metco
joining & cladding

Solutions Flash
Automotive applications benefit from cost-effective, high chromium Amdry Braze Alloys

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Today’s situation

In the past several decades, many automotive components previously fabricated from carbon steels are now fabricated from stainless steels. This fact, in itself, has necessitated changes from the previous processing methods and the braze filler metals used to join steel components, to furnace brazing using high temperature nickel-based filler metals, such as AWS BNi-2 and BNi-5.

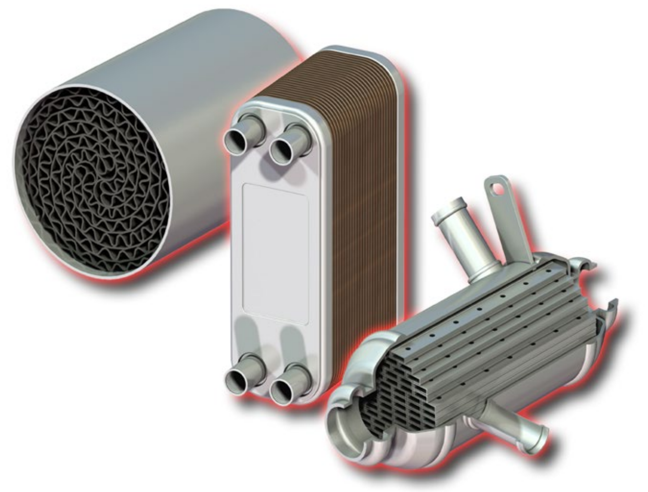
The design complexity and the demand for service reliability of components such as ERG coolers, catalytic converters and heat exchangers have continually increased. At the same time, so has the need for more cost-efficient and reliable manufacturing methods. These requirements underscore several shortcomings for the traditional braze alloys used for these applications, BNi-2 and BNi-5:

- The service life of components brazed with BNi-2 can be reduced because of the boron contained in this braze filler metal, which diffuses into grain boundaries.
- BNi-2, with its low chrome content, may provide reduced corrosion and oxidation resistance in service.
- BNi-5 (NiCrSi) has a high braze temperature range of 1150 to 1200 °C (2100 to 2200 °F) that is above the feasible temperature range for many components.
- Braze joints of BNi-5 are brittle, therefore burst strength requirements for components such as heat exchangers cannot always be achieved.
- All nickel-based braze alloys are subject to the escalating cost of nickel — an issue that many manufacturers would like to eliminate to achieve component manufacturing cost targets.

The Metco Joining & Cladding solution

Metco Joining & Cladding's family of high-chromium, boron-free braze filler metals can be used advantageously by automotive component manufacturers.

Amdry™ 105 and Amdry 806A each have a minimum of 23 % chromium by weight to produce strong, corrosion resistant braze joints for steel, stainless steel and superalloy components. The use of phosphorus and silicon in these filler metals reduce (Amdry 806A) or eliminate (Amdry 105) the need for boron to reduce the braze temperature range and increase ductility for improved burst strength in heat exchangers. In Amdry 806A, iron replaces a significant amount of the nickel content, reducing the cost and the impact of volitile nickel prices.



Amdry 105 and Amdry 806A are ideal braze filler metals for joining catalytic converters, heat exchangers and EGR coolers. These filler metals are more cost-effective than traditional nickel braze alloys, while exhibiting excellent brazing and joining characteristics.

Solution description and validation

Material design basis

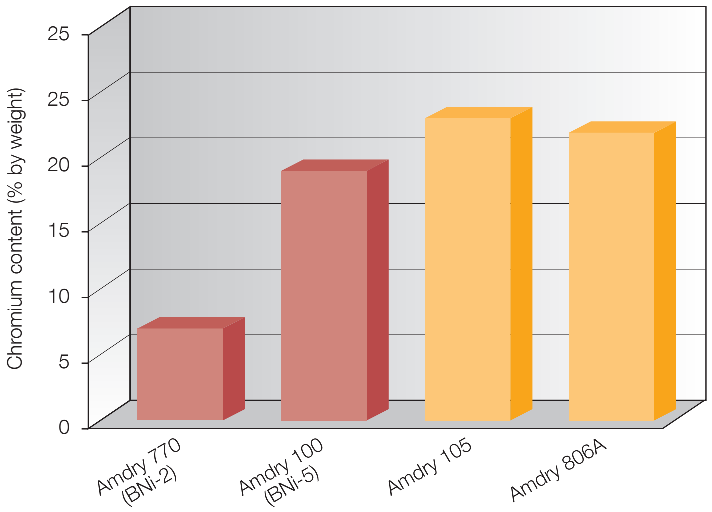
The composition of Amdry 105 and Amdry 806A has been selected to maximize brazeability and component performance in service, while reducing overall material and processing costs.

High chromium content enhances corrosion and oxidation resistance. Nickel content is minimized (Amdry 105) or completely replaced with iron (Amdry 806A) to control volatile material market costs, while maintaining strength and ductility. Phosphorus content is minimized and incorporated such that no free phosphorus is present in the brazed joints that could precipitate into grain boundaries and reduce strength or service life. At the same time, these filler metals use a controlled amounts of silicon as the main temperature suppressant.

The braze materials are manufactured using the dry gas atomization method from high purity raw materials, ensuring a high quality, homogeneous product with very repeatable and reliable processing and performance results.

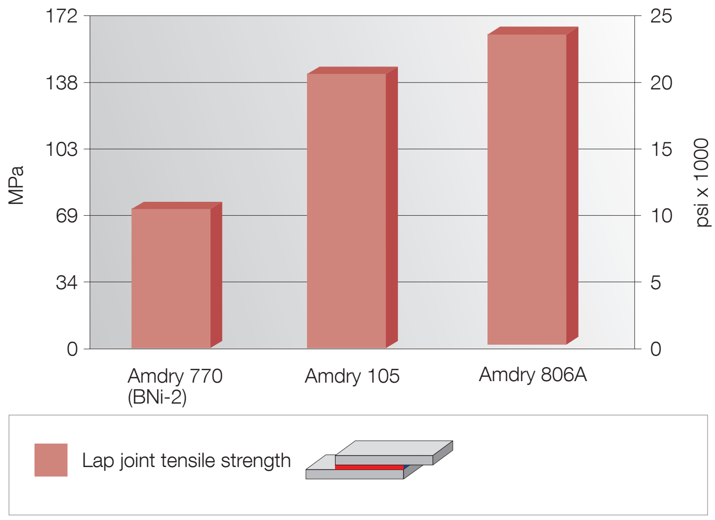
Chromium content

The chromium content of these Amdry filler metals was designed for excellent corrosion resistance and strength in applications such as heat exchangers and catalytic converters. These alloys contain much higher amounts of chromium than most other nickel-based braze alloys.



Joint strength

Tensile strength testing in lap joint configurations demonstrate that these alloys have joint strengths that are comparable to traditional nickel-based braze alloys. All test joints were brazed in a vacuum furnace, and the tensile testing performed at room temperature.



Corrosion resistance

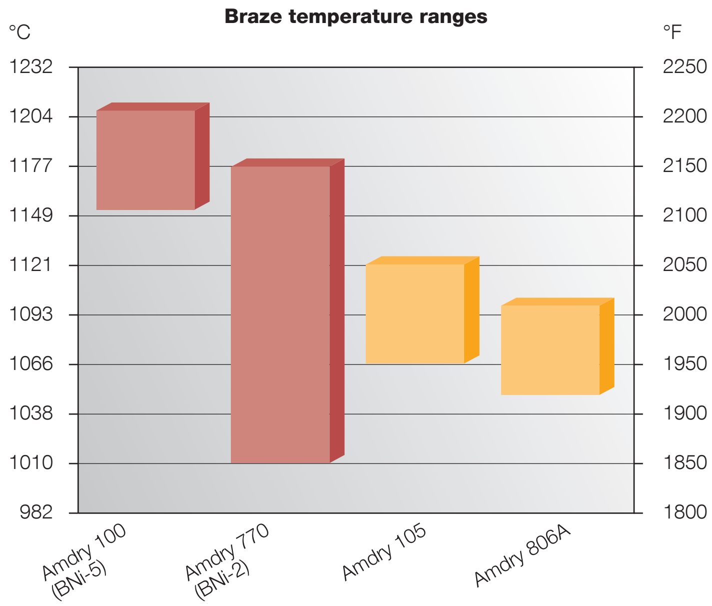
Corrosion and high temperature oxidation tests were performed on brazed samples of Amdry 105 and Amdry 806A, and compared to BNi-2 and BNi-5 control samples. In each case, the results revealed excellent corrosion resistance for the samples brazed with Amdry 105 and Amdry 806A.

Amdry 105 Corrosion Test		
Test parameters	**Test Time**	**Results**
10% H_2SO_4 Aqueous solution	150 h	Microscopic examination did not reveal any corrosive attack of the braze joint
10% HCl Aqueous solution	150 h	
10% NaCl Aqueous solution	150 h	
810 °C (1500 °F) Air atmosphere furnace	24 h	No reduction in weight compared to the pre-oxidation test sample

Amdry 806A 144 Hour Half-Immersion Corrosion Test (pH 4.0 ± 0.2)	
Test solution concentration	**Results**
100 ppm Cl^- Aqueous Solution	Minor uniform corrosion with minimal pitting of the braze joint
20 ppm NaO_3^- Aqueous Solution	
600 ppm SO_3^{2-} Aqueous Solution	

Braze temperature comparison

Amdry 105 and Amdry 806A braze in the same temperature range as the alloys currently used in heat exchangers, catalytic converters and EGR coolers. For applications where a lower braze temperature is desirable, Amdry 105 and Amdry 806A are excellent choices. To maximize cost efficiencies on components that can tolerate a somewhat higher braze range, Amdry 806A is recommended.

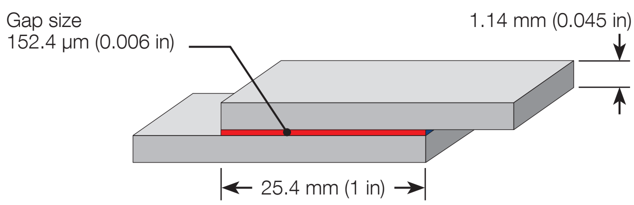


Filler metal	Solidus		Liquidus		Braze range	
	°C	°F	°C	°F	°C	°F
Amdry 105	993	1820	1010	1850	1066 to 1121	1950 to 2150
Amdry 806A	995	1823	1021	1870	1050 to 1100	1922 to 2012
Amdry 100 (BNi-5)*	1080	1975	1135	2075	1150 to 1205	2100 to 2200
Amdry 770 (BNi-2)*	970	1780	1000	1830	1010 to 1175	1850 to 2150

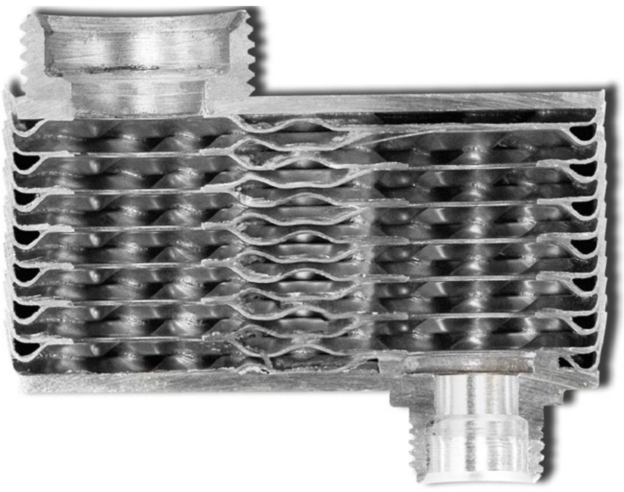
* For comparison

Flow data

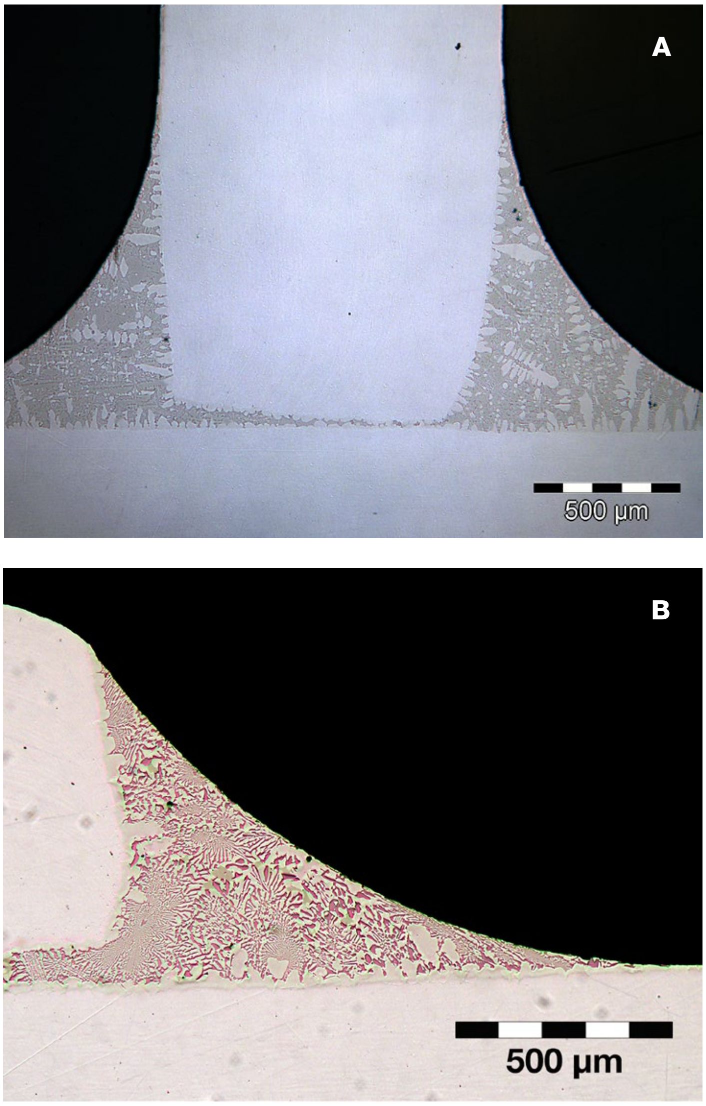
These braze filler metals are free-flowing during the braze process and can be used to fill long, narrow gaps. Standard flow testing indicates that these braze alloys will easily fill a 22T joint.



Lap joint configuration for flow testing.



Cross-section of a nickel-brazed plate heat exchanger that would have longer service life and better cost efficiency if brazed with Amdry 806A.



Photomicrographs showing examples of joints brazed with Metco Joining & Cladding's reduced-nickel, high-temperature braze filler metals. A) Amdry 105 (boron free), B) Amdry 806A (low boron).

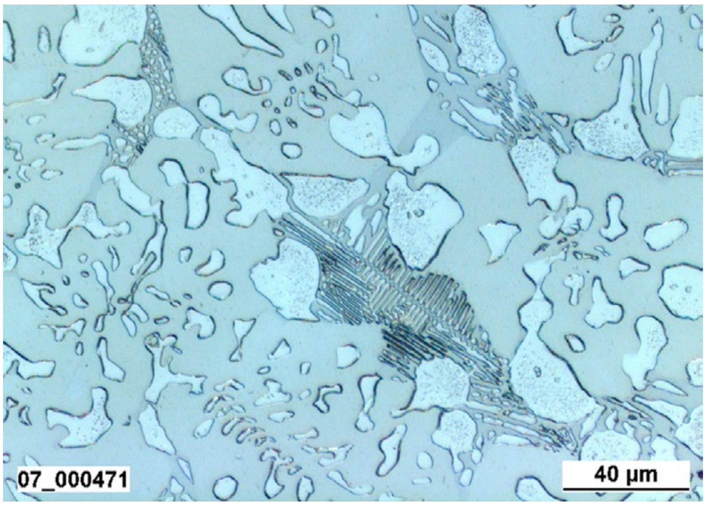
Phase analysis

Optical micrographs of brazed samples of Amdry 105 and Amdry 806A revealed distinct phases in each of the alloys. Further analysis of these phases using SEM-EDAX analysis was performed for each of the filler metals.

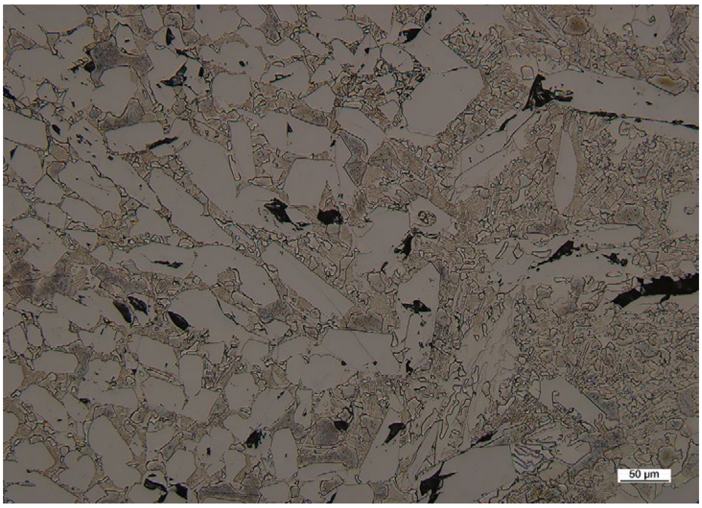
Amdry 105 has a NiCrSi-rich matrix phase, as well as NiCr silicide and CrNi silicide phases. It also has eutectic phases comprised of NiCr silicide and a phosphorus-rich, NiCrPSi phase. Amdry 806A consists of a primary phase with binary eutectic and ternary eutectic phases. The primary phase is an Fe3P type with Ni, Cr, Si in dissolution. The binary and ternary eutectic phases contain Fe3P, alpha Fe and Fe silicide. Each phase dissolves Ni, Cr, Si within its solubility limits.

All of the phases, including the matrix, for each of these alloys contain significant amounts of chromium. The relatively small amounts of phosphorus are bound in compounds containing high amounts of chromium and / or nickel with no free phosphorus present. Thus, any concern that phosphorus may precipitate into the grain boundaries is eliminated.

Optical micrographs

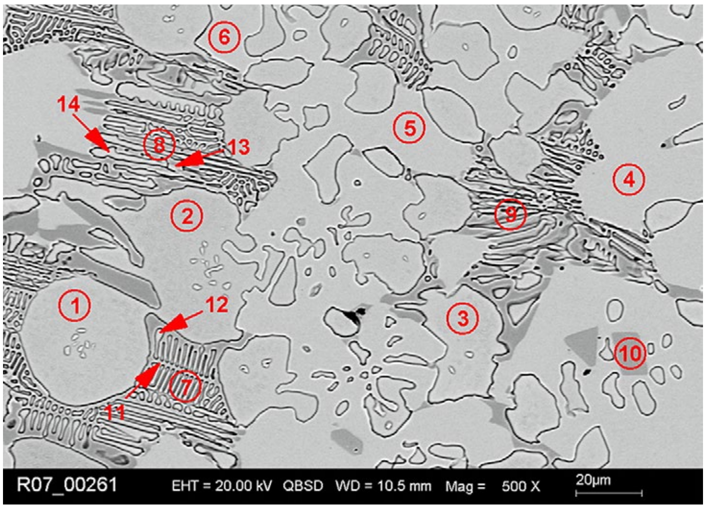


Amdry 105 Optical Micrograph
(electrolytically etched with 20:2:1 vol. ratio CH_3OH:HCl:HNO_3)

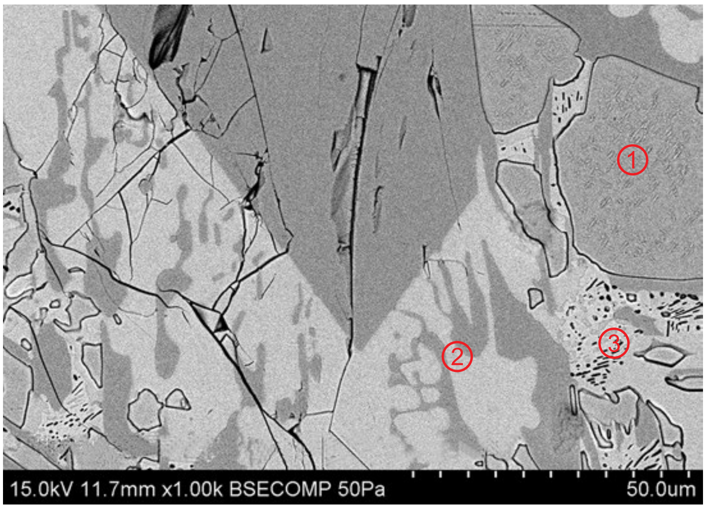


Amdry 806A Optical Micrograph
(electrolytically etched with 10 % KOH aqueous solution)

SEM micrographs



Amdry 105 SEM Micrograph
Matrix Phase: NiCrSiP
Primary Phase: NiCrSi
Eutectic Phase: NiCrP



Amdry 806A SEM Micrograph
① Primary Phase: αFe(Ni, Cr, Si)
② Binary Eutectic Phase: Fe(Ni, Cr, Si)3P + α_1Fe(Ni, Cr, Si)
③ Ternary Eutectic Phase: Fe(Ni, Cr, Si)3P + α_1Fe(Ni, Cr, Si) + FeSi

Ease of application

All Amdry braze filler metals are available as powder, pre-mixed paste and custom-sized tape and preforms. The powder is dry gas atomized, assuring clean, homogeneous, freely-flow material, held to tightly controlled particle size ranges. The powder materials are easily mixed or blended with the customer's own slurry or adhesive to apply the braze filler metal to their assembly components.

Pre-mixed paste are available in a choice of several different binders, to meet varying production needs, and package sizes to suit different application methods. Custom-sized tape and preforms are flexible, easy to apply and can supplied with adhesive to facilitate placement. Paste, tape and preforms leave virtually no residue during brazing.

Amdry braze products are available as powders, paste, custom-sized tape and custom-cut preforms.

Processing

Customers currently using traditional braze alloys on their components will find that very minimal changes to manufacturing procedures are required to switch to Amdry 105 or Amdry 806A. While vacuum furnace brazing is recommended for these braze alloys, other furnace atmospheres, such as argon, nitrogen or pure dry hydrogen can be used.

No flux is required, eliminating the processing steps that would be necessary to apply the flux and post-braze cleaning the brazed assemblies, further reducing manufacturing costs.

If necessary, substrates rich in titanium or aluminum can be nickel flashed to improved the flow of the braze alloy.

Cost comparisons

The reduced nickel content of these braze materials make them more cost effective than traditional alloys such as BNi-2 and BNi-5. Amdry 806A, being an iron-based filler metal, is the most cost effective as it contains 30 % less nickel-based filler metals, and the material is least likely to be affected by fluctuating metal market prices, yet delivers the same braze results.

Comparative cost of Amdry 806A and Amdry 105 vs. traditional braze filler metals (Amdry 100 and Amdry 770).

Customer benefits

Effective

- Produce high quality braze joints with excellent corrosion resistance and strength.
- Use on steel, stainless steel and superalloy substrates.
- Filler metal compositions improve ductility and helps to ensure component service life.
- Low viscosity filler metal can be used to join long, narrow gaps.
- Low braze temperature range compared to other nickel-base filler metals, for use on components that cannot tolerate higher ranges.
- Amdry 105:
  Very high strength routinely meets 95.7 kPa (2000 psi) burst strength requirements for heat exchangers.

Economical

- Reduced nickel material compositions save money.
- Amdry 806A:
  Unique iron-based chemistry can reduce typical braze alloy material costs by as much as 30 %.
- Amdry 806A:
  Filler metal costs are not as sensitive to fluctuating metal prices as traditional nickel-based filler metals.
- Availability of paste, customized tape / preforms reduces braze placement time and production costs.

Efficient

- Gas-atomized braze powders are clean, dry and have precise and consistent chemistry and particle size for repeatable processing results.
- Compatible with vacuum brazing and a variety of furnace atmospheres including hydrogen, nitrogen and argon.
- Reduced braze cycle times resulting from lower braze temperature range
- Available as powder, paste, custom-sized tape and custom-cut preforms, for ease of application and improved process reproducibility.
- Easily replaces traditional braze alloys with little change in processing procedures.

Environmental benefits

- Clean, furnace braze processing.
- Availability as paste and customized tape / preforms can reduce material waste and brazes with little or no residue.
- No flux is required for furnace brazing of these high chrome braze alloys, eliminating post-braze cleaning.

Information is subject to change without prior notice.

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