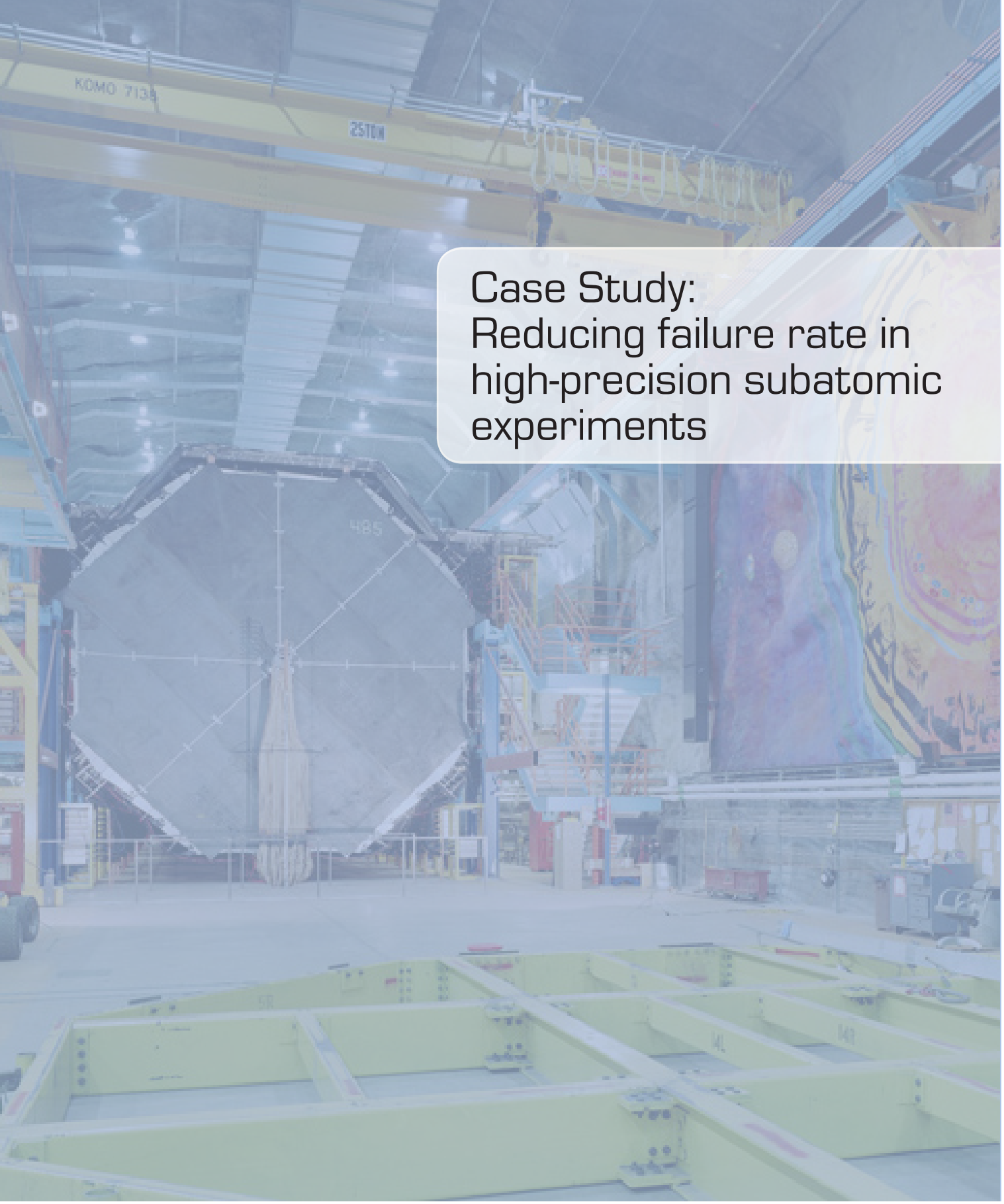

Case Study: Reducing failure rate in high-precision subatomic experiments

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The challenge

Researchers at the Department of Energy's Fermi National Accelerator Laboratory's Main Injector Neutrino Oscillation Search (MINOS) experiment were having difficulty with the failure rate of the experiment's beam targets. The technology, consisting of a series of graphite segments lined by tubes filled with water for cooling, form the targets for a high-precision beamline of neutrinos.

These targets are exposed to heat, vibration, and radiation and therefore must be robust and able to withstand significant mechanical stresses. The first series of targets lasted the expected lifetime of a year and a half each, but recently, targets had begun to fail after approximately six months.

Cory Crowley, mechanical engineer at Fermilab explains, "Since it takes a long time to build the targets and it is difficult to source all the parts for the assembly, if it fails every six months and takes a month to replace, experiment time could be severely compromised."

As a result, Fermilab began searching for new options and ultimately reached out to Morgan.

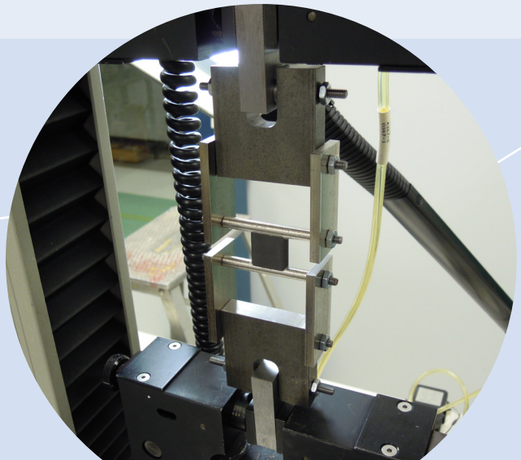
How Morgan worked with Fermilab to develop a solution

Fermilab engineers came up with a new target core design. Instead of stainless steel, the new design called for titanium tubes, which added strength and corrosion resistance. Within the tubes are the same graphite segments used in the older design.

The challenge was to find a method of attaching the graphite to the titanium. Morgan's WESGO brand is a leader in active metal brazing, a process that allows metal to be bonded directly to non-metal materials that typically require a metallization layer. Active metal brazing allows direct wetting of the alloy to the substrate material, eliminating several steps in the joining process and creating an extremely strong bond seal.

For the MINOS experiment beam target, Morgan ran samples using a variety of alloys, and put the samples through rigorous mechanical and thermal testing. After the completion of the testing program, Fermilab decided to proceed with the new design with Morgan's active metal brazing technology.

The MINOS experiment seeks to answer such questions as where do neutrinos come from, what are their masses and how they change from one kind to another



The result

Working through iterations, design changes, and perfection of sample geometry to make sure all the dimensions would work when the assembly is placed in the furnace, the Morgan/Fermilab team came up with a successful design. The graphite segments and titanium tubes were prepared at Fermi and then shipped to Morgan, who brazed and shipped the assembly back for inspection and testing.

Currently, the new target is being held as the emergency spare for this experiment, since emergency retrofitting succeeded in temporarily stemming the tide of beam target failures and scientists opted to keep the old design in place until it fails.

However, the new titanium graphite design is being considered as the prototype for a new long baseline neutrino experiment (LBNE) for which Fermilab is pursuing funding from DOE.

This is a higher energy experiment that will require an even stronger and more robust target than the MINOS one.

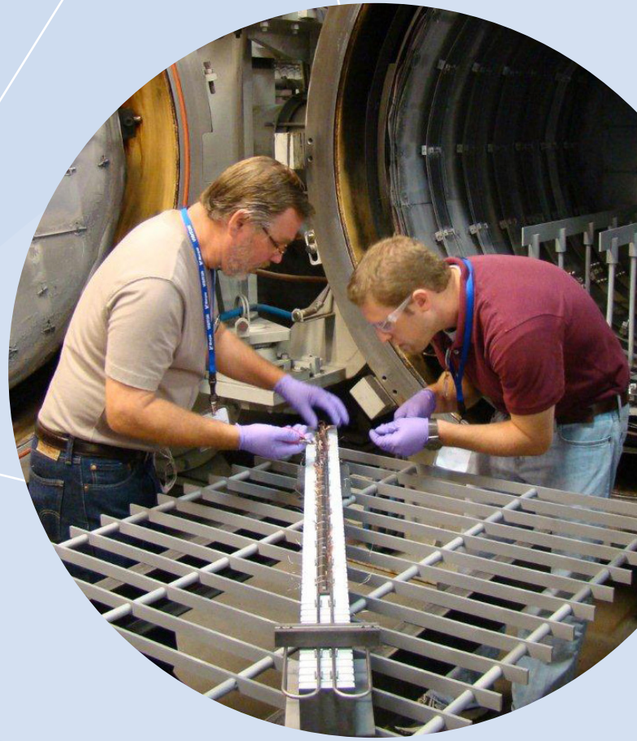
"WE WERE IMPRESSED WITH THE EXTREMELY CLEAN FACILITIES, AND PROCESSING ABILITY OF THESE EXTREMELY EXPENSIVE AND VERY FRAGILE PARTS."

Fermilab Engineer

Morgan has developed more than

15

braze alloy compositions, which directly bond oxide and non-oxide ceramics and synthetics to metal or other materials, including graphite, diamond and sapphire.



Images courtesy of FermiLab

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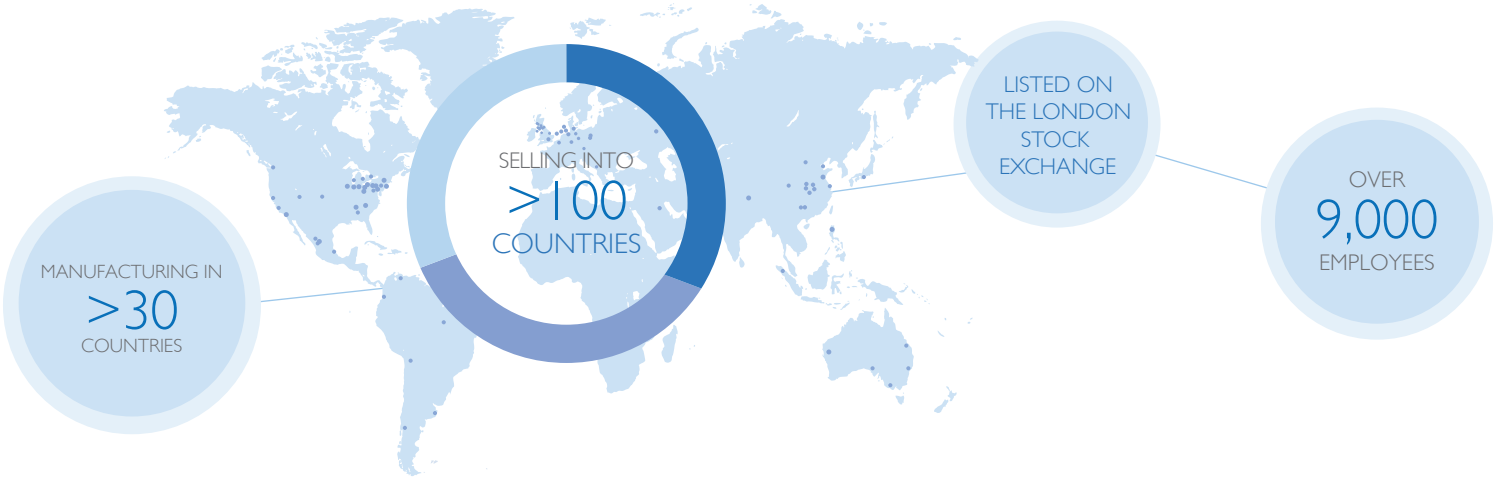
ABOUT MORGAN ADVANCED MATERIALS



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- We find and invest in the best people

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