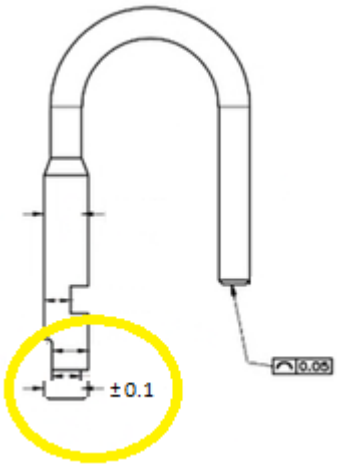
8D Report: Thin shackle release (mechanical fit)

0	**Prepare** Why does this problem require an 8D?	AP3T locks are AP3 padlocks with a thinner shackle than other AP3 variants. The shackles in a small subset of AP3T locks in the field are separating from the lock body after unlocking. This causes problems in the field as users are not expecting this to occur, are having difficulty retrofitting the shackle back into the lock to get the lock back into functioning form. A structured problem-solving methodology is appropriate to determine root cause and resolve the issue.
1	**Assemble Team** Team should have the knowledge, skill, and authority to solve the problem and implement corrective actions.	**Who is on the team**: Jerod Klink, CTO Konrad Hammel, Director of Hardware Engineering Adam Lucier, Product Development (Inertia – ODM partner) **Goals & Objectives**: Determine the root cause, incidence, severity and implement preventive measures in future production.
2	**Describe the Problem** What is the problem? What is the problem scope? Why is this a problem? Who is affected? Who is not? What provides us certainty?	The shackle is separating from the body after unlocking the lock and rotating the shackle. This problem has only been observed AP3T locks manufactured and retrofitted into locks prior to May 2022. Locks built since May 2022 have been tested and reviewed for this issue in the Sera4 factories. The problem has not been observed in other shackle configurations of AP3. The shackle should not be released from the padlock body during normal use.
3	**Interim Containment** What immediate actions do we take to contain the problem and limit impact?	For all locks in Sera4's inventory, Sera4 screened all AP3T locks and related thin shackle inventory. We found 6% occurrence of the problem. Affected shackles were replaced with a replacement shackle that meets all dimensions/criteria and retested to ensure proper performance. For all locks already in inventory at our distribution partners, we are asking partners to test locks using a standardized testing procedure that includes shackle open + rotation through 310 degrees. This simple test is sufficient to screen for this problem. Any lock that fails this test is automatically approved for an RMA.
4	**Identify Root Cause** Use a 5-whys methodology, a fishbone diagram or other root cause process.	Manufacturing Process 1. Why does a shackle release from the lock body? - The shackle, when unlocked and rotated to a specific position, is slipping past the retaining pin designed to keep the shackle in the padlock. 2. Why is the shackle able to slip past the retaining pin?

		- The shackle dimensions are out of specification in the area around the secondary locking bar gap (feature of the shackle) 3. Why is the shackle not conforming to specification? - Thin shackles were manufactured based on a "lost-wax" casting method then manually polished. The tooling development did not account for the variation in and the material lost in manual polishing. 4. Why was this problem not found in production test and product qualification? - Different tolerances (from lock to lock) in lock body size and shackle size play a role in the ultimate fit of the lock. The low occurrence of this issue contributed to our inability to detect this problem during the initial manufacturing run. - The test jig used to determine dimensions of new shackles was testing 2D for form factor and while measured for proper fit, missed a third dimension being "too thin". - Thin shackles were a new introduction to the product line and a different manufacturing process (lost-wax casting) alongside a new material (stainless steel) was introduced causing the unforeseen variation. - Reproducibility means rotating the shackle entirely around and into a specific position to exhibit the problem. Before this issue was discovered, a full shackle rotation was not a test case.
5	**Identify Solutions** What are the possible solutions? Identify the best. Address the root cause. What Permanent Corrective Actions will we take?	We implemented all of the following corrective actions: 1. Add unlock + rotation of shackle through 310 degrees to the production test process. 2. Rebuild the thin shackle tool to accommodate the proper sizing, taking into account the manual polishing stage 3. Rebuild test jigs to properly measure size and identify outliers in the minimum and maximum size tolerances 4. Implement fit checks to include not just functional performance in the open and closed state, but as well, the fully open + rotated position. 5. Quality sampling of thin shackles with caliper-based measurements
6	**Validation** Verify that the solution is working as expected. Check for undesirable side-effects.	Since these corrective actions were implemented, we have recorded zero excursions.
7	**Prevention** What improvements in systems and processes will prevent this and similar problems from recurring?	Non-Conformance Report (NCR-329) has been opened for this issue to address all items discussed within.
8	**Congratulate the Team**	Team disbanded and resolution complete on: June 1, 2023.