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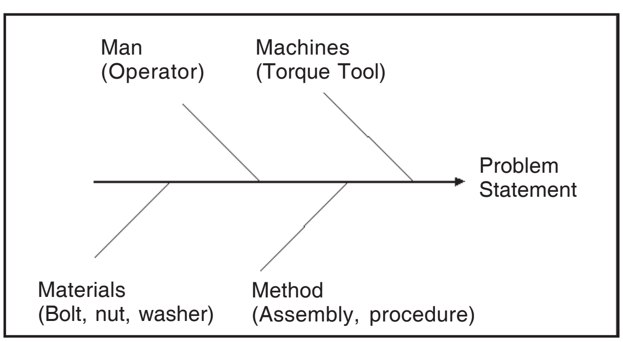
Lessons From The Field: Use The Right Tools!

Last summer I read a great book by Volker Schatz called "10 Steps for Reliable Bolted Assembly – A Guide for Achieving Outstanding Fastening Quality." In his book, Schatz applies the approach developed by Japanese scientist Karuo Ishikawa to develop a strategy to ensure high-quality bolted joints. I highly recommend this book to anyone responsible for bolted joint quality.

The Four M's: Man, Machines, Materials, Methods

Ishikawa advocated a structured approach to cause and effect analysis. The Ishikawa diagram, also known as the Fishbone diagram, is a great structured problem solving tool. The diagram, shown in figure 1 below, resembles a fish. The head of the fish is the problem statement, and the bones are the four main root cause categories: Man, Machines, Materials, and Methods. While other categories can be added in unique situations, experienced users of this technique will testify that most root causes will fall into one of the "4 M's." A popular fifth "M" is Mother Nature, to be considered when natural elements cause problems.

Figure 1: The Ishikawa or Fishbone Diagram



When problems arise in the field, try using this simple approach. You don't need to use the diagram per se, but try to look for root causes in the designated categories. Here are some things to remember when using this technique:

1) Assemble a small team of people closely associated with the problem. It's important to appoint a team leader and include a key decision maker with authority. This way you will be able to overcome organizational obstacles and implement solutions rapidly. After all, we're all in business to make money, and time is money.

2) Start with a concise problem statement that incorporates a metric. This will allow you to define your goal and know when the problem is solved.

3) Use a brainstorming process to identify possible root causes, considering the "4 M's." Be thorough, and don't discount any ideas in the brainstorming phase. You're looking for quantity of ideas in this phase.

4) Categorize the ideas into the appropriate "M." As you categorize, ask "why" to make sure everyone appreciates why it might be a root cause. Asking "why" also forces you to develop a deeper understanding of the problem, which may unveil additional root causes. In this process you identify the likely root causes, and eliminate the duds. Be patient and don't shoot from the hip. Usually more information and analysis is required to complete this step.

5) Make a plan to implement countermeasures designed to address the root cause(s). Remember, when the root cause isn't identified, or when simple shortcuts are taken that don't address the true root cause, the problem will persist.

A Simple Example from the Field

We at Applied Bolting help companies solve bolting problems in projects all over the world. A recent customer experience provides a simple opportunity to demonstrate the use of structured problem solving. Experienced bolt people will recognize that this is not a new problem.

The engineers on this project specified 1-1/4" A490 assemblies with Squirter™ DTIs. During Pre-installation Verification, the Squirters weren't squirting, indicating that the target pretension was not being achieved. The inspectors presumed that the root cause was the DTI because they were able to tighten assemblies when DTIs were removed. They were using a pneumatic impact wrench, and in all cases, they were hammering on the bolts for longer than 10 seconds. Knowing that this can cause serious thread damage and that DTIs do not increase the torque required to tighten a fastener assembly, we urged them dig a little deeper to find the true root cause of the problem.

The team assembled was comprised of inspectors, a foreman, QA managers, project engineers, and a superintendent. Crafting a problem statement was relatively easy.

"All 1-1/4 fastener assemblies couldn't be tensioned in 10 seconds."

Now let's think about possible root causes, considering the 4 Ms.

Materials: Bolts/Nuts/Washers/DTIs: They were using high quality fasteners. However, friction factors are known to vary significantly, so "High Friction" is a possible root cause. While they were convinced that the DTI was a root cause, we had to object. DTIs DON'T INCREASE TORQUE REQUIREMENTS.

Machines: Their Skidmore calibration was current, so no problem there. They were using a pneumatic impact wrench with a working torque range of 1,200 to 2,400 ft-lbs. Some assemblies required 20 seconds to achieve target tension, way over the 10-second rule of thumb. What's more, a quick calculation showed that an assembly with a k-factor of 0.25 would require 2,900 ft-lbs of torque, 20% higher than the tool's working range. Therefore, "Wrench Capacity" is a likely root cause.

Man: While they weren't Squirter pros, they had basic knowledge of best bolting practices. Our torque-tension demonstration always helps to educate iron workers and inspectors.

Methods: They were using Squirter DTIs, and they were attempting to use the proper pre-installation procedure. However, they couldn't get above 70 kips pretension. They chose not to lubricate the threads or nut faces, so "Lack of Lubrication" is another likely root cause.

That's a pretty good list, and you probably noticed that they are all interrelated. The next step was to get some data using their Skidmore Wilhelm tension calibrator. We tested a bunch of assemblies using their pneumatic impact wrench and our electric wrench (maximum torque 3,200 ft-lbs). The data is given in Table 1 on page 168.

Analysis

Gathering the data took about half an hour. None of the six assemblies tightened with their pneumatic impact wrench hit the target within 10 seconds. When no DTI was used, it took 13 to 20 seconds to tighten the assemblies. When DTIs were used, the target was not achieved, and the tests were aborted at 20 seconds to make sure the threads didn't seize. Adding stick wax to the assembly reduced the friction and increased the tension, but we still didn't hit the target in 20 seconds.

We then tightened three assemblies using our electric wrench. We had no problem hitting the target in under 10 seconds when we used our higher capacity electric wrench. They clearly needed more torque capacity.

After the tests, the discussion centered on one question. Why would it take longer to tighten an assembly with their impact wrench when a DTI was used? The answer is that slightly more nut turn is required to compress the bumps on the DTI. HOWEVER, THE MAXIMUM TORQUE REQUIRED TO DO SO IS NOT INCREASED. It simply means that the wrench has to work a little longer for the additional turn. Their impact wrench was already so overworked that it did not have the capacity to achieve the total turn in 10 seconds. We proved this when we used our higher-capacity electric wrench.

Aftermath

Open and shut case, right? Use a wrench with enough capacity and the problem will go away – for good. Unfortunately, they didn't see it that way. Buying more wrenches – either higher capacity impact or

Table 1: Tension Data: 1-1/4" A490 Fastener Assemblies

	DTI?	Wrench	Lube?	Tension	Time	Comments
1	No	Impact	No	110 kips	20 sec	
2	No	Impact	No	>110 kips	13 sec	
3	Yes	Impact	No	70 kips	>20 sec	Timed out
4	Yes	Impact	No	70 kips	>20 sec	Timed out
5	No	Impact	No	110 kips	15 sec	Retest item 4: no DTI
9	Yes	Impact	Yes	90 kips	>20 sec	Timed out
6	Yes	Electric	Yes	>110 kips	<10 sec	
7	Yes	Electric	Yes	>110 kips	<10 sec	
8	Yes	Electric	Yes	>110 kips	<10 sec	

electric wrenches – would cost money. No one wanted to stick their neck out and ask to for more money. So they decided to eliminate the DTIs and use turn-of-nut. They concluded that they could tighten all the assemblies in less than 20 seconds and not spend any money.

We politely argued that they were not addressing the root cause of the problem. Their equipment was clearly on the hairy edge, and hammering on an assembly for more than 10 seconds is not advisable. While it might appear that they were getting the required turn, in the steel work the head of the bolt is more likely to roll. What's more, they probably will damage the threads, altering the turn-tension relationship and installing loose bolts. And finally, turn-of nut is a more time-consuming process.

The bottom line is that using turn-of-nut with their wrench would compromise quality and increase installation time and inspection time. But we couldn't change their minds. I'd like to think that the outcome would have been different if a more experienced decision maker was present. In reality, the payback time for new wrenches would be very short. Oh well, you can't win 'em all. My hunch is they will continue to have problems.

As I mentioned earlier, this issue with 1-1/4" bolts has been around for ages. My colleague told me a funny story about a project where he experienced the exact same problem and proposed the exact same solution. In that case, a senior engineer was part of the team, and he told the crew to get the proper equipment. They did, and the problem went away – for good. However, one iron worker felt he had been "shown up" in the process. Apparently this ironworker had other "connections." My colleague was informed that if he ever showed up on that site again, he would be fitted with a pair of cement shoes and thrown off the end of a pier. So I guess it could be worse.

In closing, I gather the RCSC is restoring the "ten second rule" to The Specification in the next revision. This should help eliminate problems in the field caused by extended impacting, namely loss of thread strength and stripping resistance. And remember — if you ever have any questions about achieving high quality bolted joints, give us a call. We love solving problems.

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