

# Cast and Wrought Aluminium Bronzes

## Properties, Processes and Structure

### by Harry Meigh

## Detailed Contents List

#### FOREWORD

#### ACKNOWLEDGEMENTS

#### HISTORICAL NOTES

Earliest aluminium bronze  
First systematic research into copper-aluminium alloys  
Addition of other alloying elements  
Inventors of the Tilting Process  
Leading contributors to the metallurgy of aluminium bronze  
Growing use of aluminium bronze

## Part 1 - Cast and Wrought Aluminium Bronzes

### Properties and production processes

#### 1 - ALUMINIUM BRONZES AND THEIR ALLOYING ELEMENTS

The aluminium bronzes

*Properties of aluminium bronzes*

Effects of alloying elements

*Aluminium - Iron - Nickel and Iron - Manganese - Silicon - Lead - Impurities*

#### 2 - PHYSICAL PROPERTIES

*Melting range - Density - Thermal properties - Electrical and magnetic properties - Elastic properties - Non-sparking properties*

#### 3 - CAST ALUMINIUM BRONZES

##### A - Cast alloys and their properties

Standard cast alloys

*High strength alloys - Medium strength alloys - Low magnetic alloys*

Factors affecting the properties of castings

*Effect of alloy composition - Effect of impurities - Effect of section thickness - Effect of heat treatment - Effect of operating temperature*

##### B - Casting processes

*Processes - Sand casting - Shell mould casting - Ceramic mould casting - Investment casting - Die casting and permanent mould casting - Centrifugal casting - Continuous and semi-continuous casting - Choosing the most appropriate casting process - Applications and markets*

#### 4 - MANUFACTURE AND DESIGN OF ALUMINIUM BRONZE CASTINGS

##### A - Manufacture of castings

The making of sound castings

*Oxide inclusions - Shrinkage defects - Solidification range - Gas porosity*

Prevention of defects

*Avoiding oxide inclusions - Directional solidification - Directional solidification by a static method - Avoiding gas porosity - Blowing - Differential contraction and distortion*

Quality control, testing and inspection

*Importance of quality control - "Methoding" records - Pre-cast quality control - Quality checks on castings*

Design of patterns

##### B - Design of castings

Designing to avoid shrinkage defects

*Simplicity of shapes - Taper - Relationship of thin to thick sections - Wall junctions and fillet radii - Isolated masses - Web and ribs - Cored holes - Effect of machining allowance*

Other design considerations

*Fluidity and minimum wall thickness - Weight saving - Effect of thickness on strength - Hot tears - Composite castings*

Design of castings for processes other than sand casting

## 5 - WROUGHT ALUMINIUM BRONZES

Wrought processes and products

*Forging - Extruding - Rolling - Drawing - Miscellaneous processes*

Wrought alloys: properties and applications

*Composition and properties*

Single-phase alloys

*Nature and working characteristics - Mechanical properties - Corrosion resistance - Impact strength - Fatigue strength and corrosion fatigue limits - Applications*

Duplex (twin-phase) alloys

*Nature and working characteristics - Mechanical properties - Corrosion resistance - Impact strength - Fatigue strength - Applications and corrosion resistance*

Multi-phase alloys

*Nature and working characteristics - Impact strength - Fatigue strength - Torsion - Creep strength - Applications - Temper*

Factors affecting mechanical properties

*Effect of composition - Effect of wrought process and of size and shape of product - Effect of hot and cold working*

Heat treatment

## 6 - HEAT TREATMENT OF ALUMINIUM BRONZES

Forms of heat treatment

*Annealing - Normalising - Quenching - Tempering and temper anneal*

Reasons for heat treatment

*Relieving internal stresses - Increasing ductility - Increasing hardness and tensile properties - Improving corrosion resistance - Improving wear properties - Reducing magnetic permeability*

Heat treating different types of alloys

*Single-phase alloys - Duplex alloys - Cu/Al/Ni/Fe type of complex alloys - Cu/Mn/Al/Fe/Ni type of complex alloys*

## 7 - WELDING AND FABRICATION (Including metallic surfacing)

Welding applications

Welding characteristics

*Aluminium-rich oxide film - Thermal conductivity and expansion - Ductility dip*

Choice of welding process

*Tungsten-arc inert gas-shielded (TIG) process - Metal-arc inert gas-shielded (MIG) process - Other electric arc processes - Electron beam welding - Friction welding - Oxy-acetylene gas welding*

Welding practice: General

*Weld procedure and welder approval - Cleanliness and freedom from grease - Selection of filler metal for TIG and MIG welding - Selection of shielding gas - Current settings, voltage and other operating data - Fluxes*

Welding technique

*TIG - MIG - Metal-arc welding - Oxy-acetylene welding*

Welding practice: Joining wrought sections

*General - Design of joints and weld preparation - Jigging and backing techniques*

Welding practice: Joining and repairing castings

*Weld preparation - Pre-heat and inter-run temperature control - Weld deposit - Joining one casting to another or to a wrought part*

Inspection and testing

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Use of aluminium bronze in joining dissimilar metals

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*Capillary brazing using silver-based brazing alloys - Soft soldering*

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*The protective oxide film - Avoidance of corrodible phases - Avoidance of continuous corrodible phases*

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*Oxidation resistance at elevated temperatures*

Mechanism of corrosion

*Electro-chemical action: Corrosive effect of acids, Corrosive effect of salt solutions, Corrosive effect of caustic alkaline solutions, Dissimilar metals, (galvanic coupling), Selective phase attack, de-alloying, de-aluminification, Galvanic coupling of aluminium bronzes with other metals, effect of differential aeration, Effect of electrical leakage - Chemicals that attack the oxide film: Sulphides, Caustic alkaline solutions*

Types of corrosive and erosive attack

*Uniform or general corrosion - Localised corrosion: Pitting, Crevice corrosion, Impingement erosion/corrosion, Cavitation erosion/corrosion, Stress corrosion cracking, Corrosion fatigue*

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Aluminium bronze components used in corrosive environments

*Marine service - Fresh water supply - Oil and petrochemical industries - Chemical industry - Building industry*

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Aluminium bronze as a wear resisting material

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Mechanism of wear

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*Applications - Alloy selection*

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*Summary of effects of cooling rate*

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**REFERENCES**

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