

## Background

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HYTORC created this controlled fastener study to demonstrate and validate the capabilities of HYTORC's gall-resistant fastener products. The study exposed gall-resistant test hardware and conventional control hardware to elevated stress and temperature in order to create a high potential for incidences of galling. The galling resistant capabilities of the HYTORC hardware would be validated if galling was pervasive on the control group while non-existent on the gall-resistant hardware.

## Test Setups

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Three groups of hardware, a primary HYTORC Nut group, secondary HYTORC Nut group and a Hex Nut Group would be loaded to 60ksi and held at 725°F (385°C) for 1,000 hours. Each group had a joint length of 8" and all utilized an ASTM A193 Grade B16 stud with a 1-3/4"-8 thread size.

The primary group consisted of 12 bolted assemblies that were each lubricated with Jetlube 550 Extreme and preloaded to 60ksi. 6 of the 12 assemblies in the primary group would include the combination of features that HYTORC utilizes to eliminate galling. The balance of 6 assemblies were used as a control and did not include features that eliminate galling.

The secondary group was lubricated with Petroleum Jelly instead of Jetlube 550 Extreme. This group consisted of 12 assemblies that were otherwise setup identically to the primary group. Again only 6 of 12 assemblies in the group would include the proprietary combination of features that HYTORC utilizes to eliminate galling. The balance of the group was setup without galling resistant features.

The hex nut group consisted of 4 assemblies that would be loaded and unloaded by torquing a standard A194 Grade 2H nut. 2 of 4 assemblies would be lubricated with Jetlube 550 Extreme and 2 with Petroleum Jelly. These 4 control pieces were included to validate the presumption that helical threads in HYTORC nuts will behave identically to standard 2H nut threads as it relates to galling.

## Results - Primary HYTORC Nut Group (Jetlube 550 Extreme)

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The control and test hardware in the primary HYTORC Nut group showed clear and distinct performance characteristics differences. 6 of 6 of the test lot assemblies were able to be unloaded easily with hydraulic torque tools and were disassembled by hand. There were no signs of galling or wear on the test hardware. In complete contrast, 6 of 6 of the primary group's control hardware could not be unloaded easily with hydraulic torque tools. All 6 experienced torque level increases after unloading started. 5 of the 6 had threads that completely seized within 2 turns during loosening. 1 of 6 was able to be completely disassembled but it required >3 times the installation torque throughout 75% of the unthreading to overcome thread binding. It unthreaded through the last 25% of the threads with the aid of a hand operated spanner. 6 of 6 of this control group showed a high level of galling on the bearing surfaces and 5 of 6 had seized threads. The one piece that was completely unthreaded, also showed significant galling on the thread surfaces.

## Results - Secondary HYTORC Nut Group (Petroleum Jelly)

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After such glaring and thorough thread seizing occurred on the Jetlube 550 Extreme primary group's control hardware, it was understood that it might not be possible to safely apply enough torque to the secondary group to promote loosening. 6 of 6 of the secondary test hardware were tested. The torque levels to initiate the loosening process were right near the maximum capacity of the fasteners and tooling. However, it was possible to safely apply sufficient torque to 4 of 6 test pieces to promote loosening. Once loosening started each of the 4 pieces unloaded within 1 turn and all 4 were able to be completely disassembled by hand. No signs of galling or wear appeared on any of the 4 pieces. As a result of torque limitations, and the clear and confirming evidence on the primary batch, it was determined that there was nothing to gain by attempting to dis-assemble the secondary groups control pieces that were assembled with petroleum jelly instead of anti-seize.

## Results - Hex Nut Group

Attempts were first made to unload 2 of the Jetlube 550 Extreme anti-seize lubricated test pieces. Sufficient torque was applied to promote the loosening process. However, within the first loosening turn, both fasteners had significant increases in torque until they seized completely. Both showed significant signs of galling between the AISI 4140 washer bearing surfaces and the 2H nut. As a result of these findings, it was determined that it would not be worthwhile or safe to try to unload the 2 petroleum jelly lubricated assemblies in this group.

FURNACE SETUP



PRIMARY GROUP #12



SECONDARY GROUP #1



## Conclusion

HYTORC gall-resistant fasteners were able to eliminate galling under this challenging temperature and loading condition which caused the control anti-seize lubricated hardware to gall 100% of the time. Further validating the results, HYTORC gall-free fasteners were also able to eliminate galling and wear even on secondary group parts when no anti-seize was applied. HYTORC claims on galling resistance have been proven and validated in a substantial way as a result of this study. If thread galling or cold welding is causing bolting challenges, HYTORC gall-free technology should be considered as a possible mitigation strategy.

### REMOVAL DATA

ID	LUBRICATION	BOLT STRAIN	INSTALL TORQUE (lb-ft)	LOOSEN TORQUE (lb-ft)	GALLING PREVENTION	REMOVAL NOTES
<b>PRIMARY HARDWARE GROUP</b>						
1	Jetlube 550 Ex.	0.0020	2,459	4,496	HYTORC (TEST)	NO GALL
2		0.0020	2,459	4,189		NO GALL
3		0.0021	2,459	4,496		NO GALL
4		0.0020	2,459	4,342		NO GALL
5		0.0019	2,459	4,956		NO GALL
6		0.0019	2,617	4,035		NO GALL
7	Jetlube 550 Ex.	0.0019	2,301	4,035	NONE (CONTROL)	GALL
8		0.0018	3,092	5,417		GALL
9		0.0017	3,646	5,417		GALL
10		0.0019	2,617	5,724		GALL
11		0.0019	2,617	4,189		GALL
12		0.0017	2,617	-		GALL
<b>SECONDARY HARDWARE GROUP</b>						
1	Petroleum Jelly	0.0021	2,855	9,797	HYTORC (TEST)	NO GALL
2		0.0022	3,250	7,352		NO GALL
3		0.0019	3,329	7,934		NO GALL
4		0.0023	3,329	9,331		NO GALL
<b>HEX NUT GROUP</b>						
1	Jetlube 550 Ex.	0.0017	2,775	3,881	NONE (CONTROL)	GALL
2		0.0021	3,171	-		GALL