REMOVING VARIABLES

Ian MacMoy, Intermetallic Group, LLC

Ian MacMoy is president of Intermetallic Group, which helps companies design fastener coatings that will work in the field. He has been involved in bolt research, coating development, and failure analyses. He discussed his extensive experience studying IHE, failures from torque, and the effect of coatings. He is a member of API, ASTM, and NACE International.

Through his role as an applicator in the post-baking and coating process, he has had the experience of being "one of the last people to touch the product before it goes out the door," giving him a unique perspective on the variables possible in the fastener finishing process and firsthand experience working within the con-straints of applicable rules and standards. He noted that applicators need a level of understanding about many variables that are still not fully understood, such as poly-tetra-fluoro-ethylene coatings, torquing, zinc plating, and embrittlement.

MacMoy's talk focused on removing variables in order to reduce risk. He noted that the conception of "catastrophe" has changed over time. Whereas 50 years ago the term might suggest an event killing 10,000 people, today catastrophe is used fairly often to describe any loss of life or environmental damage, such as an oil spill. In some respects, he suggested, the word has changed because there are so many more variables in every situation. We have more questions, and more uncertainty about how much risk an act entails. To reduce these risks, we look to discussions like the one this workshop was designed to facilitate, in which experts enumerate the facts, identify the variables, and, if possible, find ways to remove the variables altogether.

Variables in Subsea Bolts

To remove variables in subsea bolting, we must first identify the variables and then rank them. Variables include the entire system's capabilities, the materials involved, the stress caused by internal processes, and the stress caused by environmental conditions. All of these vary depending on operating locations and conditions, and any of these could fail in a small or large way that could produce a catastrophe.

Fastener variables are tested and monitored, but we haven't yet figured out how to completely remove them, MacMoy said. Tests done during processing measure performance, quality, and reliability against the variables that exist in the field. Fasteners are also monitored for these known variables over time and after changes to the environment or processes. But we can test only for the variables we are aware of, of course, and in conditions that are known; there is no way to test for the unknown.

The removal of a variable, in MacMoy's view, means that we are certain there will be no harmful reactions in the field. For example, from testing we know that electroplating must follow API's 20E rules, such as ASTM B850, which says materials must be post-baked to mitigate HE, and ASTM F519 outlines the specifications for any hydrogen left after these processes.

However, once a material is exposed to an acid or other harsh chemical, HE susceptibility is reintroduced. Once it is exposed to the risk of HE, there is no way to reverse that exposure, though the impacts can be reduced through baking. It would be better, though, to remove all risk of HE by using other procedures that don't introduce hydrogen, MacMoy said.

Once we identify, rank, and eliminate the variables that cause critical failure, we can test and improve noncritical variables. Instead of removing plating variables, for example, MacMoy posited that it would behoove the industry to standardize testing, enforce rules, and create strict regimes meant to "cover our bases" to minimize mounting risk.

Less Is More

MacMoy shared a quote from celebrated writer and aviator Antoine de Saint-Exupery, who said, "A designer knows he has achieved perfection not when there is nothing left to add, but when there is nothing left to take away." This sentiment reflects MacMoy's belief that the industry should strive to take away risks completely, rather than focus on adding tests for designers or engineers to follow.

Listing more than 30 examples of ASTM, ISO, and API standards and testing protocols for subsea fasteners, MacMoy questioned whether the industry might be

better off without them, as they lead to a world where we are keeping variables and adding tests for them instead of eliminating them.

MacMoy suggested that subsea operations in the North Sea by DNV GL and other companies could provide a model for the type of variable-limited scenario he envisions. There, thermally diffused zinc (ASTM A1059) is the best material for topside and subsea bolts, and has never resulted in HE. There are no heavy coatings or dry lubricants applied to fasteners, which keeps the friction coefficient the same. The only variables in these contexts are time, temperature, and substrate, he said. By asking a few more questions, he suggested, it may be possible to find ways to remove the risk of HE altogether in this situation.

Supply Chain Improvements

"No plan of operations extends with any certainty beyond the first contact with the main hostile force," said Helmuth Karl Bernhard Graf von Moltke, the 19th-century German field marshal considered an army modernizer. In addition to removing variables in fastener materials, MacMoy suggested supply chain vendors should be held to a higher standard. Comparing engineers to the armed services generals who direct strategy and vendors and suppliers to the captains and colonels who provide on-the-ground intelligence, MacMoy suggested it would be best for engineers to reduce their reliance on testing and instead encourage vendors to increase their technical authority and abstract reasoning. Doing so will remove variables and allow engineers to optimize fastener performance. On the flip side, the more tests we have, the more rules and laws the government will have to enact, with the attendant legal repercussions when failures happen, including even jail time in some industries.

MacMoy concluded his talk with a personal anecdote illustrating the dangers of overreliance on testing. He had been told by a supplier that a certain material could last more than 30,000 hours of use in salt spray without developing red rust, but when he contacted the laboratory to verify the results, he found that not only could they not replicate the results, the original test wasn't even completed, and the only person who knew how to run it had left the laboratory 2 years before. Verifying processes is essential, MacMoy said, quoting Ronald Reagan: "Always trust that the right thing is being done, but verify that it has been."

We must agree that oil spills are indeed a catastrophe, and that the more variables there are in this equipment, the greater the risk of failure, MacMoy said in closing. We need to look for solutions that do not add testing and risk. Furthermore, this is not a problem that rests on engineers alone; supply chain vendors, who can impact variables and thus risk, need to be a part of the entire operations team.