Bolt Coating Thickness & Nut Overtapping—
A Lesson in Practical Necessity

We recently were faced with a problem. A client wanted us to have about a million bolts, nuts, flat washers and their associated Squirt-DTIs coated with a fluoropolymer called Xylan® applied over a zinc phosphate treatment. We knew it’s done all the time for small quantities of studs for the offshore oil industry, pipe flange bolting, that kind of thing — but a million bolts!

How to get it done, what would be the cost, how long would it take, what overlap to specify if any, and, above all, what happens to the strength of the bolt/nut assembly when the nuts are overtapped to suit the coating thickness?

First, we started with Whitford Corporation, the U.S. maker of Xylan, and they told us how to do it, where to get it done, and whether an overlap would be required for a 16 to 20 micron (a micron is a millionth of a meter) thick coating. Whitford indicated an overlap would probably NOT be needed. This was a key recommendation, because at the time we had already procured 200,000 A563M nuts, without overlap, assuming the bolting on this project would be uncoated. And, we knew if nuts are not overtapped, there cannot be any degradation of bolt strength due to poor nut fit, stripping, galling, all the really bad things that can happen with overtapped nuts get used.

Maybe their recommendation was based on the kind of individual cleaning, pre-treatment and spray coating typically done on oil platform studs, but the first thing we found, after (for cost reasons) dip/spinning the coating on, the nuts would not assemble. Some would, most wouldn’t, and it’s true, if you could get them started, a wrench could make them run up the bolt threads. But we could not ask a steel erector driving a million bolts to do this. We’d be drummed off the site.

So, back to the drawing board. Scramble for overtapped nuts, but how much overlap?

We learned that bolt threads are bolt threads, and are never (on this side of the Atlantic) made under-sized. All coating space is gathered by making the internal thread on the nut a bit bigger, called “diametral overlap.” Quick reference to a British publication (Figure 1) told us that for ISO (read 60 degree included angle) threads, you overlap eight times the coating thickness! That was a bit of a surprise, but when you look at the geometry of the thread interface, it’s correct, of course.

Eight times 20 microns is 160 microns. Practically speaking, overlap thread dies come in 200 micron increments (0.2mm and 0.4mm), so we opted for the former. Then the question arose, how are we going to be sure the bolt/nut strength is not impaired? After all, we didn’t want to measure coating thickness, and we are simply not capable of measuring actual overlap by go/no-go or indicating gages. The bolts and nuts had been coated by a dip/spin process, for reasons of economy, but the finished product looked good (See Figure 2). We thought of the “rotational capacity” test in A325, which doesn’t measure bolt tension, and we looked at the similar test in AASHTO but it also does not mandate a minimum achieved tension. Consequently, we were surprised to learn that there is no accepted test for the minimum strength of overtapped assemblies in place in North America.

So, we invented one. It seemed to us that if you put the bolt, the nut, the flat washer, and the Squirt-DTI on a Skidmore bolt tension calibrator, and tighten it until the strength will not increase any more, the assembly should demonstrate at least 90% of minimum ultimate strength of the bolt. Why 90%? Why not 100%? Why not 80%? We theorized that 90% was sufficiently above the intended installation tension (70-80%) to assure us that, with correctly manufactured bolt and nut components, the overlap was not causing a significant reduction in bolt strength.

And, in short, after testing a few hundred lots of bolts and nuts with the 0.2mm overlap on the nuts, and coated with what we were told was 16-20 microns of Xylan, only two lots failed to deliver 90% of ultimate, and in fact most demonstrated a tension greater than 100% of specified minimum. The two lots that did fail were caught in time and the nuts segregated, and subsequent investigation showed they were probably not...
Threaded Work

Although Sheradizing gives a uniform coating without any significant changes in the profile of threads, there must be adequate clearance between external and internal threads before Sherardizing to allow for the coating and to avoid interference. The method of calculating the theoretical clearance is shown below. A table of clearances required for several coating thicknesses on different thread forms is also given.

![Diagram of protective coating showing relationship between coating thickness and increase in effective diameter](image)

The relationship between coating thickness and increase in effective diameter of an external thread is shown by the triangle ABC where AB is the coating thickness ‘t’ and BC is half the increase in effective diameter.

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\text{Increase in effective diameter} = 2BC = \frac{2t}{\sin \frac{x}{2}}
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\text{Increase on I.S.O. Metric, UNF and UNC threads} = \frac{2t}{\sin 60^\circ} = 4t
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\text{Increase on BSW and BSF threads} = \frac{2t}{\sin \frac{55^\circ}{2}} = 4.33t
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Figure 1

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