3.0 Applications

The nickel aluminium bronzes have six main areas of application:

1) Aerospace
2) Architecture
3) Marine - defence
4) Marine - commercial
5) Offshore oil/gas and petrochemical
6) Desalination and water condenser systems.

3.1 Aerospace

The main application for nickel aluminium bronze in the aerospace sector is landing gear bearings for the world’s fleet of commercial aircraft. The excellent bearing properties against steel, corrosion resistance in salt conditions during de-icing of runways in winter and high mechanical properties make it an ideal alloy for this application. The main specifications are AMS 4640, AMS 4880, AMS 4881 and AMS 4590, BS2 B 23, NFL14-702, NFL14-705 and NFL14-706 (see Tables App1-22 in the Appendix).

The aircraft companies and main subcontractors also have their own specifications, for example Airbus ASN-A 3406, ASN-A 3315, ASN-A6127A and Rolls Royce MSRR 8503.

Figure 1 illustrates the range of bearings and bushing used in aircraft landing gears. Figure 2 demonstrates landing gears being examined after a set number of flying hours or landings.

In addition to landing gear bearings, applications include wing flap bearings, door hardware, wheel bearings, hydraulic actuators, valves, steering joints and helicopter controls.

In general, alloys C63000 to AMS 460, AMS 4880 or BS2 B 23 are used for the majority of the landing gear applications. For high load and greater wear requirements, the cast AMS 4881 and wrought AMS 4590 can be used (see Appendix).
3.2 Architecture

The aluminium bronzes are used in a wide spectrum of architectural applications. Their natural ability to form a protective oxide layer in oxygen-rich environments opens up applications, both for inland and marine atmospheric conditions. Nickel aluminium bronze has a rich golden oxide and, with its unique properties, can provide additional benefits.

The Parliamentary building in London, Portcullis House, is a prime example of architectural use (Figures 3 and 4) as it contains 450 tonnes of nickel aluminium bronze incorporated in the window frames, cladding and roof (artificially darkened), built to withstand bomb blasts and with a life expectancy of 120 years.

In addition, nickel aluminium bronze can be used for landscaping applications, fixtures, fittings and fasteners on buildings subjected to salt-laden coastal atmospheres.

![Figure 3 – Nickel aluminium bronze window frames, Portcullis House](image)

![Figure 4 – Nickel aluminium bronze roof, Portcullis House](image)

Alloys for architectural applications:
- In the wrought form ASTM B150 C63200, C63000
- In cast form BS EN 1982:2008 CC333G
(See Appendix).

3.3 Marine

3.3.1 Defence

There is a large market for nickel aluminium bronze in naval applications, particularly for the submarine fleets of the world. The main applications are in seawater piping and valve systems, weapons handling, flexible couplings, sonar equipment, seawater external hatches, hydraulic valves and bearings, fasteners and sealing flanges, low noise propellers, propulsion equipment and periscope assemblies (Figures 5–11). These applications make use of some of the important properties of the nickel aluminium bronzes: good corrosion resistance, non-sparking, wear resistance, high strength and good impact properties.

The alloys also exhibit good anti-damping properties, twice that of steel, which is important in submarines in suppressing sound for silent operations. Non-sparking and wear resistance become particularly important in weapons' handling systems. The various grades with lower iron and nickel contents can be manufactured with magnetic permeability below 1.03 μ.
Figure 5 - Water end entry valve
(Courtesy IMI TruFlo)

Figure 6 – Submarine penetrator, machined from forging
(Courtesy Copper Alloys Ltd, Stoke-on-Trent, UK)

Figure 7 - Submarine propeller
(Courtesy Inoxyda SA, France)

Figure 8 – Piston forging 5000 kg
(Courtesy Copper Alloys Ltd, Stoke-on-Trent, UK)

Figure 9 - Ocular box submarine periscope
(Courtesy Inoxyda SA, France)

Figure 10 - Submarine acoustic antenna
(Courtesy Inoxyda SA, France)
3.3.2 Commercial

Nickel aluminium bronze is one of the main alloys used for ship propellers on commercial vessels and cruise liners. Its high resistance to cavitation, coupled with reasonable cost and the ease of repair when damaged, makes it a leading contender for this application (Figures 12 and 13).

The main alloys used in marine defence applications are:

- UK Def Stan 02-747 Parts 1-4 (cast)
- UK Def Stan 02-833 (wrought)
- ASTM B150 C63200

(See Appendix.)
The hubs for variable pitched propellers are also made from nickel aluminium bronze (Figure 14). The alloy exhibits good anti-galling properties against itself, which is important as the propeller blades rotate within the cylindrical openings.

Nickel aluminium bronze is also used in the winch gear mechanisms of ocean-going yachts, where anti-galling, high strength and corrosion resistance to salt spray play an important part (Figure 15).

3.4 Offshore Oil/Gas and Petrochemical

The offshore oil/gas industry makes use of nickel aluminium bronze in many applications, where the alloy is used for pipework, valves and pumps in seawater pumping systems, particularly for fire-fighting equipment. It is compatible with copper-nickel piping systems and used for associated pumps and valves. It is also used in seawater pumping systems to convey water for injection back into the well (Figures 16 and 17).

The main alloys used in marine defence applications are:

- BS EN 1982:2008 CC333G and CC212E for propellers and valves in cast products
- UK Def Stan 02-833 for wrought products
(See Appendix).

![Figure 14 - Hub body 8500 kg (Courtesy Inoxyda SA, France)](image)

![Figure 15 - Winch gear with nickel aluminium bronze (Courtesy Lewmar Ltd, UK)](image)

![Figure 16 – Seawater pipe sections (Courtesy Inoxyda SA, France)](image)

![Figure 17 - Column pipe (Courtesy Inoxyda SA, France)](image)
3.4.1 Bearing Applications within Oil Rig Equipment

Wrought and cast nickel aluminium bronze are used for many bearing applications on oil rigs (Table 5). These are frequently self-lubricating, where bearings are impregnated with specialised compounds. The use of graphite or graphite-rich lubricants or seals should not be used if there is an ingress of seawater since graphite is at the noble end of the galvanic series and can cause preferential corrosion of the nickel aluminium bronze. Nickel aluminium bronze is suitable for slow moving parts where good wear and corrosion resistance is required and in applications where accessibility may be a problem (Figure 18).

![Figure 18 – Nickel aluminium bronze bearings with self-lubrication pockets](image)

Table 5 – Bearing Applications within Oil Rig Equipment

<table>
<thead>
<tr>
<th>Riser pull-in systems</th>
<th>Oil rigs</th>
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</thead>
<tbody>
<tr>
<td>Mooring and turret systems</td>
<td>Off-loading terminals including:</td>
</tr>
<tr>
<td>Fairleads/chain stoppers</td>
<td>Loading arms</td>
</tr>
<tr>
<td>Winches/windlasses</td>
<td>Loading couplings</td>
</tr>
<tr>
<td>Universal joints</td>
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<tr>
<td>Jacking and fixation systems</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Pipe-laying equipment</th>
<th>Pipe handling equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stinger handling system</td>
<td></td>
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<tr>
<td>Stinger tower hinge</td>
<td>Pipe couplings</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Riser applications</th>
<th>Tensioner systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hang-offs</td>
<td>Riser pull-in systems</td>
</tr>
<tr>
<td>Connectors</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Drilling equipment and machinery</th>
<th>Subsea applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top drive systems</td>
<td>Autonomous underwater vehicles (AUVs)</td>
</tr>
<tr>
<td>Tube handlings</td>
<td>Remote operated vehicles (ROVs)</td>
</tr>
<tr>
<td>Wellhead systems</td>
<td>Subsea tools</td>
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<tr>
<td>Drilling tools</td>
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Self-lubricating bearings are also used in the Fairlead Stopper unit and mooring lines. This unit is sometimes suspended from the structure legs and incorporates self-lubricating bearings which connect the ears for attaching the latch housing assembly.

Mud pumps are used both in offshore oil rigs and land-based drilling rigs. Figure 21 illustrates a typical mud pump and Figure 22 shows some of the spare part bearings used in these pumps.
3.4.2 Communications and Transponders

There are two areas where the corrosion resistance of nickel aluminium bronze is used in communications. The first is acoustic release transponders (Figure 23) and the second, fibre optic electrical connectors (Figure 24). Both applications make use of the alloy’s good corrosion resistance in seawater.

The transponder application allows equipment to be lowered to its operational location, at which point it can be released from the securing cable under water.

Alloy grades typically used for bearings are:

- ASTM B505, C95400, C95500, C95800
(See Appendix).

Alloys typically used for connectors and transponders are:

- UK Def Stan O2-833
- BS2 B 23
- ASTM B150, C63000 and C63200
(See Appendix).
3.4.3 Actuator Valves

Actuator valves are an important application, both on land-based pipelines and subsea where oil is being transported.

On land-based applications, pipelines can be situated in isolated areas, as well as in hostile locations. Actuator valves form a vital link in the safety of the oil line, as well as protecting the environment against oil spillage. The valves need to work under extremes of temperature ranging from -50°C in extreme cold conditions, such as those encountered in the Arctic regions, to +50°C at the height of the summer in the Middle East desert areas. They have to withstand the ingress of sand in the desert and be able to work after many years of inactivity. For this reason nickel aluminium bronze is chosen in many of the designs for its corrosion resistance and bearing properties. Nickel aluminium bronze also forms the main component which closes off the valves within the piping system (Figure 25).

Offshore, actuator valves are used on oil rig platforms (Figure 26), where valves are sometimes inaccessible and need to be activated by radio waves.

Alloy grades typically used in actuators are:

- ASTM B150, C63000, and C63200
(See Appendix).

3.4.4 Oil Tankers

Another important application which makes use of the non-sparking and high corrosion resistance properties is the gas circulating fans in sea-based oil tankers (Figure 27). The fans are used to generate the flow of an inert gas blanket over the oil cargo and to maintain its pressure in order to obviate the danger of explosion or fire. The inert gas used is produced from the exhaust gas from the main engines, auxiliary engines or sometimes from a special generator, by ‘scrubbing’ the exhaust with seawater. The operating conditions can be very corrosive, involving salt-laden water vapour, sulphurous gases and carbon. Both titanium and nickel aluminium bronze are used for this application, with the latter being the lower cost option.
3.5 Desalination and Water Condenser Systems

This industry is an important outlet for nickel aluminium bronze for pumps, valves, water boxes, impellers, condenser tube plates (Figures 28 and 29) and housings. It is used for elevated temperatures up to approximately 325°C in high pressure condenser systems. It can be used for pumping seawater to a recommended level of 4.3 m/sec, which exceeds that tolerated by 90-10 and 70-30 copper-nickel. Aluminium bronzes also have a low susceptibility to attachment of marine organisms, as shown in Section 6.6.

Alloys typically found in inert gas systems are:

- ASTM B171 C63000
- BS EN 1653, CW304G and CW307G

(See Appendix).

Figures 28 and 29 - Condenser tube plates (Courtesy Inoxyda SA, France)
There is a range of alloys used in the desalination and water condenser sector:

- For sand castings, the nickel aluminium bronze usually used is CC333G (AB2)
- For forgings and bar products BS EN 12420 CW307G and BS EN 12163 CW307G
- For plate products used in the heat exchange and desalination industry BS EN 1653 CW307G and ASTM B 171 C63000
- For maximum corrosion resistance UK Def Stan 02-833
  (See Appendix).