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Foreword

This translation has been made based on the original Japanese Industrial Standard revised by the Minister of International Trade and Industry through deliberations at the Japanese Industrial Standards Committee in accordance with the Industrial Standardization Law. Consequently **JIS C 2520 : 1986** is replaced with **JIS C 2520 : 1999**.

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4-1-24, Akasaka, Minato-ku, Tokyo, 107-8440 JAPAN

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Wires and rolled wires for electrical heating

Introduction This Japanese Industrial Standard has been prepared based on the first edition of **IEC 60182-4** *Basic dimensions of winding wires—Part 4 : Diameters of conductors for round resistance wires* issued in 1971 without modifying its technical contents. Particular requirements not specified in the relevant IEC Standard are given as JIS requirements in the clauses (3 to 5 and 7 to 12). The portions underlined with dots in Attached Table 2 do not exist in the corresponding International Standard.

By the way, **IEC 60182-4** was withdrawn in 1990 and replaced by **IEC 60317-0-1** *Specifications for particular types of winding wires—Part 0 : General requirements—Section 1 : Enamelled round copper wire*. This Standard has no corresponding relations with **IEC 60317-0-1**, since the scope is different between the both standards.

1 Scope This Standard specifies electrical heating wires and rolled wires (hereafter referred to as “wires and rolled wires”) of alloys mainly composed of nickel and chromium, or iron, chromium and aluminum, to be used mainly as heating elements.

Note : The International Standard corresponding to this Standard is as follows.

IEC 60182-4 : 1971 *Basic dimensions of winding wires—Part 4 : Diameters of conductors for round resistance wires*

2 Normative references The standards given in Attached Table 1 contain provisions which, through reference in this Standard, constitute provisions of this Standard. The most recent editions of the standards shall be applied.

3 Definitions For the purpose of this Standard, the definitions given below shall apply:

- a) **rolled wire** Wire materials to have been rolled, or rolled and drawn then wound into a coil.
- b) **volume resistivity** Electrical resistance (Ωm) per unit cross section and unit length.
- c) **effective cross section** An area of cross section of the rolled wire equivalent to the product of its thickness and its width and multiplied by a constant coefficient (mm^2).
- d) **conductor resistance** The electrical resistance per unit length in longitudinal direction of a conductor having a uniform cross section (Ω). Unit length is usually 1 m or 1 km and the conductor resistance is given in (Ω/m) or (Ω/km) respectively.
- e) **life** The number of repetitive cycles of a test piece having a diameter of 0.50 mm made from the heating element until it breaks as a result of repetition of electrical heating and cooling under the prescribed conditions (number of times).

4 Classification and symbols The classification and the symbols of wires and rolled wires are shown in Table 1.

Table 1 Classification and symbols

Class			Symbol	Properties and usage (informative)
Nickel chromium for heating	Wire	Class 1	NCHW1	Wires and rolled wires of Class 1 Wires and rolled wires of Class 1 are superior in non-oxidizing property and high temperature strength; preferably not to be used in sulfide gas, or in reducing atmosphere at high temperature and humidity. Workability does not deteriorate even after high temperature heating, and is well maintained even for cold working. Maximum operating temperature is approx. 1 100 °C (heating element surface), widely usable in high temperature heating elements. Wires and rolled wires of Class 2 Wires and rolled wires of Class 2 have non-oxidizing property and high temperature strength slightly inferior to nickel chromium heating wires and rolled wires of Class 1. Maximum operating temperature is approx. 1 000 °C (heating element surface) which suits high temperature heating elements. Wires and rolled wires of Class 3 Wires and rolled wires of Class 3 are slightly inferior to nickel chromium heating wires and rolled wires of Class 2 in non-oxidizing property but superior in sulfide resistance. Maximum operating temperature is approx. 800 °C (heating element surface) which suit heating elements.
		Class 2	NCHW2	
		Class 3	NCHW3	
	Rolled wire	Class 1	NCHRW1	
		Class 2	NCHRW2	
		Class 3	NCHRW3	
Iron chromium for heating	Wire	Class 1	FCHW1	Wires and rolled wires of Class 1 Wires and rolled wires of Class 1 are especially intended for use at high temperature and superior in non-oxidizing property, but high temperature strength is inferior to nickel chromium heating wires and rolled wires, which is to be noted. If cold working is difficult, hot (100 °C to 300 °C) working is required. Working after high temperature use should preferably be avoided. Maximum operating temperature is approx. 1 250 °C (heating element surface) which suits high temperature heating elements. Wires and rolled wires of Class 2 Cold working is slightly easier than iron chromium heating wires and rolled wires of Class 1, but high temperature strength and workability after exposure to high temperature are inferior to nickel chromium heating wires and rolled wires of Class 1, which should be noted. Maximum operating temperature is approx. 1 100 °C (heating element surface) which suits high temperature heating elements.
		Class 2	FCHW2	
	Rolled wire	Class 1	FCHRW1	
		Class 2	FCHRW2	

5 Quality

5.1 Appearance The wires and rolled wires shall have smooth surface and be free from flaws, twists, cracks, sticking substances and other defects. However, the color of finished surface shall be determined by an agreement between the parties concerned.

5.2 Chemical ingredients The chemical ingredients of the wires and rolled wires shall comply with Table 2.

Table 2 Chemical ingredients

Class	Chemical ingredients % (m/m)						
	Ni ⁽¹⁾	Cr	Al	C	Si	Mn	Fe ⁽²⁾
Nickel chromium heating wire and rolled wire of Class 1	77 min.	19 to 21	—	0.15 max.	0.75 to 1.6	2.5 max.	1.0 max.
Nickel chromium heating wire and rolled wire of Class 2	57 min.	15 to 18	—	0.15 max.	0.75 to 1.6	1.5 max.	Re- mainder
Nickel chromium heating wire and rolled wire of Class 3	34 to 37	18 to 21	—	0.15 max.	1.0 to 3.0	1.0 max.	Re- mainder
Iron chromium heating wire and rolled wire of Class 1	—	23 to 26	4 to 6	0.10 max.	1.5 max.	1.0 max.	Re- mainder
Iron chromium heating wire and rolled wire of class 2	—	17 to 21	2 to 4	0.10 max.	1.5 max.	1.0 max.	Re- mainder

Notes (1) A small amount of cobalt may be contained.

(2) Other elements may be contained.

5.3 Volume resistivity, life and elongation

5.3.1 Volume resistivity Wires and rolled wires shall be tested according to 8.2.2 and comply with the specifications in Table 3. However, this does not apply to the wires of diameter less than 0.355 mm and the rolled wires of thickness less than 0.5 mm.

5.3.2 Life Wires and rolled wires shall be tested according to 8.2.3 and comply with the specifications in Table 3.

5.3.3 Elongation Wires and rolled wires shall be tested according to 8.2.4 and comply with the specifications in Table 3. However, this applies to the nickel chromium wires of Class 1, 2 and 3 having a diameter 0.20 mm or more, to the iron chromium wires of Class 1 and 2 having a diameter 0.50 mm or more, and to the rolled wires having a thickness 0.20 mm or more.

Table 3 Volume resistivity, life and elongation

Class	Volume resistivity $\mu\Omega \cdot m$		Life		Elongation (%)
	Standard value	Tolerance	Testing method	Number of times	
Nickel chromium heating wire and rolled wire of Class 1	1.08	± 0.05	I method 1 200 °C	300 min.	20 min.
Nickel chromium heating wire and rolled wire of Class 2	1.12	± 0.05	I method 1 200 °C	200 min.	20 min.
Nickel chromium heating wire and rolled wire of Class 3	1.01	± 0.05	I method 1 200 °C	100 min.	20 min.
Iron chromium heating wire and rolled wire of Class 1	1.42	± 0.006	U method 1 300 °C	100 min.	10 min.
Iron chromium heating wire and rolled wire of class 2	1.23	± 0.06	U method 1 300 °C	70 min.	10 min.

5.4 Conductor resistance and its tolerance

5.4.1 Conductor resistance Wires and rolled wires shall be tested according to 8.2.5, and the conductor resistance of the specific wire shall satisfy the specifications for its size in Attached Table 2 and the conductor resistance of the specific rolled wire shall satisfy the specification for its size in Attached Table 4.

However, their conductor resistance with dimensions other than specified in the Tables shall satisfy the value derived from the formula in 8.2.5 subject to the agreement between the parties concerned.

5.4.2 Tolerances of conductor resistance The tolerance of conductor resistance of a wire shall comply with the specifications in Attached Table 2 and the tolerance of conductor resistance of a rolled wire shall comply with the specification in Attached Table 4.

However, their tolerances of conductor resistance with dimensions other than specified in the above mentioned Attached Tables shall comply with Attached Table 5 for wires and Attached Table 6 for rolled wires.

6 Dimensions and tolerances Dimensions and tolerances of wires and rolled wires shall be tested according to 8.2.6 and satisfy the specifications in Attached Tables 2 and 3. However, the diameters of wires with dimensions other than specified, and the thickness and width of rolled wires with dimensions other than specified may be determined, for the time being, by an agreement between the parties concerned. In this case, the tolerances shall comply with Attached Table 7.

7 Manufacturing method Wires and rolled wires shall, after drawn or rolled, be annealed at an appropriate temperature and in an appropriate atmosphere.

8 Tests

8.1 Standard conditions of the testing site The tests of 8.2.2, 8.2.4, 8.2.5 and 8.2.6 shall be carried out at ordinary temperature as specified in **JIS Z 8703**.

8.2 Testing methods

8.2.1 Chemical analysis The chemical analysis shall be carried out in accordance with **JIS H 0321** and any one of **JIS G 1211**, **JIS G 1256**, **JIS H 1411** or **JIS H 1412**.

8.2.2 Volume resistivity test The volume resistivity test shall be carried out in accordance with **JIS C 2525** under the standard test condition of temperature 23 °C.

8.2.3 Life test The life test shall be carried out in accordance with **JIS C 2524**.

8.2.4 Tensile test The tensile test shall be carried out in accordance with **JIS Z 2241**, using test pieces conforming to **JIS Z 2201**, type number of which is No. 9A for wires and No. 7 for rolled wires. The test piece of No. 9A may be substituted, if the test piece of No. 7 is not available. The gauge length of the test piece of No. 7 is regarded as 30 mm if the calculation shows that it is less than 30 mm.

8.2.5 Conductor resistance test The conductor resistance test shall be carried out in accordance with **JIS C 2525** under the standard test condition of temperature 23 °C.

The conductor resistance not specified for its size is derived from the following formula, and the figures are rounded off to 3 significant figures according to **JIS Z 8401**.

$$R_c = \rho / A$$

where, R_c : conductor resistance (Ω/m)

ρ : volume resistivity given in Table 3 ($\mu\Omega \cdot \text{m}$)

A : effective cross section having the value (mm^2) derived from the dimension agreed upon between the parties concerned and rounded off to 4 significant figures according to **JIS Z 8401**. Where, following conditional calculations are to be preceded; thickness $\times$ width $\times$ 0.96 for rolled wires having a width less than 10 mm and thickness $\times$ width $\times$ 0.98 for rolled wires having a width equal to 10 mm or more.

8.2.6 Dimension test The test for dimensions shall be as follows.

- a) **Wires** The dimension of wires shall be indicated in the mean value of two diameters, the greatest and the smallest, measured with cross section perpendicular to the longitudinal direction. Both diameters shall be within the tolerance limits.

Diameters shall be measured with an instrument capable of measuring up to 1/1 000 mm. However, a micrometer specified in **JIS B 7502** may be used for wires having a diameter 5.6 mm or more.