Copper Applications
A Case Study

Allegheny Power Insists on Copper For Substation Transformers

Reliability and Lower Ownership Costs — Important.
Cost of Copper vs. Aluminum — “Not a Big Factor,” says Allegheny
Allegheny Power, a unit of Allegheny Energy, is a regulated utility that delivers power to about 3.5 million customers in parts of Pennsylvania, Maryland, Virginia and West Virginia. Its customer base is mostly rural. Many segments of its distribution system are radial feeds, while other segments serve industrial loads that can fluctuate widely. Maintaining maximum system reliability under conditions like that is very important, even if it isn’t always easy. But the company found that one surefire way to keep the lights on — and keep its customers happy — is by buying only copper-wound transformers for its substations.

Ask Joe Leighty. He’s the engineer in Allegheny Power’s support unit responsible for designing substations and specifying transformers, a job he’s held for more than 20 years. Leighty has seen how utility transformer preferences have changed over the years and, from those changes, he’s learned what’s important when it comes to ensuring long life in critical equipment (Figure 1).

“Reliability is the Key

“The main reasons we’ve decided to go with copper are what I call strength issues,” explains Leighty. “Copper windings are stronger and better able to handle fault forces than aluminum, so a copper transformer is more likely to survive a big overload. We’re primarily a rural electric company with a lot of radial distribution in our system. If we lose a transformer, it isn’t always easy to switch to an alternate source of power on the grid. A transformer outage can affect people...
over a very large area, so we have to build maximum reliabil-
ity into our system.

“Thermal expansion is another important issue. The ther-
mal expansion of aluminum is much larger than copper’s
from normal ambient temperatures down to –20°F. That’s
important because substation transformers are built to a
specific design coil height, and coil windings are clamped to
keep that height fixed. As our load fluctuates, transformer
temperatures rise and fall. The coil wants to compress and
expand, but it can’t because it’s clamped. Instead, it com-
presses the paper insulation between turns (Figure 3). The
effect is especially pronounced when a fault occurs, but it
affects aluminum windings much more so than it does cop-
per due to the difference in thermal expansion.

“Later, when the temperature returns to normal, the
insulation in an aluminum transformer might not be as tight
as it was before the overload. That allows the windings to
loosen slightly, a condition that might lead to loose connec-
tions at some point in time.”

**Lifetime Costs Lower with Copper**

Leighty believes copper also helps reduce lifetime
ownership costs. “Again,” he says, “it’s due to copper’s
higher strength. Life-cycle cost is not just a matter of
efficiency (even though that’s important), it’s also a function
of reliability.

“For example, we expect a 40- to 50-year life cycle in our
transformers. We monitor their condition with periodic oil
analyses. When an analysis shows that gas and moisture are
increasing, it’s a sign that the oil is breaking down and that
there’s probably overheating going on at a connection inside
the transformer. If you have aluminum-wound coils, the inter-
nal connections can loosen (creep) over time, just like con-
nections in aluminum house wiring did 30 years ago. Loose
connections cause the heating that breaks down the oil. We
almost always identify the problem before it gets out of hand,
but, when we don’t, the result can be catastrophic. Even if
we don’t lose the unit, repairs are expensive and not always
easy because of the nature of our system. With copper wind-
ings, connections stay tight, transformers stay on line, there
are fewer repairs and lower ownership costs. It’s almost a no-
brainer to go with copper now because of better reliability.”

**Cost of Copper “not a big factor”**

But does buying 100% copper transformers increase the
utility’s costs? Not according to Leighty. “The cost difference
between copper and aluminum is not a big factor in this size
range,” he says. “The economics in favor of aluminum just
aren’t there. You’ve probably heard about copper transform-
ers being smaller and lighter, that they need less steel and
oil, etc. Those factors reduce costs for the manufacturer, but
they save us money, too, because a copper transformer lets
us build a smaller pad with less concrete and maybe a little
less real estate (Figure 2). From a cost standpoint, there is
no benefit to go with aluminum.”

The cost of windings — whether copper or alu-
minum — actually comprises only between 6% and
10% of the total cost of a large transformer.
Furthermore, manufacturers report that the smaller
conductor sizes needed in copper (for equivalent rat-
ing) facilitates assembly, which helps contain costs.
The fact that copper transformers are smaller means
that manufacturers can realize additional savings in
the amount of steel required, both in the core and in
structural members. Copper transformers also need a
smaller volume of oil than their aluminum counter-
parts and require smaller auxiliary equipment, such
as pumps and coolers. All of these factors help bring
the cost of medium and large copper and aluminum
transformers closer together.
High Efficiency with Copper

Like all electric utilities, Allegheny Power is mandated by its regulators to ensure high efficiency in its equipment. Here, too, copper provides a win-win situation. Leighty explains, "We can no longer use A and B values1 anymore to specify an efficiency rating in our transformers because, after deregulation, we had no way of knowing what the power we buy costs to produce. But high efficiency is still very important to us, since deregulation also meant we had to absorb the costs of inefficient equipment. There are many ways we can write our specs to guarantee high efficiency in our transformers — specifying copper is one of them."

Better fault performance, comparable up-front costs, higher reliability, high efficiency and lower cost of ownership: all good reasons why smart utilities like Allegheny Power specify only copper windings in their substation transformers.

1A and B values represent the present value cost to a utility, in dollars per kilowatt, of losses in a transformer’s core (A) and windings (B).