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**Clothing for protection against heat and
flame — Determination of heat
transmission on exposure to both flame
and radiant heat**

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Foreword

This Japanese Industrial Standard has been revised by the Minister of Economy, Trade and Industry and the Minister of Health, Labour and Welfare through deliberations at the Japanese Industrial Standards Committee as the result of proposal for revision of Japanese Industrial Standard submitted by Japan Safety Appliances Association (JSAA)/ Japanese Standards Association (JSA) with a draft being attached, based on the provision of Article 12, paragraph (1) of the Industrial Standardization Act applied mutatis mutandis pursuant to the provision of Article 16 of the said Act. This edition replaces the previous edition (**JIS T 8024: 2009**), which has been technically revised.

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Clothing for protection against heat and flame — Determination of heat transmission on exposure to both flame and radiant heat

Introduction

This Japanese Industrial Standard has been prepared based on **ISO 17492** : 2019, Edition 2, with some modifications of the technical contents in consideration of convenience in usage.

The vertical lines on both sides and dotted underlines indicate changes from the corresponding International Standard. A list of modifications with the explanations is given in Annex JA.

The measurement of the thermal energy transferred from the exterior of a material to the interior can be a significant factor in determining the level of protection or insulation provided by an assembly. While full-scale test methods are a better means of determining how an assembly performs, small scale tests such as those described in **JIS T 8020** and **JIS T 8021** can be used in establishing benchmarks of performance for the materials from which these assemblies are made. These tests specified in **JISs** enable the user of a material to anticipate how the properties of a particular material could affect the performance of the assembly when exposed to a high heat flux.

The purpose of an assembly for thermal protection is to prevent or reduce the potential for skin burn injury to the wearer. The performance of a product can be determined by comparing the total exposure energy to that which is transferred through the protective material to a known point where the thermal exposure would produce a burn injury in human tissue. The total exposure energy required to cause the onset of a second-degree burn in human tissue is identified as the thermal-protective index (TPI). In the TPI analysis of the data, the specimen is exposed to steady heat until the energy transferred through the specimen is equivalent to the energy that would cause the onset of a second-degree burn injury (e.g. a blister).

Other uses include comparison of the insulation from a high-temperature exposure in terms other than the TPI analysis of human tissue. For these uses, an alternate method of evaluating the heat transfer is provided. The total energy transferred that causes a temperature rise of the copper sensor by 12 °C and 24 °C is determined as the heat-transfer index-thermal (HTI-T_x). In the HTI-T_x analysis of the data, the specimen is exposed to heat until a specified amount of energy is transferred. This is a measure of the insulation performance and thermal capacity of the specimen.

Unlike what is specified in **JIS T 8020** and **JIS T 8021**, the heat source in this test method is adjusted so that the radiant heat becomes equivalent to the convective heat wherever possible, and this equalized radiant/convective output is set to a thermal en-

ergy exposure having a heat flux $(84 \pm 4) \text{ kW/m}^2$. The magnitude of this heat flux is intended to determine the performance of the specimen when exposed to both the high temperature radiation and hot gases that exist in actual fire situations. The level of this heat flux represents a moderately high industrial or emergency fire-fighting exposure that requires the use of a protective material.

- NOTE 1 The performance of materials made of flame-resistant fibres can be determined by the amount of heat energy transferred through the specimen and by observing any changes affected by the exposure on the specimen. The TPI and the HTI-T_x measure the accumulated thermal energy received by a sensor, which is an indication of the ability of the material to inhibit the transfer of heat.
- NOTE 2 A second-degree burn in human tissue (blister) is predicted to result when the total thermal energy transmitted by the material reaches the second-degree burn threshold identified by the Stoll curve.
- NOTE 3 The TPI or the heat-transfer index $[\text{HTI (DE)}_x, \text{HTI-T}_x]$ for flame-resistant materials can be used to establish anticipated thermal performance levels for single layer or multilayer constructions or assemblies.
- NOTE 4 Different specimen-mounting conditions, which are determined by the number of layers of material in the test specimen, are provided in this method. Each condition emphasizes a different thermal characteristic of the sample and represents the way in which the material is used in the end-use application.
- NOTE 5 The spaced configuration, with a spacer placed between the back surface of the specimen and the sensor, reflects applications in which there is an air space or gap between the specimen and the protected surface. This spaced configuration also eliminates the cooling effect, which occurs due to specimen contact with the sensor and allows the specimen to heat to a temperature during the test the same as that which might occur in an actual fire exposure. This mounting condition gives a measure of the insulation performance and thermal capacity of the specimen and air gap as a combination.
- NOTE 6 The contact configuration, with the sensor in contact with the specimen, gives a measure of the insulation performance and thermal capacity of the specimen and reflects applications in which the textile is in contact with the protected surface.

1 Scope

This Standard specifies a test method for measuring the heat transferred through horizontally mounted flame-resistant textile materials when exposed to a combination of convective and radiant heat. The exposure conditions shall be adjusted to be approximately a 50/50 mixture of pure convective heat and pure radiant heat. The total exposure heat flux shall be 84 kW/m^2 .

This test method is applicable to any type of sheet material used either as a single layer or in a multilayer construction when all structures or sub-assemblies are made of flame-resistant materials. It does not apply to materials that are not flame resistant.

This test method does not apply to the evaluation of materials exposed to any other type of thermal energy sources, such as radiant heat only or flame contact only. **JIS T 8020** is applicable when evaluating materials for exposure to radiant heat only. **JIS T 8021** is applicable when evaluating materials due to flame contact only.

Some, but not all, textiles materials can ignite and continue to burn after exposure to the convective and radiant heat produced by this test method.

This Standard should be used to measure and describe the properties of materials, products or assemblies in response to both convective and radiant energy under controlled laboratory conditions and should not be used to describe or appraise the fire hazard or fire risk of materials, products or assemblies under actual fire conditions. However, the results of this test method may be used as elements of a fire-risk assessment which takes into account all of the factors which are pertinent to an assessment of the fire hazard of a particular end-use.

NOTE 1 This test method may not correlate to heat-insulative performance of vertically oriented flame-resistant textile materials when exposed to a combination of convective and radiant heat or used in actual clothing configurations.

NOTE 2 The International Standard corresponding to this Standard and the symbol of degree of correspondence are as follows.

ISO 17492 : 2019 *Clothing for protection against heat and flame — Determination of heat transmission on exposure to both flame and radiant heat* (MOD)

In addition, symbols which denote the degree of correspondence in the contents between the relevant International Standard and JIS are IDT (identical), MOD (modified), and NEQ (not equivalent) according to **ISO/IEC Guide 21-1**.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this Standard. The most recent editions of the standards (including amendments) indicated below shall be applied.

JIS T 8020 *Protective clothing — Protection against heat and flame — Method of test : Evaluation of material and material assemblies when exposed to a source of radiant heat*

NOTE Corresponding International Standard : ISO 6942 *Protective clothing — Protection against heat and fire — Method of test : Evaluation of materials and material assemblies when exposed to a source of radiant heat*

JIS T 8021 *Protective clothing against heat and flame — Determination of heat transmission on exposure to flame*

NOTE Corresponding International Standard : ISO 9151 *Protective clothing against heat and flame — Determination of heat transmission on exposure to flame*

IEC 60584-1 Thermocouples — Part 1 : EMF specifications and tolerances

IEC 60584-3 Thermocouples — Part 3 : Extension and compensating cables —
Tolerances and identification system

3 Terms and definitions

For the purpose of this Standard, the following terms and definitions apply.

3.1

break-open

formation of a break and hole in the material during thermal exposure

3.2

burn injury

burn damage that occurs at various levels of depth within human tissue

NOTE Burn injury in human tissue occurs when the tissue is heated and kept at an elevated temperature for a critical period of time. The amount of burn injury (first, second or third degree) depends upon both the level of the elevated temperature and the duration. The material performance in this Standard is related to a second-degree burn injury and is determined by the amount of thermal energy transferred through the specimen that is sufficient to cause the onset of a second-degree burn. The onset of a second-degree burn injury involves damage to the epidermis and part of the dermis.

3.3

charring

formation of carbonaceous residue when material is exposed to heat energy

3.4

dripping

material response shown by the flow of the material and formation of falling droplets

3.5

embrittlement

formation of a brittle residue as the result of pyrolysis or incomplete combustion

3.6

exposure energy

thermal energy that is incident to the test specimen

3.7

exposure time

total time over which the exposure energy is applied to the test material

3.8

heat flux

thermal intensity indicated by the amount of energy transmitted divided by time and by area to the surface

NOTE Heat flux is expressed in kilowatts per square metre (kW/m²).

3.9

heat-transfer index

3.9.1

heat-transfer index-thermal, HTI(DE)_x

time, in whole seconds, to cause a temperature rise of the copper calorimeter by 12 °C and/or 24 °C from a combined convective and radiant heat exposure

NOTE The time to cause a 12 °C temperature rise is indicated with a subscript of 12, and time for a 24 °C rise with a subscript of 24, e.g. HTI(DE)₁₂ and HTI(DE)₂₄. The relative value between these two indices indicates the characteristic of the energy transfer. If HTI(DE)₂₄ is twice that of HTI(DE)₁₂, the rate of energy transfer is constant. If HTI(DE)₂₄ is greater than twice that of HTI(DE)₁₂, the rate of energy transfer is increasing, showing a loss in insulation performance. If HTI(DE)₂₄ is less than twice that of HTI(DE)₁₂, the rate of energy transfer is decreasing, showing increasing insulation performance.

3.9.2

heat-transfer index-thermal, HTI-T_x

total exposure energy, expressed in kJ/m², to cause a temperature rise of the copper calorimeter by 12 °C and/or 24 °C from a convective and radiant heat exposure

NOTE It is to be noted that the definition of heat-transfer index-thermal (HTI-T_x) specified in this Standard is different from that of heat-transfer index (HTI) specified in JIS T 8021.

3.10

heat-transfer burn intersection

point at which the thermal energy transferred through the material intersects the point on the Stoll curve where a second-degree burn injury is predicted to begin

3.11

heat-transfer burn time, t_i

time since the initiation of the thermal exposure to heat transfer burn intersection

NOTE Heat transfer is determined from the measured temperature rise of a sensor. In this test method, a copper calorimeter is used as the sensor. The calorimeter diameter is large enough to average the heat received through the exposed specimen. The calorimeter thickness is selected so as to cause the temperature rise of the sensor to be similar to that of

human tissue when exposed to heat. The sensor face is painted a dull black to cause it to absorb radiant heat similarly to human tissue.

3.12

human-tissue heat tolerance

amount of thermal energy transferred to human tissue that predicts a reaction in human tissue, such as a pain sensation or the onset of a second-degree burn

NOTE The tolerance of human tissue to heat exposure was developed by Stoll et al. (see Table 1) and is referred to as the Stoll curve. It is used in this method as the heat transfer criteria in determining the thermal protection index (TPI) value of the test material.

3.13

ignition

response by the specimen to heat that appears as an initiation of combustion

3.14

melting

liquefaction of a material when exposed to heat

NOTE Melting can be visually observed by appearance of flow by liquefaction or formation of droplets on the specimen entirely or partially.

3.15

shrinkage

dimensional decrease in one or more directions of a specimen caused by heat

3.16

sticking

response evidenced by softening of a material and adherence of one material to the surface of itself or another material

3.17

Stoll curve

relationship between the amount of thermal energy absorbed by human tissue and the time of exposure which predicts the onset of a second-degree burn in human tissue

NOTE For human-tissue heat tolerance to a second-degree burn, see Table 1.

Table 1 Human-tissue heat tolerance to a second-degree burn

Exposure time s	Heat flux ^{a)} kW/m ²	Total energy kJ/m ²	Copper calorimeter ^{b)} equivalent	
			ΔT °C	ΔV mV
1	50	50	8.9	0.46
2	31	61	10.8	0.57

Table 1 (concluded)

Exposure time s	Heat flux ^{a)} kW/m ²	Total energy kJ/m ²	Copper calorimeter ^{b)} equivalent	
			ΔT °C	ΔV mV
3	23	69	12.2	0.63
4	19	75	13.3	0.69
5	16	80	14.1	0.72
6	14	85	15.1	0.78
7	13	88	15.5	0.80
8	11.5	92	16.2	0.83
9	10.6	95	16.8	0.86
10	9.8	98	17.3	0.89
11	9.2	101	17.8	0.92
12	8.6	103	18.2	0.94
13	8.1	106	18.7	0.97
14	7.7	108	19.1	0.99
15	7.4	111	19.7	1.02
16	7.0	113	19.8	1.03
17	6.7	114	20.2	1.04
18	6.4	116	20.6	1.06
19	6.2	118	20.8	1.08
20	6.0	120	21.2	1.10
25	5.1	128	22.6	1.17
30	4.5	134	23.8	1.23
Notes ^{a)} See Bibliography [1].				
^{b)} Iron/constantan thermocouple (Type J).				

3.18

thermal protective index, TPI

total exposure energy, expressed in kJ/m², of heat transferred through a material to cause a second-degree burn injury in human tissue

4 Principle

A flame-resistant specimen, mounted in a static horizontal position, is placed a specific distance from a combined convective/radiant heat source and exposed to a heat flux of (84 ± 4) kW/m² until sufficient thermal energy passes through the specimen to cause the equivalent of the onset of a second-degree burn injury in human tissue, or to indicate a temperature rise of 24 °C in the copper calorimeter.

The specimen is mounted either in direct contact with the copper calorimeter, designated as the “contact configuration”, or with a (6.35 ± 0.05) mm air space between the specimen and the copper calorimeter, designated as the “spaced configuration”.

The test exposure is composed of convective energy supplied by two gas burners and radiant heat from nine halogen lamps. The combined total heat flux is achieved by first setting the radiant exposure and then adding the convective source. The total energy

exposure is then confirmed with the copper calorimeter.

The amount of energy transferred through and by the specimen is measured with a copper calorimeter and analysed by one of the following two methods.

- a) The thermal performance can be evaluated from the times for a 12 °C and 24 °C temperature rise in the copper calorimeter : the HTI(DE)_x value. The rate at which the temperature of the copper calorimeter rises is a direct measurement of the thermal energy transferred.
- b) The thermal performance can also be compared with the times for the energy transferred through and by the specimen to cause the onset of a second-degree burn : the TPI .

The effect of the exposure on the physical appearance of the specimen can also be noted in either evaluation method.

5 Apparatus

5.1 General

The test apparatus shall consist of

- combined heat source consisting of nine 500 W T3 type halogen lamps and two gas burners,
- specimen holder assembly,
- protective shutter,
- specimen support holder plate (specimen mounting plate, specimen holding plate and if necessary, spacer), and
- sensor assembly.

The apparatus shall also have a gas supply, gas rotameter, and data acquisition system. Figure 1 shows the general layout of the apparatus and the arrangement for the specimen holder assembly.

NOTE Annex A provides reference information on the availability of test equipment components.