



– BRONZ1 TECHNICAL REPORT –

Cheap edition of Lead-Free Bronze

LF5A

Japanese Patent No.4294793
CDA UNS No. C89842

For Cast

Rev.2014.1.10

Cheap edition of Lead-Free Bronze “LF5A”

Development of lead-free bronze with excellent cost performance

In recent years, bismuth bronze family has been development to comply with the regulations about Lead-leachate. Bismuth bronze is including bismuth instead of lead. So, since the first place does not contain lead, they comply with the Lead regulations. In addition, it is also compatible with NSF61 AnnexG (0.25% MAX weighted average lead content of the product) new standard to be implemented from 2014 in the United States. “LF5A” had been development for the purpose of cost reduction from conventional bismuth bronze. Furthermore, both Castability and machinability are adjusted to the equivalent to the conventional bismuth bronze. “LF5A” was developed focusing for use as switching applications from conventional bismuth bronze, or also as the alternative for bronze such as C83600 (CAC406).

1. Development Concept

We were set the concept “Cheap edition of Lead-Free bronze”. And then, we made a development on three themes below.

1.1 Lead-Free

- Under these circumstances that lead-regulations will become stricter. That the material can satisfy these lead -regulations.

1.2 Various Characteristics

- A material has what excellent mechanical property, castability and dezincification resistance are equal to or higher than that of C89844 (CAC902).

1.3 Economy

- In response to the sharp rise of copper prices in recent years, we realized cost reduction by component restructuring.

2. “LF5A”

“LF5A” is patented in Japan. And, it is a copper alloy that is registered with the CDA in the United States. (Table 1) We have two types of “LF5A”. In this report explains about “for Cast”.

3. Chemical Composition

The chemical composition of LF5A is shown in Table 2.

Table 2 Chemical Composition wt%

| | Cu | Sn | Pb | Zn | Fe | Ni | P | Bi |
|---------|---------------|-------------|----------|---------------|----------|---------|----------|-------------|
| Range | 78.0 -83.0 | 2.0 -3.0 | 0.09 max | 12.0 -17.0 | 0.30 max | 0.2 max | 0.03 max | 1.0 -2.0 |
| Nominal | 81.5 | 2.5 | - | 14.5 | - | - | - | 1.50 |

Table 1 **LF5A** Patent • registration

| Name | Over View | Japanese patent | CDA UNS No. |
|------|----------------------------------|-----------------|-------------|
| LF5A | Lead-Free Free Cutting Bronze | No.4294793 | C89842 |

4. Application

4-1 **Water Supply--Related Products**

Water-related products (elbow, cheese, etc.) such as faucet fittings, water meters, plumbing fittings, various valves, pipe fittings, and hot water supply system unit parts.

4-2 **Industrial Machinery Parts**

Various bush, pump parts, automotive parts, etc.

5. Corrosion Resistance

5-1 **Dezincification Resistance**

Dezincification corrosion didn’t observe at dezincification test of “LF5A”. The test results of “LF5A”, it shows equivalent to that of conventional bronze. (Fig 1 and 2)

Reference: * EN standards (European standard) *
Grade A: Below 200µm: maximum depth of dezincification
Test Method: according to ISO6509-1981
(Conforms to dezincification test method of brass)

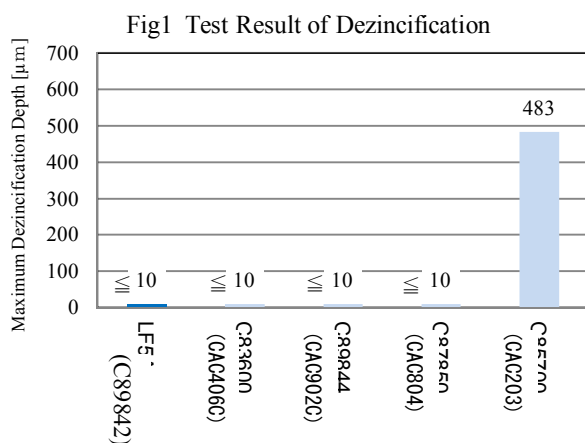
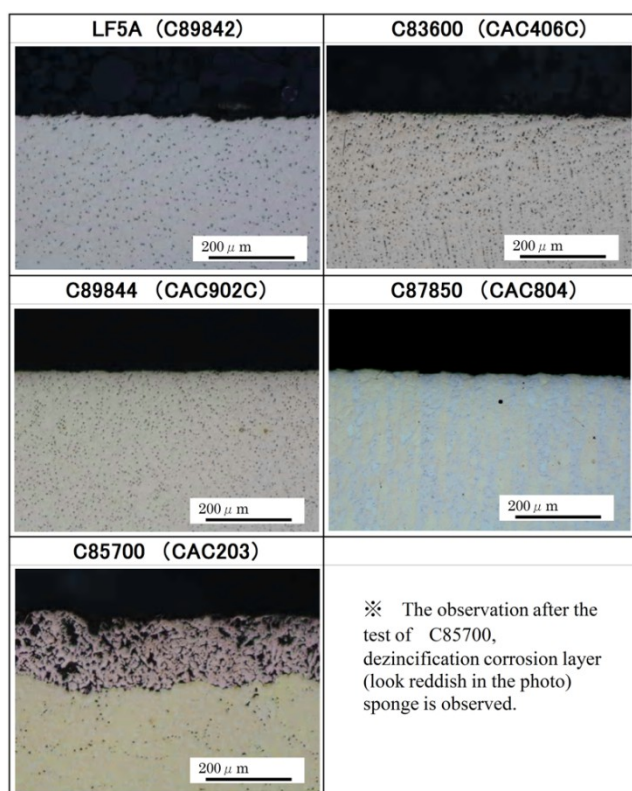


Fig2 Photograph after test of Dezincification

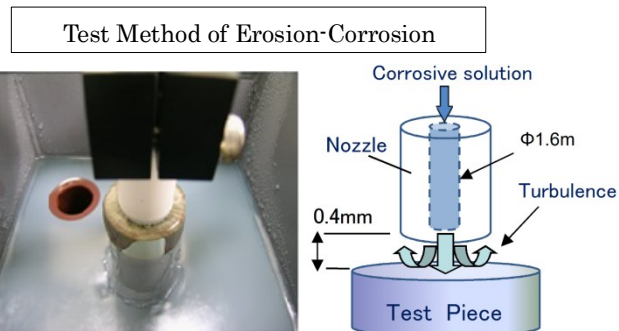


5-2 Erosion-Corrosion Resistance

The Erosion-Corrosion test result of "LF5A" is shown in Table3 and photograph. The test results of "LF5A", it shows equivalent to that of conventional bronze. (Fig 3, 4)

Table 3 Test condition of Erosion-Corrosion test

| Reagent | CuCl ₂ · 2H ₂ O 99% |
|---------------------------|---|
| Test liquid concentration | 190g reagent in 15L dissolved water(1wt%) |
| Test liquid temperature | 40 °C±1°C |
| Flow rate | 3.3 m/sec |
| quantity of flow | 400 ml/min |
| Corrosion time | 5 hours |
| Air blow | 2 L/min |



* Photograph after test of Erosion-Corrosion *

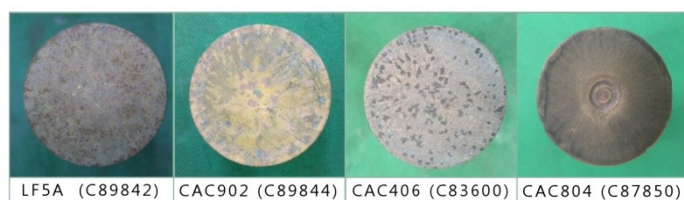


Fig 3 Erosion-Corrosion Test (1)

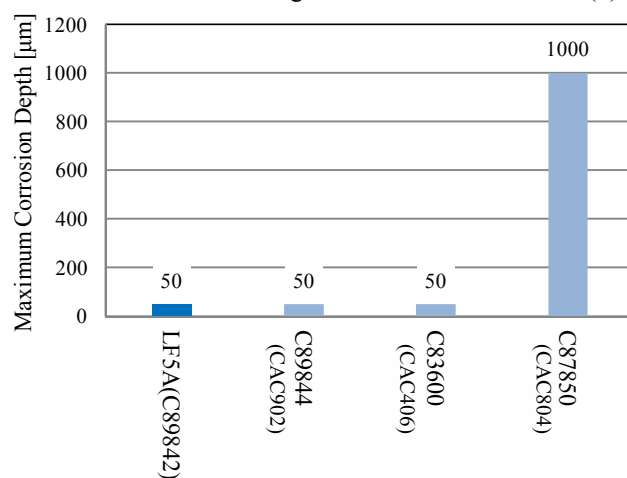
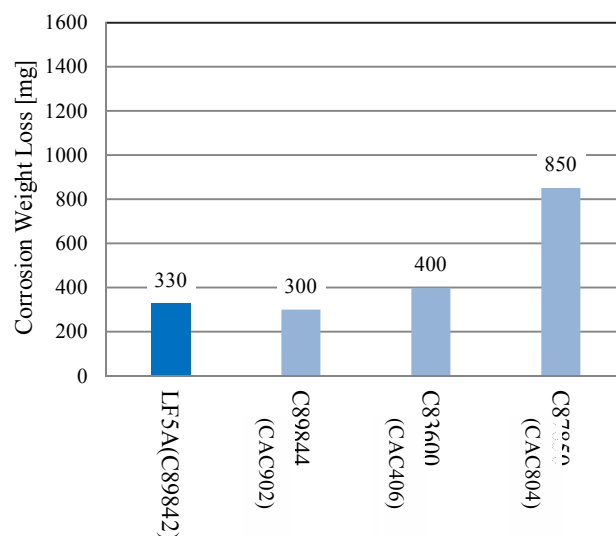


Fig 4 Erosion-Corrosion Test (2)

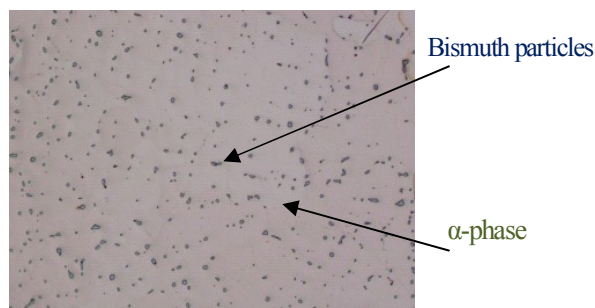


6. Metallographic Structure

Metallographic Structure of“LF5A” is shown below.

It has a composition that bismuth particles are scattered in the α -phase. (Fig 5)

Fig 5 Microstructure observation



7. Mechanical Properties

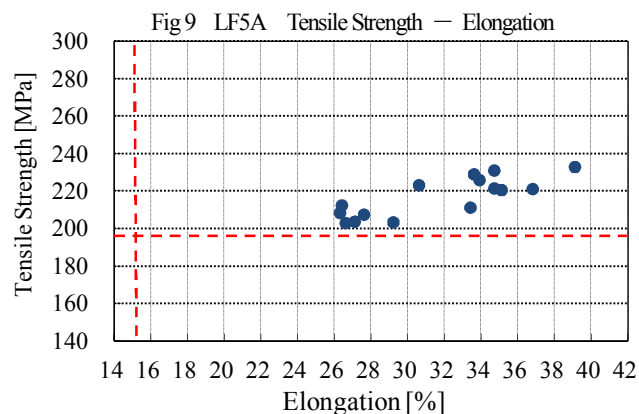
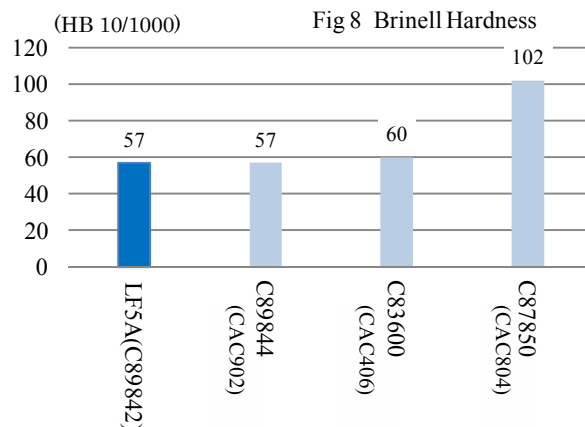
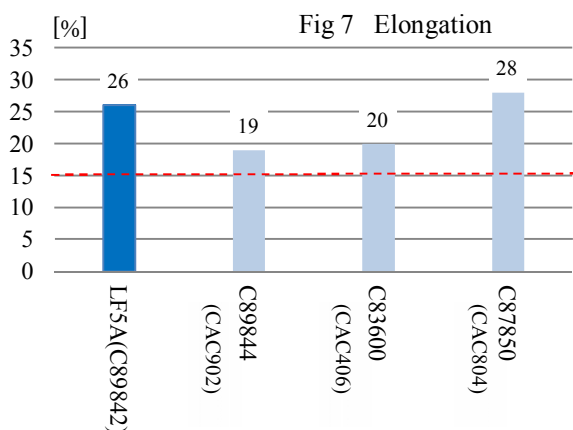
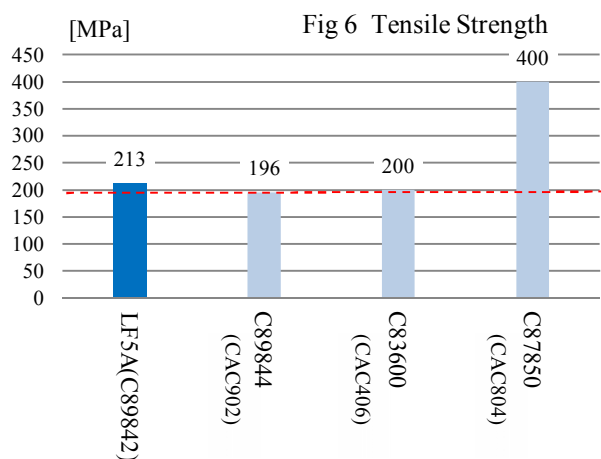
Mechanical properties of“LF5A”are shown below.

It clears that of conventional bronze, and has to ensure comparable properties. (Rep. Value: Fig 6, 7, 8)

* JIS standard *

CAC902 Cast ; tensile strength 195[MPa], Elongation 15 [%]

CAC406 Cast ; tensile strength 195[MPa], Elongation 15 [%]



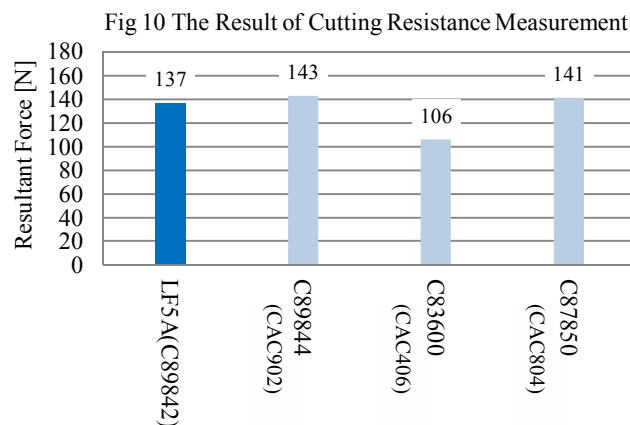
8. Machinability

8-1 Cutting Resistance Measurement

The result of cutting resistance measurement of“LF5A” is shown below. It indicates excellent value compared with C89844 (CAC902). (Table 4, Fig 10)

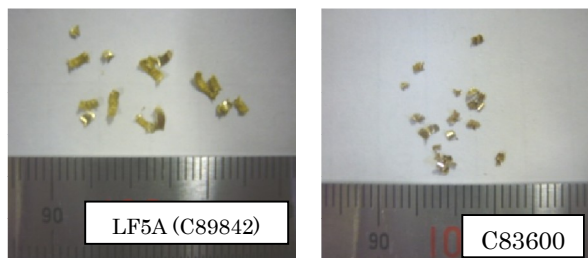
Table 4 Condition of Measurement

| | |
|-----------------|---|
| NC Lathe | The best search of setting of working condition by EGRO |
| Chip | TNGG160404L-C GH110 (with coating) |
| Cutting speed | 100 m/min |
| Depth of Cut | 1.0 mm |
| Feed rate | 0.1 mm/rev |
| Repeated Amount | 10 Times |
| Cutting Oil | Dry |



8-2 Chips Shape

Chips shape of "LF5A" is shown below.



9. Castability

9-1 Comparison of Solidus-Liquidus Temperature

The comparison of solidus-liquidus Temperature is shown in Table 5.

Table 5 Comparison of solidus-liquidus Temperature

| Material | Liquidus | Solidus | Range |
|---------------|----------|---------|-------|
| LF5A (C89842) | 998°C | 866°C | 130°C |
| C89844 | 1010°C | 853°C | 167°C |
| C83600 | 1010°C | 860°C | 150°C |
| C87850 | 880°C | 855°C | 25°C |

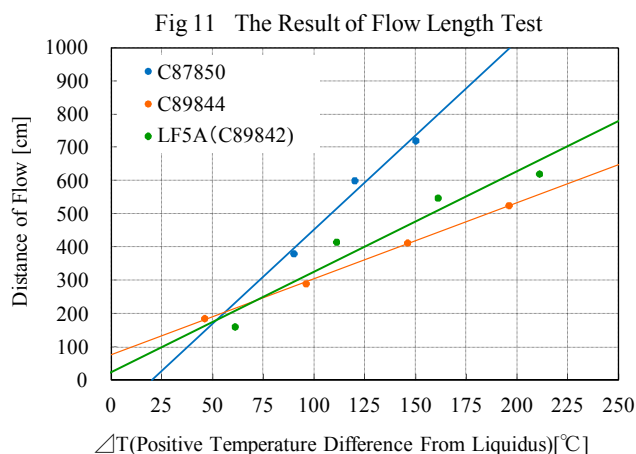
9-2 Physical Properties

| | |
|---------------------------|---------------------------------|
| Density | 8.63 gm/cm ³ at 20°C |
| Specific Gravity | 8.63 |
| Conductivity | 0.11 Mega Siemens/cm at 20°C |
| Heat transfer coefficient | 30.8 W/m ·K at 20°C |

9-3 Flow Length Test

Cast into the spiral molding mold of our CO2 sand mold, and then, we measured the flow length.

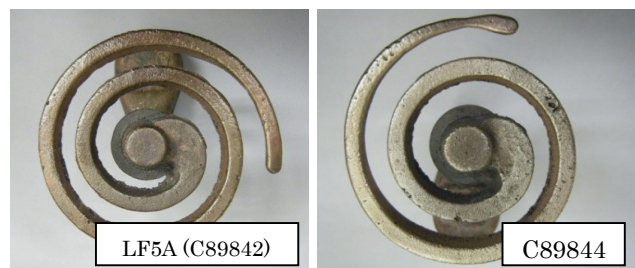
The measurement result is shown in Fig11.



* Photograph of Molten Metal Flow Test *

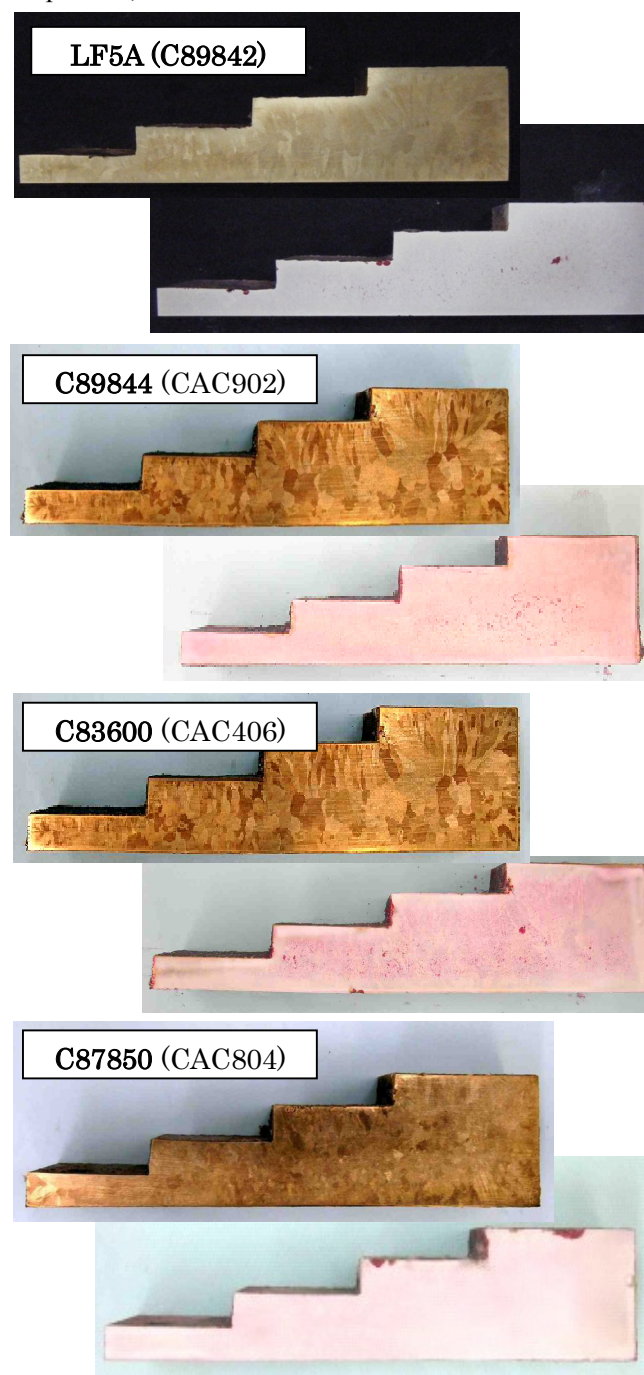
• 1132°C (Δ T=134°C)

• 1136°C (Δ T=126°C)



9-4 Stair-Step Test

Flaw detection test results of the stair shaped test specimen, and macro observation.



9-5 Cast of Prototype Case

9-5-1 20 mm Water meter body

Green sand, Casting Temp. @1170°C

After shot • machined (1)



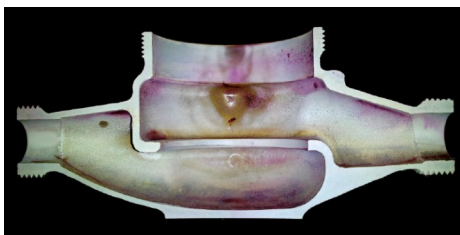
After shot • machined (2)



Macro Structure Observation



PT Test Observation



9-5-2 PE Fitting 45°, Elbow 50

Green Sand, Casting Temp. @1130°C



10. The Test Result of Lead-Leachate

Shape: 20mm Water Meter

Analysis Method ; According to JIS S3200-7 Tap-Equipment-Leachate Test Method

| Analysis Item | Result | Unit ; mg/L |
|---------------|--------------|-------------|
| • Cadmium | Under 0.0003 | |
| • Lead | 0.003 | |
| • Zinc | 0.14 | |
| • Copper | Under 0.01 | |
| • Bismuth | Under 0.001 | |

Remarks:

- (1) Without Conditioning
- (2) Analysis method is according to Annex1.
However, Bismuth analysis by ICP/MS method.
- (3) The correction value of the analysis result is a value obtained that was divided 25 of the concentration of leachate, as water supply equipment provided to the pipe midway.

(* Ref. JIS S3200-7)

Criteria regarding to leachate of water supply pipe, or water supply equipment that is installed in non-terminal water supply equipment.

| | | |
|-----------|------------------|------|
| • Cadmium | Under 0.01 | mg/L |
| • Lead | Under 0.01 | mg/L |
| • Zinc | Under 1.0 | mg/L |
| • Copper | Under 1.0 | mg/L |
| • Bismuth | Without Criteria | |
| • Nickel | Without Criteria | |

11. The Test Result of Nickel-Leachate

Shape: 20mm Water Meter (Ni content 0.29%)

Analysis Method ; According to JIS S3200-7 Tap-Equipment-Leachate Test Method

| Analysis Item | Result | Unit ; mg/L |
|---------------|--------|-------------|
| • Nickel | 0.001 | |

Remarks:

- (1) Without Conditioning
- (2) Analysis method is according to Annex1.
However, Bismuth's by ICP/MS method.
- (3) The correction value of the analysis result is a value obtained that was divided 25 of the concentration of leachate, as water supply equipment provided to the pipe midway.