2026 NSRP Panel Project PP 26-44:
Evaluate Nord-Lock Wedge Washers for Electrical Applications on Navy Ships

Electrical Technologies Panel Meeting

May 6, 2026

Jim Cunard
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Team Members:
- Ingalls Shipbuilding
- Newport News Shipbuilding

PTR: Walt Skalniak, Ashby and Company
ATI PM: Lydia Szydlo

Agenda

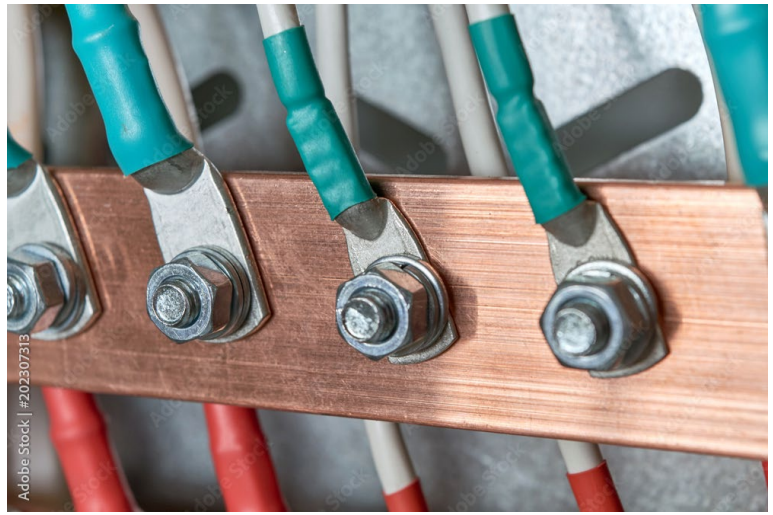
- Background
- Common Locking Features
- Current Plan
- Tech Warrant Holder Concerns
- Desired Alternative Plan
- Questions

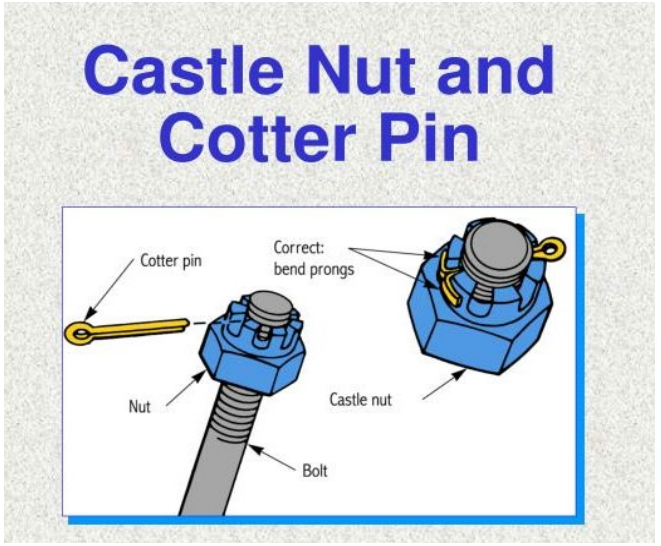
Background

- Loosening connections on electrical circuits can have catastrophic consequences (fires, equipment failure, personnel injury/death)
- Technologies employed in switchboards for instance as preventative measures to reduce the risk of these events include:
  - Ionization detection
  - Arc detection
  - Ultrasonic detection
  - IR windows / FLIR camera to detect loose connections
  - FO temperature sensing
  - Preventative Maintenance – periodic torque inspections

The Focus of This Effort is To Make Connections That Won't Fail

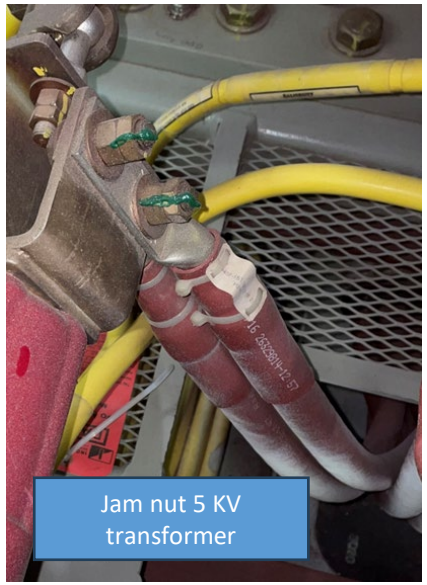
Common Locking Features

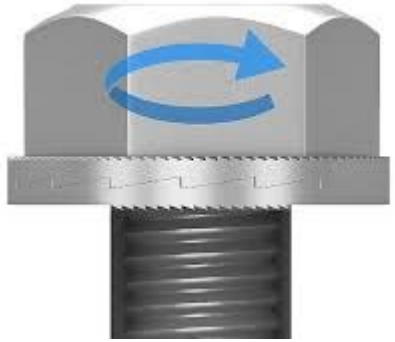




jam nut

nylon insert lock nut





wedge washer

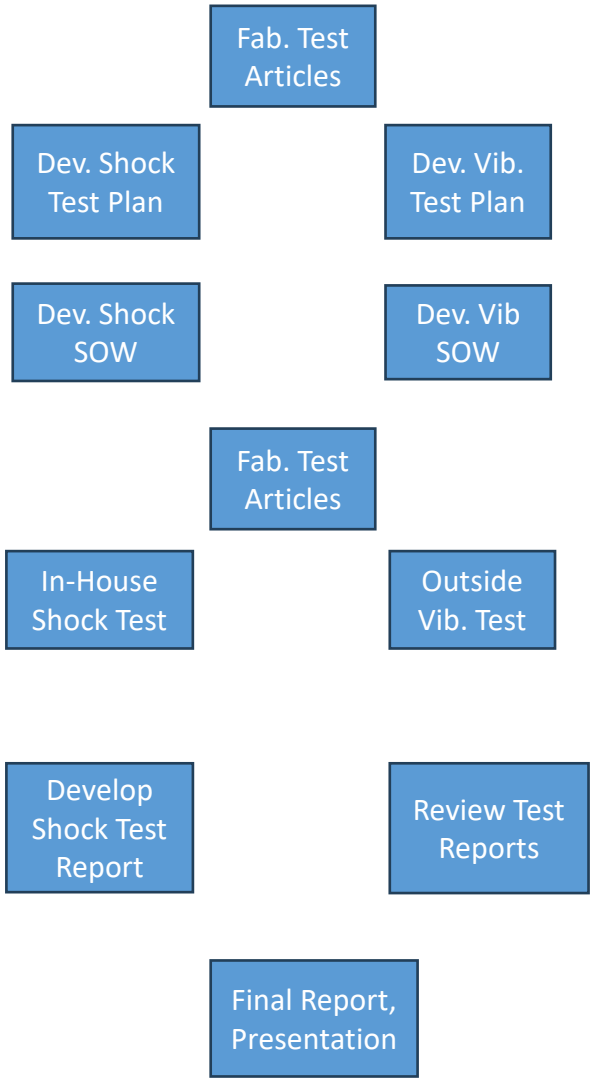
spring (split) washer locking feature

Locking Feature Comparisons

	DETAIL SPECIFICATION - SWITCHGEAR, POWER, LOW VOLTAGE, NAVAL SHIPBOARD	Detailed Specification - Electric Power Equipment, Basic Requirements For	Fastener Design Manual
	MIL-DTL-16036M(SH) (3/7/2013)	MIL-DTL-917F (8/5/2014)	NASA Reference Publication 1228 (March 1990)
split spring washer		preferred solution	useless for locking
nyloc (locking nut)	preferred		max. temp. of 250° F, insert can be damaged
castelled nuts (cotter pin)	not practical for many electrical connections		
wedge washer		other (requires NAVSEA approval)	
jam nut	prohibited	prohibited	
liquid locking adhesives	prohibited	IAW MIL-STD-32258	
serrated washer		prohibited	
star lockwashers		prohibited	
belleville lockwashers	prohibited	prohibited	
internal tooth wlockwashers		acceptable (with restrictions)	
external tooth lock washers		acceptable (with restrictions)	

Current Plan – MIL-DTL-901, MIL-STD-167-1A Testing

MIL-DTL-901 MIL-STD-167-1A



Task 1 – Project Initiation & Kick-Off

Task 2 – Develop Test Plans for Testing

Task 3 – Testing

Task 4– Test Reports

Task 10 – Develop Final Report

MIL-DTL-901 (shock), MIL-STD-167-1A (vibration)

Lightweight High-Impact shock machine (MIL-DTL-901)

Shaker Table (MIL-STD-167-1A)

MIL-DTL-901 (shock), MIL-STD-167-1A (vibration)

Note – there are definite advantages and disadvantages of performing these tests.

Advantages

Primary advantage is these tests are recognized as path to approval

Disadvantages

- If EUT is not “actual” installed condition, must mimic installed condition as closely as possible (possibly adding dummy weights, lengths of cable, etc.) to achieve realistic acceleration forces and resonances. Therefore, not good for broad application of results say for establishing general guidance or standard methods.
- Unable to explore test conditions in a cost-effective, timely manner,
- Unable to test a variety of methods in a cost-effective, timely manner,
- Do not test to failure which is an indicator of robustness

Focus on TWH Concerns

RE: NSRP Panel Project Proposal for FY26

KF Kachele, Fredrick R CIV USN NSWCDIV PHL P/

Reply | Reply All | Forward | ...

To Nemarich, Christopher P CIV USN SEA 05 (USA); Brick, Darren C
Cc Abadilla, Christopher W CIV USN SEA 05 (USA); Farmer, Jason P; Lazur, Andrew J CIV USN NSWCDIV PHL PA (USA)

Thu 7/31/2025 7:21 AM

Signed By fredrick.r.kachele.civ@us.navy.mil

This sender fredrick.r.kachele.civ@us.navy.mil is from outside your organization.

You replied to this message on 8/1/2025 10:45 AM.

Darren,

I have three main concerns wrt. Nordlock washers in electrical equipment:

- Will the knurling on the outside of the nord-lock damage the clamped surfaces?
- Most of the technical data that I have seen shows that Nord-locks work really well when the fastener is installed with a controlled high preload. This means to replicate that high preload the nord-lock will have to be installed with a torque wrench. High preload to a known value (i.e. with a torque wrench) is also a known method of keeping a fastener tight. Where is the value added with the Nord-lock?
- How does using Nord-locks improve performance or save money over just using a torque wrench?

If the whole point is to meet the requirement of being "self locking" as required by the spec then I think there needs to be a discussion about how to meet the intent of the spec requiring "self locking" rather than looking at a device to do it. For example, if using Nord-locks is only effective if you use a torque wrench, is there something else that could be added to the procedure so that using a torque wrench + something else could mean torque wrench + nordlock, match mark paint, other to be discussed? Is there something that makes the installation process and hardware more robust to handle construction deviations or in-service issues?

V/r,

Rick

- Determine cost benefit of using wedge washers
- Determine whether wedge lock washers "damage" the clamped surface (i.e., increase contact resistance)
- How do we make the installation process more robust and able to handle construction deviations / in-service issues?
- Determine sensitivity of wedge washer success as a function of preload (and explore other or complimentary methods). Ex.

Note – when torque is applied, bolt stretches, the stretch creates tension, and the tension produces clamping force which holds the bolt together. Ideally the proper preload keeps the joint from loosening.

🤔 Does wedge washer, lubricant, or something else improve this?

Best Outcome is to Work with TWH to Design Experiments To Learn the Most

Desired Plan: DOE using Junker for DOE Validation

- DOE.1 Plan
- DOE.2 Plan
- DOE.3 Plan
- DOE.4 Plan
- Develop Junker SOW
- In-House DOE.1, DOE.2, DOE.4, DOE.5
- Outside DOE.3, DOE.5 Junker Test
- Review Test Reports
- Final Report, Presentation

Fab. Test Articles, perform activity, Record Results

DOE.1 – use bus bar and compression lugs in controlled environment to establish torque vs. clamping force vs. electrical resistance (with and without lubrication)

DOE.2 – use a pool of experienced technicians / mechanics (i.e., electrical craftsman) to "torque by feel" (no torque wrench) a quantity of compression lugs to bus bar with the various locking methods (with and without lubricant). Report Results.

DOE.3 – in a controlled environment (i.e., using a torque wrench to provide precise results) and with the various locking methods, with and without lubrication, varying torque applied in order to evaluate vibration resistance as a function of torque value

DOE.4 – record clamping force vs. contact resistance for a variety of surface conditions (i.e., completely smooth vs. minor pits / scratches from wedge washers)

Bonus DOE.5 – compare wedge lock products (Nord-Lock vs. other manufacturers)

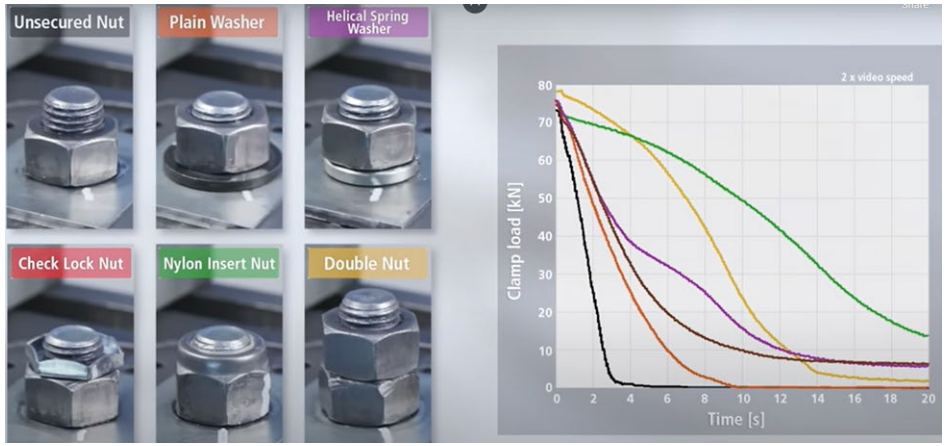
Collaboration with TWH and NNS, Consensus on Revised Approach

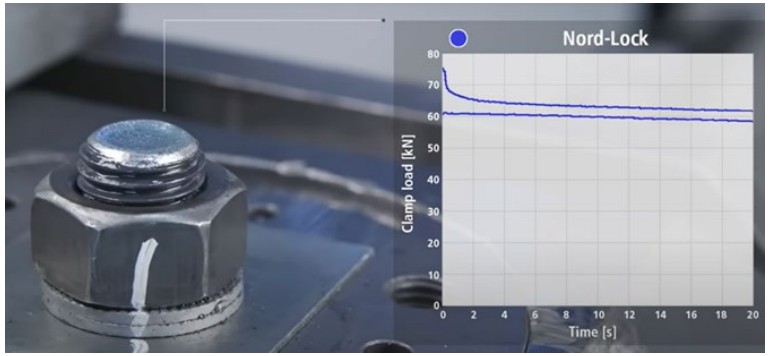
Aggressive Accelerated Test (Junker)

method	A. No Lube	B. With Lube
a. Spring washer		
b. Nyloc nut		
c. Wedge washer		
d. Etc.		

Torque value	T	F	R	Junker F vs t
Qty @70% T				
Qty @80% T				
Qty @90% T				
Qty @100% T				

Experienced Mechanic "Torque By Feel"	1A, 1B T/F/R			2A, 2B T/F/R			3A, 3B T/F/R		
Mech #1									
Mech #2									
Mech #3									
Mech #4									
Mech #5									
Mech #6									
Mech #7									
Mech #8									
Etc.									





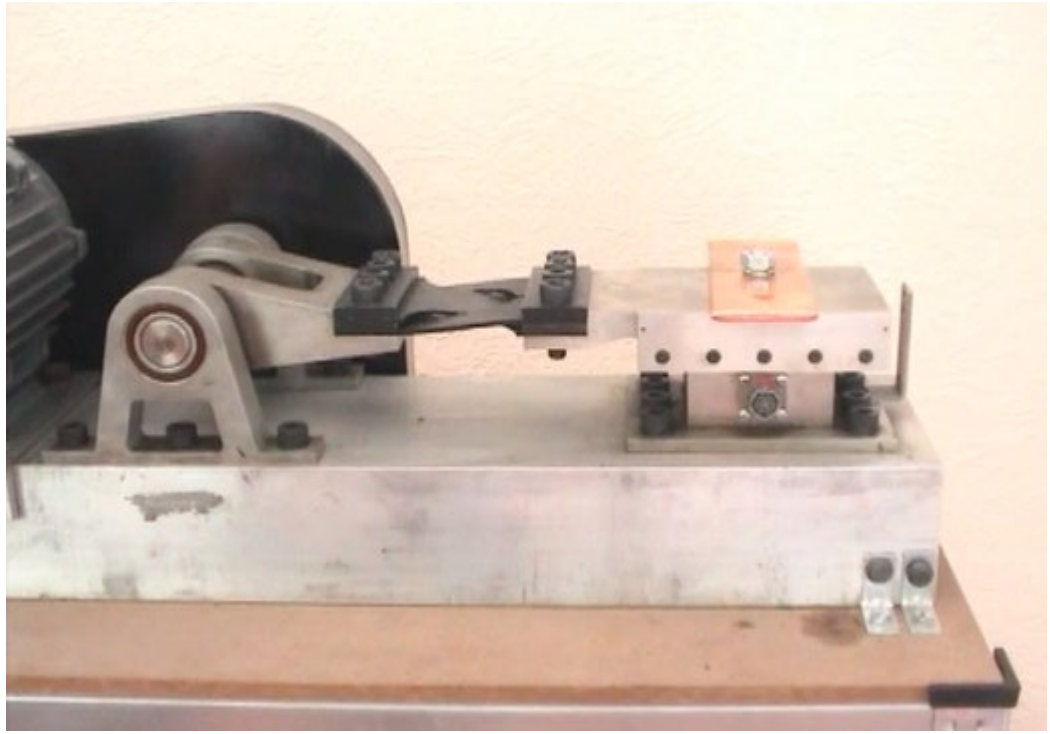
Measure Bolt Load / Elongation

Ultrasonic , Low resistance meter to measure contact resistance

Measure Contact Resistance

4 Wire, Low resistance meter to measure contact resistance

Junker Test (ISO 16130, DIN 65151)

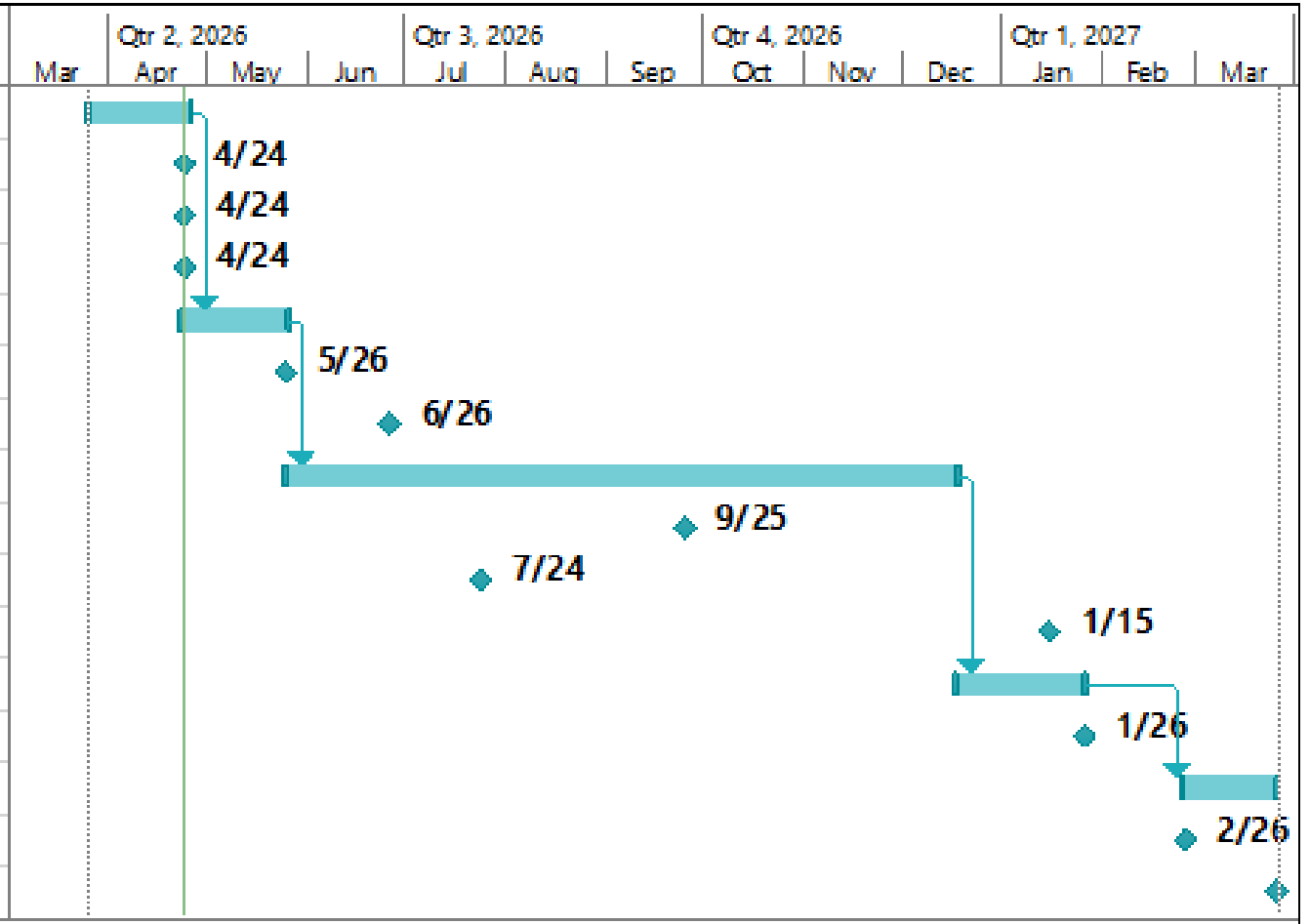


Junker Vibration test
(great for exploratory work)

Note:
An extreme accelerated test.
A great way to test to failure and compare a variety of methods and test conditions

Schedule

ID	Task Mode	Task Name
1		**Task 1: Project Initiation and Kickoff**
2		Project Plan
3		Schedule
4		Project Kickoff
5		**Task 2: Develop Test Plans for Testing**
6		Shock/Vibe Test Plan and/or Junker Test Plan
7		Quarterly Status Report 1
8		**Task 3: Testing**
9		Quarterly Status Report 2
10		SOWs Issued to testing labs
11		Quarterly Status Report 3
12		**Task 4: Test Reports**
13		Test Report Issued
14		**Task 5: Develop Final Report**
15		Final Report Briefing
16		Final Report with Recommendations



Roles and Responsibilities

Task Description	Ingalls	05Z	NNS
Task 1 – Project initiation and kickoff	L	P	P
Task 2 – Develop Test Plans for Testing	L	R	C
Task 3 – Testing	L	R	P
Task 4 – Test Reports	L	P	P
Task 5 – Develop Final Report	L	R	C

(L=Lead, C=Contributor, P=Participant, R=Reviewer)

Deliverables (ECD)

1. Project Plan & Schedule (4/26/26)
2. Test Plan(s) (5/26/26)
3. Quarterly Status Report 1 (6/26/26)
4. Statement of Work for Labs (7/26/26)
5. Quarterly Status Report 2 (9/26/26)
6. Quarterly Status Report 3 (1/15/27)
7. Test Reports (1/26/27)
8. Final Project Briefing (2/26/27)
9. Final Report with Recommendations (3/26/27)

QUESTIONS?

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BACKUP

Evaluate Nord-Lock Wedge Washers for Electrical Applications on Navy Ships

Project Lead Organization: HII - Ingalls Shipbuilding
Project Team Members: HII – Ingalls, HII - NNS

Concept/Idea

Issue: No perfect solution for long term bolted connections in the shipboard environment currently exists; MIL STDs and NSTMs conflict. Wedge washers are either not mentioned or require NAVSEA approval for each application. Too difficult to implement a novel solution due to uncertainty from approving agents. Better guidance supported by test data is needed.

Proposed Solution(s): Get consensus from community on what to test (ex., switchboard connections, Insulated Bus Pipe (IBP) connections, etc.), mockup installation methods using various securing methods and subject methods to shock and vibration testing.

Benefits/Justification

Benefits of the Project: Achieving repeatable high performance, long lasting bolted connections for electrical applications. Currently numerous "protections" are in place or are being developed for detecting loosening connections in electrical applications to prevent catastrophic failure (i.e., ionization detection, ultrasonic arc detection, arc fault detection, IR windows / FLIR to enable periodic inspection of connections under load, fiber optic temperature sensing, periodic torque inspection, etc.). A simpler, less costly solution is envisioned with a technology enabling better connections. The benefits include: simpler, lower cost systems; improved personnel safety; reduced repair costs (in the event of an arc flash or electrical fire), higher operational availability (this is because arc flash event would result in a long mean time to repair), etc.

Project Approach

High Level Statement of Work: Perform precision resistance measurements (low resistance ohmmeter) and clamping force measurements (ultrasonic bolt measurement instrument) before and after testing on multiple securing methods subjected to shock and vibration testing. This would be a comparative test comparing multiple securing methods. Follow on phase could be to develop detailed guidance (data supported) on how to successfully implement the solution

Metric(s) of Success: Demonstrate superiority with MIL-DTL-901 (shock) and MIL-STD-167-1A, and possibly ISO 16130 Junker Vibration test (for exploratory work).

Cost/Images/Relevant Information

Project Estimated Cost: $200K

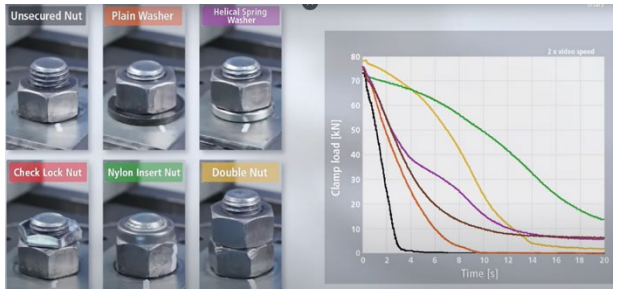

Figure 1. Standard Methods to Combat Vibration (20 seconds on Junker Machine – ISO 16130)

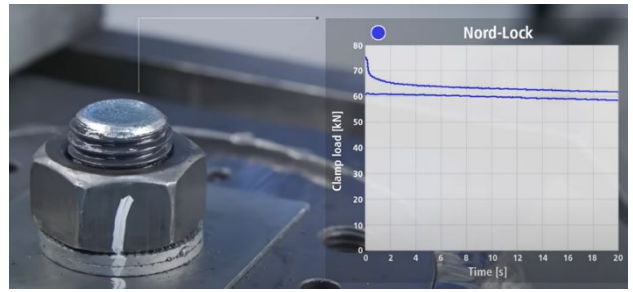

Figure 2. Nord-Lock Wedge Washers Subjected to Vibration on Junker Machine – ISO 16130) Note - top line is 0-20s, bottom line is 20-40s