will not bring about changes in the hardware for environmental testing equipment, but rather will bring about changes in testing methods and in ways of indicating or expressing performance. Therefore, although the equipment may be the same, there is some concern that these changes have produced the misunderstanding that a loss of performance has occurred.

However, if we should disregard this international standard and remain at the current stage of domestic industrial standards, the situation would not be conducive to preparing for the coming global development. Japan Testing Machinery Association has borne the mission of supporting the development of the Japanese testing technology and the environmental equipment testing technology that have laid the foundation for the high quality of Japanese products, and JTM will bear the mission for taking a leading role globally in the future as well. Because of this, the new JTM standard is coordinated with the contents of the IEC 60068-3-5 standard, supplementing obscure points and producing a more well-developed standard.

Regarding temperature and humidity test chambers, the IEC 60068-3-6 standard was enacted in 2001. For this international standard as well, JTM plans to create a new JTM standard that supplements the obscure points and further develops the standard.

## 5 Conclusion

The IEC and JIS standards for temperature test chambers are utilized for all equipment used in environmental testing and are provided for the general use of the ***user*** to confirm the performance of test chambers. However, the contents are ***guidance***, and there is a danger that they can be subject to all kinds of interpretations when applied. To eliminate the variations caused by the interpretations among different users, we highly recommend that the new standards published by JTM be confirmed.

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