Q: We are joining two carbon steel components using a high-temperature brazing filler metal. The assembly is a fairly simple design consisting of a tube with a cap on the end. There is a step on the rim of the cap where it is inserted into the tube end. We place a braze ring on this step before inserting it into the tube. The braze alloy is 55% copper, 4% manganese, 6% nickel, and 36% zinc. The process we use is induction brazing using a circular coil with two turns. The process is done in air. The assembly is placed in a fixture to hold it vertically with the cap on top. We have a very short heating time of 3 s and we rotate the part while heating. To ensure we have no braze alloy on the outside of the tube after brazing, we continue rotating the assembly after the power has shut off and the operator “scrapes” the outside of the joint with a rasp to remove any excess braze alloy that may have oozed out. We have enjoyed success with the process for a long time, but the odd thing is we do not use flux. We are being advised that we should be using flux. These parts get heat treated after brazing and we would need to add a step to remove it after brazing, and we would rather not. It's both messy and time consuming to remove it and put it on in the first place. We destructively test a part periodically and we always break the cap. We've looked at the joints and we get good adhesion of the braze alloy. We have no complaints about the parts in service. What is your take on the use of flux?

A: I must tell you that in my more than 40 years in the industry, I've never run across a similar scenario to the one you've described. It reminds me of why I love baseball. I have been playing or watching baseball my entire life and, every five or six games I watch, I see something I've never seen before. It makes it more fun. While I have not heard or seen this exact situation, I have seen customers doing unconventional things for my entire career. People on shop floors figure out ways of getting a product made and out the door, and they don’t always follow the book.

While, at first glance, it would seem you are asking for trouble, you’ve indicated the parts are acceptable and exhibit no issues in field service. A good track record is hard to argue with but a few things come to mind.

The first is I’m not sure you have much margin for error. I will explore the reason I think it is working for you in a moment but, as brazing has so many variables that need to be accounted for, I do not know how close to the edge you are running. Things that come to mind are component cleanliness, joint clearances, and the pressure applied during rasp cleanup to name a few. Since you do not destructively test all parts, I'm not sure
what the joint quality is overall.

The second thing is you may be able
to give yourselves a better margin of
error, not by using flux, but rather, a gas
cover of some nature. It is common to
flood the joint area during inductive
heating with nitrogen. It does not re-
duce the oxides that are present on the
parts prior to heating but will help in-
hbit further oxidation during brazing.
Sometimes the process design allows for
a simple “chamber” to be used to en-
close the joint and others simply flow
the nitrogen over the joint. There are
other cover gases that can be used that
contain a small amount of hydrogen.
The hydrogen contents are only a few
percent to keep them nonexplosive, but
it may be enough to offer a small
amount of oxide reduction.

While there is not enough informa-
tion to make a definitive comment as
to why this process works, there are
some clues. They include the use of in-
ductive heating, the constituents of
the brazing filler metal, and the ras-
ping of the joint.

One of the contributing factors is
the fast heating cycle. The longer you
heat the assembly, the more oxidation
that will occur. With such a fast heat-
ing cycle, there is limited time for an
oxide layer to build up. This is possible
because of your use of induction heat-
ing. Other methods would typically be
much slower. In addition, by rotating
the assembly during heating, you im-
prove the uniformity of heating. This
filler metal contains manganese and
longer heating times can cause it to
oxidize, so the short heating time
helps you in this regard as well.

The brazing filler metal you are us-
ing lends itself to increasing the odds
of success for its use without flux. In
other applications, they are difficult-
to-join materials that are commonly
brazed. These include a series of car-
bide materials used in a variety of cut-
ting tools and wear applications. In all
of these, we recommend the addition
of nickel. The nickel wets and adheres
to the carbide surface well and adds
great strength to the joint. This attrib-
ute will help make it work well on steel
in your application.

When there are applications that call
for an added capability to wet and ad-
here to a carbide surface, there are cer-
tain braze filler metals in use that con-
tain manganese (Mn). This addition im-
proves wettability of the filler metal on
the base metals. Its presence in the filler
metal you are using should help greatly.

A review of the websites of several
brazing filler suppliers showed filler metals
with manganese are selected due to
their enhanced wettability on carbides.
The AWS Brazing Handbook, 5th Edition,
page 420, in the chapter on cemented
carbides and cermets, states, “Carbon-
ides brazed with Mn-containing brazing
filler metals require less critical surface
preparation than in a case where lower
melting temperature filler metals are
used.” The Mn addition enhances the
ability of the filler metal you are using
to wet the steel.

So it would seem that the selection
of the CuZnNiMn filler metal and the
induction heating sets up the condi-
tions for possible success without flux,
but you still have the pesky issue of
oxidation to deal with. I believe this is
where the rapsing comes in. What is
most likely helping to put you over the
top is the abrasive action of the raps-
ing, just after heating, while the filler
metal is still molten. There are other
precedents that have been set in ma-
terials joining where a mechanical abra-
sion of the oxide layer during heating
can disturb this layer and create a con-
dition for the molten braze filler metal
to wet and adhere to the base metals.

Conventional wisdom says that a
flux or reducing atmosphere is needed
to make a braze joint such as you are
producing. Your results would seem to
contradict this. The books and collec-
tive years of experience result in
things called “best practice.” In an
application such as yours, I believe the
use of flux gives you the best overall
chance to be successful in your joining
operation. You have demonstrated
that, for your specific set of condi-
tions, an “alternative practice,” is ac-
ceptable. The caution I would issue to
anyone else who wants to attempt this
process, i.e., free of flux, is that a dif-
ferent set of conditions may not yield
such a successful result. WJ

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rently serves as a BSNC vice chair and
owns his own consulting business.
This column is written sequentially
by Tim P. Hritha, Alexander E. Shapiro,
and Dan Kay. Hritha and Shapiro are
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C3 Committee on Brazing and Soldering.
All three have contributed to the 5th edi-
tion of the AWS Brazing Handbook. Con-
tact information for this issue’s author follows.
Readers are requested to post their
questions for use in this column on the
Brazing Forum section of the BSNC Web site
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