Operation Manual

High temperature
WELDABLE STRIAN GAUGE
AWMD series

Tokyo Measuring Instruments Lab.

Introduction

This manual describes the handling methods and work procedures for the **High temperature Weldable Strain Gauge AWMD Series**.

In order to ensure proper installation of and measuring with this product, please read this manual thoroughly and understand the performance and handling of this product well prior to use.
Please keep this manual with care so that you can read anytime.

■ Notes for reading this manual

In this manual, the following indications are used to describe important matters. Please ensure to read these indications.

⚠ Danger	This indicates a content which erroneous handling by ignoring this indication can cause a risk of death or serious injury / disease to human.
⚠ Warning	This indicates a content which erroneous handling by ignoring this indication can cause a risk of injury / damage to human.
⚠ Caution	This indicates a content which erroneous handling by ignoring this indication can cause a physical hazard.
Note	This indicates a note or supplement for operations that are easily mistaken, etc.
✍	This indicates a content and helpful information to deepen understanding of the contents of the main text.

Safety precautions

⚠ Warning

Handling	Implement safety measures to prevent your hand from being cut by the gauge base during installation work.
Spot welding	Wear goggles to prevent welding sparks from getting into your eyes during spot welding.

⚠ Caution

Malfunction	Do not drop or hit this product. Strong vibration or impact causes a malfunction.
	Do not disassemble or modify this product in any case. Failure to follow this instruction causes injuries or malfunction.
	Avoid the use beyond the operational temperature range. Failure to follow this instruction causes malfunction.
Trial welding	Put the welding holder tip vertically on to the metal ribbon and push the welding holder downward. In the case that a crack or hole is generated on the metal ribbon at this point, lower the output energy of the welder and try again. In the case that the metal ribbon is not welded at all, increase the output energy.
Overcurrent	Do not operate beyond the maximum allowable current of 50mA.
Exciting voltage	Continuous operation beyond the allowable exciting voltage may cause drifts and may not satisfy the specifications.
	When using any measuring device other than a strain meter, use the device with sufficiently stable exciting voltage to the bridge.
MI cable	Do not forcibly bend the MI cable. Do not put any object on the cable, do not pull the cable, and do not otherwise damage the cable.

Check and storage

Check	Measure the insulation resistance [Ω] between the input/output wire of the cable and the specimen by using an insulation resistance tester (with excitation voltage of DC 50V or lower) and confirm that it is 1000 MΩ or over.
Storage	For storage, avoid a high or low temperature and/or high humid place, dirt, dust, water drops, vibration, impact, etc.

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✎Memo

Chapter 1

Overview

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1.1 Overview and features

High temperature Weldable Strain Gauses are installed on metal surfaces by spot welding using a dedicated welder (separately sold). As the sensing elements and lead wires are fully encapsulated in corrosion-resisting and heat-resisting alloys, they can be used for measurement in various environment including in seawaters or gases. Their maximum operational temperature is higher than that of bonded strain gauges, and coating is basically not required.

The AWMD Series gauges are applicable to the high-temperature range up to + 800°C and are dedicated to dynamic strain measurement. A high pass filter is supplied as the standard part. By using the high pass filter, unnecessary direct current component and low frequency component (thermal output, drift, etc.) in the phenomenon waveforms to measure can be cancelled. A high pass filter can be selected from 1.6 Hz, 7.2 Hz or 16 Hz according to the frequency to measure.

The measurement method is full bridge method. An instrument with DC bridge excitation such as dynamic strain meter DC-96A/DC-97A, ultra-small dynamic strain recorder DC-204R or multi-recorder TMR Series (separately sold) should be used for measurement.

This product is a CE-compliant product.

1.2 Specifications

Standard type name *1		AWMD-5-AKM-2(6F)-1.6Hz	AWMD-8-A-2-1.6Hz
Gauge length		5 mm	8 mm
Resistance element material		Special alloy	
Gauge base	Dimensions (mm)	L10 × W3 × T0.7	L16 × W5 × T0.7
	Material	Inconel 600	
Resistance		Approx. 60 Ω	Approx. 120 Ω
Operational temperature range *2		Dynamic: -196 ~ +800°C	
Temperature compensation range		N/A	
Measurement target materials		Inconel 600 or equivalent	
Applicable coefficient of expansion		12×10^{-6}/°C	
Installation method		Spot welding	
Standard lead wire *1		φ1.6mm MI cable: 2m, φ1.6mm FEP cable: 0.5m	φ1.6mm MI cable: 2m, φ4.1mm shielded vinyl cable: 0.5m
MI cable sheath material		Inconel 600	
Connection method		Full bridge method	
Insulation resistance		1000 MΩ or more (at room temperature)	
Maximum allowable current		50 mA (at room temperature)	
Frequency response		Approx. 2 ~ 3 kHz	
Strain limit *3		1% (10000 μm/m)	
Fatigue life *4		1×10^{6} times	

As the features described here are for reference, they may change by the influence of temperature, operating conditions, etc.

*1: The type name varies by temperature compensation range, MI cable length and supplied cable length.

*2: Although the low-temperature side (-196°C ~ room temperature) can be used (for measurement) owing to the structure, prior check is required.

*3: Strain limit shows a result at room temperature.

*4: Fatigue life shows a result at room temperature with a strain level of ± 1000μm/m (15 Hz).

1.3 Standard accessories

Operation manual		1 copy
Test data		1 copy
Metal ribbon	Material: Inconel 600 Dimensions: L40×W5×T0.08 mm	2 pcs.

1.4 Name of each part and external dimensions

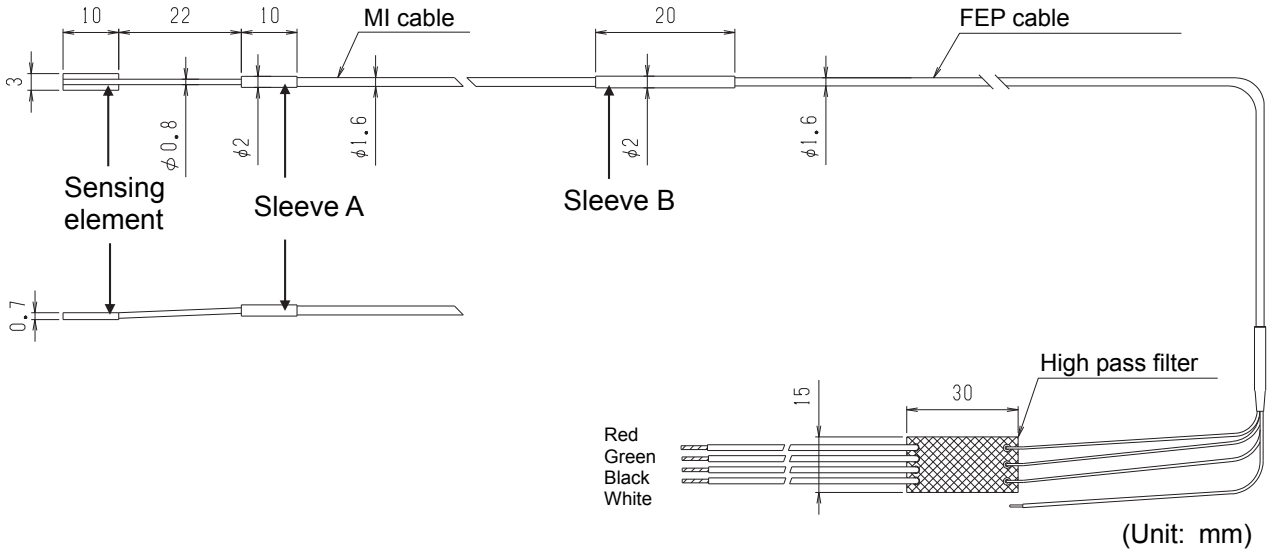


Figure 1.1: Appearance of AWMD-5

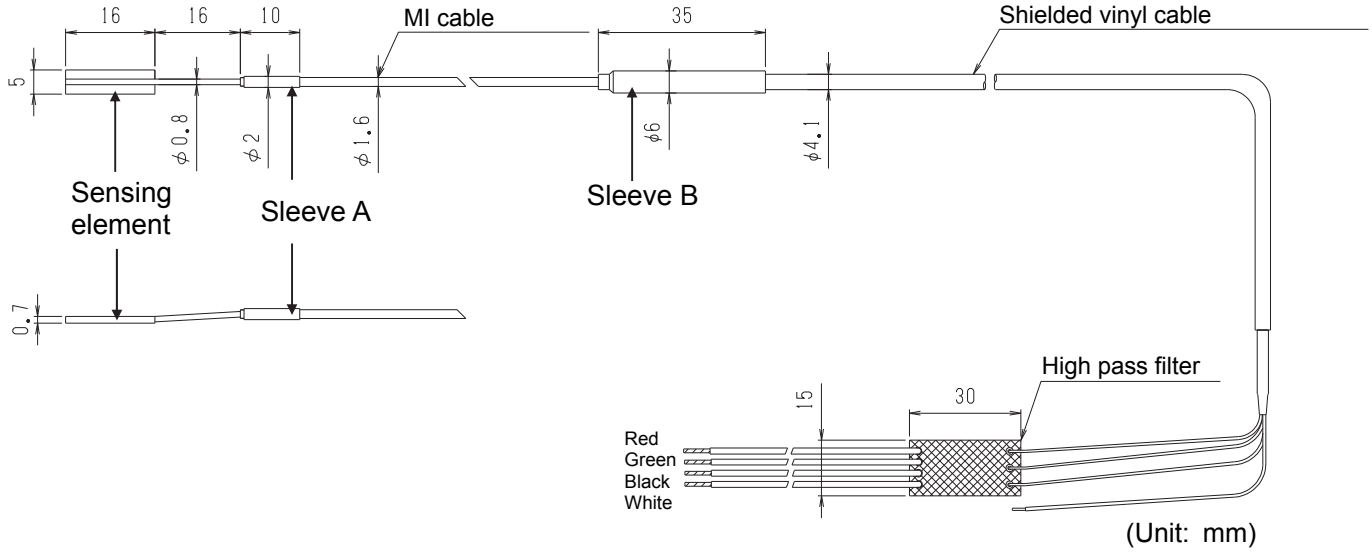


Figure 1.2: Appearance of AWMD-8

⚠ Caution The cable end is processed by lead-free soldering. Use a lead-free solder (of Sn-Ag) for soldering.

✍ The center of sensing element is at the center of the gauge base.

1.5 Circuit

■ Sensing element

Figure 1.3: Sensing element

■ Circuit

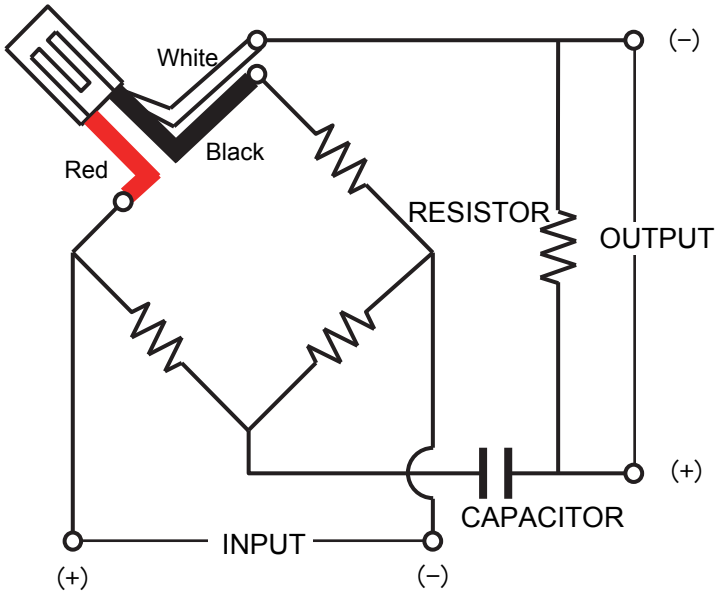


Figure 1.4: Circuit

Chapter 2

Installation method

2.1 Installation method ····· 2 - 2

2.1 Installation method

■ 시편의 표면처리

(1) 스트레인 게이지를 설치하기 전에 설치 표면의 밀스케일, 녹, 오일 등을 완전히 제거하십시오. 일반적인 본딩형 스트레인 게이지와 마찬가지로 아세톤이나 기타 적절한 용매로 오일을 제거한 후 120호 정도의 사포로 철저히 연마하십시오.

(2) 연마 후 게이지를 다시 설치할 표면을 아세톤이나 기타 적절한 용매로 세척하십시오. 세척 후 손이나 손가락으로 표면을 만지지 마십시오.

⚠ Caution 게이지 베이스의 점용접 중 시편 및/또는 게이지 베이스가 더러우면 스파크가 발생할 수 있습니다.

■ Trial welding

(1) 게이지를 설치하기 전에 제공된 금속 리본으로 시운전 용접을 수행하여 용접 조건을 확인합니다.
(2) 용접기의 용접 출력을 초당 약 10와트로 설정하고 점용접을 수행합니다. 이때 금속 리본에 균열이나 구멍이 발생하는 경우 용접기의 출력 에너지를 낮추고 다시 시도합니다. 금속 리본이 전혀 용접되지 않는 경우 출력을 높입니다.

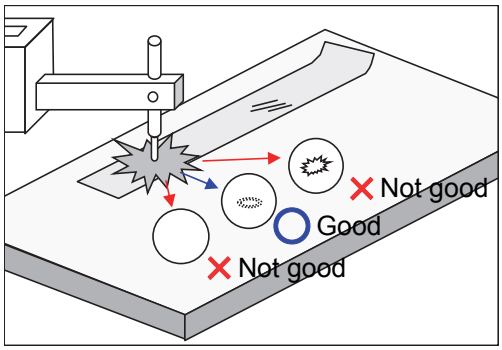


Figure 2-1: Check of trial welding

(3) 시용접 후 금속리본을 벗겨낸다. 용접부에 구멍이 생기면 용접강도가 충분하다는 뜻이다.

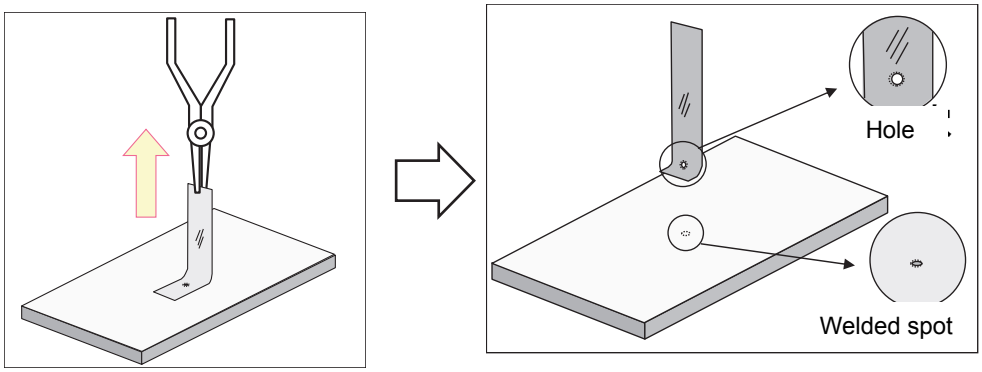


Figure 2-2: 금속 리본의 벗겨짐 확인

참고: 전용 용접기를 사용하기 전에 제품과 함께 제공된 사용 설명서를 반드시 읽어보세요.

■ Installation of the strain gauge

(1) The strain gauge is installed in the following order: fix the Sleeve A; fix the MI cable; and fix the gauge base.

(2) Set the center of gauge base to the center of marking-off and fix the Sleeve A by using the supplied metal ribbon.

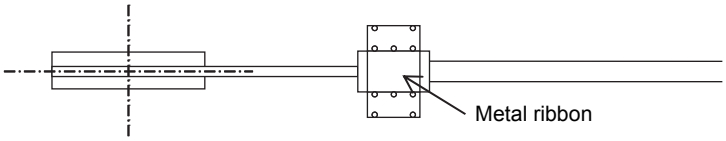


Figure 2.3: Fixing of the Sleeve A

(3) Fix the MI cable at the appropriate length for one section, while avoiding any load on the fixed Sleeve A.

(4) Slightly curve the MI cable and fix toward the direction of the Sleeve B, while avoiding any excessive force on the sensing element. Keep the distance of approximately 10 mm or over between the section for curving the MI cable and both of the Sleeve A and Sleeve B, and also secure the curvature diameter (approx. 10 mm or more) which is five times or more of the diameter of MI cable (1.6 mm).

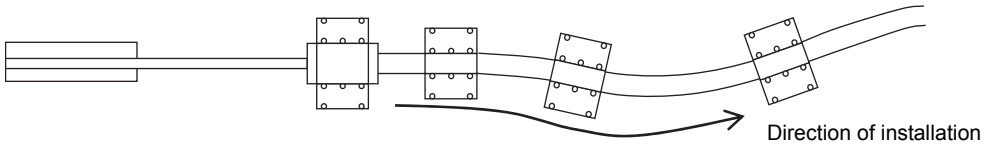


Figure 2.4: Fixing of the MI cable

(5) Align the sensing element to the position of marking-off and temporarily fix the both sides of gauge base on each one point by spot welding.

(6) Perform sport welding in order of the number along the gauge pipe. The appropriate welding interval is approximately 0.8mm-pitch.

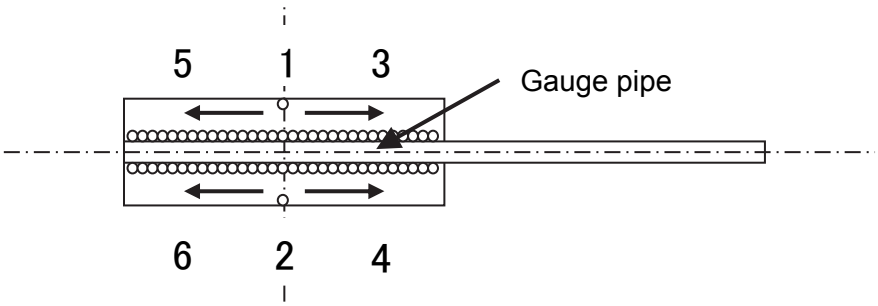


Figure 2.5: Fixing of the gauge base

⚠ Caution	Sandblast treatment has been implemented for the strain gauge to prevent sparks during welding work. Do not touch it directly by hand to avoid any dirt or damage.

■ Bending

● MI cable

MI 케이블을 구부릴 때는 굽힘 반경을 5mm 이상으로 확보하고 조심스럽게 구부리십시오.

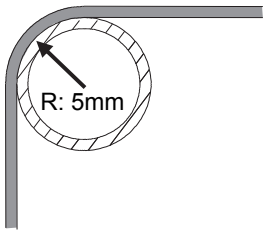
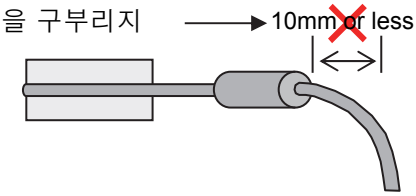


Figure 2.6: Bending of the MI cable

⚠ Caution MI 케이블 굽힘 시작점과 슬리브 A, 슬리브 B 사이의 거리는 10mm 이상 유지하세요.

이 부분을 구부리지 마세요



✍ **감지 요소를 보호하기 위한 게이지 보호 튜브의 직경은 10mm입니다.**

● 게이지 베이스

스트레인 게이지는 굽힘 없이 직경 80mm 이상의 시편에 설치할 수 있습니다.

직경이 40~80mm인 경우 다음 절차에 따라 굽힘을 수행합니다.

(1) 시편과 같은 직경의 지그와 실리콘 고무 등의 완충재를 준비합니다.

(2) 손가락으로 게이지 베이스를 지그에 단단히 밀어 넣고 굽힘 표면을 따라 천천히 구부립니다. 구부린 후 게이지 베이스는 약간 원래 위치로 구부러집니다.

(3) 게이지 베이스를 아세톤 또는 기타 적절한 용매로 세척합니다. 세척 후 손이나 손가락으로 만지지 마십시오.

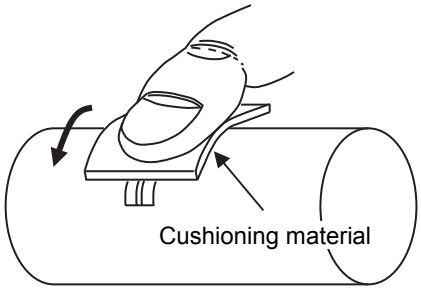


Figure 2.7:게이지 베이스 굽힘

⚠ Caution **감지 요소를 굽힐 수 있는 최소 직경은 40mm입니다.**

⚠ Caution 굽힘 후 반대 방향으로 굽히면 감지소자가 손상됩니다.

⚠ Caution **굽힘으로 인해 저항값의 균형이 깨지므로, 열 출력 추세가 제공된 시험 데이터의 특성 데이터와 다를 수 있습니다.**

Chapter 3

Measurement

3.1 Measurement method ····· 3 - 2

3.1 Measurement method

■ Wiring method

● When measuring with the supplied high pass filter

(1) Install the strain gauge on to the specimen under the procedures described in “2.1 Installation method”.

(2) The cable end is not equipped with a connector as the standard specifications. Connect the cable wires to the terminal of our bridge box (example: SB-120B or SB-128A) by screwing or soldering.

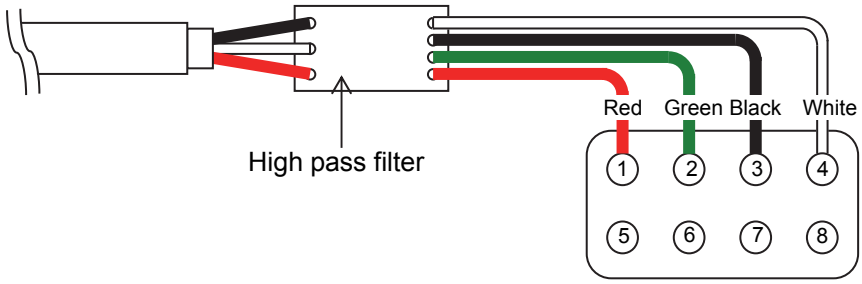


Figure 3.1: Connection to the instrument (Example of SB-120B or/ SB-128A)

⚠Caution	The excitation voltage must be 50 V or less when checking the insulation resistance, etc.
⚠Caution	The strain gauge temperature is required for organizing the measured data. Be sure to measure the temperature as well as the strain at the same time.
⚠Caution	The MI cable may pick up noise if it is moved. Pay enough attention to firmly fix the MI cable in the wiring works, and prevent the MI cable from moving during measurement.
⚠Caution	Lead-free soldering has been performed for the cable end. Use the lead-free solder (Sn-Ag) for soldering.

●When measuring without the use of supplied high pass filter or when measuring by using an AC amplifier (dynamic strain meter with AC bridge excitation).

(1) Install the strain gauge on to the specimen under the procedures described in “2.1 Installation method”.

(2) Remove the high pass filter by using a soldering iron.

(3) The wiring method varies depending on the strain gauge to be used. Connect to the terminal of our bridge box (example: SB-120B or SB-128A) by screwing or soldering.

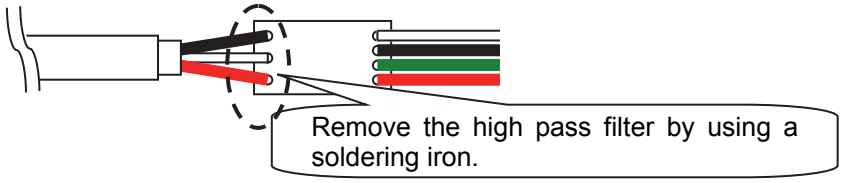


Figure 3.2: Removing the high pass filter

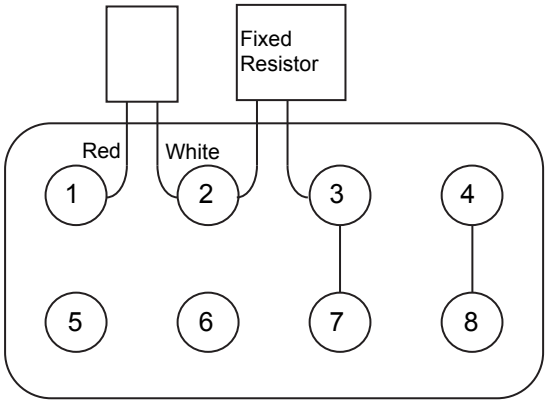
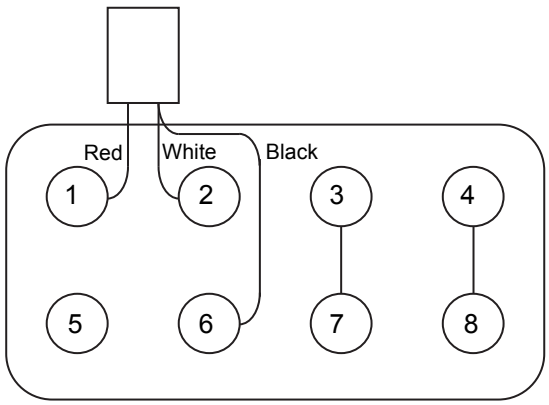
	
Half bridge connection with the strain gauge on active side and a fixed resistor of approx. 60Ω on dummy side	Quarter bridge 3-wire connection
AWMD-5 (Gauge resistance: 60Ω)	AWMD-8 (Gauge resistance: 120Ω)

Figure 3.3: Connection to the instrument (example of instrument: SB-120B / SB-128A)

⚠Caution	If the high pass filter is removed, temperature influence on the thermal output and/or drift may significantly change.
⚠Caution	When temporarily disconnecting the temperature compensation circuit board on the end of the strain gauge lead wire for wiring works and so on, be sure to return it to the original position by checking the serial number.
⚠Caution	The excitation voltage must be 50 V or less when checking the insulation resistance, etc.
⚠Caution	The strain gauge temperature is required for organizing the measured data. Be sure to measure the temperature as well as the strain at the same time.
⚠Caution	The MI cable may pick up noise if it is moved. Pay enough attention to firmly fix the MI cable in the wiring works, and prevent the MI cable from moving during measurement.
⚠Caution	Lead-free soldering has been performed for the cable end. Use the lead-free solder (Sn-Ag) for soldering.

- When measuring by configuring an optional high pass filter, without the use of supplied high pass filter

  (1) Install the strain gauge on to the specimen under the procedures described in the “2.2 Installation method”.

  (2) Remove the high pass filter by using a soldering iron.

  (3) Connect an optional resistor and a capacitor to the terminal of our bridge box (example: SB-120B or SB-128A) by screwing or soldering.

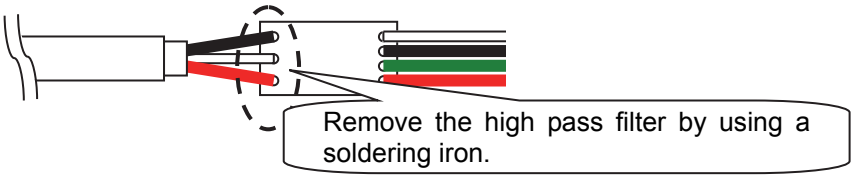
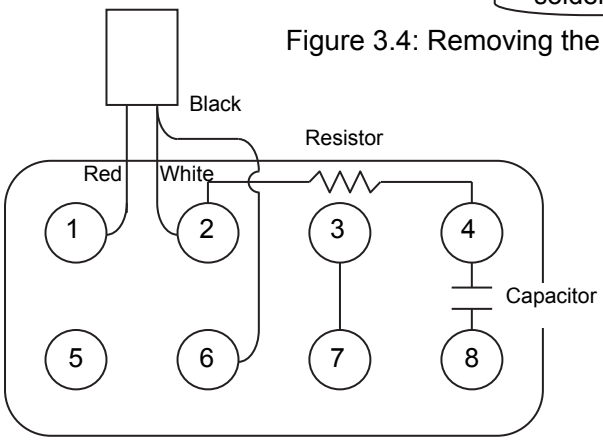


Figure 3.4: Removing the high pass filter



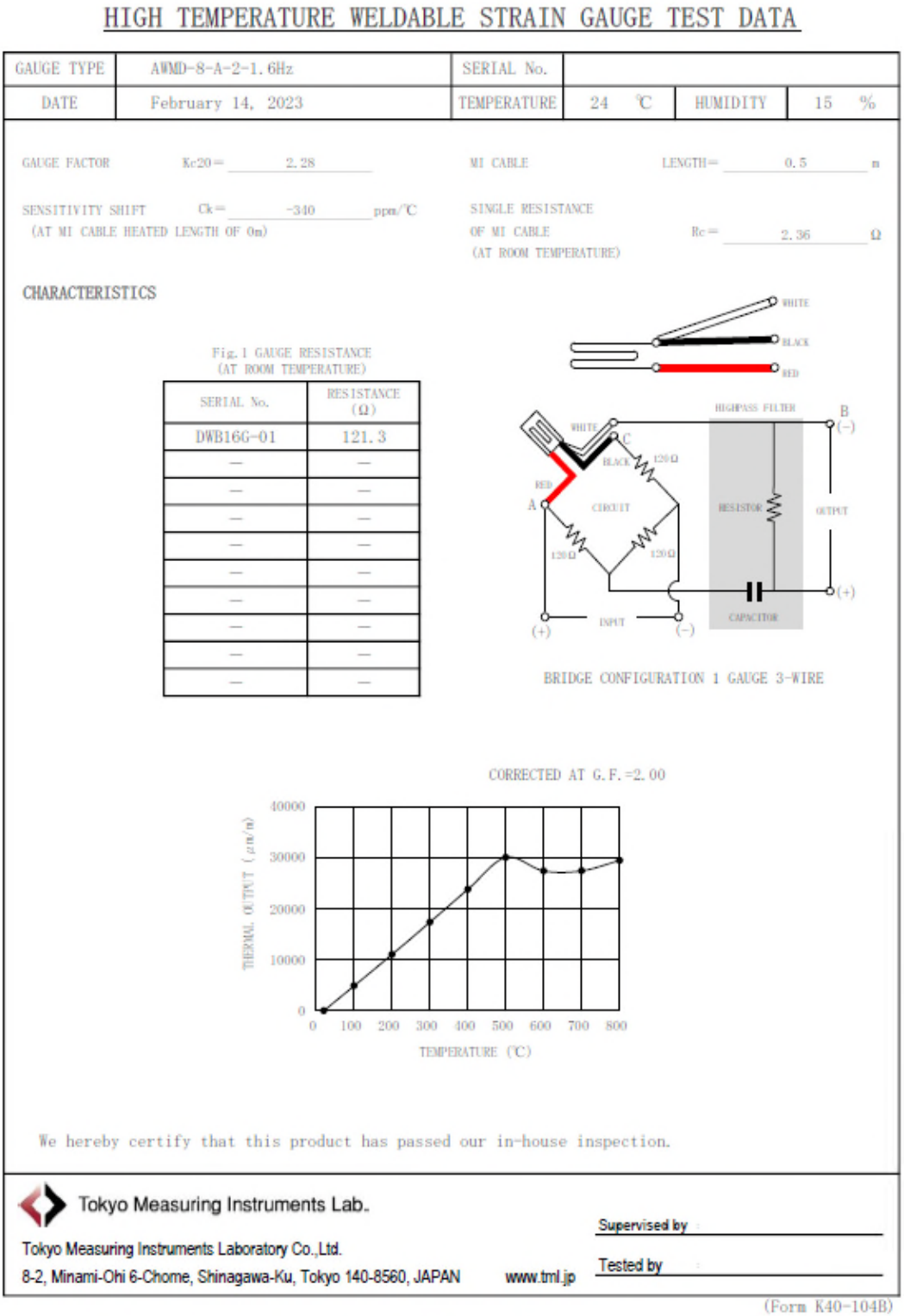
	Number for connection
Red	1
White	2
Black	6
Resistor	Between 2 and 4
Capacitor	Between 4 and 8
Short-circuit wire	Between 3 and 7

Figure 3.5: Connection to the instrument (example of instrument: SB-120B / SB-128A)

✍	A resistor of 10kΩ is recommended. Use a capacitor without polarity.
✍	Various filters with lower cut-off frequency can be configured by connecting a resistor and a capacitor to the bridge box SB-120B or SB-128A according to the Expression 4 on the page 3-7. A bridge box other than SB-120B or SB-128A cannot be used in this case.
⚠ Caution	In the case that the strain gauge AWMD-5 (gauge resistance of 60Ω) is used, perform the gauge factor correction (K_3) due to the influence of resistance outside the bridge according to the Expression 3-2 on the page 3-6.
⚠ Caution	If the high pass filter is removed, temperature influence on the thermal output and/or drift may significantly change.
⚠ Caution	When temporarily disconnecting the temperature compensation circuit board for wiring works and so on, be sure to return it to the original position by checking the serial number.
⚠ Caution	The excitation voltage must be 50 V or less when checking the insulation resistance, etc.
⚠ Caution	The strain gauge temperature is required for organizing the measured data. Be sure to measure the temperature as well as the strain at the same time.
⚠ Caution	The MI cable may pick up noise if it is moved. Pay enough attention to firmly fix the MI cable in the wiring works, and prevent the MI cable from moving during measurement.
⚠ Caution	Lead-free soldering has been performed for the cable end. Use the lead-free solder (Sn-Ag) for soldering.

■ Data organizing method

In addition to the measured values of strain, it requires temperature measurement and the test data supplied to the strain gauge for organizing the data. Check these before organizing the data. Note that necessary information such as gauge factor and rate of thermal sensitivity shift are described on the test data.



HIGH TEMPERATURE WELDABLE STRAIN GAUGE TEST DATA

GAUGE TYPE	AWMD-8-A-2-1.6Hz	SERIAL No.			
DATE	February 14, 2023	TEMPERATURE	24 ℃	HUMIDITY	15 %

GAUGE FACTOR Kc20= 2.28

SENSITIVITY SHIFT Ck= -340 ppm/℃
(AT MI CABLE HEATED LENGTH OF 0m)

MI CABLE LENGTH= 0.5 m

SINGLE RESISTANCE OF MI CABLE (AT ROOM TEMPERATURE) Rc= 2.36 Ω

CHARACTERISTICS

Fig.1 GAUGE RESISTANCE (AT ROOM TEMPERATURE)

SERIAL No.	RESISTANCE (Ω)
DWB16G-01	121.3
—	—
—	—
—	—
—	—
—	—
—	—
—	—
—	—
—	—

BRIDGE CONFIGURATION 1 GAUGE 3-WIRE

CORRECTED AT G.F.=2.00

We hereby certify that this product has passed our in-house inspection.

Tokyo Measuring Instruments Lab.

Tokyo Measuring Instruments Laboratory Co.,Ltd.
8-2, Minami-Ohi 6-Chome, Shinagawa-Ku, Tokyo 140-8560, JAPAN www.tml.jp

Supervised by

Tested by

(Form K40-104B)

Figure 3.6: Example of the test data of AWMD Series

Strain outputs vary by the influence of the following items. For precise measurement, it is necessary to perform gauge factor correction for each item as needed.

● Change in gauge factor by temperature

As the temperature increases, the sensitivity becomes lower.

$K_1 = 1 + (T-20) \times Ck \times 10^{-6}$ <Expression 1>

Legend for the expression
T : Measurement temperature (°C)
Ck : Rate of thermal sensitivity shift (ppm/°C)

✍ At 800 °C, the sensitivity lowers by approximately 20%.

● Change in MI cable resistance by temperature

The MI cable resistance varies by the MI cable heated length and the temperature difference, which results in lowering of the sensitivity.

$$K_2 = \frac{R_A}{R_A + R_C}$$ < Expression 2>

Legend for the expression
R_A : Gauge resistance (Ω)
Rc : One-way resistance of the MI cable (Ω)

✍ When the length of MI cable is 2m and there is a temperature change of 800 °C for the full length, the sensitivity lowers by approx. 18% for AWMD-5 (gauge resistance: 60Ω) and by approx. 2% for AWMD-8 (gauge resistance: 120Ω).

● Influence of resistance outside the bridge

The external resistance which configures the high pass filter causes lowering of sensitivity. The expression is different according to the strain gauge to be used.

For AWMD-5 (Gauge resistance: 60Ω)

$$K_3 = \frac{R_4}{\frac{60 \times R_A}{60 + R_A} + R_4 + 60}$$ <Expression 3-1>

For AWMD-8 (Gauge resistance: 120Ω)

For AWMD-5 without using the supplied high pass filter and measuring by configuring an optional high pass filter

$$K_3 = \frac{R_4}{\frac{120 \times R_A}{120 + R_A} + R_4 + 60}$$ <Expression 3-2>

Legend for the expressions
R_A : Gauge resistance value (Ω)
R_4 : External resistance value (Ω)

✍ When the external resistance is 10kΩ, the sensitivity lowers by approx. 1%.

● Influence of high pass filter

This product includes a high pass filter supplied as the standard part. By using the high pass filter, unnecessary direct current component and low frequency component (thermal output, drift, etc.) in the phenomenon waveforms to measure can be cancelled. In this case, it is necessary to use a dynamic strain meter with direct current bridge excitation (DC type dynamic strain meter) for the measurement. Also, as a decrease in gauge factor, phase shift and/or other phenomenon due to lower cut-off frequency will be caused, it is necessary to select a filter of the frequency suitable for the measurement target phenomenon. The sensitivity can be reduced depending on the relation between the frequency of measurement target phenomenon and the lower cut-off frequency.

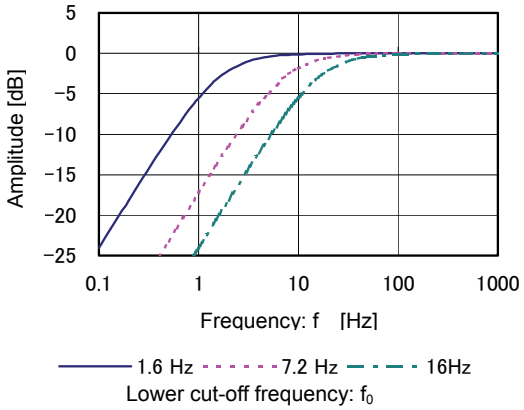


Figure 3.7: Amplitude characteristic

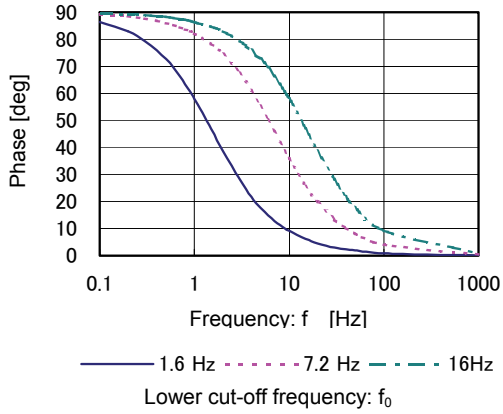


Figure 3.8: Phase characteristic

$$f_0 = \frac{1}{2\times\pi\times R\times C}$$ <Expression 4>

$$K_4 = \frac{1}{\sqrt{1+\left(\frac{f_0}{f}\right)^2}}$$ <Expression 5>

Legend for the expressions

f_0	: Lower cut-off frequency (Hz)
f	: Frequency of the measurement target phenomenon (Hz)
R	: Resistance (Ω)
C	: Capacity of the capacitor (F)

If the frequency of measurement target phenomenon equals to the cut-off frequency, the gauge factor lowers by approx. 30%. If the frequency of measurement target phenomenon is ten times higher than the cut-off frequency, the gauge factor lowers by approx. 0.5%.

● Calculation of the actual strain according to the gauge factor correction

Determine the actual strain by the Expressions 1 to 5.

Actual strain = $1/K_1 \times 1/K_2 \times 1/K_3 \times 1/K_4 \times$ Measured value <Expression 6>

⚠Caution In the case of a rapid change in test temperature (thermal transient), performance of the strain gauge may be different from the property data on the supplied test data.

✍ The gauge factor in the property data on the supplied test data has been corrected by Kc20.

Note Use a value which is corrected by the gauge factor for the measured value.

Note As unit conversion such as ppm/°C has been performed for the expressions, use the values on the supplied test data as they are.

High temperature WELDABLE STRAIN GAUGE **AWMD series**

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