



White Paper Synopsis Axle/Spindle Nut Deficiencies on Aircraft

ATTN: All Aircraft Mechanics, Owners and Operators of Fixed and Rotorcraft

The following is an update regarding the work Leslie J. Weinstein is involved with in the aviation industry. In the early 90s, National Transportation Safety Board (NTSB) documented PB92-917004, a report on 5 catastrophic wheel end failures, which resulted in 7 fatalities in the trucking industry. The axle nut was the problem. However, at the time of the report, no one understood the significance or the importance of the axle nut. Weinstein was invited to join the Society of Automotive Engineers (SAE) Spindle Nut Testing & Performance Task Force Committee, developing the standards and testing methodology for axle/spindle nuts used on commercial trucks and busses. The SAE Committee defined the problems and the various Original Equipment Manufacturers (OEM), including bearing manufacturers and industry associations have made and continue to make changes to improve. The axle/spindle nut changes made in the trucking industry have proven to reduce premature wear and failure of the wheel end assembly components (brake, tire, seal, bearing, axle and hub). Conversely, the Aerospace Industry has made none: not in Part 23, 25, 27 or 29. The antiquated poor design of the castellated and sleeved axle/spindle nut systems, used by aircraft manufacturers Cessna, Piper, Beech, Boeing, Airbus, Bell, including Military aircraft, etc., makes it impossible to achieve measured preload and reduce endplay accurately to within 0.001- 0.005.

The following document titled; Spindle/Axle Nut Life Cycle Service Deficiencies on Aircraft & Solution will illustrate and give you further understanding of how important the *mundane* axle nut is to your wheel-end assembly. The antiquated conventional axle nut system you are currently using is costing you more than is imaginable.



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Leslie J. Weinstein White Paper Synopsis Spindle/Axle Nut Life Cycle Service Deficiencies on Aircraft & Solution

Aircraft ground operations, taxi, tow, take-off or landing impose wheel, axle and bearing loads and wear due to a many variables with less than smooth pavement being a relatively secondary factor. The taxi and tow modes are dominated by static loads while the take-off and landing modes are dominated by impact and some dynamic loads.

The bearing, axle, tire and brake wear is directly related to a key variable: endplay. Endplay is caused by axle nut torque settings. Even on fresh, smooth pavement, the off-optimum torque, inherent in the conventional axle nut, causes wheel chatter, which transmits adverse loads to the bearings and axles. The conventional axle nut design is locked in place by a castle nut and cotter pin with inadequate indexing. The cotter pin can only be pushed into one of 6 holes in the castle nut that is aligned with the keyway or pinhole in the axle (60° apart on the circumference). This causes the castle nut preload torque to become non-optimum if it needs to be overly tightened or overly loosened (as in most cases), for the cotter pin to be inserted.



Excessive bearing loads result due to 2 cases:

1. Excessive endplay: the worst case in axle nut looseness comes when the castle nut is backed off after establishing bearing preload by the use of a torque wrench by almost a full 60° to ensure cotter pin insertion alignment. For standard 16-pitch threaded axles, this results in 0.010+ of an inch lateral slack on the spindle axis. The result is excessive bearing wear, as well as, wheel chatter or axial floating. Scored axles from the bearing rotating on the axle, damage to the bearings and premature brake and tire wear are a result of excessive wheel endplay. Bearing manufacturers specifies an endplay of 0.001 to 0.005 thousands.
2. Excessive preload: the ideal bearing to wheel fit should have a gap equal to the film thickness of the lubricant. Hence, over tightening the axle nut by 30° would cause the bearing to be too tight allowing them to overheat from their lubricant film extruding out of the gap. This will rapidly cause further damage and a chain reaction of damage to further components.

The True-Lock solution employs an infinite variable locking mechanism that can be set to the optimal torque (patented and FAA STC'd for use on over 1,000 aircraft). The True-Lock system eliminates the conventional axle nut systems' inherent un-optimum torque setting characteristics imposed by the use of the castle nut and cotter pin. This not only provides a smoother running wheel bearing, but

also a controlled preload torque specification for maintenance manuals and reduces parts count. The True-Lock system reduces maintenance inspection time, extends the life of high load and stress mechanical parts, and saves maintenance costs.

Setting Bearing Preload & Verifying Wheel Endplay

To establish a controlled setting, the proper tools are needed. To control and verify measurements of the installation of the axle/spindle nut, a torque wrench and dial indicator are required. These are the 2 important tools to tighten the axle nut and establish bearing preload and wheel endplay. On most GA Aircraft the following torque settings can be used.

1. Bearings need to be lubricated with clean grease and installed in the hub.
2. Install hub assembly on axle. While rotating wheel, install and tighten the axle nut with a torque wrench to 150-200 inch pounds. 2 to 3 strikes to the top or side of the tire while rotating, using a dead blow hammer is advised. This sends slight vibrations throughout the system facilitating the seating process of the bearings. The rotation of the wheel should gradually become more difficult, but at no time should that difficulty be excessive.
3. After installing and tightening, back the axle nut off by 1 full turn.
4. The final axle nut torque adjustment is made by rotating the wheel again while tightening the axle nut with a torque wrench to 30-40 inch pounds.
5. Apply the True-Lock retainer tab into both the slotted nut and the pinhole or keyway of axle to engage. If the tab does not align, tighten the slotted axle nut to the next available key position.
6. Install FAA PMA snap ring or spiral ring provided by True-Lock and engage into grooves of slotted nut.
7. Use the dial indicator to verify endplay. Acceptable endplay tolerances range from .001 - .005 thousands. Verify measurements and adjust if necessary. To adjust, repeat steps 3 through 7.

Table I True-Lock Axle-Nut System advantage over Conventional Axle-Nut/Cotter Pin

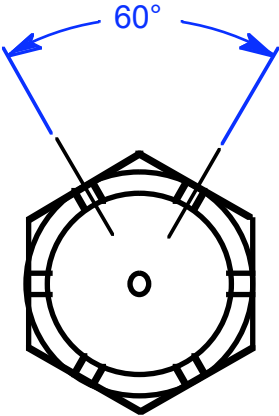
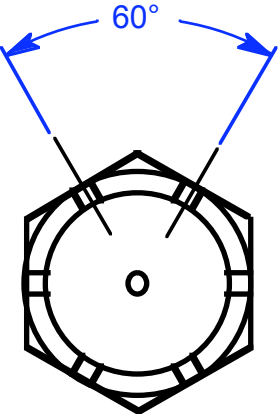
Conventional		True-Lock
	<p>Worst Case Over Torqued The axle nut is almost 30° over torqued. Bearing manufacturers spec gives endplay @ .001 - .005 Bearing damage will occur causing further damage via chain reaction to other components.</p>	<p>Controlled preload adjustment setting resulting in optimum torque & wheel endplay.</p> <p>Significantly increases safety & reliability Guaranteed for life</p> <p><u>Problem Solved</u></p>

Table II

Conventional

True-Lock

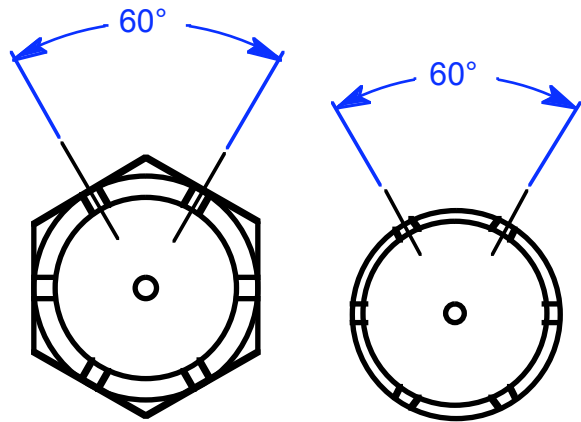
	<p>Worst Case Too Loose The axle nut is almost 60° backed off torque or loose. Approximately 0.010+ too loose. Bearing manufacturers spec gives endplay @ .001 - .005 thousands Excessive bearing endplay results in: Excessive Bearing Wear Axle Scoring Wheel Vibration Tire Wear Brake Wear</p>	<p>Controlled preload adjustment setting resulting in optimum torque & wheel endplay. Significantly increases safety & reliability Guaranteed for life <u>Problem Solved</u></p>
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CESSNA AXLE



Cessna Axle on left is a casualty of bearing rotational wear

Cause: Deficient Conventional Axle Nut



Conventional Axle Nuts - Castellated & Sleeved

TRUE-LOCK Infinite Axle Nut System



TRUE-LOCK Axle Nut System

