Brazing Technical Bulletin

Improvement of Joint Quality and Reduction of Flux Usage with Ag Based Handy One® Products

LucasMilhaupt
A Handy & Harman Company
Join with the Best!

Lucas-Milhaupt, Inc.
5656 S. Pennsylvania Ave • Cudahy, WI 53110
Phone: 414.769.6000 • Fax: 414.769.1093
www.lucasmilhaupt.com

Introduction

Brazing is an important process used in many industries today including HVAC/R, automotive, aerospace, construction, electronics, etc. Brazing's versatility allows numerous different assemblies and base metals to be joined together.

Several brazing methods can be employed ranging from torch brazing in open air to vacuum furnace brazing. Torch and induction brazing are two of the most common brazing methods used in industry. These processes are commonly performed in open air with the use of a Ag-Cu-Zn braze alloy. When heating an assembly in open air, oxides form on the surface of the base metal being brazed prohibiting the filler metal from wetting the assembly properly. Brazing fluxes applied to the assemblies to be joined prevent oxidation from occurring during heating and dissolve the oxides already present on the base metal surface allowing the braze alloy to wet the base metal and flow into the joint interface.

Traditionally, the fluxes used in conjunction with torch and induction brazing come in a variety of forms including pastes, slurries, liquids, and powders. These fluxes, however, typically require a separate application on the assembly to be brazed prior to heating. The application of external flux when brazing with solid wire is typically performed manually by an operator prior to brazing. The solid braze alloy is then often applied by hand during heating or pre-placed in the joint prior to heating. This manual fluxing operation introduces a pre-braze step that increases cycle times and introduces a variable into the braze process that can vary joint consistency and quality, increase post-braze clean up time, and safety concerns.

Handy One® flux cored brazing alloys have been introduced to the brazing industry in order to limit the inconsistencies seen with traditional application of brazing fluxes and solid alloy. Flux cored alloys reduce brazing process times and safety/environmental concerns while improving braze joint quality and consistency. This increase of joint quality and the reduction of flux usage and environmental concerns will be the focus of this bulletin.

What is Handy One®?

Handy One alloys reduce the two steps of applying the flux and alloy prior to brazing into one. For these flux core products, the flux is proportionally added to the inside of a braze alloy wire so that no external flux application is required. Handy One can also be applied during heating or pre-placed in the joint region prior to brazing.

Figure 1 shows an example of the stages a Handy One goes through during heating. After the ring is placed on the assembly (1), heat is applied during brazing and the flux inside the wire becomes molten and flows out of the wire into the joint interface (2). The flux that flows into the joint interface prevents and removes oxide formation during heating allowing the molten braze alloy to wet the base material and capillary into the joint (3). Capillary attraction pulls the alloy through the joint, forcing the flux out of the joint interface and completes the braze (4).

Figure 1 - Stages of Handy One® During Heating

Handy One is available using several different Ag based braze alloys and flux combinations that accommodate a wide variety of applications and base metals. Table 1 shows several of the brazing filler metals that are offered in Handy One.

Table 1: Filler Metal Options for Handy One® Products

General Purpose Filler Metals											
Product Name	AWS Spec	Solidus		Liquidus		Alloy Compositions					General Comments and Description
		°F	°C	°F	°C	Ag	Cu	Zn	Sn	Ni	
Braze™ 300	BAg-20	1250	675	1410	765	30	38	32	---	---	An economical general purpose filler metal for joining ferrous and non-ferrous metals. Sluggish flow, enables filling large gaps. Not recommended for stainless steel.
Braze 380	BAg-34	1200	648	1330	720	38	32	28	2	---	Free flowing general purpose filler metal for joining ferrous and non-ferrous metals. Not recommended for stainless steel.
Braze 401	---	1245	675	1340	725	40	30	30	---	---	Fairly narrow melt range, alloy has application for both steel and copper-based materials.
Braze 505	BAg-24	1220	659	1305	707	50	20	28	---	2	Best overall general purpose alloy, joins all common metals (except aluminum) including stainless steel. Fast flow.
Braze 560	BAg-7	1145	618	1205	651	56	22	17	5	---	Lowest temperature, cadmium-free brazing filler metal. Very fluid alloy joins ferrous and non-ferrous metals. Not recommended for stainless steel.

Reduction of Flux Usage and Losses

As stated above one of the primary advantages of Handy One is the consistency of flux application it introduces into the brazing process. Providing a consistent amount of flux to an assembly prior to brazing will reduce process waste and improve braze joint quality.

The testing discussed in the following sections investigated how much flux was applied prior to brazing using solid wire and flux cored wire along with the amount of waste produced for each form.

This test was performed by torch brazing a series of 304 L stainless steel coupons with a Handy One Braze 505 wire and also with a solid Braze™ 505 wire and Handy Flux. The coupons brazed were 1.00" in width with a joint overlap of 0.500" and were mechanically cleaned prior to brazing. An example of the brazed assembly is shown in Figure 2.

The first set of specimens was brazed with solid wire and was manually fluxed with an acid brush. The amount of paste flux applied was kept as uniform as possible by the operator. A pre-cut slug of Braze 505 solid wire (0.055" diameter) was placed on one side of the lap joint.

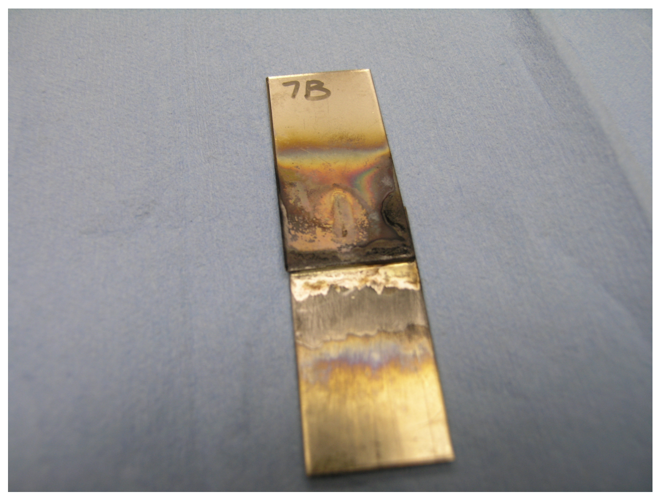

Figure 2 - Example of Brazed Stainless Steel Assembly

For the second set of specimens brazed, only a pre-cut slug of Handy One Braze 505 (0.053" x 0.092") oval wire was placed on one side of the joint. No external flux was applied. Measurements of the amount of alloy and flux applied for each specimen were recorded.

The amount of alloy applied for both sets of specimens was consistent because pre-cut slugs of alloy were applied to the assembly. The amount of flux applied, however, between both sets of samples varied greatly. The average weight of flux applied to each specimen brazed with external flux was 0.150 grams while the average weight of flux applied with the flux cored product was 0.073 grams. These values and the percent difference between each set of specimens are shown in Table 2. It should also be noted that the consistency of the amount of flux applied varied between both forms. The maximum amount of flux applied for the external flux was 0.196 grams while the minimum was 0.100 grams. This difference in the amount of flux used can significantly affect the consistency of the brazing/heating process and the overall quality of the resulting braze joint. The maximum and minimum amount of flux applied with the flux cored slugs were 0.074 grams and 0.071 grams, respectively. This translates into a much more consistent brazing process and braze joint.

After all the specimens were brazed with the solid and flux cored wire, each assembly was weighed in order to determine the weight lost during brazing. The majority of weight lost can be attributed to the loss of flux. Flux loss can occur due to spitting and vaporization during heating. It can be seen in Table 2 that there was 84.3% less weight loss during heating when using the flux cored alloy. This limits the amount of fume exposure to the environment and operator.

Table 2: Amount of Flux Applied and Waste Produced During Brazing

	Weight of Flux Applied (g)	Weight Loss after Brazing (g)	Weight of Residue Loss after 1st 10 min. (g)	Weight of Residue Loss after 2nd 10 min. (g)	Total Weight of Residue Loss After Water Soak (g)	Total Loss During Braze Process (g)
Average Value for Joints Brazed with Solid Braze™ 505 and Handy Flux® Type B-1	0.150	0.073	0.068	0.008	0.076	0.149
Average Value for Joints Brazed with Handy One® Braze 505	0.073	0.011	0.063	0.003	0.066	0.077
Percent Difference between Flux Cored and Solid Form	51.33%	84.30%	7.35%	62.5%	13.15%	48.3%

Each set of specimens were then cleaned by being placed in a 600 ml bath of hot water (as shown in Figure 3) for an initial time period of 10 minutes. The hot water bath was held at a temperature of approximately 150ºF (66 ºC). After the initial water soak, weights were again measured to determine the amount of weight lost during cleaning. The same procedure was repeated for a second hot water soak for 10 minutes. The resulting weight losses were recorded in Table 2. These weight losses, again, were primarily considered to be flux residue.

The results of these tests revealed a significant decrease in the amount of flux used and flux residue produced when brazing with flux cored wire versus a solid wire and an external flux. The amount of residue produced per braze joint directly impacts the amount of cleaning required after brazing has to be removed. As shown by the values in Table 2, flux cored alloys reduced the total amount of losses during the brazing process by 48%. It should also be noted that 51% less flux was used with the flux cored alloys. On a production basis this can equate to a very significant decrease in waste removal and consumable cost to the end user.

Table 3 shows an approximation of how much less flux would be used by a manufacturer during brazing when using flux cored rings versus solid rings and paste flux. The data used to determine the values in Table 3 were taken from Table 2 and were calculated assuming a ring I.D. of 0.320”.

Table 3: Reduction of Flux by Using Flux Cored Rings

	# of Rings Used per Week	# of Rings Used per Year	Average Amount Flux per Ring (g)	Amount of Flux per Year (kg)	Amount of Flux Reduced by Using Flux Cored Rings (kg)
Data for Solid Rings and External Flux	1,000	52,000	0.150	7.8	N/A
	10,000	520,000	0.150	78.0	N/A
	100,000	5,200,000	0.150	780.0	N/A
Data for Flux Cored Rings	1,000	52,000	0.073	3.8	4.0
	10,000	520,000	0.073	38.0	40.0
	100,000	5,200,000	0.073	380.0	400.0

Improved Joint Quality with Handy One

By controlling the amount of flux applied to the assembly being brazed as described in Section 3, the resulting braze joint using Handy One should be a more consistent quality and exhibit fewer flux voids. This reduction of voids should translate directly into a reduction of assembly leaks and failures. This can be a significant benefit for manufacturers who are experiencing significant failure rates in their brazed assemblies.

Figure 3 illustrates an example of the improvements in failure rates that consumers can realize with Handy One alloys. The data shown in this table was produced by a compressor manufacturer who was torch brazing a tube to shell assembly with hand fed Braze 505 and a boron modified flux. As shown in the graph the manufacturer was experiencing two failures relating to brazing.

The first failure was related to a leak in the tube to shell joints produced by brazing. Prior to using Handy One the compressor manufacturer saw failures due to leaks at a rate of 3800 ppm. After being introduced to Handy One 505 and implementing it into their joining process. The frequency of failure was reduced was reduced by over 30% to 2500 ppm. The use of Handy One reduced the number of leaks by reducing the amount of flux voids present in the tube to shell joint and limiting the path for a leak.

The second failure that occurred due to brazing was excess alloy flowing into the internal components of the assembly causing improper function. Prior to using Handy One, the compressor manufacturer failures caused by excessive alloy at 3500ppm. After introducing Handy One into their brazing process, failures were reduced from 3500 ppm down to 200 ppm. This significant decrease helped limit the amount of repairs that needed to be performed while reducing the amount of alloy/flux that was consumed.

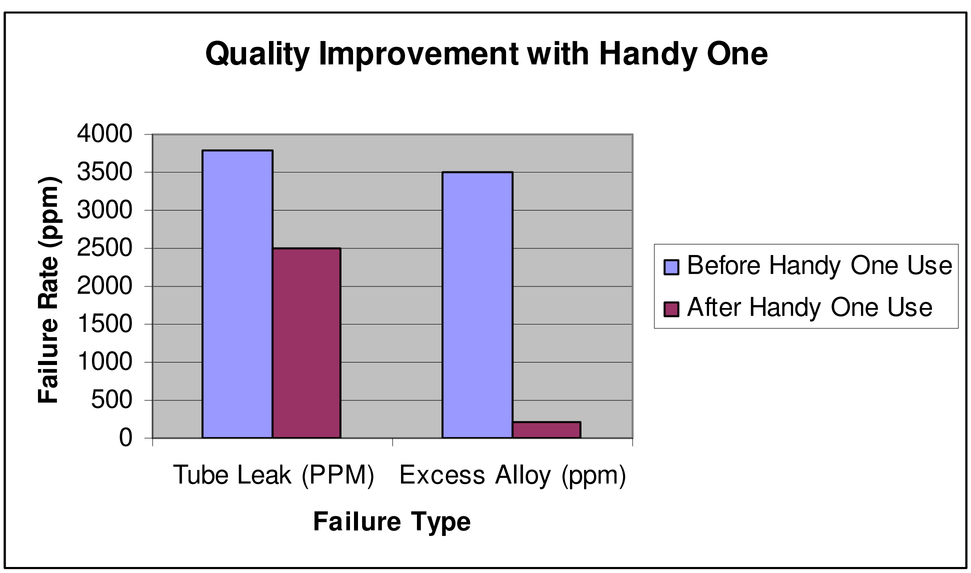

Figure 3

Conclusion

Traditionally solid wire and an external flux have been predominately used for torch and induction brazing in many industries. External flux is typically applied manually by an operator prior to brazing. This step increases process time and introduces inconsistency in the amount of flux applied. Often times the operator applies more flux than is required which also increase the overall cost of the brazing process. Varying amounts of flux applied can cause inconsistent braze quality and fluctuating heating cycles.

With their introduction, Handy One products have helped manufacturers who utilize torch and induction heating to improve their joining process consistency and braze quality, while limiting the amount of brazing consumable used. The studies documented in this bulletin illustrate and confirm the many benefits that Handy One products offer. The Handy One wire used provided a more consistent amount of flux to the assemblies brazed, creating a high strength joint while limiting the amount of flux used and the waste produced during heating.

For further information, please contact Lucas Milhaupt North America Technical Service Department at 1-800-558-3856.

Handy One® is a registered trademark of Lucas-Milhaupt, Inc.

About the Author:
Creed F. Darling is a Brazing Applications Engineer at Lucas-Milhaupt, Inc., Cudahy, WI. Mr. Darling obtained his BSME from Marquette University and is an active on the AWS C3 Committee on Brazing and Soldering.