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Reducing the Variability and Cost of Determining the Coefficient of Friction of Various Lubricants

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Executive Summary

Per reference (a), "Accurate preloading of fasteners for Naval applications depends on many factors, including fastener material properties, fastener geometries, and the coefficient of friction (COF) between the mating fastener surfaces. The COF acting on a fastener's head and threads is a critical value needed to accurately predict the torque coefficient, K_t, and ultimately the torque-load relationship. The coefficient of friction is dependent on the materials in contact, the total contact surface area, the condition and finish of the contact surfaces, and any lubricant in these contact areas."

Reference (a) is a Naval Sea Systems Command (NAVSEA) approved document, developed by the Portsmouth Naval Shipyard (PNSY) Deep Submergence Systems Program (DSSP), that provides a method that may be used to determine a particular lubricant's COF. I was tasked by PNSY to assist in testing two lubricants, TRI Marine Grease and Christo-Lube MCG 111, in accordance with reference (a) and provide recommendations for optimizing the process and improving its efficiency. An additional task included determining if a decreased sample size of fasteners may be used to calculate the COF of a given lubricant while still maintaining a high degree of confidence in the results. As the Navy seeks to increase the number of lubricants with a known COF, establishing methods for reducing the overall cost and timeline, of testing is of the utmost importance.

DDSP completed testing of TRI Marine Grease between May 2022 and August 2022, after which a list of initial recommendations was provided to PNSY for consideration. This list included proposed changes to the physical procedure as well as recommended material purchases and may be found in the Appendix – Fall Recommendations of this report.

Prior to the testing of Christo-Lube MCG 111, which completed in January 2023, PNSY enacted a number of the proposed recommendations. This resulted in an approximate decrease of 41.5 man-hours to complete the testing.

Following the testing of Christo-Lube MCG 111, another list of recommendations was provided to PNSY. This list may be found in the Appendix – Spring Recommendations of this report, and if enacted, will save approximately 165.5 man-hours.

This report briefly outlines the approved testing procedure of reference (a), summarizes the previously submitted recommendations and the results of enacting them, and provides a viable decreased sample size for the testing. This report was requested by PNSY such that it may be referenced in support of future changes and improvements to their existing testing procedure.

Contents

Design Problem and Objectives

The COF values of US Navy approved lubricants must be known. This is vital because fastened applications require those values for calculating the torque needed to achieve a necessary preload, which is the compressive force that holds a fastened joint together. Without an accurate COF, calculations to determine joint integrity are incomplete, increasing the risk of a structural failure. It is for this reason that, for any application where a specific torque value is required, a lubricant with a known COF is necessary. The US Navy uses a number of lubricants with known COF values, but these tend to be more expensive, less readily available, and less efficient than those with an unknown COF. Because of this, PNSY is testing several Navy approved lubricants to determine the COF values, so they can be used on any fastened applications. Through calculating the COF for two lubricants, TRI Marine and Christo-Lube MCG 111, I was tasked with generating process and procedural changes which will improve the testing efficiency without sacrificing effectiveness or accuracy.

The testing process takes three to four people roughly two to three weeks to complete per lubricant. It requires strenuous work in an environment that is not climate controlled, making it even more difficult in the summer months. These fasteners require torque wrenches that vary from a foot to six feet in length, and they need to be used with precision which compounds the difficult physical work. Additionally, due to the critical nature of the testing and the stress placed on each fastener during the conduct of the test, the tested fasteners can not be used in any other application or tested again. This means that any way to reduce this waste would be beneficial. For this task, recommendations were given to PNSY, so they can implement changes to the process, purchase new equipment, continue aspects of the process that are successful, or make other improvements.

There is no consequential budget attached to this project; however, there are a few other restrictions. All procedural changes need higher-level approval, which can be time consuming. Also, the naval documents off of which the procedure is based are precise with their requirements. This precision does not allow for leeway in certain areas of testing, such as how to lubricate the fasteners and therefore limits the changes that can be made in the methods of the study.

Detailed Design Documentation

The objective of the test is to determine the value of applied torque at which a particular value of tensile load (preload) is achieved on a lubricated fastener assembly. Each fastener assembly consists of a hex head bolt, a flat washer, and a hex nut. As stated in reference (a) “a minimum of 16 fastener assemblies of each material and size should be used” in the testing to ensure a sufficient amount of data points are collected to have a high degree of confidence in the results. The fastener materials and quantities are listed in Table 1.

To perform the reference (a) testing procedure, each fastener's material yield strength is used to calculate two values of tensile load (preload) that serve as "target" values. One-thirds and two-thirds of the material yield strength ($1/3\sigma_y$ and $2/3\sigma_y$) are used as the target values. The fastener assembly is thoroughly cleaned before being lubricated and inserted into a testing apparatus. The apparatus, shown in Figures 1 and 2, consists of a Skidmore-Wilhelm MZ-100 calibrated hydraulic load cell that is mounted on a rigid mount and displays the applied tension within the assembly on an AMETEK CP2i digital pressure gauge.

The nut is tightened using a calibrated torque wrench or torque multiplier, which is a device that has a gear ratio of approximately 20x when comparing the input and output forces, of appropriate capacity until the applied tensile load on the gauge is equivalent to the $1/3\sigma_y$ target value. The actual applied tensile load and the torque required to achieve that load is then recorded in Excel spreadsheets, an excerpt of which is shown in the Appendix – Table or Table 2. This process is then repeated for the $2/3\sigma_y$ target value. The tensile load is then removed by loosening the nut, after which the process is repeated two more times. At the end of the three cycles, the nut and washer are removed and the crush diameter, the diameter scribed on the washer by the bearing face of the nut, is also measured and recorded. This process of three cycles per fastener is repeated for all 256 fasteners with every data point being entered into a data sheet corresponding to the fastener's size and material, which calculates the COF for each cycle using Equation 1. The 256 fasteners produce a total of 1536 COF values which comes from six COF values per fastener: three from the $1/3\sigma_y$ and three from the $2/3\sigma_y$. These are then averaged to obtain the desired information and results, which are shown in Table 3. MATLAB code was utilized to plot this data to try and determine any trends. This can be seen in Code 1 which created Graph 1. Graph 1's trend will be discussed later in the report.

The materials used (KMONEL, INCONEL 625, CRES 316, MONEL) are procured in accordance with the applicable commercial material specification and are all considered long lead time (LLT) materials, which are both expensive and require extended manufacturing time. Additionally, the act of preloading a fastener inherently stretches a fastener's threads, so each item in the fastener assembly may only be used to test one lubricant. As such, there is a strong desire to calculate a decrease to the overall number of fastener assemblies that must be tested. This calculation was completed using Equation 2. *CI* is the only variable not to be determined through testing or is a constant. It was decided that 5% of the average COF value for a group is a strong interval. Having a five percent error during a test is commonly an acceptable value because the results are seen as accurate and precise. Code 2 displays the method to make the calculations, and it allows for the confidence interval to be easily altered, if necessary.

While this testing regime is simple, it is both physically demanding and extremely mundane. Its repetitive nature may lead to physical and mental fatigue, higher risk of injury, and decreased accuracy in the results. These factors are what drove the task to determine ways in which the process of performing the experiment may be improved and optimized. Recommendations for these improvements and optimization were written in a report and provided to PNSY. These recommendations and their impact will be discussed later in this report, but the more in-depth copies can be seen in the Appendix – Fall Recommendations and Appendix – Spring Recommendations.

Results, Recommendations, and Impacts

Results

The calculated COF values can be seen in Table 3. They are averaged per group, then per metal. It is uncertain which values were preferred by PNSY and the NAVSEA, so this table was given to them to provide a variety of options for their selection. Table 4 shows the results for the new number of fasteners per group. Calculations show that the original amount of 16 fasteners is excessive since almost half that number can be tested while still achieving a 99% confidence that the final results will fall between the 5% error. Comparing the confidence interval results between the two lubricant tests give more validity to reducing the number of fasteners needed for testing, as the results from both tests indicate high degree of confidence using far fewer fasteners. Based on the analysis a recommendation can be made to reduce the fastener quantity and as more lubricants are tested, the number of fasteners needed may be further refined.

Fall Recommendations

Between the two testing periods, summer of 2022 and January 2023, recommendations were given to PNSY. These were based on experience running the tests and the analysis conducted using the data collected.

- Reduce the number of fasteners to nine per group. This choice of a smaller number is based on the results from the statistical analysis and shown in Table 4. A change in the number of fasteners will alter the procedure, so this would need to be approved by PNSY and NAVSEA before it can be modified and implemented; however, a significant cost reduction and a reduction in the time required to complete the testing would be the outcome of this change.
- Have two observers watching the AMETEK CP2i pressure gauge on the load cell. It was observed that this gauge rapidly fluctuates, making it difficult to accurately read and record the peak preload achieved. This issue is most apparent when using a torque wrench verse a torque multiplier to tighten the fastener. Although, this increases the number of individuals needed to accomplish the test, having two people present will reduce the chance of an error. If the two observers disagree on a value, they should record the highest value since the procedure requires the maximum preload value for each iteration.
- Have the person typing the data also be one of the people watching the gauge. This can be accomplished by either moving the desktop computer in the work area or by using the standalone laptop. During testing, this person would not be participating in the process

when the fasteners were being torqued. It became clear that there were methods to allow them to fully participate during the entirety of the tests. With this change, it would allow for the tests to be performed efficiently by fewer people because of the previous recommendation's need of two people watching the gauge.

- Purchase more torque multipliers and use them when testing. This will allow for more consistent preload values to be reached during testing. Even though, as Graph 1 shows, a more consistent preload does not correlate to a more consistent COF, it is essential to aim for consistency. This is because the threads are stretched under an immense force, so if they are put under different forces, there is an uncertainty in how they are altered between iterations for one fastener. If the forces are the same, it removes the uncertainty. Also, the torque multipliers cause less fatigue than the torque wrenches. A purchase of additional torque multipliers will allow for them to replace the wrenches, and the testing will be less strenuous and more efficient which will reduce the man-hours and therefore reduce the cost of testing.
- Choose a new torque and preload value if the expected $1/3\sigma_y$ or $2/3\sigma_y$ values cause the use of two different torque wrenches or multipliers for testing one fastener. This can be done because the target values are arbitrary; it is the relationship between the preload and torque that is important. Using one torque wrench or torque multiplier will decrease the time it takes to test a fastener because the testers will not have to switch between torque wrenches or multipliers. Additionally, the testers also will not have to concentrate on exceeding the torque limits of these tools which allows them to focus on the preload target. This will allow for more consistent results which will aid in removing the aforementioned uncertainty.
- Choose a specific location for the fasteners and attempt to place the lubricated ones close to the testing apparatus. A change to the setup of the testing area became evident when the fasteners had to be moved across the workspace to be tested. This made it easy for the fastener to be dropped and the lubricant to be smudged on the threads. Having a specific area will maintain an organized workspace and will decrease the chance of altering the lubricated fasteners, resulting in more efficient testing.
- Purchase a step stool. It will allow for a larger range of motion for the person using the torque wrench and provide more stable footing during testing. Also, it is an ergonomic correction which will cause less strain on the back, and it will reduce the chance of injury.

Fall Impact

Following these recommendations made an impact on the second set of testing in January. Not all recommendations were followed, but the ones that were followed allowed for a:

- Decrease in the number of man-hours. Based on reference (b), there was a reduction of 200.5 hours from the projected time when compared to the January

tests. Also, at the conclusion of the January testing, it was noted that there was a reduction of 41.5 hours between the summer and January tests. For three people, this is a decrease of roughly 14 hours which results in about two fewer days spent testing per lubricant. The recommendations regarding having the person typing watch the gauge, using one torque wrench or multiplier, and purchasing a step stool caused this improvement.

- Increase in the consistency of preload values. This change came added experience using the torque wrenches and multipliers along with selecting new preload and torque target values when it was determined that more than one tool would be needed to complete the testing for a fastener. This made it so a single tool could be used.
- Reduction of the risk of injury. This comes from ergonomic corrections and an effort to make the testing less repetitive for each participant. Those participating in tests rotated jobs during testing, such as recording the data or torquing the fasteners, which helped in the limitation of repetitive actions and broke up the monotony of testing.

Spring Continuations and Recommendations

After the January testing, continuations - these were changes made for the January testing that should be continued – and recommendations were given to the PNSY. A list of continuations consisted of changes that might be overlooked since they might be seen as minor, but they had a positive impact:

- Continue using a standalone laptop instead of a desktop. The benefits were previously discussed.
- Continue using a clearly defined organizational system for the fasteners. This will allow anyone who partakes in this process, whether they have been constantly active in it or not, to know what stage of the testing in which each bolt, washer, and nut are currently.
- Continue using tactics to help with the mundane and repetitive nature of the tests. This was accomplished by having a radio playing, rotating jobs, and employing other methods.
- Continue using the same core group of people to run the tests. As previously stated, the nature of the testing leads to individuals participating when they have availability. If the same small group of people were present for every test, the standardization of the procedure should increase, and the chance of a mistake occurring should diminish.

Similar to what was done at the conclusion of the summer testing, recommendations were provided after the completion of the January testing.

- Decrease the number of fasteners. As Table 4 shows, Christo-Lube MCG 111 has values that were lower than the TRI Marine. This means that a decrease to nine fasteners per group is still valid and is reaffirmed.

- Purchase an impact wrench. As of now, the nut must be tightened and loosened along the entirety of the thread five times by hand. The drill currently in the workspace does have attachments for sockets, but they are not securely attached. The purchase of this equipment will increase the efficiency of the lubrication process since the sockets will more easily and securely attach to this piece of equipment than the current drill. With this wrench, this task is simpler and requires significantly less effort.
- Purchase smaller lubricant containers than the summer testing, but larger than the January testing. The summer testing had a large container that allowed for easy lubrication, but a large amount of lubricant was left over. The January testing had small tubes that made it difficult to lubricate the threads. A middle size between these two would allow for less waste, which will reduce the cost, while allowing for more efficient lubrication.
- Appoint a designated space for the fasteners and the rest of the testing equipment. As of now, this testing uses any area in the workspace that is not being used by another project. If there was a designated space that could be used for each test, it would allow for fasteners and equipment to be better organized. Also, if the area is the same for each test, the most efficient setup will be determined.

Other Recommendations during Testing

There were other changes and ideas that arose during the two testing phases that were not listed above, but they still made an impact in optimizing the process. Examples of these were the purchasing of a larger ultrasonic cleaner to aid in cleaning the fasteners as well as an automated machine to complete the torquing. The first was already purchased, and the second is in the process of being bought. An automated machine would make the purchase of more torque multipliers unnecessary, so the recommendations regarding this would be altered. These suggestions and others like them, though they were not written recommendations, they were verbally communicated, and considered by PNSY.

Future Impact (if all Recommendations are Followed)

If all the recommendations are implemented, there will be the following estimated impacts:

- Decrease of 165.5 man-hours from the January testing. This comes from the decreased number of fasteners, and an assumption that the automated machine purchase will be finalized and that using the machine requires only one tester. The total number of man-hours will be reduced to below 40, so one lubricant can be tested in less than a week.
- Decrease of the cost. The smaller amount of fasteners and lubricant, decreased time of testing, fewer cleaning materials, and all other reductions will lower the overall cost.

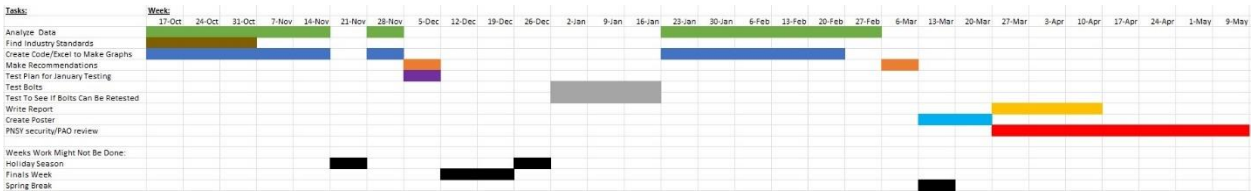
- Increase in the consistency of the preload. The automated machine will reach the same preload during every iteration.
- Increase in the diversity of users. With the automated machine, anyone will be able to complete the testing since it will remove the physical aspect of testing.
- Decrease in the needed storage. With the reduction of each material, there will be less storage requirements, which is important as there is limited space in the work area.
- Reduce the risk of damaging the equipment. The automated machine is a relatively simple program, and the testing is drastically easier to complete when compared to using torque wrenches and multipliers with great precision. Torque wrenches and multipliers were continually being picked up and moved which could result in hitting or dropping them. This could alter the calibration or damage the equipment. The automated machine reduces this risk because it will remain on a workbench and will not be moved.
- Decrease in the required calibration. As of now, four torque wrenches, two torque multipliers, and a load cell must be properly calibrated. With the use of an automated machine, only the load cell will need to be calibrated. This results in less work needed to be completed before testing occurs.

There is a negative to the new recommendations: increase in offsite upkeep of the machines. A 480-volt socket must be installed in the workspace to accommodate for the new torque testing machine. This cost is expected to be higher than the current cost to maintain six wrenches and multipliers.

Bill of Materials

Table 1 details the quantity of fastener assemblies needed to complete each round of testing. The testing also requires roughly 64 oz of the lubricant that is being tested. To clean the fasteners, Lestoil and isopropyl alcohol were employed in order to complete the task.

Gantt Chart



Ethical Considerations

There are no ethical considerations needed to complete this test or with its results.

Safety

Safety measures should be taken while performing the test. During the cleaning and lubricating stage, gloves should be worn to prevent prolonged contact with skin. Also, during the torquing stage, safety glasses should be worn to protect the eyes from any particles or foreign objects in the event of an accident. The long-term safety of personnel should be considered due to the repetitive and strenuous nature of the testing. The recommendations above cover different ways to improve the ergonomic nature of the testing.

During testing, the machines used made the process safer. An example of this is using torque multipliers instead of torque wrenches. This is because the multipliers put less strain on the body since it reduces the force needed to turn the nut. In the future, the introduction of an automated machine would take away all or most of the strain on the body during the torquing process.

Future Effort

As discussed, a major aspect of this project was to make recommendations for future work and attempt to improve the process. This section is not going to repeat the previous ideas, instead it will discuss the precedent that was set for testing:

During future testing, improvements to the process may be more difficult to discover; however, they are still necessary. There are still several lubricants that need to be tested for their COF, and revised procedures and new machines will be used. These additions will require either major or minor changes to the process, and these changes will require fine-tuning to make them more efficient. Also, they might require alterations to the previous recommendations. An example of this could be regarding statistical data. As more tests are conducted on new lubricants using new equipment, the data that are collected may reveal that the number of fasteners needed to be tested, as shown in Table 4, can be redefined. New results may determine that a smaller or larger group than the nine recommended here, is necessary. In other words, data obtained during future testing may alter that recommendation. This is one of many changes that could be made for the future tests, but overall, the optimization process is never complete since improvements can always be made.

Conclusion

- The determination of the COF values for both lubricants was a significant product of this project. With these results and the proper approval, TRI Marine and Christo-Lube MCG 111 can be used by the US Navy in torqued applications. This will allow for the use of less expensive, more readily available, and more efficient lubricants, providing greater flexibility to meet the fleet's needs.
- The decrease of 41.5 man-hours between the two tests shows that changes can have a major impact on the overall testing duration. Approximately two days of work were saved between the first and second round of testing. The future changes recommended here provide a further opportunity to reduce time and cost. The estimation of the influence of future changes has the testing being completed in less than one work week for one person. This will greatly improve the process since there are several lubricants that still need to be tested, and instead of it taking several months, it will take several weeks.
- The reduced risk of being injured is always important when running tests. With the large force that is being applied to the fasteners, there is the risk of something going wrong, and someone getting hurt. Steps have been and should continue to be taken to mitigate this risk and increase the safety of the testers as much as possible.

Acknowledgements

Portsmouth Naval Shipyard

CACI Inc. – FEDERAL

References

(a) DDS-COF-TP-0060 - Procedure for Determining the Coefficient of Friction of Various Lubricants on Common Naval Fastener Materials
(b) C206.4 Summer Assignment – Data Analysis

Appendices
Images

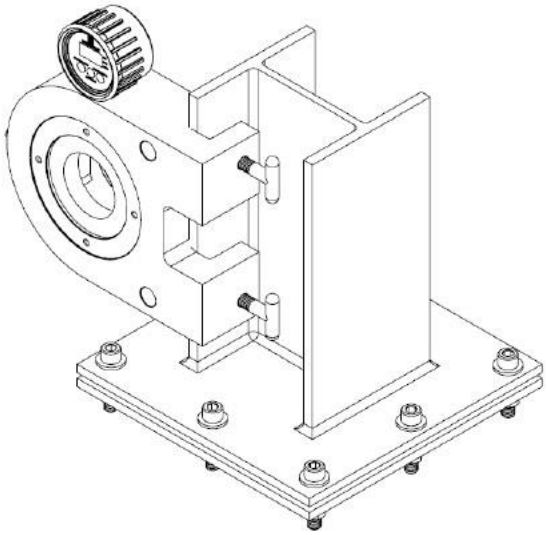


Image 1: The MZ-100 load cell and testing fixture.

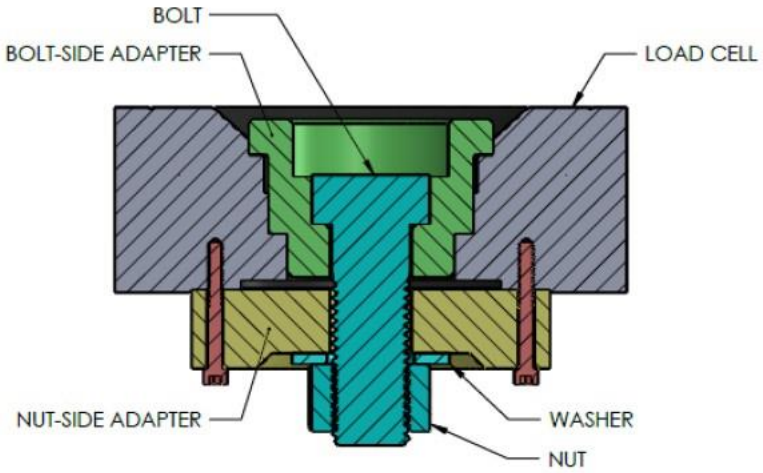


Image 2: A cross section of the MZ-100 which displays how a fastener is loaded into the device for testing.

Equations

$$\mu = \frac{D_c + E_m \sec\alpha + \frac{24T \tan\lambda \sec\alpha}{P} - \sqrt{\left(D_c + E_m \sec\alpha + \frac{24T \tan\lambda \sec\alpha}{P}\right)^2 - 4D_c \tan\lambda \sec\alpha \left(\frac{24T}{P} - E_m \tan\lambda\right)}}{2D_c \tan\lambda \sec\alpha} \quad (1)$$

T = Applied Torque (ft-lbs)
P = Tensile Load (preload) on bolt (lbs)
D = Nominal Bolt Diameter (in)
K_t = Torque Coefficient (dimensionless)
E_m = Mean Pitch Diameter (in) (function of thread geometry and mean diameter)
D_c = Mean Diameter of Nut Contact Area (in)
D_{co} = Maximum Mean Diameter of Nut Contact Area (in)
D_{ci} = Minimum Mean Diameter of Nut Contact Area (in)
λ = Lead Angle of the Thread (function of thread geometry)
α = 1/2 of the Thread Angle (function of thread geometry)
μ_t = Coefficient of Friction in the Thread
μ_c = Coefficient of Friction of the Nut Contact Area
μ = General Coefficient of Friction (COF) (assuming that $\mu c = \mu t$)

$$n = \left(\frac{ts}{CI}\right)^2 \quad (2)$$

t = t-value for the Specific Confidence Interval
s = Standard Deviation of the Data for a Group
CI = Chosen Confidence Interval

Tables

Fastener size:	Bolt Material			
	KMONEL	INCONEL 625	CRES316	MONEL
0.50-13UNC-2A	16	16	16	16
0.75-10UNC-2A	16	16	16	16
1.00-8UNC-2A	16	16	16	16
1.25-7UNC-2A	16	16	16	16
QTY	64	64	64	64
TOTAL QTY				256

Table 1: The number of fasteners and how they are distributed with the bolt material and size.

DDS-COF-TP-0060 ENCLOSURE (1)								DATE:	1/13/2023	
LUBRICANT:	CHRISTOLUBE MCG111			BOLT PROPERTIES:				TARGETS:		
SIZE:	0.50-13UNC-2A	TPI:	13	Nominal Diameter (in):	0.5		LEAD ANGLE (Deg)(B1.1):		1/3Y	2/3Y
BOLT MATERIAL:	KMONEL GR 500 MIL-DTL-1222 / QQ-N-286 A &AH			Yield Strength (ksi):	90	MIL-DTL-1222	3.114			
NUT MATERIAL:	NICU GR 400 MIL-DTL-1222 / QQ-N-281 CL A			Tensile Stress Area (in^2):	0.1419	ASME B1.1	Em (in) (B1.1):	PRELOAD (LBS)	4257	8514
WASHER MATERIAL:	NICU GR 400 FF-W-92			Torque Coefficient (assumed):	0.188	S9086-CJ-STM-010	0.450	EST. TORQUE (FT-LB)	33	67

Fastener No.	Trial	1/3 Yield Strength		2/3 Yield Strength		Crush Diameter			COF (Method 2)		
		Torque (ft lbs)	Preload (lbs)	Torque (ft lbs)	Preload (lbs)	Dco (in)	Dci (in)	Dc (in)	1/3Y	2/3Y	AVG
A	1.1	29.5	4257	70	8515				0.124	0.151	0.137
	1.2	28	4258	62	8515				0.116	0.131	0.124
	1.3	29	4256	70	8518	0.71	0.53		0.121	0.151	0.136
	Avg	29	4257	67	8516	0.71	0.53	0.62	0.121	0.144	**0.132**

Table 2: The spreadsheet used for collecting data, and it had the COF calculation and values. This is an example of one fastener of one group.

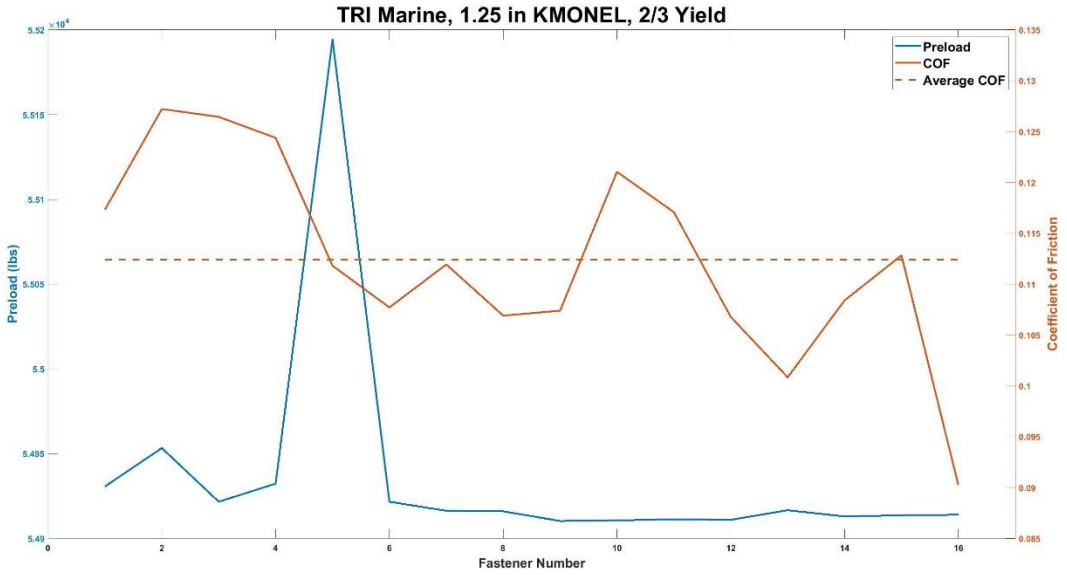
AVERAGE COEFFICIENT OF FRICTION RESULTS								
	TRI Marine				Christo-Lube MCG 111			
	KMONEL	INCONEL 625	CRES 316	MONEL	KMONEL	INCONEL 625	CRES 316	MONEL
.50-13UNC-2A	0.133	0.120	0.187	0.134	0.126	0.097	0.153	0.103
.75-10UNC-2A	0.120	0.125	0.189	0.149	0.109	0.114	0.164	0.131
1.00-8UNC-2A	0.105	0.112	0.162	0.139	0.092	0.118	0.174	0.126
1.25-7UNC-2A	0.120	0.105	0.165	0.141	0.112	0.115	0.174	0.138
ALL SIZES	0.12	0.12	0.18	0.14	0.11	0.11	0.17	0.12

Table 3: The COF average for each group and for the two lubricants tested.

'Confidence Intervals'	'Tri-Marine'	'Christolube'
'95% Confidence'	5	4
'97.5% Confidence'	6	5
'99% Confidence'	9	7

Table 4: The calculated number of fasteners per group while maintaining a high degree of confidence in the COF results.

Graph



Graph 1: This shows the consistency of preload argument. As seen above, the preload value a spike in the data; however, this spike has a COF value closer to the average COF for the group. It is an example of the trend that occurs throughout the data.

Codes

```
%% 1.25 KMONEL, TRI Marine, 2/3 yield
clear
data = readmatrix('(DISTRO A) Method 2 DDS-COF-TP-0060 Enclosure (1) Rev (-) - TRI
FINAL.xlsx','Sheet',7);
% STD = data(86, 11);
data(:,1:5) = [];
data(:,7:end) = [];
data(1:3,:) = [];
data(82:end,:) = [];
data(5:5:end,:) = [];
data(1:4:end,:) = [];
data(1:3:end,:) = [];
data(1:2:end,:) = [];
data(:,2:5) = [];
P = data(:,1);
COF = data(:,2);
x = (1:length(COF))';
val = mean(COF);
one = ones(length(COF),1);
avg = val*one;

figure
yyaxis left
plot(x,P,'LineWidth',2.0)
ylabel('Preload (lbs)', 'FontSize', 15, 'FontWeight', 'bold')
yyaxis right
plot(x,COF,x,avg,'LineWidth',2.0)
ylabel('Coefficient of Friction', 'FontSize', 15, 'FontWeight', 'bold')
title('TRI Marine, 1.25 in KMONEL, 2/3 Yield', 'FontSize', 25, 'FontWeight', 'bold')
xlabel('Fastener Number', 'FontSize', 15, 'FontWeight', 'bold')
axis([0 17 0.085 0.135])
legend('Preload','COF','Average COF', 'FontSize', 15, 'FontWeight', 'bold')
a = gca;
a.XAxis.FontWeight = 'bold';
a.YAxis(1).FontWeight = 'bold';
a.YAxis(2).FontWeight = 'bold';
```

Code 1: This code was used for creating the graph shown in Graph 1.

```
clear
%creating arrays for information to be put in later - this allows for the
%code to run faster and more efficiently
    %Continue to add the names of the spreadsheets to this list
lubricants = ["(DISTRO A) Method 2 DDS-COF-TP-0060 Enclosure (1) Rev (-) - TRI
FINAL.xlsx","MCG111 DDS-COF-TP-0060 Enclosure (1) Rev (A).xlsx"];
avg = zeros(4,length(lubricants) + 1);
sample_size_95 = zeros(17,length(lubricants) + 2);
sample_size_975 = zeros(17,length(lubricants) + 2);
sample_size_99 = zeros(17,length(lubricants) + 2);

for j = 1:length(lubricants)
    for i = 4:19
        %retrieving data
        data = readmatrix(lubricants(j),'Sheet',i);
        %managing matrix
        data(:,1:11) = [];
        data(:,2:end) = [];
        data(1:length(data)-5,:) = [];
        %calculating 5 percent of the COF for the confidence interval - this
        %can change if a larger or smaller range is desired
        COF = data(1);
        CI = COF/20;
        %retrieving standard deviation
        SD = data(3);
        %calculating t-values for sample size equation
        t_95 = tinv(0.95,95);
        t_975 = tinv(0.975,95);
        t_99 = tinv(0.99,95);
        %calculating the new sample size - values are rounded up
        n_95 = ((SD*t_95)/(CI))^2;
        size_95 = ceil(n_95/6);
        n_975 = ((SD*t_975)/(CI))^2;
        size_975 = ceil(n_975/6);
        n_99 = ((SD*t_99)/(CI))^2;
        size_99 = ceil(n_99/6);
        %making an array of the calculated sample sizes
        sample_size_95(i-2,j+2) = size_95;
        sample_size_975(i-2,j+2) = size_975;
        sample_size_99(i-2,j+2) = size_99;
    end
    %averaging the calculated sample sizes - values are rounded up
    avg(2,j+1) = ceil(mean(sample_size_95(2:end,j+2)));
    avg(3,j+1) = ceil(mean(sample_size_975(2:end,j+2)));
    avg(4,j+1) = ceil(mean(sample_size_99(2:end,j+2)));
end

%This section adds the headers to tables, so they are easier to read
avg = num2cell(avg);
avg(2:end,1) = {'95% Confidence','97.5% Confidence','99% Confidence'};
sample_size_95 = num2cell(sample_size_95);
sample_size_975 = num2cell(sample_size_975);
sample_size_99 = num2cell(sample_size_99);
```

```
sample_size_95(2:end,1) = {'KMONEL',' ',' ',' ','INCONEL',' ',' ',' ','CRES 316','
',' ',' ','MONEL',' ',' ',' '};
sample_size_975(2:end,1) = {'KMONEL',' ',' ',' ','INCONEL',' ',' ',' ','CRES 316','
',' ',' ','MONEL',' ',' ',' '};
sample_size_99(2:end,1) = {'KMONEL',' ',' ',' ','INCONEL',' ',' ',' ','CRES 316','
',' ',' ','MONEL',' ',' ',' '};
sample_size_95(2:end,2) =
{'0.5','0.75','1','1.25','0.5','0.75','1','1.25','0.5','0.75','1','1.25','0.5','0.75'
,'1','1.25'};
sample_size_975(2:end,2) =
{'0.5','0.75','1','1.25','0.5','0.75','1','1.25','0.5','0.75','1','1.25','0.5','0.75'
,'1','1.25'};
sample_size_99(2:end,2) =
{'0.5','0.75','1','1.25','0.5','0.75','1','1.25','0.5','0.75','1','1.25','0.5','0.75'
,'1','1.25'};
    %Continue to add names of the lubricants. An error will occur if you do
    %not add the names.
avg(1,1:end) = {'Confidence Intervals','Tri-Marine','Christolube'};
sample_size_95(1,1:end) = {'Material','Size','Tri-Marine','Christolube'};
sample_size_975(1,1:end) = {'Material','Size','Tri-Marine','Christolube'};
sample_size_99(1,1:end) = {'Material','Size','Tri-Marine','Christolube'};

%The avg array averages all materials and sizes for each lubricant, and
%organizes them for the 3 calculated confidence interval.
%The three sample_size arrays have the average printed for each specific
%size and material. Also the ending information gives the specific
%confidence intervals being calculated. _95, _975, and _99 correspond to
%95 percent confidence, 97.5 percent confidence, and 99 percent confidence,
%respectively.

%For those who do not use MATLAB, to easily see the results, you can delete
%the semi-colons from the lines under the message that tells to add
% lubricant names and gives the error warning, and the information will be
% given in the Command Window. The other option (which I prefer) is to
% click on the desired array in the Workspace window, and it will open a
% table of the results.
```

Code 2: The code used to calculate the new number of fasteners per group. There are also directions in the code, so if someone is not well versed in MATLAB, they will be able to use it.

Testing Information

TABLE 1: CALIBRATION DATA		
RECORD SERIAL NUMBER, RANGE, TOLERANCE, AND CALIBRATION DATES FOR EACH MEASUREMENT DEVICE USED		
DEVICE DESCRIPTION	CALIBRATION INFORMATION	
SKIDMORE-WILHELM MZ-100 BOLT TENSION CALIBRATOR	SERIAL NUMBER	USN 71930
	RANGE	0 - 126000 LBF
	TOLERANCE	+/- 1%
	CALIBRATION DATES	CALIBRATED 7 APR 22, DUE 7 APR 23
DIAL TORQUE WRENCH, 0-50 FT-LB	SERIAL NUMBER	USN 74460
	RANGE	0 - 50 FT LB
	TOLERANCE	2% (ACCURACY)
	CALIBRATION DATES	CALIBRATED 4 JAN 22, DUE 4 JAN 24
DIAL TORQUE WRENCH, 0-250 FT-LB	SERIAL NUMBER	USN 25FD5272
	RANGE	0 - 250 FT LB
	TOLERANCE	2% (ACCURACY)
	CALIBRATION DATES	CALIBRATED 29 JUN 21, DUE 29 JUN 23
DIAL TORQUE WRENCH, 0-600 FT-LB	SERIAL NUMBER	USN 60FD5274
	RANGE	0 - 600 FT LB
	TOLERANCE	
	CALIBRATION DATES	CALIBRATED 29 JUN 21, DUE 29 DEC 23
DIAL TORQUE WRENCH, 0-1000 FT-LB	SERIAL NUMBER	USN 100FD5273
	RANGE	0 - 1000 FT LB
	TOLERANCE	
	CALIBRATION DATES	CALIBRATED 29 JUN 21, DUE 29 JUN 23
TONE DIGITORQON TORQUE MULTIPLIER, 200 - 1100 FT LB	SERIAL NUMBER	PNH10007
	RANGE	200 - 1100 FT LB
	TOLERANCE	
	CALIBRATION DATES	CALIBRATED 17 NOV 2022, DUE 17 NOV 2023
TONE DIGITORQON TORQUE MULTIPLIER, 450 - 2200 FT LB	SERIAL NUMBER	20 007
	RANGE	450 - 2200 FT LB
	TOLERANCE	
	CALIBRATION DATES	CALIBRATED 17 NOV 2022, DUE 17 NOV 2023

KMONEL	.50-13UNC-2A	PRELOAD (LBS)	4257	8514
		EST. TORQUE (FT-LBS)	33	67
	.75-10UNC-2A	PRELOAD (LBS)	10020	20040
		EST. TORQUE (FT-LBS)	116	233
	1.00-8UNC-2A	PRELOAD (LBS)	17170	34340
		EST. TORQUE (FT-LBS)	265	529
	1.25-7UNC-2A	PRELOAD (LBS)	27455	54910
		EST. TORQUE (FT-LBS)	526	1052

INCONEL	.50-13UNC-2A	PRELOAD (LBS)	2838	5676
		EST. TORQUE (FT-LBS)	24	47
	.75-10UNC-2A	PRELOAD (LBS)	6680	13360
		EST. TORQUE (FT-LBS)	83	165
	1.00-8UNC-2A	PRELOAD (LBS)	12120	24240
		EST. TORQUE (FT-LBS)	199	398
	1.25-7UNC-2A	PRELOAD (LBS)	19380	38760
		EST. TORQUE (FT-LBS)	396	791
CRES316	.50-13UNC-2A	PRELOAD (LBS)	1419	2838
		EST. TORQUE (FT-LBS)	13	25
	.75-10UNC-2A	PRELOAD (LBS)	3340	6680
		EST. TORQUE (FT-LBS)	44	88
	1.00-8UNC-2A	PRELOAD (LBS)	6060	12120
		EST. TORQUE (FT-LBS)	106	211
	1.25-7UNC-2A	PRELOAD (LBS)	9690	19380
		EST. TORQUE (FT-LBS)	210	420
MONEL	.50-13UNC-2A	PRELOAD (LBS)	1892	3784
		EST. TORQUE (FT-LBS)	15	30
	.75-10UNC-2A	PRELOAD (LBS)	4453	8907
		EST. TORQUE (FT-LBS)	52	104
	1.00-8UNC-2A	PRELOAD (LBS)	8080	16160
		EST. TORQUE (FT-LBS)	125	249
	1.25-7UNC-2A	PRELOAD (LBS)	12920	25840
		EST. TORQUE (FT-LBS)	248	495

Note: Used PC Bolts to estimate torque coefficient, assuming Krytox 240AC was lubricant.

TRI Marine Data Sheets

Summary

DDS-COF-TP-0060 ENCLOSURE (1) - SUMMARY OF RESULTS				
AVERAGE COEFFICIENT OF FRICTION RESULTS				
	KMONEL	INCONEL 625	CRES 316	MONEL
.50-13UNC-2A	0.133	0.120	0.187	0.134
.75-10UNC-2A	0.120	0.125	0.189	0.149
1.00-8UNC-2A	0.105	0.112	0.162	0.139
1.25-7UNC-2A	0.120	0.105	0.165	0.141
ALL SIZES	0.12	0.12	0.18	0.14
STANDARD DEVIATION OF RESULTS				
	KMONEL	INCONEL 625	CRES 316	MONEL
.50-13UNC-2A	0.005	0.006	0.006	0.007
.75-10UNC-2A	0.006	0.006	0.011	0.007
1.00-8UNC-2A	0.009	0.008	0.008	0.007
1.25-7UNC-2A	0.008	0.012	0.006	0.013
ALL SIZES	0.012	0.011	0.015	0.010

FASTENER ID	KMONEL			
	.50-13UNC-2A	.75-10UNC-2A	1.00-8UNC-2A	1.25-7UNC-2A
A	0.138	0.122	0.097	0.122
B	0.125	0.119	0.112	0.132
C	0.132	0.126	0.112	0.131
D	0.135	0.118	0.091	0.126
E	0.137	0.130	0.119	0.110
F	0.136	0.130	0.099	0.117
G	0.131	0.110	0.124	0.120
H	0.129	0.114	0.103	0.115
I	0.128	0.116	0.111	0.120
J	0.126	0.115	0.099	0.132
K	0.136	0.121	0.095	0.127
L	0.137	0.121	0.111	0.117
M	0.135	0.120	0.107	0.114
N	0.131	0.125	0.099	0.118
O	0.142	0.120	0.110	0.119
P	0.135	0.120	0.098	0.103
AVG	0.133	0.120	0.105	0.120
STD DEV	0.005	0.006	0.009	0.008

FASTENER ID	INCONEL 625			
	.50-13UNC-2A	.75-10UNC-2A	1.00-8UNC-2A	1.25-7UNC-2A
A	0.118	0.132	0.120	0.112
B	0.119	0.136	0.113	0.107
C	0.111	0.117	0.113	0.111
D	0.121	0.112	0.108	0.098
E	0.123	0.130	0.111	0.103
F	0.121	0.118	0.117	0.113
G	0.133	0.126	0.118	0.105
H	0.125	0.125	0.099	0.111
I	0.114	0.125	0.116	0.098
J	0.110	0.129	0.116	0.108
K	0.116	0.124	0.118	0.113
L	0.128	0.123	0.095	0.088
M	0.124	0.123	0.118	0.137
N	0.116	0.127	0.098	0.084
O	0.120	0.131	0.124	0.094
P	0.119	0.118	0.110	0.104
AVG	0.120	0.125	0.112	0.105
STD DEV	0.006	0.006	0.008	0.012

FASTENER ID	CRES 316			
	.50-13UNC-2A	.75-10UNC-2A	1.00-8UNC-2A	1.25-7UNC-2A
A	0.187	0.181	0.157	0.155
B	0.182	0.172	0.168	0.163
C	0.180	0.192	0.143	0.166
D	0.176	0.185	0.164	0.168
E	0.190	0.160	0.165	0.156
F	0.186	0.183	0.157	0.165
G	0.186	0.203	0.161	0.163
H	0.186	0.197	0.163	0.170
I	0.188	0.193	0.160	0.161
J	0.191	0.192	0.173	0.161
K	0.187	0.195	0.175	0.166
L	0.198	0.197	0.152	0.167
M	0.180	0.190	0.153	0.172
N	0.190	0.182	0.158	0.173
O	0.190	0.205	0.165	0.179
P	0.193	0.196	0.171	0.158
AVG	0.187	0.189	0.162	0.165
STD DEV	0.006	0.011	0.008	0.006

FASTENER ID	MONEL			
	.50-13UNC-2A	**.75-10UNC-2A**	**1.00-8UNC-2A**	**1.25-7UNC-2A**
A	0.143	0.151	0.145	0.131
B	0.138	0.146	0.141	0.147
C	0.126	0.146	0.156	0.140
D	0.142	0.151	0.142	0.154
E	0.140	0.156	0.136	0.152
F	0.141	0.147	0.140	0.161
G	0.133	0.153	0.134	0.150
H	0.132	0.152	0.142	0.143
I	0.142	0.136	0.146	0.140
J	0.135	0.149	0.141	0.138
K	0.133	0.150	0.140	0.120
L	0.142	0.153	0.125	0.127
M	0.126	0.143	0.139	0.129
N	0.133	0.162	0.138	0.117
O	0.123	0.136	0.125	0.156
P	0.125	0.146	0.134	0.156
AVG	0.134	0.149	0.139	0.141
STD DEV	0.007	0.007	0.007	0.013

KMONEL

DDS-COF-TP-0060 ENCLOSURE (1)								DATE:	7/5/2022	
LUBRICANT:	TRI MARINE GREASE			BOLT PROPERTIES:				TARGETS:		
SIZE:	0.50-13UNC-2A	TPI:	13	Nominal Diameter (in):	0.5		LEAD ANGLE (Degrees):			
BOLT MATERIAL:	KMONEL GR 500 MIL-DTL-1222 / QQ-N-286 A &AH			Yield Strength (ksi):	90	MIL-DTL-1222	3.114		1/3Y	2/3Y
NUT MATERIAL:	NICU GR 400 MIL-DTL-1222 / QQ-N-281 CL A			Tensile Stress Area (in^2):	0.1419	ASME B1.1	Em (in):	PRELOAD (LBS)	4257	8514
WASHER MATERIAL:	NICU GR 400 FF-W-92			Torque Coefficient (assumed):	0.188	S9086-CJ-STM-010	0.450	EST. TORQUE (FT-LB)	33	67

Fastener No.	Trial	1/3 Yield Strength		2/3 Yield Strength		Crush Diameter			COF (Method 2)		
		Torque (ft lbs)	Preload (lbs)	Torque (ft lbs)	Preload (lbs)	Dco (in)	Dci (in)	Dc (in)	1/3Y	2/3Y	AVG
A	1.1	34	4270	63	8510				0.146	0.134	0.140
	1.2	33	4253	63	8524				0.141	0.134	0.137
	1.3	30	4269	70	8620	0.711	0.527		0.126	0.149	0.137
	Avg	32	4264	65	8551	0.711	0.527	0.619	0.138	0.139	**0.138**
B	2.1	29	4252	68	8518				0.123	0.148	0.135
	2.2	27	4356	60	8541				0.110	0.127	0.119
	2.3	26	4268	63	8547	0.685	0.526		0.108	0.135	0.121
	Avg	27	4292	64	8535	0.685	0.526	0.6055	0.114	0.137	**0.125**
C	3.1	31	4267	68	8540				0.132	0.147	0.140
	3.2	29	4274	63	8515				0.122	0.135	0.129
	3.3	30	4316	61	8576	0.6895	0.527		0.126	0.129	0.127
	Avg	30	4286	64	8544	0.6895	0.527	0.60825	0.127	0.137	**0.132**
D	4.1	35	4303	66	8526				0.151	0.143	0.147
	4.2	30	4250	60	8515				0.128	0.128	0.128
	4.3	31	4254	60	8540	0.69	0.52		0.133	0.128	0.130
	Avg	32	4269	62	8527	0.69	0.52	0.605	0.137	0.133	**0.135**
E	5.1	31	4257	68	8519				0.131	0.146	0.139
	5.2	33	4259	73	8511				0.141	0.158	0.150
	5.3	29	4269	60	8513	0.71	0.526		0.121	0.127	0.124
	Avg	31	4262	67	8514	0.71	0.526	0.618	0.131	0.144	**0.137**
F	6.1	32	4273	70	8559				0.137	0.151	0.144
	6.2	30	4256	69	8509				0.128	0.150	0.139
	6.3	29	4265	60	8526	0.693	0.524		0.122	0.127	0.125
	Avg	30	4265	66	8531	0.693	0.524	0.6085	0.129	0.143	**0.136**
G	7.1	34	4240	65	8515				0.148	0.140	0.144
	7.2	30	4260	60	8532				0.128	0.127	0.127
	7.3	29	4276	58	8506	0.688	0.527		0.122	0.123	0.122
	Avg	31	4259	61	8518	0.688	0.527	0.6075	0.133	0.130	**0.131**
H	8.1	31.5	4259	70	8508				0.135	0.152	0.144
	8.2	27	4263	64	8527				0.113	0.137	0.125
	8.3	26	4268	60	8519	0.69	0.527		0.107	0.127	0.117
	Avg	28	4263	65	8518	0.69	0.527	0.6085	0.118	0.139	**0.129**
I	9.1	32	4287	62	8517				0.135	0.131	0.133
	9.2	32	4257	67	8513				0.136	0.143	0.140
	9.3	26	4257	55	8524	0.712	0.528		0.107	0.114	0.110
	Avg	30	4267	61	8518	0.712	0.528	0.62	0.126	0.129	**0.128**
J	10.1	33	4288	66	8540				0.139	0.139	0.139
	10.2	28	4262	63	8509				0.115	0.133	0.124
	10.3	28	4269	57	8526	0.732	0.529		0.115	0.118	0.116
	Avg	30	4273	62	8525	0.732	0.529	0.6305	0.123	0.130	**0.126**
K	11.1	31	4264	70	8549				0.133	0.152	0.142
	11.2	32	4297	61	8518				0.136	0.130	0.133
	11.3	31	4257	62	8559	0.687	0.523		0.133	0.132	0.133
	Avg	31	4273	64	8542	0.687	0.523	0.605	0.134	0.138	**0.136**
L	12.1	34	4268	70	8524				0.146	0.152	0.149
	12.2	33	4252	60	8510				0.142	0.127	0.135
	12.3	31	4265	58	8515	0.698	0.527		0.132	0.122	0.127
	Avg	33	4262	63	8516	0.698	0.527	0.6125	0.140	0.134	**0.137**
M	13.1	32	4243	68	8538				0.137	0.146	0.142
	13.2	32	4285	62	8517				0.136	0.132	0.134
	13.3	31	4313	63	8670	0.702	0.528		0.130	0.131	0.131
	Avg	32	4280	64	8575	0.702	0.528	0.615	0.134	0.136	**0.135**
N	14.1	32	4258	70	8518				0.136	0.151	0.143
	14.2	28	4268	67	8540				0.116	0.143	0.130
	14.3	27	4293	61	8555	0.713	0.527		0.110	0.128	0.119
	Avg	29	4273	66	8538	0.713	0.527	0.62	0.121	0.141	**0.131**
O	15.1	38	4296	70	8534				0.166	0.152	0.159
	15.2	31	4286	63	8516				0.132	0.135	0.133
	15.3	32	4246	60	8536	0.685	0.529		0.138	0.127	0.133
	Avg	34	4276	64	8529	0.685	0.529	0.607	0.145	0.138	**0.142**
P	16.1	34	4264	63	8535				0.146	0.134	0.140
	16.2	28	4248	66	8516				0.117	0.142	0.130
	16.3	32	4275	62	8523	0.7	0.528		0.136	0.132	0.134
	Avg	31	4262	64	8525	0.7	0.528	0.614	0.133	0.136	**0.135**
	AVG	31	4270	64	8532			0.613	0.130	0.136	**0.133**

Standard Deviation	0.0126	0.0105	0.0119
95% +-	0.0037	0.0030	0.0024
99% +-	0.0049	0.0041	0.0032

DDS-COF-TP-0060 ENCLOSURE (1)									DATE:	7/7/2022	
LUBRICANT:	TRI MARINE GREASE			BOLT PROPERTIES:					TARGETS:		
SIZE:	0.75-10UNC-2A	TPI:	10	Nominal Diameter (in):	0.75		LEAD ANGLE (Degrees):			1/3Y	2/3Y
BOLT MATERIAL:	KMONEL GR 500 MIL-DTL-1222 / QQ-N-286 A &AH			Yield Strength (ksi):	90	MIL-DTL-1222	2.660				
NUT MATERIAL:	NICU GR 400 MIL-DTL-1222 / QQ-N-281 CL A			Tensile Stress Area (in^2):	0.334	ASME B1.1	Em (in):		PRELOAD (LBS)	10020	20040
WASHER MATERIAL:	NICU GR 400 FF-W-92			Torque Coefficient (assumed):	0.186	S9086-CJ-STM-010	0.685		EST. TORQUE (FT-LB)	116	233

Fastener No.	Trial	1/3 Yield Strength		2/3 Yield Strength		Crush Diameter			COF (Method 2)		
		Torque (ft lbs)	Preload (lbs)	Torque (ft lbs)	Preload (lbs)	Dco (in)	Dci (in)	Dc (in)	1/3Y	2/3Y	AVG
A	1.1	124	10013	213	20045				0.153	0.129	0.141
	1.2	90	10019	174	20044				0.106	0.102	0.104
	1.3	121	10026	168	20040	1.068	0.809		0.148	0.098	0.123
	Avg	112	10019	185	20043	1.068	0.809	0.9385	0.136	0.109	**0.122**
B	2.1	129	10044	220	20100				0.159	0.133	0.146
	2.2	107	10100	180	20060				0.128	0.106	0.117
	2.3	84	10124	161	20026	1.075	0.808		0.096	0.093	0.094
	Avg	107	10089	187	20062	1.075	0.808	0.9415	0.128	0.110	**0.119**
C	3.1	138	10006	221	20054				0.172	0.134	0.153
	3.2	109	10025	189	20040				0.132	0.112	0.122
	3.3	90	10036	172	20078	1.066	0.811		0.106	0.100	0.103
	Avg	112	10022	194	20057	1.066	0.811	0.9385	0.137	0.115	**0.126**
D	4.1	129	10148	206	20058				0.158	0.124	0.141
	4.2	98	10128	190	20037				0.116	0.113	0.114
	4.3	90	10300	160	20026	1.06	0.805		0.103	0.092	0.098
	Avg	106	10192	185	20040	1.06	0.805	0.9325	0.125	0.110	**0.118**
E	5.1	135	10021	221	20046				0.168	0.134	0.151
	5.2	110	10045	191	20042				0.133	0.114	0.123
	5.3	102	10042	185	20063	1.062	0.81		0.122	0.109	0.116
	Avg	116	10036	199	20050	1.062	0.81	0.936	0.141	0.119	**0.130**
F	6.1	140	10200	222	19999				0.168	0.132	0.150
	6.2	112	10205	210	20026				0.131	0.124	0.127
	6.3	106	10170	181	20043	1.0815	0.8645		0.123	0.104	0.114
	Avg	119	10192	204	20023	1.0815	0.8645	0.973	0.141	0.120	**0.130**
G	7.1	122	10010	211	20062				0.147	0.124	0.135
	7.2	92	10024	179	20041				0.106	0.103	0.104
	7.3	80	10017	160	20045	1.062	0.897		0.090	0.090	0.090
	Avg	98	10017	183	20049	1.062	0.897	0.9795	0.114	0.106	**0.110**
H	8.1	122	10038	220	20050				0.145	0.129	0.137
	8.2	103	10013	185	20034				0.120	0.106	0.113
	8.3	81	10019	163	20079	1.065	0.9255		0.091	0.091	0.091
	Avg	102	10023	189	20054	1.065	0.9255	0.99525	0.118	0.109	**0.114**
I	9.1	128	10036	209	20042				0.153	0.122	0.137
	9.2	100	10034	190	20032				0.115	0.109	0.112
	9.3	88	10044	171	20053	1.078	0.92		0.099	0.096	0.098
	Avg	105	10038	190	20042	1.078	0.92	0.999	0.122	0.109	**0.116**
J	10.1	120	10018	219	20087				0.142	0.128	0.135
	10.2	110	10030	182	20035				0.129	0.104	0.116
	10.3	83	10050	170	20024	1.0775	0.9245		0.093	0.096	0.094
	Avg	104	10033	190	20049	1.0775	0.9245	1.001	0.121	0.109	**0.115**
K	11.1	124	10062	210	20092				0.152	0.127	0.139
	11.2	104	10032	179	20043				0.125	0.106	0.115
	11.3	98	10118	171	20062	1.057	0.808		0.116	0.100	0.108
	Avg	109	10071	187	20066	1.057	0.808	0.9325	0.131	0.111	**0.121**
L	12.1	130	10030	210	20065				0.158	0.125	0.141
	12.2	107	10064	180	20042				0.127	0.104	0.116
	12.3	100	10059	170	20074	1.092	0.835		0.117	0.097	0.107
	Avg	112	10051	187	20060	1.092	0.835	0.9635	0.134	0.109	**0.121**
M	13.1	130	10083	220	20069				0.158	0.132	0.145
	13.2	100	10317	185	20101				0.114	0.108	0.111
	13.3	92	10170	180	20089	1.0825	0.8335		0.106	0.104	0.105
	Avg	107	10190	195	20086	1.0825	0.8335	0.958	0.126	0.115	**0.120**
N	14.1	125	10049	217	20167				0.150	0.128	0.139
	14.2	110	10017	211	20009				0.131	0.125	0.128
	14.3	96	10050	181	20014	1.112	0.84		0.111	0.104	0.108
	Avg	110	10039	203	20063	1.112	0.84	0.976	0.131	0.119	**0.125**
O	15.1	123	10042	201	20018				0.150	0.120	0.135
	15.2	109	10030	192	20041				0.131	0.114	0.122
	15.3	89	10026	171	20036	1.0875	0.8075		0.104	0.099	0.102
	Avg	107	10033	188	20032	1.0875	0.8075	0.9475	0.128	0.111	**0.120**
P	16.1	130	10024	206	20050				0.161	0.124	0.142
	16.2	110	10085	181	20044				0.133	0.107	0.120
	16.3	87	10024	160	20025	1.068	0.8055		0.102	0.092	0.097
	Avg	109	10044	182	20040	1.068	0.8055	0.93675	0.132	0.108	**0.120**
	AVG	108	10068	191	20051			0.959	0.129	0.112	**0.120**

Standard Deviation	0.023012407	0.013579	0.0206124
95% +-	0.006682107	0.003943	0.0041765
99% +-	0.008916899	0.005262	0.0055299

DDS-COF-TP-0060 ENCLOSURE (1)									DATE:	7/8/2022	
LUBRICANT:	TRI MARINE GREASE			BOLT PROPERTIES:					TARGETS:		
SIZE:	1.00-8UNC-2A	TPI:	8	Nominal Diameter (in):	1.00		LEAD ANGLE (Degrees):			1/3Y	2/3Y
BOLT MATERIAL:	KMONEL GR 500 MIL-DTL-1222 / QQ-N-286 A &AH			Yield Strength (ksi):	85	MIL-DTL-1222	2.480				
NUT MATERIAL:	NICU GR 400 MIL-DTL-1222 / QQ-N-281 CL A			Tensile Stress Area (in^2):	0.606	ASME B1.1	Em (in):		PRELOAD (LBS)	17170	34340
WASHER MATERIAL:	NICU GR 400 FF-W-92			Torque Coefficient (assumed):	0.185	S9086-CJ-STM-010	0.919		EST. TORQUE (FT-LB)	265	529

Fastener No.	Trial	1/3 Yield Strength		2/3 Yield Strength		Crush Diameter			COF (Method 2)		
		Torque (ft lbs)	Preload (lbs)	Torque (ft lbs)	Preload (lbs)	Dco (in)	Dci (in)	Dc (in)	1/3Y	2/3Y	AVG
A	1.1	230	17170	384	34340				0.122	0.099	0.110
	1.2	206	17170	364	34340				0.107	0.093	0.100
	1.3	175	17170	308	34340	1.435	1.057		0.089	0.076	0.082
	Avg	204	17170	352	34340	1.435	1.057	1.246	0.106	0.089	**0.097**
B	2.1	250	17170	433	34360				0.134	0.114	0.124
	2.2	219	17180	385	34341				0.115	0.099	0.107
	2.3	225	17205	356	34342	1.428	1.059		0.119	0.090	0.104
	Avg	231	17185	391	34348	1.428	1.059	1.2435	0.122	0.101	**0.112**
C	3.1	246	17171	427	34489				0.132	0.111	0.121
	3.2	224	17171	395	34340				0.118	0.102	0.110
	3.3	206	17171	388	34341	1.424	1.06		0.107	0.100	0.104
	Avg	225	17171	403	34390	1.424	1.06	1.242	0.119	0.105	**0.112**
D	4.1	206	17171	340	34342				0.107	0.086	0.096
	4.2	194	17219	349	34340				0.100	0.088	0.094
	4.3	169	17181	317	34342	1.429	1.058		0.085	0.079	0.082
	Avg	190	17190	335	34341	1.429	1.058	1.2435	0.097	0.084	**0.091**
E	5.1	280	17170	451	34341				0.153	0.120	0.137
	5.2	231	17170	416	34342				0.123	0.109	0.116
	5.3	205	17170	379	34341	1.394	1.058		0.108	0.098	0.103
	Avg	239	17170	415	34341	1.394	1.058	1.226	0.128	0.109	**0.119**
F	6.1	219	17170	376	34341				0.115	0.097	0.106
	6.2	212	17166	341	34340				0.111	0.086	0.099
	6.3	200	17176	334	34349	1.4235	1.0575		0.104	0.084	0.094
	Avg	210	17171	350	34343	1.4235	1.0575	1.2405	0.110	0.089	**0.099**
G	7.1	280	17171	472	34341				0.152	0.125	0.138
	7.2	228	17170	451	34365				0.120	0.119	0.120
	7.3	222	17168	416	34340	1.4325	1.06		0.117	0.108	0.113
	Avg	243	17170	446	34349	1.4325	1.06	1.24625	0.130	0.118	**0.124**
H	8.1	230	17173	391	34340				0.122	0.101	0.111
	8.2	203	17170	363	34341				0.105	0.093	0.099
	8.3	213	17168	341	34340	1.4305	1.0575		0.112	0.086	0.099
	Avg	215	17170	365	34340	1.4305	1.0575	1.244	0.113	0.093	**0.103**
I	9.1	270	17173	444	34404				0.146	0.117	0.131
	9.2	210	17171	383	34342				0.110	0.099	0.104
	9.3	204	17177	347	34341	1.424	1.058		0.106	0.088	0.097
	Avg	228	17174	391	34362	1.424	1.058	1.241	0.121	0.101	**0.111**
J	10.1	221	17171	397	34342				0.116	0.102	0.109
	10.2	211	17166	338	34341				0.110	0.085	0.097
	10.3	201	17215	318	34344	1.4465	1.058		0.104	0.079	0.091
	Avg	211	17184	351	34342	1.4465	1.058	1.25225	0.110	0.089	**0.099**
K	11.1	210	17171	358	34342				0.110	0.091	0.101
	11.2	218	17171	343	34341				0.115	0.087	0.101
	11.3	178	17171	310	34364	1.4175	1.0585		0.091	0.077	0.084
	Avg	202	17171	337	34349	1.4175	1.0585	1.238	0.105	0.085	**0.095**
L	12.1	262	17169	394	34341				0.141	0.102	0.122
	12.2	235	17179	377	34343				0.125	0.097	0.111
	12.3	219	17179	336	34342	1.4305	1.0555		0.115	0.084	0.100
	Avg	239	17176	369	34342	1.4305	1.0555	1.243	0.127	0.094	**0.111**
M	13.1	250	17175	393	34353				0.133	0.101	0.117
	13.2	222	17178	379	34340				0.116	0.097	0.107
	13.3	207	17188	358	34340	1.4555	1.058		0.107	0.091	0.099
	Avg	226	17180	377	34344	1.4555	1.058	1.25675	0.119	0.096	**0.107**
N	14.1	231	17181	365	34342				0.122	0.093	0.108
	14.2	217	17168	345	34342				0.114	0.087	0.100
	14.3	191	17175	330	34341	1.437	1.0585		0.098	0.082	0.090
	Avg	213	17175	347	34342	1.437	1.0585	1.24775	0.111	0.087	**0.099**
O	15.1	261	17196	397	34341				0.140	0.103	0.121
	15.2	228	17165	384	34341				0.121	0.099	0.110
	15.3	216	17168	343	34341	1.432	1.0585		0.113	0.086	0.100
	Avg	235	17176	375	34341	1.432	1.0585	1.24525	0.125	0.096	**0.110**
P	16.1	230	17171	367	34342				0.122	0.094	0.108
	16.2	200	17184	336	34342				0.104	0.085	0.094
	16.3	199	17170	323	34341	1.4165	1.057		0.103	0.081	0.092
	Avg	210	17175	342	34342	1.4165	1.057	1.23675	0.110	0.086	**0.098**
	AVG	220	17175	372	34347			1.243	0.116	0.095	**0.105**

Standard Deviation	0.014760466	0.011894	0.0168018
95% +-	0.004285993	0.003454	0.0034044
99% +-	0.005719418	0.004609	0.0045075

DDS-COF-TP-0060 ENCLOSURE (1)									DATE:	7/6/2022	
LUBRICANT:	TRI MARINE GREASE			BOLT PROPERTIES:					TARGETS:		
SIZE:	1.25-7UNC-2A	TPI:	7	Nominal Diameter (in):	1.25		LEAD ANGLE (Degrees):				
BOLT MATERIAL:	KMONEL GR 500 MIL-DTL-1222 / QQ-N-286 A &AH			Yield Strength (ksi):	85	MIL-DTL-1222	2.250			1/3Y	2/3Y
NUT MATERIAL:	NICU GR 400 MIL-DTL-1222 / QQ-N-281 CL A			Tensile Stress Area (in^2):	0.969	ASME B1.1	Em (in):		PRELOAD (LBS)	27455	54910
WASHER MATERIAL:	NICU GR 400 FF-W-92			Torque Coefficient (assumed):	0.184	S9086-CJ-STM-010	1.157		EST. TORQUE (FT-LB)	526	1052

Fastener No.	Trial	1/3 Yield Strength		2/3 Yield Strength		Crush Diameter			COF (Method 2)		
		Torque (ft lbs)	Preload (lbs)	Torque (ft lbs)	Preload (lbs)	Dco (in)	Dci (in)	Dc (in)	1/3Y	2/3Y	AVG
A	1.1	551	27440	1058	54945				0.148	0.142	0.145
	1.2	467	27462	869	54932				0.123	0.114	0.118
	1.3	407	27457	754	54915	1.823	1.367		0.106	0.097	0.101
	Avg	475	27453	894	54931	1.823	1.367	1.595	0.126	0.117	**0.122**
B	2.1	648	27477	1162	54940				0.177	0.157	0.167
	2.2	468	27524	917	54950				0.123	0.121	0.122
	2.3	421	27515	800	54970	1.811	1.371		0.110	0.103	0.107
	Avg	512	27505	960	54953	1.811	1.371	1.591	0.137	0.127	**0.132**
C	3.1	613	27565	1145	54905				0.167	0.155	0.161
	3.2	478	27460	885	54910				0.127	0.117	0.122
	3.3	432	27460	823	54950	1.789	1.373		0.113	0.107	0.110
	Avg	508	27495	951	54922	1.789	1.373	1.581	0.136	0.126	**0.131**
D	4.1	557	27457	1084	54925				0.151	0.146	0.149
	4.2	477	27527	892	54935				0.127	0.118	0.122
	4.3	399	27483	833	54937	1.785	1.37		0.104	0.109	0.106
	Avg	478	27489	936	54932	1.785	1.37	1.5775	0.127	0.124	**0.126**
E	5.1	479	27460	988	55730				0.127	0.129	0.128
	5.2	376	27445	855	54920				0.097	0.112	0.104
	5.3	390	27502	736	54933	1.814	1.369		0.100	0.094	0.097
	Avg	415	27469	860	55194	1.814	1.369	1.5915	0.108	0.112	**0.110**
F	6.1	520	27480	847	54906				0.139	0.111	0.125
	6.2	455	27426	823	54915				0.120	0.107	0.114
	6.3	445	27510	808	54944	1.798	1.37		0.117	0.105	0.111
	Avg	473	27472	826	54922	1.798	1.37	1.584	0.126	0.108	**0.117**
G	7.1	545	27690	912	54917				0.146	0.121	0.133
	7.2	480	27470	883	54919				0.128	0.116	0.122
	7.3	430	27450	764	54913	1.789	1.369		0.113	0.099	0.106
	Avg	485	27537	853	54916	1.789	1.369	1.579	0.129	0.112	**0.120**
H	8.1	505	27440	862	54914				0.135	0.113	0.124
	8.2	440	27468	807	54917				0.116	0.105	0.110
	8.3	442	27560	791	54917	1.794	1.37		0.116	0.103	0.109
	Avg	462	27489	820	54916	1.794	1.37	1.582	0.122	0.107	**0.115**
I	9.1	544	27470	927	54913				0.146	0.122	0.134
	9.2	498	27640	794	54907				0.131	0.103	0.117
	9.3	460	27460	760	54911	1.824	1.371		0.121	0.097	0.109
	Avg	501	27523	827	54910	1.824	1.371	1.5975	0.133	0.107	**0.120**
J	10.1	695	27803	1124	54912				0.188	0.152	0.170
	10.2	500	27425	855	54911				0.133	0.112	0.123
	10.3	410	27507	775	54909	1.817	1.37		0.106	0.100	0.103
	Avg	535	27578	918	54911	1.817	1.37	1.5935	0.143	0.121	**0.132**
K	11.1	579	27501	1025	54909				0.157	0.137	0.147
	11.2	492	27451	866	54915				0.131	0.113	0.122
	11.3	456	27455	780	54910	1.81	1.37		0.120	0.101	0.110
	Avg	509	27469	890	54911	1.81	1.37	1.59	0.136	0.117	**0.127**
L	12.1	499	27457	855	54909				0.133	0.112	0.122
	12.2	500	27507	814	54910				0.133	0.106	0.119
	12.3	448	27463	794	54914	1.808	1.372		0.118	0.103	0.110
	Avg	482	27476	821	54911	1.808	1.372	1.59	0.128	0.107	**0.117**
M	13.1	530	27438	800	54912				0.142	0.103	0.123
	13.2	500	27720	775	54919				0.132	0.100	0.116
	13.3	410	27456	772	54919	1.82	1.37		0.106	0.099	0.103
	Avg	480	27538	782	54917	1.82	1.37	1.595	0.127	0.101	**0.114**
N	14.1	542	27990	924	54911				0.142	0.122	0.132
	14.2	473	27467	814	54914				0.125	0.106	0.115
	14.3	435	27505	762	54914	1.82	1.371		0.114	0.098	0.106
	Avg	483	27654	833	54913	1.82	1.371	1.5955	0.127	0.108	**0.118**
O	15.1	542	27449	952	54911				0.146	0.126	0.136
	15.2	435	27600	833	54918				0.113	0.108	0.111
	15.3	435	27450	802	54912	1.819	1.365		0.114	0.104	0.109
	Avg	471	27500	862	54914	1.819	1.365	1.592	0.124	0.113	**0.119**
P	16.1	481	27453	738	54910				0.128	0.094	0.111
	16.2	442	27457	722	54915				0.116	0.092	0.104
	16.3	409	27451	671	54917	1.812	1.372		0.106	0.084	0.095
	Avg	444	27454	710	54914	1.812	1.372	1.592	0.117	0.090	**0.103**
	AVG	482	27506	859	54937			1.589	0.128	0.112	**0.120**

Standard Deviation	0.019290035	0.01666	0.0194239
95% +-	0.005601242	0.004838	0.0039356
99% +-	0.007474546	0.006456	0.005211

INCONEL 625

DDS-COF-TP-0060 ENCLOSURE (1)								DATE:	7/18/2022	
LUBRICANT:	TRI MARINE GREASE			BOLT PROPERTIES:				TARGETS:		
SIZE:	0.50-13UNC-2A	TPI:	13	Nominal Diameter (in):	0.5		LEAD ANGLE (Degrees):			
BOLT MATERIAL:	INCONEL 625 MIL-DTL-1222/ASTM B446 GR 1			Yield Strength (ksi):	60	MIL-DTL-1222	3.114		1/3Y	2/3Y
NUT MATERIAL:	NICU GR 400 MIL-DTL-1222 / QQ-N-281 CL A			Tensile Stress Area (in^2):	0.1419	ASME B1.1	Em (in):	PRELOAD (LBS)	2838	5676
WASHER MATERIAL:	NICU GR 400 FF-W-92			Torque Coefficient (assumed):	0.2	S9086-CJ-STM-010	0.450	EST. TORQUE (FT-LB)	24	47

Fastener No.	Trial	1/3 Yield Strength		2/3 Yield Strength		Crush Diameter			COF (Method 2)		
		Torque (ft lbs)	Preload (lbs)	Torque (ft lbs)	Preload (lbs)	Dco (in)	Dci (in)	Dc (in)	1/3Y	2/3Y	AVG
A	1.1	21.5	2839	39.5	5676				0.138	0.125	0.132
	1.2	18	2839	35	5677				0.112	0.109	0.110
	1.3	18	2838	35.5	5676	0.697	0.5275		0.112	0.110	0.111
	Avg	19	2839	37	5676	0.697	0.5275	0.61225	0.121	0.115	**0.118**
B	2.1	22	2838	41.5	5677				0.142	0.133	0.137
	2.2	18	2838	36.5	5686				0.112	0.114	0.113
	2.3	18	2838	33.5	5678	0.6975	0.5275		0.112	0.103	0.108
	Avg	19	2838	37	5680	0.6975	0.5275	0.6125	0.122	0.117	**0.119**
C	3.1	19.5	2838	37	5679				0.123	0.116	0.119
	3.2	18.5	2838	34	5679				0.116	0.104	0.110
	3.3	17	2840	34	5676	0.7055	0.527		0.104	0.105	0.105
	Avg	18	2839	35	5678	0.7055	0.527	0.61625	0.114	0.108	**0.111**
D	4.1	20	2839	40	5677				0.126	0.126	0.126
	4.2	19	2840	39	5676				0.119	0.123	0.121
	4.3	19	2853	36.5	5689	0.71	0.5285		0.118	0.113	0.116
	Avg	19	2844	39	5681	0.71	0.5285	0.61925	0.121	0.121	**0.121**
E	5.1	21.5	2838	41	5677				0.138	0.131	0.134
	5.2	19.5	2844	38.5	5682				0.123	0.121	0.122
	5.3	18.5	2838	36	5677	0.704	0.526		0.116	0.112	0.114
	Avg	20	2840	39	5679	0.704	0.526	0.615	0.126	0.121	**0.123**
F	6.1	20	2839	39.5	5677				0.126	0.125	0.125
	6.2	19.5	2839	39.5	5676				0.123	0.125	0.124
	6.3	18.5	2838	35.5	5679	0.71	0.5285		0.115	0.110	0.113
	Avg	19	2839	38	5677	0.71	0.5285	0.61925	0.121	0.120	**0.121**
G	7.1	24.5	2838	45	5672				0.161	0.146	0.154
	7.2	21	2862	39.5	5674				0.134	0.126	0.130
	7.3	19.5	2837	34.5	5679	0.6885	0.53		0.124	0.107	0.115
	Avg	22	2846	40	5675	0.6885	0.53	0.60925	0.139	0.126	**0.133**
H	8.1	23.5	2837	45.5	5675				0.153	0.147	0.150
	8.2	19	2871	38	5675				0.118	0.119	0.119
	8.3	16.5	2836	36.5	5685	0.71	0.523		0.101	0.114	0.107
	Avg	20	2848	40	5678	0.71	0.523	0.6165	0.124	0.127	**0.125**
I	9.1	20.5	2843	39	5678				0.130	0.123	0.127
	9.2	17.5	2834	35	5675				0.109	0.109	0.109
	9.3	17.5	2838	34	5676	0.698	0.5295		0.108	0.105	0.107
	Avg	19	2838	36	5676	0.698	0.5295	0.61375	0.116	0.112	**0.114**
J	10.1	19	2839	38	5680				0.120	0.120	0.120
	10.2	17.5	2838	31.5	5676				0.109	0.096	0.102
	10.3	17.5	2838	35	5675	0.6995	0.518		0.109	0.109	0.109
	Avg	18	2838	35	5677	0.6995	0.518	0.60875	0.113	0.108	**0.110**
K	11.1	19.5	2839	43.5	5676				0.123	0.140	0.131
	11.2	18	2837	37	5678				0.112	0.116	0.114
	11.3	16.5	2839	34	5677	0.703	0.53		0.101	0.105	0.103
	Avg	18	2838	38	5677	0.703	0.53	0.6165	0.112	0.120	**0.116**
L	12.1	21.5	2837	45	5676				0.138	0.145	0.141
	12.2	20	2835	39	5677				0.127	0.123	0.125
	12.3	19.5	2843	36	5683	0.7085	0.528		0.123	0.112	0.117
	Avg	20	2838	40	5679	0.7085	0.528	0.61825	0.129	0.126	**0.128**
M	13.1	22	2839	43	5678				0.142	0.138	0.140
	13.2	19	2843	38	5673				0.120	0.120	0.120
	13.3	19	2840	34	5676	0.7015	0.5185		0.120	0.105	0.112
	Avg	20	2841	38	5676	0.7015	0.5185	0.61	0.127	0.121	**0.124**
N	14.1	20	2846	40.5	5673				0.126	0.128	0.127
	14.2	18	2841	35.5	5676				0.112	0.110	0.111
	14.3	18.5	2835	35	5677	0.7195	0.519		0.115	0.108	0.112
	Avg	19	2841	37	5675	0.7195	0.519	0.61925	0.118	0.115	**0.116**
O	15.1	21	2841	40	5676				0.135	0.128	0.132
	15.2	17.5	2835	36	5675				0.110	0.113	0.111
	15.3	18	2846	37.5	5676	0.692	0.517		0.113	0.119	0.116
	Avg	19	2841	38	5676	0.692	0.517	0.6045	0.119	0.120	**0.120**
P	16.1	21	2834	43	5666				0.134	0.138	0.136
	16.2	18	2837	37.5	5676				0.112	0.117	0.115
	16.3	17.5	2835	33.5	5673	0.707	0.5275		0.108	0.103	0.105
	Avg	19	2835	38	5672	0.707	0.5275	0.61725	0.118	0.119	**0.119**
	AVG	19	2840	38	5677			0.614	0.121	0.119	**0.120**

Standard Deviation	0.012912824	0.012413	0.0126068
95% +-	0.003749493	0.003604	0.0025544
99% +-	0.00500349	0.00481	0.0033821

DDS-COF-TP-0060 ENCLOSURE (1)								DATE:	7/12/2022	
LUBRICANT:	TRI MARINE GREASE			BOLT PROPERTIES:				TARGETS:		
SIZE:	0.75-10UNC-2A	TPI:	10	Nominal Diameter (in):	0.75		LEAD ANGLE (Degrees):		1/3Y	2/3Y
BOLT MATERIAL:	INCONEL 625 MIL-DTL-1222/ASTM B446 GR 1			Yield Strength (ksi):	60	MIL-DTL-1222	2.660			
NUT MATERIAL:	NICU GR 400 MIL-DTL-1222 / QQ-N-281 CL A			Tensile Stress Area (in^2):	0.334	ASME B1.1	Em (in):	PRELOAD (LBS)	6680	13360
WASHER MATERIAL:	NICU GR 400 FF-W-92			Torque Coefficient (assumed):	0.198	S9086-CJ-STM-010	0.685	EST. TORQUE (FT-LB)	83	165

Fastener No.	Trial	1/3 Yield Strength		2/3 Yield Strength		Crush Diameter			COF (Method 2)		
		Torque (ft lbs)	Preload (lbs)	Torque (ft lbs)	Preload (lbs)	Dco (in)	Dci (in)	Dc (in)	1/3Y	2/3Y	AVG
A	1.1	80	6685	149	13357				0.146	0.135	0.140
	1.2	79	6680	140	13361				0.144	0.125	0.134
	1.3	70	6681	130	13357	1.101	0.809		0.125	0.115	0.120
	Avg	76	6682	140	13358	1.101	0.809	0.955	0.138	0.125	**0.132**
B	2.1	89	6686	158	13370				0.164	0.143	0.154
	2.2	75	6688	140	13374				0.135	0.125	0.130
	2.3	70	6679	138	13363	1.106	0.8095		0.125	0.123	0.124
	Avg	78	6684	145	13369	1.106	0.8095	0.95775	0.141	0.130	**0.136**
C	3.1	80	6673	138	13371				0.149	0.125	0.137
	3.2	65	6680	121	13368				0.117	0.108	0.112
	3.3	60	6678	111	13680	1.041	0.8065		0.107	0.095	0.101
	Avg	68	6677	123	13473	1.041	0.8065	0.92375	0.124	0.109	**0.117**
D	4.1	79	6681	144	13359				0.146	0.131	0.138
	4.2	55	6681	125	13362				0.096	0.111	0.104
	4.3	51	6679	112	13361	1.0575	0.8075		0.088	0.098	0.093
	Avg	62	6680	127	13361	1.0575	0.8075	0.9325	0.110	0.113	**0.112**
E	5.1	82	6684	158	13361				0.150	0.144	0.147
	5.2	75	6683	129	13360				0.136	0.115	0.125
	5.3	69	6678	128	13518	1.081	0.8105		0.124	0.112	0.118
	Avg	75	6682	138	13413	1.081	0.8105	0.94575	0.137	0.124	**0.130**
F	6.1	82	6691	158	13389				0.151	0.145	0.148
	6.2	65	6683	115	13356				0.116	0.101	0.109
	6.3	59	6679	108	13376	1.062	0.809		0.104	0.093	0.099
	Avg	69	6684	127	13374	1.062	0.809	0.9355	0.124	0.113	**0.118**
G	7.1	81	6679	150	13363				0.149	0.137	0.143
	7.2	70	6681	129	13359				0.126	0.115	0.121
	7.3	69	6682	120	13359	1.0725	0.8095		0.124	0.106	0.115
	Avg	73	6681	133	13360	1.0725	0.8095	0.941	0.133	0.119	**0.126**
H	8.1	84	6677	150	13360				0.155	0.136	0.146
	8.2	71	6683	124	13396				0.128	0.109	0.119
	8.3	66	6680	120	13396	1.076	0.81		0.118	0.105	0.112
	Avg	74	6680	131	13384	1.076	0.81	0.943	0.134	0.117	**0.125**
I	9.1	80	6670	140	13358				0.147	0.126	0.137
	9.2	70	6692	131	13366				0.126	0.117	0.122
	9.3	68	6686	123	13371	1.0705	0.809		0.122	0.109	0.115
	Avg	73	6683	131	13365	1.0705	0.809	0.93975	0.132	0.117	**0.125**
J	10.1	85	6677	148	13359				0.157	0.134	0.145
	10.2	75	6677	139	13363				0.136	0.125	0.131
	10.3	69	6686	112	13364	1.0885	0.8045		0.124	0.097	0.110
	Avg	76	6680	133	13362	1.0885	0.8045	0.9465	0.139	0.119	**0.129**
K	11.1	90	6685	157	13351				0.167	0.144	0.155
	11.2	69	6683	119	13374				0.124	0.104	0.114
	11.3	61	6695	110	13360	1.0755	0.81		0.107	0.095	0.101
	Avg	73	6688	129	13362	1.0755	0.81	0.94275	0.133	0.115	**0.124**
L	12.1	83	6679	153	13369				0.153	0.139	0.146
	12.2	71	6682	122	13359				0.128	0.108	0.118
	12.3	60	6680	117	13374	1.082	0.8065		0.106	0.102	0.104
	Avg	71	6680	131	13367	1.082	0.8065	0.94425	0.129	0.116	**0.123**
M	13.1	81	6681	139	13365				0.149	0.125	0.137
	13.2	74	6691	125	13374				0.134	0.111	0.122
	13.3	63	6678	121	13367	1.0805	0.8055		0.112	0.107	0.109
	Avg	73	6683	128	13369	1.0805	0.8055	0.943	0.132	0.114	**0.123**
N	14.1	89	6679	153	13355				0.164	0.138	0.151
	14.2	78	6827	122	13374				0.138	0.107	0.122
	14.3	61	6676	121	13359	1.1095	0.8055		0.107	0.106	0.106
	Avg	76	6727	132	13363	1.1095	0.8055	0.9575	0.136	0.117	**0.127**
O	15.1	80	6684	150	13359				0.147	0.136	0.142
	15.2	81	6694	131	13374				0.148	0.117	0.133
	15.3	70	6689	125	13356	1.0805	0.806		0.126	0.111	0.118
	Avg	77	6689	135	13363	1.0805	0.806	0.94325	0.140	0.121	**0.131**
P	16.1	76	6693	139	13369				0.138	0.125	0.132
	16.2	68	6685	128	13354				0.122	0.114	0.118
	16.3	60	6680	119	13363	1.0685	0.81		0.106	0.105	0.105
	Avg	68	6686	129	13362	1.0685	0.81	0.93925	0.122	0.115	**0.118**
	AVG	73	6685	132	13375			0.943	0.132	0.118	**0.125**

Standard Deviation	0.018902051	0.014919	0.0181793
95% +-	0.005488584	0.004332	0.0036835
99% +-	0.007324209	0.005781	0.0048771

DDS-COF-TP-0060 ENCLOSURE (1)								DATE:	7/21/2022	
LUBRICANT:	TRI MARINE GREASE			BOLT PROPERTIES:				TARGETS:		
SIZE:	1.00-8-UNC-2A	TPI:	8	Nominal Diameter (in):	1.00		LEAD ANGLE (Degrees):		1/3Y	2/3Y
BOLT MATERIAL:	INCONEL 625 MIL-DTL-1222/ASTM B446 GR 1			Yield Strength (ksi):	60	MIL-DTL-1222	2.480			
NUT MATERIAL:	NICU GR 400 MIL-DTL-1222 / QQ-N-281 CL A			Tensile Stress Area (in^2):	0.606	ASME B1.1	Em (in):	PRELOAD (LBS)	12120	24240
WASHER MATERIAL:	NICU GR 400 FF-W-92			Torque Coefficient (assumed):	0.197	S9086-CJ-STM-010	0.919	EST. TORQUE (FT-LB)	199	398

Fastener No.	Trial	1/3 Yield Strength		2/3 Yield Strength		Crush Diameter			COF (Method 2)		
		Torque (ft lbs)	Preload (lbs)	Torque (ft lbs)	Preload (lbs)	Dco (in)	Dci (in)	Dc (in)	1/3Y	2/3Y	AVG
A	1.1	191	12298	345	24240				0.143	0.129	0.136
	1.2	169	12152	296	24240				0.126	0.109	0.117
	1.3	158	12192	269	24240	1.4695	1.0595		0.116	0.097	0.107
	Avg	173	12214	303	24240	1.4695	1.0595	1.2645	0.128	0.112	**0.120**
B	2.1	203	12169	315	24246				0.156	0.117	0.137
	2.2	158	12122	291	24241				0.118	0.107	0.113
	2.3	131	12124	244	24241	1.4345	1.059		0.095	0.087	0.091
	Avg	164	12138	283	24243	1.4345	1.059	1.24675	0.123	0.104	**0.113**
C	3.1	192	12123	308	24287				0.146	0.113	0.130
	3.2	158	12170	281	24242				0.117	0.102	0.109
	3.3	155	12133	244	24240	1.4655	1.0595		0.114	0.087	0.101
	Avg	168	12142	278	24256	1.4655	1.0595	1.2625	0.126	0.101	**0.113**
D	4.1	178	12159	307	24240				0.135	0.114	0.125
	4.2	160	12250	274	24318				0.118	0.100	0.109
	4.3	132	12249	237	24240	1.4325	1.0485		0.095	0.084	0.090
	Avg	157	12219	273	24266	1.4325	1.0485	1.2405	0.116	0.100	**0.108**
E	5.1	169	12121	324	24240				0.128	0.122	0.125
	5.2	150	12154	297	24240				0.111	0.110	0.111
	5.3	140	12133	253	24320	1.4145	1.054		0.103	0.091	0.097
	Avg	153	12136	291	24267	1.4145	1.054	1.23425	0.114	0.108	**0.111**
F	6.1	201	12104	308	24241				0.155	0.115	0.135
	6.2	158	12146	288	24240				0.118	0.106	0.112
	6.3	150	12121	260	24241	1.4225	1.06		0.111	0.094	0.103
	Avg	170	12124	285	24241	1.4225	1.06	1.24125	0.128	0.105	**0.117**
G	7.1	158	12121	336	24241				0.118	0.126	0.122
	7.2	157	12108	324	24241				0.117	0.121	0.119
	7.3	149	12124	317	24241	1.4495	1.0485		0.110	0.118	0.114
	Avg	155	12118	326	24241	1.4495	1.0485	1.249	0.115	0.122	**0.118**
H	8.1	148	12110	295	24240				0.110	0.109	0.110
	8.2	139	12111	245	24245				0.102	0.088	0.095
	8.3	138	12117	230	24241	1.423	1.0565		0.101	0.081	0.091
	Avg	142	12113	257	24242	1.423	1.0565	1.23975	0.104	0.093	**0.099**
I	9.1	174	12163	314	24242				0.131	0.117	0.124
	9.2	150	12120	310	24243				0.111	0.115	0.113
	9.3	150	12112	295	24242	1.4345	1.06		0.111	0.109	0.110
	Avg	158	12132	306	24242	1.4345	1.06	1.24725	0.118	0.114	**0.116**
J	10.1	169	12167	337	24240				0.127	0.127	0.127
	10.2	148	12158	315	24242				0.110	0.118	0.114
	10.3	140	12122	291	24241	1.412	1.0595		0.103	0.108	0.105
	Avg	152	12149	314	24241	1.412	1.0595	1.23575	0.113	0.118	**0.116**
K	11.1	185	12139	341	24240				0.141	0.129	0.135
	11.2	161	12149	285	25140				0.121	0.101	0.111
	11.3	155	12111	268	24240	1.4195	1.0555		0.116	0.098	0.107
	Avg	167	12133	298	24540	1.4195	1.0555	1.2375	0.126	0.109	**0.118**
L	12.1	160	12127	273	24239				0.120	0.100	0.110
	12.2	130	12127	252	24240				0.094	0.091	0.092
	12.3	120	12118	233	24240	1.4295	1.058		0.086	0.083	0.084
	Avg	137	12124	253	24240	1.4295	1.058	1.24375	0.100	0.091	**0.095**
M	13.1	178	12030	371	24239				0.136	0.141	0.139
	13.2	170	12119	274	24240				0.128	0.100	0.114
	13.3	149	12118	248	24241	1.428	1.0625		0.110	0.089	0.100
	Avg	166	12089	298	24240	1.428	1.0625	1.24525	0.125	0.110	**0.118**
N	14.1	161	12117	295	24240				0.120	0.109	0.115
	14.2	132	12136	264	24241				0.096	0.096	0.096
	14.3	120	12119	230	24240	1.438	1.056		0.085	0.081	0.083
	Avg	138	12124	263	24240	1.438	1.056	1.247	0.101	0.095	**0.098**
O	15.1	182	12143	335	24240				0.139	0.127	0.133
	15.2	160	12132	336	24242				0.120	0.127	0.124
	15.3	160	12133	304	24240	1.421	1.0445		0.120	0.113	0.117
	Avg	167	12136	325	24241	1.421	1.0445	1.23275	0.126	0.122	**0.124**
P	16.1	190	12137	297	24239				0.145	0.110	0.127
	16.2	151	12127	269	24241				0.112	0.098	0.105
	16.3	148	12130	248	24240	1.452	1.0515		0.109	0.089	0.099
	Avg	163	12131	271	24240	1.452	1.0515	1.25175	0.122	0.099	**0.110**
	AVG	158	12139	289	24264			1.245	0.118	0.106	**0.112**

Standard Deviation	0.016533191	0.014927	0.0165982
95% +-	0.004800738	0.004334	0.0033631
99% +-	0.006406318	0.005784	0.0044529

DDS-COF-TP-0060 ENCLOSURE (1)									DATE:	7/14/2022	
LUBRICANT:	TRI MARINE GREASE			BOLT PROPERTIES:					TARGETS:		
SIZE:	1.25-7UNC-2A	TPI:	7	Nominal Diameter (in):	1.25		LEAD ANGLE (Degrees):			1/3Y	2/3Y
BOLT MATERIAL:	INCONEL 625 MIL-DTL-1222/ASTM B446 GR 1			Yield Strength (ksi):	60	MIL-DTL-1222	2.250				
NUT MATERIAL:	NICU GR 400 MIL-DTL-1222 / QQ-N-281 CL A			Tensile Stress Area (in^2):	0.969	ASME B1.1	Em (in):		PRELOAD (LBS)	19380	38760
WASHER MATERIAL:	NICU GR 400 FF-W-92			Torque Coefficient (assumed):	0.196	S9086-CJ-STM-010	1.157		EST. TORQUE (FT-LB)	396	791

Fastener No.	Trial	1/3 Yield Strength		2/3 Yield Strength		Crush Diameter			COF (Method 2)		
		Torque (ft lbs)	Preload (lbs)	Torque (ft lbs)	Preload (lbs)	Dco (in)	Dci (in)	Dc (in)	1/3Y	2/3Y	AVG
A	1.1	424	19380	691	38760				0.163	0.130	0.147
	1.2	291	19379	512	38762				0.107	0.092	0.100
	1.3	264	19380	470	38762	1.8165	1.372		0.096	0.084	0.090
	Avg	326	19380	558	38761	1.8165	1.372	1.59425	0.122	0.102	**0.112**
B	2.1	389	19381	708	38762				0.149	0.134	0.141
	2.2	274	19380	516	38764				0.100	0.093	0.097
	2.3	237	19381	452	38761	1.803	1.3725		0.085	0.080	0.082
	Avg	300	19381	559	38762	1.803	1.3725	1.58775	0.111	0.102	**0.107**
C	3.1	406	19379	712	38760				0.156	0.135	0.145
	3.2	278	19380	515	38762				0.102	0.093	0.098
	3.3	252	19380	501	38768	1.796	1.3725		0.091	0.090	0.091
	Avg	312	19380	576	38763	1.796	1.3725	1.58425	0.116	0.106	**0.111**
D	4.1	401	19380	634	38760				0.154	0.118	0.136
	4.2	243	19381	449	38759				0.087	0.079	0.083
	4.3	217	19380	431	38762	1.8095	1.3725		0.076	0.075	0.076
	Avg	287	19380	505	38760	1.8095	1.3725	1.591	0.106	0.091	**0.098**
E	5.1	394	19380	678	38761				0.151	0.128	0.139
	5.2	250	19384	490	38760				0.090	0.088	0.089
	5.3	220	19382	472	38761	1.804	1.3725		0.077	0.084	0.081
	Avg	288	19382	547	38761	1.804	1.3725	1.58825	0.106	0.100	**0.103**
F	6.1	396	19380	691	38762				0.151	0.130	0.140
	6.2	313	19381	570	38759				0.116	0.104	0.110
	6.3	237	19381	503	38761	1.832	1.3725		0.084	0.090	0.087
	Avg	315	19381	588	38761	1.832	1.3725	1.60225	0.117	0.108	**0.113**
G	7.1	386	19380	656	38760				0.147	0.123	0.135
	7.2	273	19380	518	38760				0.100	0.094	0.097
	7.3	235	19381	455	38762	1.808	1.3725		0.084	0.081	0.082
	Avg	298	19380	543	38761	1.808	1.3725	1.59025	0.110	0.099	**0.105**
H	8.1	404	19380	678	38761				0.155	0.127	0.141
	8.2	298	19380	548	38761				0.110	0.100	0.105
	8.3	258	19381	459	38762	1.814	1.3725		0.093	0.081	0.087
	Avg	320	19380	562	38761	1.814	1.3725	1.59325	0.119	0.103	**0.111**
I	9.1	379	19381	682	38760				0.144	0.128	0.136
	9.2	243	19382	472	38761				0.087	0.084	0.086
	9.3	206	19381	424	38761	1.815	1.371		0.071	0.074	0.073
	Avg	276	19381	526	38761	1.815	1.371	1.593	0.101	0.095	**0.098**
J	10.1	425	19380	715	38760				0.163	0.135	0.149
	10.2	262	19413	507	38761				0.095	0.091	0.093
	10.3	234	19380	452	38762	1.8235	1.373		0.083	0.080	0.081
	Avg	307	19391	558	38761	1.8235	1.373	1.59825	0.114	0.102	**0.108**
K	11.1	402	19381	762	38820				0.153	0.144	0.149
	11.2	299	19380	528	38762				0.110	0.096	0.103
	11.3	250	19380	488	38760	1.8135	1.389		0.090	0.087	0.088
	Avg	317	19380	593	38781	1.8135	1.389	1.60125	0.118	0.109	**0.113**
L	12.1	347	19390	582	38760				0.131	0.107	0.119
	12.2	210	19382	429	38759				0.073	0.075	0.074
	12.3	208	19750	410	38762	1.813	1.3725		0.071	0.071	0.071
	Avg	255	19507	474	38760	1.813	1.3725	1.59275	0.091	0.084	**0.088**
M	13.1	447	19380	689	38760				0.173	0.130	0.152
	13.2	358	19379	735	38761				0.136	0.140	0.138
	13.3	330	19372	645	38772	1.808	1.3645		0.124	0.121	0.122
	Avg	378	19377	690	38764	1.808	1.3645	1.58625	0.144	0.130	**0.137**
N	14.1	306	19380	562	38764				0.113	0.103	0.108
	14.2	240	19420	412	38768				0.085	0.071	0.078
	14.3	196	19383	380	38779	1.839	1.3545		0.067	0.065	0.066
	Avg	247	19394	451	38770	1.839	1.3545	1.59675	0.089	0.080	**0.084**
O	15.1	402	19378	570	38762				0.154	0.105	0.130
	15.2	241	19381	457	38759				0.086	0.081	0.084
	15.3	206	19380	386	38762	1.8005	1.3705		0.072	0.066	0.069
	Avg	283	19380	471	38761	1.8005	1.3705	1.5855	0.104	0.084	**0.094**
P	16.1	409	19380	699	38760				0.157	0.132	0.145
	16.2	260	19381	492	38764				0.094	0.088	0.091
	16.3	219	19379	439	38761	1.803	1.366		0.077	0.077	0.077
	Avg	296	19380	543	38762	1.803	1.366	1.5845	0.110	0.099	**0.104**
	AVG	300	19390	546	38763			1.592	0.111	0.100	**0.105**

Standard Deviation	0.032186794	0.023078	0.0282925
95% +-	0.009346071	0.006701	0.0057326
99% +-	0.012471811	0.008942	0.0075903

CRES 316

DDS-COF-TP-0060 ENCLOSURE (1)								DATE:	7/11/2022	
LUBRICANT:	TRI MARINE GREASE			BOLT PROPERTIES:				TARGETS:		
SIZE:	0.50-13UNC-2A	TPI:	13	Nominal Diameter (in):	0.5		LEAD ANGLE (Degrees):			
BOLT MATERIAL:	CRES 316 MIL-DTL-1222 / ASTM F593 GR 2 COND A			Yield Strength (ksi):	30	MIL-DTL-1222	3.114		1/3Y	2/3Y
NUT MATERIAL:	CRES 304 MIL-DTL-1222 / UNS S30400			Tensile Stress Area (in^2):	0.1419	ASME B1.1	Em (in):	PRELOAD (LBS)	1419	2838
WASHER MATERIAL:	CRES 316 FF-W-92			Torque Coefficient (assumed):	0.212	S9086-CJ-STM-010	0.450	EST. TORQUE (FT-LB)	13	25

Fastener No.	Trial	1/3 Yield Strength		2/3 Yield Strength		Crush Diameter			COF (Method 2)		
		Torque (ft lbs)	Preload (lbs)	Torque (ft lbs)	Preload (lbs)	Dco (in)	Dci (in)	Dc (in)	1/3Y	2/3Y	AVG
A	1.1	16	1455	28	2855				0.208	0.183	0.195
	1.2	14.5	1421	28	2834				0.191	0.185	0.188
	1.3	14	1424	26.5	2837	0.72	0.53		0.184	0.173	0.178
	Avg	15	1433	28	2842	0.72	0.53	0.625	0.194	0.180	**0.187**
B	2.1	15	1418	29.5	2847				0.199	0.195	0.197
	2.2	14	1417	27	2842				0.185	0.177	0.181
	2.3	13.5	1422	25	2840	0.72	0.53		0.177	0.162	0.169
	Avg	14	1419	27	2843	0.72	0.53	0.625	0.187	0.178	**0.182**
C	3.1	14	1410	26	2838				0.187	0.171	0.179
	3.2	15	1432	27	2835				0.199	0.179	0.189
	3.3	13.5	1419	25	2849	0.7	0.53		0.178	0.163	0.171
	Avg	14	1420	26	2841	0.7	0.53	0.615	0.188	0.171	**0.180**
D	4.1	14.5	1413	27.5	2834				0.193	0.182	0.187
	4.2	13.5	1449	26	2837				0.174	0.170	0.172
	4.3	13	1419	25.5	2851	0.71	0.53		0.170	0.166	0.168
	Avg	14	1427	26	2841	0.71	0.53	0.62	0.179	0.173	**0.176**
E	5.1	15	1423	28.5	2839				0.198	0.188	0.193
	5.2	14.5	1421	29	2840				0.191	0.191	0.191
	5.3	15	1463	27.5	2835	0.7215	0.528		0.192	0.181	0.187
	Avg	15	1436	28	2838	0.7215	0.528	0.62475	0.194	0.187	**0.190**
F	6.1	15.5	1421	30	2838				0.208	0.201	0.204
	6.2	14	1418	27.5	2841				0.186	0.182	0.184
	6.3	13.5	1418	25	2832	0.704	0.526		0.179	0.164	0.171
	Avg	14	1419	28	2837	0.704	0.526	0.615	0.191	0.182	**0.186**
G	7.1	15	1432	27.5	2837				0.196	0.180	0.188
	7.2	15	1416	29.5	2837				0.199	0.195	0.197
	7.3	13.5	1433	26.5	2850	0.7295	0.526		0.175	0.172	0.173
	Avg	15	1427	28	2841	0.7295	0.526	0.62775	0.190	0.182	**0.186**
H	8.1	15	1417	29	2841				0.200	0.192	0.196
	8.2	14	1420	27	2840				0.185	0.177	0.181
	8.3	14	1422	27	2834	0.7155	0.528		0.184	0.178	0.181
	Avg	14	1420	28	2838	0.7155	0.528	0.62175	0.190	0.182	**0.186**
I	9.1	14.5	1420	27.5	2843				0.194	0.183	0.188
	9.2	14.5	1415	27.5	2831				0.195	0.183	0.189
	9.3	14	1417	28	2840	0.6915	0.5285		0.187	0.187	0.187
	Avg	14	1417	28	2838	0.6915	0.5285	0.61	0.192	0.184	**0.188**
J	10.1	14.5	1420	30	2836				0.194	0.202	0.198
	10.2	15	1416	27	2837				0.202	0.179	0.191
	10.3	14	1415	27.5	2838	0.69	0.53		0.187	0.183	0.185
	Avg	15	1417	28	2837	0.69	0.53	0.61	0.194	0.188	**0.191**
K	11.1	15.5	1429	30.5	2832				0.206	0.205	0.206
	11.2	14.5	1478	26	2835				0.185	0.171	0.178
	11.3	14	1424	26	2841	0.701	0.529		0.185	0.171	0.178
	Avg	15	1444	28	2836	0.701	0.529	0.615	0.192	0.182	**0.187**
L	12.1	17	1418	31.5	2832				0.231	0.213	0.222
	12.2	15	1432	28	2832				0.199	0.187	0.193
	12.3	14	1460	27	2844	0.699	0.525		0.181	0.179	0.180
	Avg	15	1437	29	2836	0.699	0.525	0.612	0.203	0.193	**0.198**
M	13.1	15	1429	27	2839				0.197	0.177	0.187
	13.2	15.5	1478	27	2860				0.197	0.175	0.186
	13.3	12.5	1419	26	2834	0.723	0.527		0.162	0.170	0.166
	Avg	14	1442	27	2844	0.723	0.527	0.625	0.186	0.174	**0.180**
N	14.1	15	1421	29	2838				0.198	0.191	0.195
	14.2	17	1620	29	2840				0.197	0.191	0.194
	14.3	14	1432	27	2828	0.7275	0.523		0.182	0.178	0.180
	Avg	15	1491	28	2835	0.7275	0.523	0.62525	0.193	0.187	**0.190**
O	15.1	15	1420	28	2844				0.199	0.184	0.191
	15.2	14.5	1415	27.5	2827				0.192	0.181	0.187
	15.3	14.5	1417	29	2845	0.723	0.529		0.192	0.191	0.191
	Avg	15	1417	28	2839	0.723	0.529	0.626	0.194	0.185	**0.190**
P	16.1	15	1420	28.5	2840				0.200	0.189	0.194
	16.2	15.5	1424	29	2836				0.207	0.193	0.200
	16.3	15	1420	26	2837	0.706	0.53		0.200	0.171	0.185
	Avg	15	1421	28	2838	0.706	0.53	0.618	0.202	0.184	**0.193**
	AVG	15	1430	28	2839			0.620	0.192	0.182	**0.187**

Standard Deviation	0.011651686	0.010977	0.0122104
95% +-	0.003383297	0.003187	0.0024741
99% +-	0.004514821	0.004253	0.0032758

DDS-COF-TP-0060 ENCLOSURE (1)								DATE:	7/19/2022	
LUBRICANT:	TRI MARINE GREASE			BOLT PROPERTIES:				TARGETS:		
SIZE:	0.75-10UNC-2A	TPI:	10	Nominal Diameter (in):	0.75		LEAD ANGLE (Degrees):		1/3Y	2/3Y
BOLT MATERIAL:	CRES 316 MIL-DTL-1222 / ASTM F593 GR 2 COND A			Yield Strength (ksi):	30	MIL-DTL-1222	2.660			
NUT MATERIAL:	CRES 304 MIL-DTL-1222 / UNS S30400			Tensile Stress Area (in^2):	0.334	ASME B1.1	Em (in):	PRELOAD (LBS)	3340	6680
WASHER MATERIAL:	CRES 316 FF-W-92			Torque Coefficient (assumed):	0.21	S9086-CJ-STM-010	0.685	EST. TORQUE (FT-LB)	44	88

Fastener No.	Trial	1/3 Yield Strength		2/3 Yield Strength		Crush Diameter			COF (Method 2)		
		Torque (ft lbs)	Preload (lbs)	Torque (ft lbs)	Preload (lbs)	Dco (in)	Dci (in)	Dc (in)	1/3Y	2/3Y	AVG
A	1.1	59	3472	98	6687				0.215	0.183	0.199
	1.2	57	4021	89	6691				0.177	0.165	0.171
	1.3	58	4001	90	6695	1.0755	0.812		0.181	0.167	0.174
	Avg	58	3831	92	6691	1.0755	0.812	0.94375	0.190	0.172	**0.181**
B	2.1	59	3560	88	6684				0.209	0.162	0.185
	2.2	56	3720	81	6681				0.188	0.148	0.168
	2.3	57	3962	81	6684	1.095	0.8095		0.179	0.148	0.163
	Avg	57	3747	83	6683	1.095	0.8095	0.95225	0.191	0.153	**0.172**
C	3.1	69	4011	100	6670				0.219	0.188	0.204
	3.2	65	4004	91	6695				0.205	0.169	0.187
	3.3	61	4030	96	6681	1.068	0.8115		0.190	0.180	0.185
	Avg	65	4015	96	6682	1.068	0.8115	0.93975	0.205	0.179	**0.192**
D	4.1	63	4004	96	6732				0.199	0.178	0.188
	4.2	60	4052	100	6673				0.186	0.188	0.187
	4.3	60	3993	91	6677	1.07	0.81		0.189	0.170	0.179
	Avg	61	4016	96	6694	1.07	0.81	0.94	0.191	0.179	**0.185**
E	5.1	64	4027	88	6689				0.200	0.163	0.181
	5.2	59	4532	80	6682				0.161	0.146	0.154
	5.3	48	3994	80	6684	1.0805	0.81		0.147	0.146	0.147
	Avg	57	4184	83	6685	1.0805	0.81	0.94525	0.169	0.152	**0.160**
F	6.1	62	4019	96	6691				0.193	0.178	0.186
	6.2	59	4000	98	6663				0.184	0.183	0.184
	6.3	57	4008	98	6674	1.092	0.8095		0.177	0.183	0.180
	Avg	59	4009	97	6676	1.092	0.8095	0.95075	0.185	0.182	**0.183**
G	7.1	69	4010	109	6675				0.219	0.207	0.213
	7.2	69	3999	102	6702				0.220	0.192	0.206
	7.3	60	4000	100	6689	1.0585	0.812		0.189	0.188	0.189
	Avg	66	4003	104	6689	1.0585	0.812	0.93525	0.209	0.196	**0.203**
H	8.1	67	4015	111	6702				0.210	0.208	0.209
	8.2	62	4012	101	6698				0.193	0.188	0.190
	8.3	62	4008	101	6690	1.1	0.8125		0.193	0.188	0.191
	Avg	64	4012	104	6697	1.1	0.8125	0.95625	0.199	0.195	**0.197**
I	9.1	69	4002	105	6678				0.218	0.197	0.208
	9.2	63	4011	98	6676				0.197	0.183	0.190
	9.3	61	4014	94	6685	1.0875	0.811		0.190	0.175	0.182
	Avg	64	4009	99	6680	1.0875	0.811	0.94925	0.202	0.185	**0.193**
J	10.1	68	4009	108	6688				0.215	0.204	0.209
	10.2	58	4003	100	6819				0.181	0.183	0.182
	10.3	59	4014	100	6681	1.0825	0.8105		0.184	0.187	0.186
	Avg	62	4009	103	6729	1.0825	0.8105	0.9465	0.193	0.191	**0.192**
K	11.1	70	4011	105	6685				0.222	0.198	0.210
	11.2	60	4002	100	6691				0.188	0.188	0.188
	11.3	59	3999	99	6681	1.0695	0.8105		0.185	0.186	0.186
	Avg	63	4004	101	6686	1.0695	0.8105	0.94	0.199	0.191	**0.195**
L	12.1	76	4016	99	6689				0.241	0.185	0.213
	12.2	65	4002	100	6680				0.205	0.187	0.196
	12.3	60	3997	98	6845	1.0805	0.813		0.188	0.178	0.183
	Avg	67	4005	99	6738	1.0805	0.813	0.94675	0.211	0.184	**0.197**
M	13.1	68	4020	101	6688				0.213	0.188	0.200
	13.2	60	4006	100	6689				0.186	0.186	0.186
	13.3	59	4006	98	6710	1.1005	0.8135		0.183	0.181	0.182
	Avg	62	4011	100	6696	1.1005	0.8135	0.957	0.194	0.185	**0.190**
N	14.1	62	4024	93	6673				0.194	0.174	0.184
	14.2	60	4006	98	6704				0.188	0.183	0.186
	14.3	55	4006	95	6692	1.063	0.813		0.171	0.178	0.174
	Avg	59	4012	95	6690	1.063	0.813	0.938	0.185	0.178	**0.182**
O	15.1	73	3997	110	6686				0.234	0.209	0.221
	15.2	69	4006	101	6682				0.220	0.191	0.205
	15.3	60	4003	100	6691	1.057	0.813		0.189	0.188	0.189
	Avg	67	4002	104	6686	1.057	0.813	0.935	0.214	0.196	**0.205**
P	16.1	72	3981	105	6704				0.229	0.196	0.212
	16.2	65	4014	100	6830				0.203	0.182	0.192
	16.3	62	4003	95	6701	1.1015	0.8135		0.193	0.175	0.184
	Avg	66	3999	100	6745	1.1015	0.8135	0.9575	0.208	0.184	**0.196**
	AVG	62	3992	97	6697			0.946	0.197	0.181	**0.189**
								Standard Deviation	0.018727872	0.0149	0.018424
								95% +-	0.005438007	0.004327	0.0037331
								99% +-	0.007256718	0.005774	0.0049428

DDS-COF-TP-0060 ENCLOSURE (1)									DATE:	7/13/2022	
LUBRICANT:	TRI MARINE GREASE			BOLT PROPERTIES:					TARGETS:		
SIZE:	1.00-8UNC-2A	TPI:	8	Nominal Diameter (in):	1.00		LEAD ANGLE (Degrees):			1/3Y	2/3Y
BOLT MATERIAL:	CRES 316 MIL-DTL-1222 / ASTM F593 GR 2 COND A			Yield Strength (ksi):	30	MIL-DTL-1222	2.480				
NUT MATERIAL:	CRES 304 MIL-DTL-1222 / UNS S30400			Tensile Stress Area (in^2):	0.606	ASME B1.1	Em (in):		PRELOAD (LBS)	6060	12120
WASHER MATERIAL:	CRES 316 FF-W-92			Torque Coefficient (assumed):	0.209	S9086-CJ-STM-010	0.919		EST. TORQUE (FT-LB)	106	211

Fastener No.	Trial	1/3 Yield Strength		2/3 Yield Strength		Crush Diameter			COF (Method 2)		
		Torque (ft lbs)	Preload (lbs)	Torque (ft lbs)	Preload (lbs)	Dco (in)	Dci (in)	Dc (in)	1/3Y	2/3Y	AVG
A	1.1	118	6059	215	12116				0.184	0.167	0.175
	1.2	105	6084	196	12145				0.161	0.150	0.156
	1.3	94	6093	181	12123	1.424	1.07		0.143	0.137	0.140
	Avg	106	6079	197	12128	1.424	1.07	1.247	0.163	0.151	**0.157**
B	2.1	130	6040	222	12184				0.207	0.172	0.190
	2.2	109	6074	201	12124				0.170	0.155	0.162
	2.3	102	6092	190	12122	1.405	1.061		0.157	0.146	0.152
	Avg	114	6069	204	12143	1.405	1.061	1.233	0.178	0.158	**0.168**
C	3.1	110	6103	203	12129				0.170	0.156	0.163
	3.2	90	6061	175	12122				0.137	0.133	0.135
	3.3	90	6071	165	12118	1.427	1.059		0.137	0.124	0.130
	Avg	97	6078	181	12123	1.427	1.059	1.243	0.148	0.138	**0.143**
D	4.1	121	6055	239	12117				0.188	0.185	0.187
	4.2	104	6069	202	12132				0.159	0.154	0.156
	4.3	100	6065	192	12118	1.4715	1.06		0.152	0.146	0.149
	Avg	108	6063	211	12122	1.4715	1.06	1.26575	0.166	0.162	**0.164**
E	5.1	117	6076	216	12116				0.181	0.166	0.174
	5.2	111	6071	205	12123				0.171	0.157	0.164
	5.3	107	6080	200	12152	1.4655	1.061		0.164	0.152	0.158
	Avg	112	6076	207	12130	1.4655	1.061	1.26325	0.172	0.158	**0.165**
F	6.1	111	6068	210	12130				0.171	0.161	0.166
	6.2	100	6130	195	12174				0.151	0.148	0.150
	6.3	107	6200	195	12123	1.455	1.061		0.161	0.149	0.155
	Avg	106	6133	200	12142	1.455	1.061	1.258	0.161	0.153	**0.157**
G	7.1	119	6055	218	12127				0.187	0.170	0.178
	7.2	107	6069	193	12113				0.166	0.148	0.157
	7.3	99	6070	185	12125	1.4155	1.0615		0.152	0.141	0.147
	Avg	108	6065	199	12122	1.4155	1.0615	1.2385	0.168	0.153	**0.161**
H	8.1	120	6124	225	12139				0.185	0.174	0.180
	8.2	105	6053	199	12122				0.162	0.153	0.157
	8.3	102	6093	194	12139	1.4385	1.061		0.156	0.148	0.152
	Avg	109	6090	206	12133	1.4385	1.061	1.24975	0.168	0.158	**0.163**
I	9.1	120	6072	220	12154				0.186	0.169	0.177
	9.2	108	6090	196	12128				0.165	0.149	0.157
	9.3	100	6145	189	12118	1.4705	1.061		0.150	0.143	0.147
	Avg	109	6102	202	12133	1.4705	1.061	1.26575	0.167	0.154	**0.160**
J	10.1	129	6138	232	12136				0.201	0.181	0.191
	10.2	113	6065	210	12146				0.176	0.162	0.169
	10.3	109	6106	193	12138	1.417	1.0615		0.168	0.148	0.158
	Avg	117	6103	212	12140	1.417	1.0615	1.23925	0.182	0.164	**0.173**
K	11.1	128	6062	229	12124				0.201	0.178	0.190
	11.2	111	6059	213	12114				0.173	0.165	0.169
	11.3	106	6062	219	12149	1.431	1.061		0.164	0.169	0.167
	Avg	115	6061	220	12129	1.431	1.061	1.246	0.179	0.171	**0.175**
L	12.1	111	6096	198	12129				0.171	0.151	0.161
	12.2	99	6067	179	12136				0.151	0.135	0.143
	12.3	100	6096	198	12260	1.451	1.062		0.152	0.149	0.151
	Avg	103	6086	192	12175	1.451	1.062	1.2565	0.158	0.145	**0.152**
M	13.1	107	6071	201	12191				0.166	0.154	0.160
	13.2	102	6052	190	12171				0.158	0.145	0.151
	13.3	100	6066	184	12150	1.424	1.0595		0.154	0.140	0.147
	Avg	103	6063	192	12171	1.424	1.0595	1.24175	0.159	0.146	**0.153**
N	14.1	110	6046	213	12127				0.173	0.167	0.170
	14.2	108	6058	190	12179				0.169	0.146	0.158
	14.3	99	6066	185	12141	1.3815	1.059		0.154	0.142	0.148
	Avg	106	6057	196	12149	1.3815	1.059	1.22025	0.165	0.152	**0.158**
O	15.1	120	6061	219	12121				0.187	0.169	0.178
	15.2	111	6083	201	12122				0.171	0.154	0.163
	15.3	104	6071	195	12174	1.4425	1.0615		0.160	0.148	0.154
	Avg	112	6072	205	12139	1.4425	1.0615	1.252	0.173	0.157	**0.165**
P	16.1	122	6083	222	12149				0.192	0.173	0.182
	16.2	110	6069	210	12116				0.172	0.163	0.168
	16.3	110	6076	205	12276	1.4	1.0605		0.171	0.157	0.164
	Avg	114	6076	212	12180	1.4	1.0605	1.23025	0.178	0.164	**0.171**
	AVG	109	6079	202	12141			1.247	0.168	0.155	**0.162**

Standard Deviation	0.015948054	0.013268	0.0158123
95% +-	0.004630832	0.003853	0.0032039
99% +-	0.006179588	0.005141	0.0042421

DDS-COF-TP-0060 ENCLOSURE (1)								DATE:	7/21/2022	
LUBRICANT:	TRI MARINE GREASE			BOLT PROPERTIES:				TARGETS:		
SIZE:	1.25-7UNC-2A	TPI:	7	Nominal Diameter (in):	1.25		LEAD ANGLE (Degrees):		1/3Y	2/3Y
BOLT MATERIAL:	CRES 316 MIL-DTL-1222 / ASTM F593 GR 2 COND A			Yield Strength (ksi):	30	MIL-DTL-1222	2.250			
NUT MATERIAL:	CRES 304 MIL-DTL-1222 / UNS S30400			Tensile Stress Area (in^2):	0.969	ASME B1.1	Em (in):	PRELOAD (LBS)	9690	19380
WASHER MATERIAL:	CRES 316 FF-W-92			Torque Coefficient (assumed):	0.208	S9086-CJ-STM-010	1.157	EST. TORQUE (FT-LB)	210	420

Fastener No.	Trial	1/3 Yield Strength		2/3 Yield Strength		Crush Diameter			COF (Method 2)		
		Torque (ft lbs)	Preload (lbs)	Torque (ft lbs)	Preload (lbs)	Dco (in)	Dci (in)	Dc (in)	1/3Y	2/3Y	AVG
A	1.1	202	9690	394	19380				0.155	0.151	0.153
	1.2	200	9771	431	19402				0.152	0.166	0.159
	1.3	196	9717	405	19380	1.807	1.373		0.149	0.155	0.152
	Avg	199	9726	410	19387	1.807	1.373	1.59	0.152	0.157	**0.155**
B	2.1	225	9723	451	19380				0.175	0.176	0.175
	2.2	200	9687	425	19380				0.154	0.165	0.159
	2.3	199	9674	405	19411	1.769	1.374		0.154	0.156	0.155
	Avg	208	9695	427	19390	1.769	1.374	1.5715	0.161	0.165	**0.163**
C	3.1	220	9810	429	19380				0.169	0.166	0.167
	3.2	213	9735	428	19380				0.164	0.166	0.165
	3.3	210	9624	425	19381	1.7715	1.376		0.164	0.165	0.164
	Avg	214	9723	427	19380	1.7715	1.376	1.57375	0.165	0.166	**0.166**
D	4.1	233	9789	436	19380				0.179	0.168	0.174
	4.2	220	9631	446	19380				0.171	0.172	0.172
	4.3	202	9658	417	19380	1.802	1.3775		0.155	0.160	0.158
	Avg	218	9693	433	19380	1.802	1.3775	1.58975	0.169	0.167	**0.168**
E	5.1	213	9691	418	19384				0.163	0.159	0.161
	5.2	198	9754	411	19380				0.149	0.157	0.153
	5.3	200	9688	404	19380	1.8525	1.3735		0.152	0.154	0.153
	Avg	204	9711	411	19381	1.8525	1.3735	1.613	0.155	0.157	**0.156**
F	6.1	210	9834	447	19382				0.159	0.173	0.166
	6.2	211	9662	452	19400				0.163	0.175	0.169
	6.3	208	9680	420	19383	1.795	1.376		0.160	0.162	0.161
	Avg	210	9725	440	19388	1.795	1.376	1.5855	0.161	0.170	**0.165**
G	7.1	213	9724	445	19381				0.163	0.171	0.167
	7.2	218	9719	437	19380				0.167	0.168	0.167
	7.3	199	9718	417	19380	1.8405	1.3735		0.151	0.159	0.155
	Avg	210	9720	433	19380	1.8405	1.3735	1.607	0.160	0.166	**0.163**
H	8.1	219	9785	437	19380				0.167	0.168	0.167
	8.2	215	9690	451	19416				0.165	0.173	0.169
	8.3	228	9691	464	20000	1.83	1.377		0.176	0.173	0.175
	Avg	221	9722	451	19599	1.83	1.377	1.6035	0.169	0.172	**0.170**
I	9.1	218	9696	425	19381				0.168	0.163	0.165
	9.2	209	9690	414	19381				0.160	0.159	0.159
	9.3	211	9774	407	19384	1.8205	1.377		0.160	0.156	0.158
	Avg	213	9720	415	19382	1.8205	1.377	1.59875	0.163	0.159	**0.161**
J	10.1	217	9692	436	19381				0.167	0.168	0.168
	10.2	205	9684	412	19386				0.157	0.158	0.158
	10.3	203	9696	421	19383	1.808	1.3785		0.155	0.162	0.159
	Avg	208	9691	423	19383	1.808	1.3785	1.59325	0.160	0.163	**0.161**
K	11.1	217	9690	429	19382				0.167	0.165	0.166
	11.2	219	9691	425	19381				0.169	0.164	0.166
	11.3	214	9690	430	19380	1.811	1.369		0.165	0.166	0.165
	Avg	217	9690	428	19381	1.811	1.369	1.59	0.167	0.165	**0.166**
L	12.1	230	9700	442	19380				0.178	0.171	0.174
	12.2	213	9689	423	19380				0.164	0.163	0.163
	12.3	217	9690	421	19381	1.808	1.374		0.167	0.162	0.165
	Avg	220	9693	429	19380	1.808	1.374	1.591	0.170	0.165	**0.167**
M	13.1	234	9690	466	19381				0.181	0.180	0.181
	13.2	217	9701	440	19376				0.167	0.169	0.168
	13.3	218	9689	433	19380	1.819	1.3785		0.168	0.167	0.167
	Avg	223	9693	446	19379	1.819	1.3785	1.59875	0.172	0.172	**0.172**
N	14.1	232	9691	456	19381				0.180	0.177	0.178
	14.2	215	9693	434	19380				0.166	0.167	0.166
	14.3	228	9693	440	19382	1.806	1.3775		0.176	0.170	0.173
	Avg	225	9692	443	19381	1.806	1.3775	1.59175	0.174	0.171	**0.173**
O	15.1	234	9701	459	19409				0.181	0.178	0.180
	15.2	237	9695	460	19381				0.184	0.178	0.181
	15.3	233	9700	442	19379	1.8025	1.378		0.181	0.171	0.176
	Avg	235	9699	454	19390	1.8025	1.378	1.59025	0.182	0.176	**0.179**
P	16.1	219	9690	425	19380				0.170	0.164	0.167
	16.2	200	9691	410	19383				0.154	0.158	0.156
	16.3	200	9977	403	19394	1.8	1.361		0.149	0.155	0.152
	Avg	206	9786	413	19386	1.8	1.361	1.5805	0.157	0.159	**0.158**
	AVG	214	9711	430	19397			1.592	0.165	0.166	**0.165**

Standard Deviation	0.009609298	0.007154	0.0083915
95% +-	0.002790249	0.002077	0.0017003
99% +-	0.003723432	0.002772	0.0022513

MONEL

DDS-COF-TP-0060 ENCLOSURE (1)								DATE:	7/11/2022	
LUBRICANT:	TRI MARINE GREASE			BOLT PROPERTIES:				TARGETS:		
SIZE:	0.50-13UNC-2A	TPI:	13	Nominal Diameter (in):	0.5		LEAD ANGLE (Degrees):			
BOLT MATERIAL:	NICU GR 400 MIL-DTL-1222 / QQ-N-281 CL A			Yield Strength (ksi):	40	MIL-DTL-1222	3.114		1/3Y	2/3Y
NUT MATERIAL:	NICU GR 400 MIL-DTL-1222 / QQ-N-281 CL A			Tensile Stress Area (in^2):	0.1419	ASME B1.1	Em (in):	PRELOAD (LBS)	1892	3784
WASHER MATERIAL:	NICU GR 400 FF-W-92			Torque Coefficient (assumed):	0.188	S9086-CJ-STM-010	0.450	EST. TORQUE (FT-LB)	15	30

Fastener No.	Trial	1/3 Yield Strength		2/3 Yield Strength		Crush Diameter			COF (Method 2)		
		Torque (ft lbs)	Preload (lbs)	Torque (ft lbs)	Preload (lbs)	Dco (in)	Dci (in)	Dc (in)	1/3Y	2/3Y	AVG
A	1.1	15.5	1892	29	3787				0.152	0.141	0.146
	1.2	15.5	1888	28	3784				0.152	0.135	0.144
	1.3	15	1896	27	3779	0.6865	0.529		0.146	0.130	0.138
	Avg	15	1892	28	3783	0.6865	0.529	0.60775	0.150	0.135	**0.143**
B	2.1	16.5	1909	28.5	3798				0.162	0.138	0.150
	2.2	16	1917	26	3796				0.156	0.124	0.140
	2.3	13	1906	26	3773	0.6805	0.527		0.123	0.125	0.124
	Avg	15	1911	27	3789	0.6805	0.527	0.60375	0.147	0.129	**0.138**
C	3.1	14.5	1891	27.5	3782				0.140	0.131	0.135
	3.2	13.5	1892	25.5	3781				0.128	0.120	0.124
	3.3	12.5	1893	25.5	3781	0.7055	0.53		0.117	0.120	0.119
	Avg	14	1892	26	3781	0.7055	0.53	0.61775	0.128	0.124	**0.126**
D	4.1	16	1892	31	3785				0.159	0.153	0.156
	4.2	15	1895	27	3786				0.147	0.131	0.139
	4.3	14	1890	26	3783	0.6655	0.5295		0.136	0.125	0.131
	Avg	15	1892	28	3785	0.6655	0.5295	0.5975	0.148	0.136	**0.142**
E	5.1	15.5	1895	31	3783				0.153	0.153	0.153
	5.2	13.5	1890	28.5	3785				0.131	0.139	0.135
	5.3	14	1889	26	3784	0.6675	0.526		0.137	0.125	0.131
	Avg	14	1891	29	3784	0.6675	0.526	0.59675	0.140	0.139	**0.140**
F	6.1	16	1892	30.5	3786				0.157	0.149	0.153
	6.2	15	1895	28	3783				0.146	0.135	0.140
	6.3	14	1894	26	3794	0.691	0.5305		0.135	0.123	0.129
	Avg	15	1894	28	3788	0.691	0.5305	0.61075	0.146	0.136	**0.141**
G	7.1	15.5	1895	28	3790				0.152	0.135	0.143
	7.2	14.5	1896	26.5	3791				0.140	0.127	0.134
	7.3	13	1894	25	3785	0.683	0.53		0.124	0.118	0.121
	Avg	14	1895	27	3789	0.683	0.53	0.6065	0.139	0.127	**0.133**
H	8.1	15	1898	28	3785				0.146	0.135	0.140
	8.2	14	1890	27	3789				0.135	0.129	0.132
	8.3	13	1896	26	3790	0.6865	0.5275		0.124	0.124	0.124
	Avg	14	1895	27	3788	0.6865	0.5275	0.607	0.135	0.129	**0.132**
I	9.1	15.5	1887	29	3799				0.154	0.141	0.147
	9.2	15	1892	27	3790				0.148	0.130	0.139
	9.3	14.5	1894	28.5	3802	0.6665	0.529		0.142	0.138	0.140
	Avg	15	1891	28	3797	0.6665	0.529	0.59775	0.148	0.137	**0.142**
J	10.1	13.5	1891	28	3781				0.130	0.135	0.133
	10.2	14	1893	27.5	3784				0.135	0.133	0.134
	10.3	14.5	1895	28	3783	0.684	0.5275		0.141	0.135	0.138
	Avg	14	1893	28	3783	0.684	0.5275	0.60575	0.135	0.134	**0.135**
K	11.1	15	1892	29	3785				0.147	0.141	0.144
	11.2	14	1891	26.5	3786				0.136	0.127	0.131
	11.3	13.5	1893	24.5	3783	0.6815	0.5275		0.130	0.116	0.123
	Avg	14	1892	27	3785	0.6815	0.5275	0.6045	0.137	0.128	**0.133**
L	12.1	15	1893	28.5	3785				0.148	0.140	0.144
	12.2	15.5	1892	28.5	3786				0.154	0.140	0.147
	12.3	14	1892	27	3785	0.6585	0.5275		0.137	0.131	0.134
	Avg	15	1892	28	3785	0.6585	0.5275	0.593	0.146	0.137	**0.142**
M	13.1	14.5	1893	27.5	3785				0.141	0.132	0.137
	13.2	13.5	1892	25	3785				0.130	0.118	0.124
	13.3	12.5	1893	24.5	3784	0.682	0.531		0.118	0.116	0.117
	Avg	14	1893	26	3785	0.682	0.531	0.6065	0.130	0.122	**0.126**
N	14.1	15.5	1894	26.5	3790				0.151	0.126	0.139
	14.2	14.5	1893	27	3788				0.140	0.129	0.135
	14.3	13	1892	27	3800	0.688	0.53		0.124	0.129	0.126
	Avg	14	1893	27	3793	0.688	0.53	0.609	0.139	0.128	**0.133**
O	15.1	14	1900	27	3789				0.135	0.129	0.132
	15.2	12.5	1905	25.5	3787				0.117	0.121	0.119
	15.3	13	1925	24.5	3778	0.684	0.53		0.122	0.116	0.119
	Avg	13	1910	26	3785	0.684	0.53	0.607	0.124	0.122	**0.123**
P	16.1	14	1897	26	3787				0.135	0.124	0.129
	16.2	13.5	1891	26	3792				0.130	0.124	0.127
	16.3	12.5	1908	25	3783	0.685	0.53		0.117	0.118	0.118
	Avg	13	1899	26	3787	0.685	0.53	0.6075	0.127	0.122	**0.125**
	AVG	14	1895	27	3787			0.605	0.139	0.130	**0.134**

Standard Deviation	0.012150763	0.009151	0.01143
95% +-	0.003528214	0.002657	0.0023159
99% +-	0.004708205	0.003546	0.0030664

DDS-COF-TP-0060 ENCLOSURE (1)									DATE:	7/19/2022	
LUBRICANT:	TRI MARINE GREASE			BOLT PROPERTIES:					TARGETS:		
SIZE:	0.75-10UNC-2A	TPI:	10	Nominal Diameter (in):	0.75		LEAD ANGLE (Degrees):			1/3Y	2/3Y
BOLT MATERIAL:	NICU GR 400 MIL-DTL-1222 / QQ-N-281 CL A			Yield Strength (ksi):	40	MIL-DTL-1222	2.660				
NUT MATERIAL:	NICU GR 400 MIL-DTL-1222 / QQ-N-281 CL A			Tensile Stress Area (in^2):	0.334	ASME B1.1	Em (in):		PRELOAD (LBS)	4453	8907
WASHER MATERIAL:	NICU GR 400 FF-W-92			Torque Coefficient (assumed):	0.186	S9086-CJ-STM-010	0.685		EST. TORQUE (FT-LB)	52	104

Fastener No.	Trial	1/3 Yield Strength		2/3 Yield Strength		Crush Diameter			COF (Method 2)		
		Torque (ft lbs)	Preload (lbs)	Torque (ft lbs)	Preload (lbs)	Dco (in)	Dci (in)	Dc (in)	1/3Y	2/3Y	AVG
A	1.1	60	3723	112	8897				0.203	0.155	0.179
	1.2	60	5078	101	8902				0.144	0.138	0.141
	1.3	60	5092	98	8924	1.0815	0.81		0.144	0.133	0.138
	Avg	60	4631	104	8908	1.0815	0.81	0.94575	0.160	0.142	**0.151**
B	2.1	60	4176	110	8904				0.179	0.152	0.166
	2.2	60	5050	102	8911				0.145	0.139	0.142
	2.3	60	5206	92	8903	1.0775	0.8105		0.140	0.124	0.132
	Avg	60	4811	101	8906	1.0775	0.8105	0.944	0.153	0.138	**0.146**
C	3.1	71	5100	112	8922				0.172	0.154	0.163
	3.2	60	5100	98	8917				0.143	0.132	0.138
	3.3	62	5097	95	8907	1.1	0.809		0.148	0.128	0.138
	Avg	64	5099	102	8915	1.1	0.809	0.9545	0.155	0.138	**0.146**
D	4.1	78	5106	120	8902				0.192	0.167	0.180
	4.2	61	5101	102	8922				0.147	0.139	0.143
	4.3	58	5100	90	8907	1.074	0.8115		0.138	0.121	0.130
	Avg	66	5102	104	8910	1.074	0.8115	0.94275	0.159	0.143	**0.151**
E	5.1	79	5099	119	8964				0.194	0.164	0.179
	5.2	62	5097	100	8907				0.149	0.136	0.142
	5.3	65	5099	100	8910	1.0915	0.808		0.157	0.136	0.146
	Avg	69	5098	106	8927	1.0915	0.808	0.94975	0.167	0.145	**0.156**
F	6.1	70	5099	115	8921				0.171	0.160	0.165
	6.2	61	5093	105	8917				0.147	0.144	0.146
	6.3	58	5102	91	8907	1.0685	0.8105		0.139	0.123	0.131
	Avg	63	5098	104	8915	1.0685	0.8105	0.9395	0.152	0.142	**0.147**
G	7.1	70	5111	118	8912				0.169	0.163	0.166
	7.2	69	5100	105	8914				0.167	0.143	0.155
	7.3	60	5101	98	8917	1.0985	0.8105		0.143	0.132	0.138
	Avg	66	5104	107	8914	1.0985	0.8105	0.9545	0.160	0.146	**0.153**
H	8.1	76	5111	118	8907				0.186	0.164	0.175
	8.2	70	5504	112	8908				0.156	0.154	0.155
	8.3	56	5099	90	8912	1.092	0.808		0.133	0.120	0.127
	Avg	67	5238	107	8909	1.092	0.808	0.95	0.158	0.146	**0.152**
I	9.1	68	5115	118	8908				0.165	0.165	0.165
	9.2	55	5132	92	8905				0.130	0.125	0.127
	9.3	50	5108	85	8907	1.0625	0.8105		0.117	0.114	0.115
	Avg	58	5118	98	8907	1.0625	0.8105	0.9365	0.137	0.134	**0.136**
J	10.1	71	5107	121	8904				0.174	0.169	0.171
	10.2	60	5106	98	8904				0.144	0.134	0.139
	10.3	59	5099	99	8943	1.0695	0.8085		0.141	0.135	0.138
	Avg	63	5104	106	8917	1.0695	0.8085	0.939	0.153	0.146	**0.149**
K	11.1	71	5114	110	8901				0.171	0.151	0.161
	11.2	65	5112	105	8921				0.155	0.143	0.149
	11.3	61	5102	99	8907	1.1065	0.811		0.145	0.134	0.139
	Avg	66	5109	105	8910	1.1065	0.811	0.95875	0.157	0.142	**0.150**
L	12.1	80	5106	124	8905				0.198	0.174	0.186
	12.2	61	5104	97	8918				0.147	0.132	0.139
	12.3	60	5093	91	8904	1.0715	0.8105		0.144	0.123	0.133
	Avg	67	5101	104	8909	1.0715	0.8105	0.941	0.163	0.143	**0.153**
M	13.1	75	5097	110	8908				0.184	0.152	0.168
	13.2	59	5094	89	8909				0.141	0.119	0.130
	13.3	60	5097	89	8923	1.073	0.8115		0.144	0.119	0.132
	Avg	65	5096	96	8913	1.073	0.8115	0.94225	0.157	0.130	**0.143**
N	14.1	88	5106	130	8910				0.219	0.183	0.201
	14.2	65	5131	101	8916				0.156	0.138	0.147
	14.3	59	5105	98	8900	1.07	0.8105		0.141	0.134	0.137
	Avg	71	5114	110	8909	1.07	0.8105	0.94025	0.172	0.152	**0.162**
O	15.1	72	5123	109	8902				0.175	0.150	0.163
	15.2	59	5102	90	8907				0.141	0.121	0.131
	15.3	53	5104	80	8901	1.075	0.8095		0.125	0.106	0.115
	Avg	61	5110	93	8903	1.075	0.8095	0.94225	0.147	0.126	**0.136**
P	16.1	76	5094	109	8893				0.187	0.151	0.169
	16.2	64	5108	93	8912				0.154	0.126	0.140
	16.3	57	5113	90	8901	1.0745	0.8115		0.135	0.121	0.128
	Avg	66	5105	97	8902	1.0745	0.8115	0.943	0.159	0.132	**0.146**
	AVG	64	5065	103	8911			0.945	0.157	0.140	**0.149**

Standard Deviation	0.022186153	0.017579	0.0215132
95% +-	0.006442187	0.005104	0.004359
99% +-	0.00859674	0.006812	0.0057715

DDS-COF-TP-0060 ENCLOSURE (1)									DATE:	7/22/2022	
LUBRICANT:	TRI MARINE GREASE			BOLT PROPERTIES:					TARGETS:		
SIZE:	1.00-8UNC-2A	TPI:	8	Nominal Diameter (in):	1.00		LEAD ANGLE (Degrees):			1/3Y	2/3Y
BOLT MATERIAL:	NICU GR 400 MIL-DTL-1222 / QQ-N-281 CL A			Yield Strength (ksi):	40	MIL-DTL-1222	2.480				
NUT MATERIAL:	NICU GR 400 MIL-DTL-1222 / QQ-N-281 CL A			Tensile Stress Area (in^2):	0.606	ASME B1.1	Em (in):		PRELOAD (LBS)	8080	16160
WASHER MATERIAL:	NICU GR 400 FF-W-92			Torque Coefficient (assumed):	0.185	S9086-CJ-STM-010	0.919		EST. TORQUE (FT-LB)	125	249

Fastener No.	Trial	1/3 Yield Strength		2/3 Yield Strength		Crush Diameter			COF (Method 2)		
		Torque (ft lbs)	Preload (lbs)	Torque (ft lbs)	Preload (lbs)	Dco (in)	Dci (in)	Dc (in)	1/3Y	2/3Y	AVG
A	1.1	155	8074	278	16224				0.182	0.160	0.171
	1.2	125	8063	235	16160				0.143	0.134	0.138
	1.3	118	8080	206	16159	1.4305	1.061		0.134	0.115	0.125
	Avg	133	8072	240	16181	1.4305	1.061	1.24575	0.153	0.136	**0.145**
B	2.1	145	8082	257	16160				0.167	0.146	0.157
	2.2	128	8143	231	16162				0.145	0.130	0.137
	2.3	122	8079	218	16159	1.4675	1.0585		0.138	0.122	0.130
	Avg	132	8101	235	16160	1.4675	1.0585	1.263	0.150	0.133	**0.141**
C	3.1	160	8147	287	16161				0.186	0.166	0.176
	3.2	133	8100	250	16194				0.153	0.142	0.148
	3.3	131	8079	240	16169	1.4485	1.053		0.150	0.136	0.143
	Avg	141	8109	259	16175	1.4485	1.053	1.25075	0.163	0.148	**0.156**
D	4.1	128	8084	267	16160				0.147	0.154	0.151
	4.2	135	8075	236	16160				0.156	0.134	0.145
	4.3	120	8077	214	16161	1.4215	1.0615		0.137	0.120	0.129
	Avg	128	8079	239	16160	1.4215	1.0615	1.2415	0.147	0.136	**0.142**
E	5.1	130	8091	246	16163				0.149	0.140	0.144
	5.2	130	8118	217	16160				0.148	0.122	0.135
	5.3	120	8080	216	16161	1.451	1.059		0.136	0.121	0.129
	Avg	127	8096	226	16161	1.451	1.059	1.255	0.144	0.127	**0.136**
F	6.1	139	8131	252	16163				0.160	0.145	0.153
	6.2	125	8090	228	16160				0.143	0.129	0.136
	6.3	128	8071	209	16208	1.4185	1.059		0.148	0.117	0.132
	Avg	131	8097	230	16177	1.4185	1.059	1.23875	0.150	0.130	**0.140**
G	7.1	130	8070	262	16160				0.150	0.151	0.150
	7.2	110	8078	223	16162				0.124	0.126	0.125
	7.3	116	8106	216	16160	1.4365	1.06		0.131	0.121	0.126
	Avg	119	8085	234	16161	1.4365	1.06	1.24825	0.135	0.133	**0.134**
H	8.1	139	8073	282	16162				0.162	0.164	0.163
	8.2	120	8103	228	16163				0.137	0.129	0.133
	8.3	119	8073	216	16169	1.4225	1.057		0.136	0.122	0.129
	Avg	126	8083	242	16165	1.4225	1.057	1.23975	0.145	0.138	**0.142**
I	9.1	127	8078	269	16161				0.145	0.155	0.150
	9.2	124	8137	269	16196				0.140	0.154	0.147
	9.3	125	8144	252	16169	1.451	1.06		0.141	0.144	0.142
	Avg	125	8120	263	16175	1.451	1.06	1.2555	0.142	0.151	**0.146**
J	10.1	125	8083	260	16159				0.143	0.149	0.146
	10.2	119	8079	240	16161				0.135	0.137	0.136
	10.3	120	8187	256	16168	1.4445	1.0505		0.135	0.147	0.141
	Avg	121	8116	252	16163	1.4445	1.0505	1.2475	0.138	0.144	**0.141**
K	11.1	130	8075	282	16164				0.150	0.163	0.156
	11.2	119	8083	258	16170				0.135	0.148	0.142
	11.3	115	8093	206	16160	1.4355	1.059		0.130	0.115	0.122
	Avg	121	8084	249	16165	1.4355	1.059	1.24725	0.138	0.142	**0.140**
L	12.1	125	8108	239	16168				0.143	0.136	0.139
	12.2	116	8065	205	16165				0.132	0.114	0.123
	12.3	104	8093	200	16166	1.427	1.0615		0.116	0.111	0.114
	Avg	115	8089	215	16166	1.427	1.0615	1.24425	0.130	0.121	**0.125**
M	13.1	140	8101	276	16163				0.161	0.159	0.160
	13.2	123	8101	223	16163				0.140	0.125	0.132
	13.3	113	8064	213	16169	1.4595	1.052		0.128	0.119	0.123
	Avg	125	8089	237	16165	1.4595	1.052	1.25575	0.143	0.134	**0.139**
N	14.1	135	8128	250	16160				0.155	0.143	0.149
	14.2	120	8081	228	16162				0.137	0.129	0.133
	14.3	123	8174	221	16172	1.427	1.058		0.139	0.125	0.132
	Avg	126	8128	233	16165	1.427	1.058	1.2425	0.144	0.132	**0.138**
O	15.1	130	8071	230	16158				0.149	0.130	0.140
	15.2	117	8073	211	16162				0.133	0.118	0.125
	15.3	102	8086	195	16158	1.444	1.062		0.113	0.108	0.110
	Avg	116	8077	212	16159	1.444	1.062	1.253	0.132	0.118	**0.125**
P	16.1	180	11056	255	16167				0.151	0.146	0.148
	16.2	127	8122	202	16160				0.144	0.112	0.128
	16.3	123	8069	198	16158	1.446	1.0585		0.140	0.110	0.125
	Avg	143	9082	218	16162	1.446	1.0585	1.25225	0.146	0.123	**0.134**
	AVG	127	8157	237	16166			1.249	0.144	0.134	**0.139**

Standard Deviation	0.013782155	0.016282	0.015654
95% +-	0.004001921	0.004728	0.0031718
99% +-	0.00534034	0.006309	0.0041996

DDS-COF-TP-0060 ENCLOSURE (1)								DATE:	7/15/2022	
LUBRICANT:	TRI MARINE GREASE			BOLT PROPERTIES:				TARGETS:		
SIZE:	1.25-7UNC-2A	TPI:	7	Nominal Diameter (in):	1.25		LEAD ANGLE (Degrees):		1/3Y	2/3Y
BOLT MATERIAL:	NICU GR 400 MIL-DTL-1222 / QQ-N-281 CL A			Yield Strength (ksi):	40	MIL-DTL-1222	2.250			
NUT MATERIAL:	NICU GR 400 MIL-DTL-1222 / QQ-N-281 CL A			Tensile Stress Area (in^2):	0.969	ASME B1.1	Em (in):	PRELOAD (LBS)	12920	25840
WASHER MATERIAL:	NICU GR 400 FF-W-92			Torque Coefficient (assumed):	0.184	S9086-CJ-STM-010	1.157	EST. TORQUE (FT-LB)	248	495

Fastener No.	Trial	1/3 Yield Strength		2/3 Yield Strength		Crush Diameter			COF (Method 2)		
		Torque (ft lbs)	Preload (lbs)	Torque (ft lbs)	Preload (lbs)	Dco (in)	Dci (in)	Dc (in)	1/3Y	2/3Y	AVG
A	1.1	271	12947	561	25841				0.156	0.162	0.159
	1.2	224	12917	429	25841				0.126	0.120	0.123
	1.3	209	12913	378	25840	1.803	1.374		0.117	0.104	0.111
	Avg	235	12926	456	25841	1.803	1.374	1.5885	0.133	0.129	**0.131**
B	2.1	321	12915	671	25840				0.187	0.196	0.191
	2.2	252	12921	460	25838				0.143	0.130	0.136
	2.3	210	12917	399	25841	1.8315	1.3715		0.117	0.110	0.114
	Avg	261	12918	510	25840	1.8315	1.3715	1.6015	0.149	0.145	**0.147**
C	3.1	324	12922	542	25841				0.190	0.156	0.173
	3.2	294	12952	403	25840				0.170	0.112	0.141
	3.3	199	12942	365	25841	1.795	1.3755		0.110	0.100	0.105
	Avg	272	12939	437	25841	1.795	1.3755	1.58525	0.157	0.123	**0.140**
D	4.1	350	12997	686	25841				0.204	0.201	0.202
	4.2	255	12917	460	25849				0.146	0.130	0.138
	4.3	235	12919	392	25843	1.822	1.3705		0.133	0.108	0.121
	Avg	280	12944	513	25844	1.822	1.3705	1.59625	0.161	0.146	**0.154**
E	5.1	352	12972	702	25844				0.206	0.206	0.206
	5.2	245	13035	453	25840				0.138	0.128	0.133
	5.3	220	12907	402	25845	1.821	1.372		0.124	0.111	0.118
	Avg	272	12971	519	25843	1.821	1.372	1.5965	0.156	0.148	**0.152**
F	6.1	339	12905	701	25846				0.199	0.206	0.203
	6.2	270	12989	520	25842				0.155	0.149	0.152
	6.3	235	12923	434	25841	1.799	1.374		0.133	0.122	0.128
	Avg	281	12939	552	25843	1.799	1.374	1.5865	0.162	0.159	**0.161**
G	7.1	295	12933	529	25840				0.170	0.151	0.160
	7.2	295	12931	471	25840				0.170	0.133	0.151
	7.3	249	12922	478	25840	1.8445	1.374		0.141	0.135	0.138
	Avg	280	12929	493	25840	1.8445	1.374	1.60925	0.160	0.139	**0.150**
H	8.1	318	12916	654	25840				0.186	0.192	0.189
	8.2	230	12915	457	25843				0.130	0.129	0.130
	8.3	203	12934	382	25840	1.7925	1.373		0.113	0.106	0.109
	Avg	250	12922	498	25841	1.7925	1.373	1.58275	0.143	0.142	**0.143**
I	9.1	298	12941	551	25845				0.172	0.158	0.165
	9.2	253	12938	449	25841				0.144	0.126	0.135
	9.3	220	12977	412	25844	1.815	1.375		0.123	0.115	0.119
	Avg	257	12952	471	25843	1.815	1.375	1.595	0.146	0.133	**0.140**
J	10.1	320	12939	623	25840				0.187	0.182	0.184
	10.2	230	12928	416	25840				0.130	0.116	0.123
	10.3	205	12970	367	25842	1.795	1.3745		0.114	0.101	0.107
	Avg	252	12946	469	25841	1.795	1.3745	1.58475	0.144	0.133	**0.138**
K	11.1	260	12933	511	25853				0.149	0.146	0.148
	11.2	212	12980	396	25842				0.118	0.110	0.114
	11.3	183	13068	366	25841	1.8005	1.3745		0.099	0.100	0.100
	Avg	218	12994	424	25845	1.8005	1.3745	1.5875	0.122	0.119	**0.120**
L	12.1	305	12991	543	25840				0.176	0.156	0.166
	12.2	210	12917	393	25840				0.118	0.109	0.113
	12.3	195	12921	341	25843	1.799	1.374		0.108	0.093	0.100
	Avg	237	12943	426	25841	1.799	1.374	1.5865	0.134	0.119	**0.127**
M	13.1	290	12941	510	25841				0.167	0.145	0.156
	13.2	224	12964	425	26350				0.125	0.116	0.121
	13.3	211	12958	378	25840	1.8205	1.3725		0.117	0.104	0.111
	Avg	242	12954	438	26010	1.8205	1.3725	1.5965	0.137	0.122	**0.129**
N	14.1	261	13020	517	25839				0.148	0.148	0.148
	14.2	199	12943	378	25840				0.110	0.104	0.107
	14.3	185	12919	339	25841	1.8155	1.374		0.101	0.092	0.097
	Avg	215	12961	411	25840	1.8155	1.374	1.59475	0.120	0.114	**0.117**
O	15.1	339	12918	693	25841				0.199	0.203	0.201
	15.2	257	12922	478	25840				0.147	0.136	0.141
	15.3	232	12945	424	25840	1.8065	1.3725		0.131	0.119	0.125
	Avg	276	12928	532	25840	1.8065	1.3725	1.5895	0.159	0.153	**0.156**
P	16.1	318	12934	684	25840				0.185	0.200	0.193
	16.2	280	13164	530	25841				0.158	0.152	0.155
	16.3	224	12910	414	25840	1.811	1.375		0.126	0.115	0.121
	Avg	274	13003	543	25840	1.811	1.375	1.593	0.157	0.156	**0.156**
	AVG	256	12948	481	25852			1.592	0.146	0.136	**0.141**

Standard Deviation	0.030147799	0.033493	0.0319134
95% +-	0.008754008	0.009725	0.0064662
99% +-	0.011681736	0.012978	0.0085616

Christo-Lube MCG 111 Data Sheets

Summary

DDS-COF-TP-0060 ENCLOSURE (1) - SUMMARY OF RESULTS				
AVERAGE COEFFICIENT OF FRICTION RESULTS				
	KMONEL	INCONEL 625	CRES 316	MONEL
.50-13UNC-2A	0.126	0.097	0.153	0.103
.75-10UNC-2A	0.109	0.114	0.164	0.131
1.00-8UNC-2A	0.092	0.118	0.174	0.126
1.25-7UNC-2A	0.112	0.115	0.174	0.138
ALL SIZES	0.110	0.111	0.166	0.124
STANDARD DEVIATION OF RESULTS				
	KMONEL	INCONEL 625	CRES 316	MONEL
.50-13UNC-2A	0.011	0.007	0.006	0.007
.75-10UNC-2A	0.010	0.010	0.009	0.014
1.00-8UNC-2A	0.007	0.015	0.011	0.014
1.25-7UNC-2A	0.012	0.009	0.013	0.013
ALL SIZES	0.016	0.013	0.013	0.018

FASTENER ID	KMONEL			
	.50-13UNC-2A	.75-10UNC-2A	1.00-8UNC-2A	1.25-7UNC-2A
A	0.132	0.109	0.085	0.103
B	0.127	0.113	0.098	0.100
C	0.125	0.101	0.088	0.102
D	0.129	0.105	0.096	0.142
E	0.139	0.104	0.101	0.107
F	0.137	0.109	0.093	0.118
G	0.142	0.123	0.106	0.107
H	0.136	0.101	0.093	0.102
I	0.123	0.117	0.085	0.117
J	0.136	0.118	0.087	0.113
K	0.103	0.111	0.087	0.099
L	0.119	0.115	0.090	0.117
M	0.123	0.099	0.102	0.121
N	0.121	0.127	0.087	0.099
O	0.119	0.095	0.091	0.124
P	0.110	0.094	0.087	0.116
AVG	0.126	0.109	0.092	0.112
STD DEV	0.011	0.010	0.007	0.012

FASTENER ID	INCONEL 625			
	.50-13UNC-2A	.75-10UNC-2A	1.00-8UNC-2A	1.25-7UNC-2A
A	0.091	0.120	0.113	0.117
B	0.088	0.110	0.127	0.104
C	0.097	0.117	0.121	0.113
D	0.088	0.117	0.094	0.111
E	0.103	0.123	0.130	0.126
F	0.113	0.115	0.122	0.115
G	0.092	0.120	0.123	0.119
H	0.096	0.107	0.091	0.116
I	0.094	0.124	0.123	0.123
J	0.092	0.113	0.130	0.126
K	0.096	0.119	0.133	0.109
L	0.099	0.113	0.096	0.099
M	0.097	0.121	0.116	0.112
N	0.098	0.117	0.131	0.110
O	0.105	0.106	0.138	0.135
P	0.098	0.083	0.104	0.111
AVG	0.097	0.114	0.118	0.115
STD DEV	0.007	0.010	0.015	0.009

FASTENER ID	CRES 316			
	.50-13UNC-2A	.75-10UNC-2A	1.00-8UNC-2A	1.25-7UNC-2A
A	0.157	0.166	0.166	0.168
B	0.149	0.170	0.176	0.168
C	0.154	0.159	0.166	0.184
D	0.154	0.170	0.182	0.173
E	0.158	0.149	0.174	0.169
F	0.142	0.179	0.165	0.160
G	0.152	0.170	0.166	0.175
H	0.154	0.164	0.167	0.162
I	0.149	0.175	0.162	0.183
J	0.153	0.175	0.170	0.168
K	0.146	0.165	0.180	0.171
L	0.155	0.157	0.188	0.218
M	0.151	0.154	0.205	0.174
N	0.153	0.150	0.168	0.172
O	0.166	0.163	0.179	0.170
P	0.152	0.165	0.167	0.168
AVG	0.153	0.164	0.174	0.174
STD DEV	0.006	0.009	0.011	0.013

FASTENER ID	MONEL			
	.50-13UNC-2A	**.75-10UNC-2A**	**1.00-8UNC-2A**	**1.25-7UNC-2A**
A	0.092	0.131	0.135	0.142
B	0.098	0.109	0.142	0.136
C	0.104	0.118	0.126	0.130
D	0.105	0.136	0.151	0.148
E	0.104	0.113	0.147	0.127
F	0.100	0.111	0.150	0.155
G	0.106	0.125	0.118	0.155
H	0.092	0.112	0.116	0.150
I	0.118	0.138	0.116	0.130
J	0.104	0.134	0.117	0.121
K	0.096	0.145	0.117	0.133
L	0.114	0.144	0.117	0.141
M	0.100	0.153	0.115	0.122
N	0.100	0.139	0.116	0.121
O	0.101	0.141	0.115	0.135
P	0.111	0.139	0.113	0.158
AVG	0.103	0.131	0.126	0.138
STD DEV	0.007	0.014	0.014	0.013

KMONEL

DDS-COF-TP-0060 ENCLOSURE (1)								DATE:	1/13/2023	
LUBRICANT:	CHRISTOLUBE MCG111			BOLT PROPERTIES:				TARGETS:		
SIZE:	0.50-13UNC-2A	TPI:	13	Nominal Diameter (in):	0.5		LEAD ANGLE (Deg)(B1.1):			
BOLT MATERIAL:	KMONEL GR 500 MIL-DTL-1222 / QQ-N-286 A &AH			Yield Strength (ksi):	90	MIL-DTL-1222	3.114		1/3Y	2/3Y
NUT MATERIAL:	NICU GR 400 MIL-DTL-1222 / QQ-N-281 CL A			Tensile Stress Area (in^2):	0.1419	ASME B1.1	Em (in) (B1.1):	PRELOAD (LBS)	4257	8514
WASHER MATERIAL:	NICU GR 400 FF-W-92			Torque Coefficient (assumed):	0.188	S9086-CJ-STM-010	0.450	EST. TORQUE (FT-LB)	33	67

Fastener No.	Trial	1/3 Yield Strength		2/3 Yield Strength		Crush Diameter			COF (Method 2)		
		Torque (ft lbs)	Preload (lbs)	Torque (ft lbs)	Preload (lbs)	Dco (in)	Dci (in)	Dc (in)	1/3Y	2/3Y	AVG
A	1.1	29.5	4257	70	8515				0.124	0.151	0.137
	1.2	28	4258	62	8515				0.116	0.131	0.124
	1.3	29	4256	70	8518	0.71	0.53		0.121	0.151	0.136
	Avg	29	4257	67	8516	0.71	0.53	0.62	0.121	0.144	**0.132**
B	2.1	31	4258	65	8518				0.131	0.138	0.134
	2.2	30	4257	60	8516				0.126	0.126	0.126
	2.3	28	4256	60	8517	0.7195	0.5295		0.116	0.126	0.121
	Avg	30	4257	62	8517	0.7195	0.5295	0.6245	0.124	0.130	**0.127**
C	3.1	31	4254	61	8515				0.132	0.129	0.130
	3.2	29.5	4259	60	8517				0.124	0.126	0.125
	3.3	27.5	4259	60	8513	0.707	0.5295		0.114	0.126	0.120
	Avg	29	4257	60	8515	0.707	0.5295	0.61825	0.123	0.127	**0.125**
D	4.1	32	4256	60	8513				0.136	0.127	0.132
	4.2	30.5	4257	62	8515				0.129	0.131	0.130
	4.3	29.5	4267	60	8513	0.7065	0.5285		0.124	0.127	0.125
	Avg	31	4260	61	8514	0.7065	0.5285	0.6175	0.130	0.128	**0.129**
E	5.1	34	4251	70	8516				0.147	0.152	0.150
	5.2	32	4257	65	8516				0.137	0.140	0.139
	5.3	31	4257	60	8549	0.694	0.526		0.132	0.127	0.130
	Avg	32	4255	65	8527	0.694	0.526	0.61	0.139	0.140	**0.139**
F	6.1	36	4261	72	8517				0.156	0.156	0.156
	6.2	30.5	4261	61	8520				0.129	0.129	0.129
	6.3	29	4258	60	8510	0.7015	0.528		0.122	0.127	0.124
	Avg	32	4260	64	8516	0.7015	0.528	0.61475	0.136	0.138	**0.137**
G	7.1	34.5	4253	73	8520				0.149	0.159	0.154
	7.2	28.5	4257	69	8515				0.119	0.149	0.134
	7.3	30	4255	69	8519	0.706	0.526		0.127	0.149	0.138
	Avg	31	4255	70	8518	0.706	0.526	0.616	0.132	0.152	**0.142**
H	8.1	31.5	4256	70	8513				0.134	0.151	0.143
	8.2	31	4275	65	8512				0.131	0.139	0.135
	8.3	31	4258	61	8516	0.7085	0.524		0.132	0.129	0.130
	Avg	31	4263	65	8514	0.7085	0.524	0.61625	0.132	0.140	**0.136**
I	9.1	28	4256	62	8514				0.117	0.132	0.124
	9.2	29	4260	65	8515				0.122	0.139	0.130
	9.3	27	4257	57	8520	0.7045	0.5285		0.112	0.119	0.116
	Avg	28	4258	61	8516	0.7045	0.5285	0.6165	0.117	0.130	**0.123**
J	10.1	32	4257	70	8516				0.137	0.152	0.144
	10.2	30	4256	61	8516				0.127	0.129	0.128
	10.3	32.5	4257	62	8518	0.699	0.527		0.139	0.132	0.136
	Avg	32	4257	64	8517	0.699	0.527	0.613	0.134	0.138	**0.136**
K	11.1	25	4252	58	8517				0.102	0.122	0.112
	11.2	24	4257	52	8516				0.097	0.107	0.102
	11.3	22	4258	50	8515	0.706	0.526		0.087	0.102	0.095
	Avg	24	4256	53	8516	0.706	0.526	0.616	0.096	0.110	**0.103**
L	12.1	29.5	4260	68	8516				0.124	0.147	0.135
	12.2	25	4259	59	8524				0.102	0.124	0.113
	12.3	24	4257	58	8522	0.702	0.5275		0.097	0.122	0.110
	Avg	26	4259	62	8521	0.702	0.5275	0.61475	0.108	0.131	**0.119**
M	13.1	30	4258	67	8514				0.126	0.143	0.135
	13.2	26	4261	60	8515				0.106	0.126	0.116
	13.3	27.5	4259	59	8515	0.7125	0.5295		0.114	0.124	0.119
	Avg	28	4259	62	8515	0.7125	0.5295	0.621	0.115	0.131	**0.123**
N	14.1	32	4257	62	8515				0.136	0.131	0.133
	14.2	27	4260	58	8514				0.111	0.121	0.116
	14.3	25.5	4257	58	8514	0.714	0.5295		0.104	0.121	0.113
	Avg	28	4258	59	8514	0.714	0.5295	0.62175	0.117	0.124	**0.121**
O	15.1	28.5	4257	60	8514				0.119	0.126	0.123
	15.2	26.5	4254	60	8514				0.109	0.126	0.118
	15.3	27	4260	58	8514	0.712	0.5295		0.111	0.121	0.116
	Avg	27	4257	59	8514	0.712	0.5295	0.62075	0.113	0.125	**0.119**
P	16.1	29	4264	61	8510				0.123	0.131	0.127
	16.2	23	4263	55	8514				0.093	0.116	0.104
	16.3	23	4257	51	8517	0.6825	0.5275		0.093	0.106	0.099
	Avg	25	4261	56	8514	0.6825	0.5275	0.605	0.103	0.117	**0.110**
	AVG	29	4258	62	8516			0.617	0.121	0.132	**0.126**

Standard Deviation	0.0151	0.0130	0.0149
95% +-	0.0044	0.0038	0.0030
99% +-	0.0058	0.0050	0.0040

DDS-COF-TP-0060 ENCLOSURE (1)								DATE:	1/18/2023	
LUBRICANT:	CHRISTOLUBE MCG111			BOLT PROPERTIES:				TARGETS:		
SIZE:	0.75-10UNC-2A	TPI:	10	Nominal Diameter (in):	0.75		LEAD ANGLE (Deg)(B1.1):		1/3Y	2/3Y
BOLT MATERIAL:	KMONEL GR 500 MIL-DTL-1222 / QQ-N-286 A &AH			Yield Strength (ksi):	90	MIL-DTL-1222	2.660			
NUT MATERIAL:	NICU GR 400 MIL-DTL-1222 / QQ-N-281 CL A			Tensile Stress Area (in^2):	0.334	ASME B1.1	Em (in) (B1.1):	PRELOAD (LBS)	10020	20040
WASHER MATERIAL:	NICU GR 400 FF-W-92			Torque Coefficient (assumed):	0.186	S9086-CJ-STM-010	0.685	EST. TORQUE (FT-LB)	116	233

Fastener No.	Trial	1/3 Yield Strength		2/3 Yield Strength		Crush Diameter			COF (Method 2)		
		Torque (ft lbs)	Preload (lbs)	Torque (ft lbs)	Preload (lbs)	Dco (in)	Dci (in)	Dc (in)	1/3Y	2/3Y	AVG
A	1.1	110	10020	192	20058				0.133	0.114	0.123
	1.2	101	10420	170	20039				0.115	0.099	0.107
	1.3	81	10016	172	20039	1.082	0.81		0.093	0.100	0.097
	Avg	97	10152	178	20045	1.082	0.81	0.946	0.114	0.104	**0.109**
B	2.1	120	10050	184	20070				0.146	0.108	0.127
	2.2	101	10035	173	20042				0.120	0.100	0.110
	2.3	89	10023	171	20043	1.088	0.809		0.104	0.099	0.101
	Avg	103	10036	176	20052	1.088	0.809	0.9485	0.123	0.102	**0.113**
C	3.1	111	10021	180	20037				0.135	0.106	0.120
	3.2	81	10019	160	20040				0.093	0.092	0.093
	3.3	81	10020	151	20210	1.0665	0.811		0.093	0.085	0.089
	Avg	91	10020	164	20096	1.0665	0.811	0.93875	0.107	0.094	**0.101**
D	4.1	110	10022	180	20039				0.133	0.105	0.119
	4.2	82	10029	159	20041				0.094	0.091	0.093
	4.3	94	10020	163	20033	1.086	0.811		0.111	0.094	0.102
	Avg	95	10024	167	20038	1.086	0.811	0.9485	0.112	0.097	**0.105**
E	5.1	108	10021	185	20058				0.130	0.109	0.119
	5.2	100	10025	170	20046				0.119	0.098	0.109
	5.3	75	10019	152	20048	1.084	0.8105		0.085	0.086	0.085
	Avg	94	10022	169	20051	1.084	0.8105	0.94725	0.111	0.098	**0.104**
F	6.1	116	10020	182	20034				0.141	0.107	0.124
	6.2	90	10038	170	20039				0.105	0.099	0.102
	6.3	89	10021	169	20041	1.082	0.8085		0.104	0.098	0.101
	Avg	98	10026	174	20038	1.082	0.8085	0.94525	0.117	0.101	**0.109**
G	7.1	129	10023	204	20052				0.158	0.121	0.140
	7.2	105	10320	185	20040				0.121	0.109	0.115
	7.3	105	10039	177	20062	1.0905	0.812		0.125	0.103	0.114
	Avg	113	10127	189	20051	1.0905	0.812	0.95125	0.135	0.111	**0.123**
H	8.1	110	10022	183	20050				0.133	0.108	0.120
	8.2	85	10066	160	20035				0.098	0.092	0.095
	8.3	80	10032	152	20040	1.073	0.8115		0.092	0.086	0.089
	Avg	92	10040	165	20042	1.073	0.8115	0.94225	0.108	0.095	**0.101**
I	9.1	120	10027	210	20085				0.146	0.125	0.135
	9.2	90	10021	167	20055				0.105	0.096	0.100
	9.3	103	10035	182	20043	1.097	0.8105		0.122	0.106	0.114
	Avg	104	10028	186	20061	1.097	0.8105	0.95375	0.124	0.109	**0.117**
J	10.1	115	10023	195	20052				0.140	0.116	0.128
	10.2	109	10024	185	20062				0.131	0.109	0.120
	10.3	91	10037	182	20044	1.08	0.811		0.107	0.107	0.107
	Avg	105	10028	187	20053	1.08	0.811	0.9455	0.126	0.110	**0.118**
K	11.1	113	10038	210	20081				0.137	0.126	0.131
	11.2	100	10020	170	20035				0.119	0.099	0.109
	11.3	80	10021	165	20043	1.089	0.802		0.092	0.095	0.093
	Avg	98	10026	182	20053	1.089	0.802	0.9455	0.116	0.106	**0.111**
L	12.1	118	10041	192	20038				0.142	0.113	0.127
	12.2	92	10076	160	20041				0.107	0.091	0.099
	12.3	109	10020	185	20041	1.115	0.806		0.130	0.108	0.119
	Avg	106	10046	179	20040	1.115	0.806	0.9605	0.126	0.104	**0.115**
M	13.1	109	10031	192	20048				0.132	0.114	0.123
	13.2	85	10026	152	20040				0.099	0.086	0.093
	13.3	71	10026	150	20036	1.073	0.8075		0.080	0.085	0.082
	Avg	88	10028	165	20041	1.073	0.8075	0.94025	0.103	0.095	**0.099**
N	14.1	120	10022	218	20140				0.144	0.129	0.137
	14.2	105	10022	219	20046				0.124	0.130	0.127
	14.3	103	10035	191	20032	1.132	0.8085		0.121	0.111	0.116
	Avg	109	10026	209	20073	1.132	0.8085	0.97025	0.130	0.124	**0.127**
O	15.1	110	10019	190	20038				0.132	0.112	0.122
	15.2	82	10018	150	20045				0.094	0.085	0.089
	15.3	66	10038	134	20040	1.0925	0.809		0.072	0.074	0.073
	Avg	86	10025	158	20041	1.0925	0.809	0.95075	0.100	0.090	**0.095**
P	16.1	99	10032	169	20040				0.118	0.098	0.108
	16.2	79	10028	141	20037				0.090	0.079	0.085
	16.3	79	10019	159	20047	1.082	0.805		0.090	0.091	0.091
	Avg	86	10026	156	20041	1.082	0.805	0.9435	0.100	0.089	**0.094**
	AVG	98	10043	175	20051			0.949	0.116	0.102	**0.109**

Standard Deviation	0.020554214	0.012922	0.018348
95% +-	0.005968322	0.003752	0.0037177
99% +-	0.007964393	0.005007	0.0049224

DDS-COF-TP-0060 ENCLOSURE (1)								DATE:	1/19/2023	
LUBRICANT:	CHRISTOLUBE MCG111			BOLT PROPERTIES:				TARGETS:		
SIZE:	1.00-8UNC-2A	TPI:	8	Nominal Diameter (in):	1.00		LEAD ANGLE (Deg)(B1.1):		1/3Y	2/3Y
BOLT MATERIAL:	KMONEL GR 500 MIL-DTL-1222 / QQ-N-286 A &AH			Yield Strength (ksi):	85	MIL-DTL-1222	2.480			
NUT MATERIAL:	NICU GR 400 MIL-DTL-1222 / QQ-N-281 CL A			Tensile Stress Area (in^2):	0.606	ASME B1.1	Em (in) (B1.1):	PRELOAD (LBS)	17170	34340
WASHER MATERIAL:	NICU GR 400 FF-W-92			Torque Coefficient (assumed):	0.185	S9086-CJ-STM-010	0.919	EST. TORQUE (FT-LB)	265	529

Fastener No.	Trial	1/3 Yield Strength		2/3 Yield Strength		Crush Diameter			COF (Method 2)		
		Torque (ft lbs)	Preload (lbs)	Torque (ft lbs)	Preload (lbs)	Dco (in)	Dci (in)	Dc (in)	1/3Y	2/3Y	AVG
A	1.1	206	18210	347	34378				0.100	0.087	0.093
	1.2	172	17176	304	34343				0.086	0.074	0.080
	1.3	161	17170	321	34342	1.4505	1.06		0.080	0.079	0.080
	Avg	180	17519	324	34354	1.4505	1.06	1.25525	0.089	0.080	**0.085**
B	2.1	210	17184	379	34340				0.110	0.097	0.103
	2.2	193	17174	363	34366				0.099	0.092	0.096
	2.3	193	17177	357	34340	1.434	1.058		0.099	0.091	0.095
	Avg	199	17178	366	34349	1.434	1.058	1.246	0.103	0.093	**0.098**
C	3.1	208	17169	330	34340				0.109	0.083	0.096
	3.2	171	17218	332	34341				0.086	0.083	0.085
	3.3	178	17171	315	34340	1.427	1.0605		0.090	0.078	0.084
	Avg	186	17186	326	34340	1.427	1.0605	1.24375	0.095	0.081	**0.088**
D	4.1	201	17171	356	34341				0.104	0.090	0.097
	4.2	197	17175	364	34341				0.101	0.092	0.097
	4.3	194	17172	344	34340	1.449	1.06		0.100	0.086	0.093
	Avg	197	17173	355	34341	1.449	1.06	1.2545	0.102	0.090	**0.096**
E	5.1	220	17201	364	34425				0.115	0.092	0.103
	5.2	208	17186	377	34340				0.108	0.096	0.102
	5.3	208	17233	349	34341	1.466	1.0595		0.107	0.088	0.097
	Avg	212	17207	363	34369	1.466	1.0595	1.26275	0.110	0.092	**0.101**
F	6.1	217	17169	342	34340				0.113	0.086	0.099
	6.2	199	17163	336	34343				0.102	0.084	0.093
	6.3	181	17199	321	34340	1.4565	1.0605		0.091	0.079	0.085
	Avg	199	17177	333	34341	1.4565	1.0605	1.2585	0.102	0.083	**0.093**
G	7.1	219	17186	395	34340				0.115	0.102	0.108
	7.2	212	17163	397	34341				0.111	0.103	0.107
	7.3	212	17237	380	34341	1.4385	1.0595		0.110	0.097	0.104
	Avg	214	17195	391	34341	1.4385	1.0595	1.249	0.112	0.101	**0.106**
H	8.1	221	17269	356	34340				0.115	0.090	0.103
	8.2	182	17172	338	34340				0.093	0.085	0.089
	8.3	179	17163	328	34340	1.43	1.0615		0.091	0.082	0.086
	Avg	194	17201	341	34340	1.43	1.0615	1.24575	0.100	0.086	**0.093**
I	9.1	189	17170	332	34339				0.097	0.083	0.090
	9.2	170	17169	338	34341				0.085	0.085	0.085
	9.3	169	17170	308	34340	1.438	1.0595		0.085	0.076	0.080
	Avg	176	17170	326	34340	1.438	1.0595	1.24875	0.089	0.081	**0.085**
J	10.1	196	17160	327	34340				0.102	0.082	0.092
	10.2	170	17170	326	34341				0.086	0.082	0.084
	10.3	180	17169	312	34346	1.4175	1.058		0.092	0.077	0.085
	Avg	182	17166	322	34342	1.4175	1.058	1.23775	0.093	0.080	**0.087**
K	11.1	198	17174	337	34341				0.102	0.085	0.094
	11.2	170	17171	341	34374				0.086	0.086	0.086
	11.3	171	17171	309	34342	1.434	1.055		0.086	0.076	0.081
	Avg	180	17172	329	34352	1.434	1.055	1.2445	0.091	0.082	**0.087**
L	12.1	198	17177	340	34341				0.103	0.086	0.094
	12.2	191	17167	330	34341				0.098	0.083	0.091
	12.3	180	17176	316	34341	1.4235	1.059		0.092	0.078	0.085
	Avg	190	17173	329	34341	1.4235	1.059	1.24125	0.098	0.082	**0.090**
M	13.1	225	17167	350	34341				0.118	0.088	0.103
	13.2	209	17243	362	34340				0.108	0.092	0.100
	13.3	219	17164	356	34341	1.449	1.0585		0.115	0.090	0.102
	Avg	218	17191	356	34341	1.449	1.0585	1.25375	0.114	0.090	**0.102**
N	14.1	189	17171	335	34340				0.097	0.084	0.091
	14.2	182	17170	341	34340				0.093	0.086	0.089
	14.3	170	17168	312	34341	1.436	1.055		0.086	0.077	0.081
	Avg	180	17170	329	34340	1.436	1.055	1.2455	0.092	0.082	**0.087**
O	15.1	200	17167	332	34340				0.104	0.083	0.093
	15.2	180	17178	330	34349				0.092	0.083	0.087
	15.3	189	17178	352	34341	1.428	1.0585		0.097	0.089	0.093
	Avg	190	17174	338	34343	1.428	1.0585	1.24325	0.097	0.085	**0.091**
P	16.1	198	17176	307	34340				0.102	0.075	0.089
	16.2	185	17170	314	34346				0.094	0.078	0.086
	16.3	187	17184	318	34343	1.439	1.059		0.096	0.079	0.087
	Avg	190	17177	313	34343	1.439	1.059	1.249	0.097	0.077	**0.087**
	AVG	193	17202	340	34345			1.249	0.099	0.085	**0.092**

Standard Deviation	0.009937716	0.006793	0.010809
95% +-	0.002885612	0.001972	0.0021901
99% +-	0.003850688	0.002632	0.0028998

DDS-COF-TP-0060 ENCLOSURE (1)								DATE:	1/20/2023	
LUBRICANT:	CHRISTOLUBE MCG111			BOLT PROPERTIES:				TARGETS:		
SIZE:	1.25-7UNC-2A	TPI:	7	Nominal Diameter (in):	1.25		LEAD ANGLE (Deg)(B1.1):		1/3Y	2/3Y
BOLT MATERIAL:	KMONEL GR 500 MIL-DTL-1222 / QQ-N-286 A &AH			Yield Strength (ksi):	85	MIL-DTL-1222	2.250			
NUT MATERIAL:	NICU GR 400 MIL-DTL-1222 / QQ-N-281 CL A			Tensile Stress Area (in^2):	0.969	ASME B1.1	Em (in) (B1.1):	PRELOAD (LBS)	27455	54910
WASHER MATERIAL:	NICU GR 400 FF-W-92			Torque Coefficient (assumed):	0.184	S9086-CJ-STM-010	1.157	EST. TORQUE (FT-LB)	526	1052

Fastener No.	Trial	1/3 Yield Strength		2/3 Yield Strength		Crush Diameter			COF (Method 2)		
		Torque (ft lbs)	Preload (lbs)	Torque (ft lbs)	Preload (lbs)	Dco (in)	Dci (in)	Dc (in)	1/3Y	2/3Y	AVG
A	1.1	477	27455	833	54910				0.127	0.109	0.118
	1.2	375	27455	734	54911				0.096	0.094	0.095
	1.3	371	27456	747	54914	1.8045	1.37		0.095	0.096	0.095
	Avg	408	27455	771	54912	1.8045	1.37	1.58725	0.106	0.099	**0.103**
B	2.1	420	27454	738	54910				0.109	0.094	0.102
	2.2	374	27456	676	54910				0.095	0.085	0.090
	2.3	431	27455	795	54910	1.837	1.3725		0.112	0.102	0.107
	Avg	408	27455	736	54910	1.837	1.3725	1.60475	0.106	0.094	**0.100**
C	3.1	410	27455	681	54910				0.106	0.085	0.096
	3.2	390	27456	693	54914				0.100	0.087	0.093
	3.3	468	27455	875	54910	1.855	1.3705		0.123	0.114	0.118
	Avg	423	27455	750	54911	1.855	1.3705	1.61275	0.110	0.095	**0.102**
D	4.1	501	27456	1008	54912				0.133	0.134	0.134
	4.2	536	27455	1046	54913				0.144	0.140	0.142
	4.3	585	27456	1052	54912	1.8215	1.37		0.158	0.141	0.150
	Avg	541	27456	1035	54912	1.8215	1.37	1.59575	0.145	0.138	**0.142**
E	5.1	449	27455	820	54912				0.118	0.106	0.112
	5.2	386	27456	760	54930				0.099	0.097	0.098
	5.3	419	27455	871	54912	1.821	1.3695		0.109	0.114	0.112
	Avg	418	27455	817	54918	1.821	1.3695	1.59525	0.109	0.106	**0.107**
F	6.1	425	27455	842	54912				0.111	0.109	0.110
	6.2	457	27456	913	54910				0.120	0.120	0.120
	6.3	479	27456	901	54912	1.8305	1.3715		0.127	0.118	0.122
	Avg	454	27456	885	54911	1.8305	1.3715	1.601	0.119	0.116	**0.118**
G	7.1	452	27456	786	54910				0.119	0.101	0.110
	7.2	402	27456	764	54911				0.104	0.098	0.101
	7.3	402	27455	888	54910	1.828	1.3675		0.104	0.116	0.110
	Avg	419	27456	813	54910	1.828	1.3675	1.59775	0.109	0.105	**0.107**
H	8.1	432	27456	794	54928				0.113	0.102	0.108
	8.2	377	27469	796	54911				0.097	0.103	0.100
	8.3	378	27455	794	54910	1.822	1.372		0.097	0.103	0.100
	Avg	396	27460	795	54916	1.822	1.372	1.597	0.102	0.103	**0.102**
I	9.1	487	27455	656	54910				0.130	0.082	0.106
	9.2	429	27455	834	54910				0.112	0.109	0.111
	9.3	510	27455	996	54910	1.801	1.371		0.137	0.133	0.135
	Avg	475	27455	829	54910	1.801	1.371	1.586	0.126	0.108	**0.117**
J	10.1	450	27456	842	54911				0.118	0.110	0.114
	10.2	434	27455	805	54912				0.113	0.104	0.109
	10.3	435	27455	885	54912	1.826	1.37		0.114	0.116	0.115
	Avg	440	27455	844	54912	1.826	1.37	1.598	0.115	0.110	**0.113**
K	11.1	423	27458	769	54910				0.110	0.099	0.104
	11.2	336	27454	717	54910				0.084	0.091	0.088
	11.3	387	27456	856	54913	1.8345	1.3685		0.099	0.112	0.105
	Avg	382	27456	781	54911	1.8345	1.3685	1.6015	0.098	0.100	**0.099**
L	12.1	422	27459	773	54911				0.110	0.099	0.104
	12.2	460	27456	810	54937				0.121	0.105	0.113
	12.3	529	27456	948	54911	1.8345	1.3705		0.141	0.125	0.133
	Avg	470	27457	844	54920	1.8345	1.3705	1.6025	0.124	0.110	**0.117**
M	13.1	427	27456	793	54910				0.113	0.104	0.108
	13.2	434	27457	888	54911				0.115	0.118	0.117
	13.3	522	27454	1011	54914	1.745	1.3685		0.141	0.137	0.139
	Avg	461	27456	897	54912	1.745	1.3685	1.55675	0.123	0.119	**0.121**
N	14.1	418	27455	777	54910				0.109	0.100	0.104
	14.2	353	27467	745	54911				0.089	0.095	0.092
	14.3	367	27455	824	54912	1.823	1.3695		0.094	0.107	0.100
	Avg	379	27459	782	54911	1.823	1.3695	1.59625	0.097	0.101	**0.099**
O	15.1	489	27455	894	54912				0.129	0.117	0.123
	15.2	455	27455	901	54910				0.119	0.118	0.118
	15.3	536	27456	921	54911	1.8545	1.3705		0.143	0.121	0.132
	Avg	493	27455	905	54911	1.8545	1.3705	1.6125	0.130	0.118	**0.124**
P	16.1	449	27455	857	54910				0.118	0.112	0.115
	16.2	427	27456	899	54910				0.112	0.118	0.115
	16.3	450	27456	900	54911	1.808	1.3705		0.119	0.119	0.119
	Avg	442	27456	885	54910	1.808	1.3705	1.58925	0.116	0.116	**0.116**
	AVG	438	27456	836	54912			1.596	0.115	0.109	**0.112**

Standard Deviation	0.015756409	0.014159	0.0151219
95% +-	0.004575184	0.004111	0.003064
99% +-	0.006105329	0.005486	0.0040569

INCONEL 625

DDS-COF-TP-0060 ENCLOSURE (1)								DATE:	1/13/2023 & 1/17/2023	
LUBRICANT:	CHRISTOLUBE MCG111			BOLT PROPERTIES:				TARGETS:		
SIZE:	0.50-13UNC-2A	TPI:	13	Nominal Diameter (in):	0.5		LEAD ANGLE (Deg)(B1.1):			
BOLT MATERIAL:	INCONEL 625 MIL-DTL-1222/ASTM B446 GR 1			Yield Strength (ksi):	60	MIL-DTL-1222	3.114		1/3Y	2/3Y
NUT MATERIAL:	NICU GR 400 MIL-DTL-1222 / QQ-N-281 CL A			Tensile Stress Area (in^2):	0.1419	ASME B1.1	Em (in) (B1.1):	PRELOAD (LBS)	2838	5676
WASHER MATERIAL:	NICU GR 400 FF-W-92			Torque Coefficient (assumed):	0.2	S9086-CJ-STM-010	0.450	EST. TORQUE (FT-LB)	24	47

Fastener No.	Trial	1/3 Yield Strength		2/3 Yield Strength		Crush Diameter			COF (Method 2)		
		Torque (ft lbs)	Preload (lbs)	Torque (ft lbs)	Preload (lbs)	Dco (in)	Dci (in)	Dc (in)	1/3Y	2/3Y	AVG
A	1.1	16.5	2838	27	5007				0.101	0.093	0.097
	1.2	15	2837	25	5000				0.090	0.084	0.087
	1.3	15	2859	25.5	5002	0.692	0.528		0.089	0.086	0.088
	Avg	16	2845	26	5003	0.692	0.528	0.61	0.094	0.088	**0.091**
B	2.1	16.5	2838	28.5	5003				0.101	0.098	0.100
	2.2	13	2838	26	5004				0.075	0.088	0.081
	2.3	14.5	2843	24	5003	0.704	0.5295		0.086	0.079	0.083
	Avg	15	2840	26	5003	0.704	0.5295	0.61675	0.087	0.089	**0.088**
C	3.1	18	2835	29.5	5000				0.112	0.103	0.108
	3.2	16	2838	27	5003				0.097	0.092	0.095
	3.3	16	2840	24	4999	0.698	0.5295		0.097	0.080	0.089
	Avg	17	2838	27	5001	0.698	0.5295	0.61375	0.102	0.092	**0.097**
D	4.1	16	2836	28	5007				0.097	0.096	0.097
	4.2	14.5	2843	24.5	5007				0.086	0.082	0.084
	4.3	14.5	2854	25	5002	0.7	0.529		0.086	0.084	0.085
	Avg	15	2844	26	5005	0.7	0.529	0.6145	0.090	0.087	**0.088**
E	5.1	18	2835	29.5	5004				0.112	0.103	0.107
	5.2	17	2842	27.5	5000				0.104	0.094	0.099
	5.3	17	2844	29.5	5000	0.7025	0.53		0.104	0.103	0.103
	Avg	17	2840	29	5001	0.7025	0.53	0.61625	0.107	0.100	**0.103**
F	6.1	20	2839	32.5	5000				0.127	0.115	0.121
	6.2	18	2843	30.5	4999				0.112	0.107	0.109
	6.3	17.5	2838	31.5	5000	0.7035	0.527		0.108	0.111	0.110
	Avg	19	2840	32	5000	0.7035	0.527	0.61525	0.116	0.111	**0.113**
G	7.1	16	2844	27	5004				0.096	0.092	0.094
	7.2	15.5	2838	26.5	5000				0.093	0.090	0.091
	7.3	15.5	2837	26.5	5000	0.7165	0.5295		0.093	0.090	0.091
	Avg	16	2840	27	5001	0.7165	0.5295	0.623	0.094	0.090	**0.092**
H	8.1	18.5	2842	29	5000				0.115	0.100	0.108
	8.2	15.5	2844	26	5000				0.093	0.088	0.090
	8.3	15	2838	26.5	5001	0.707	0.5305		0.090	0.090	0.090
	Avg	16	2841	27	5000	0.707	0.5305	0.61875	0.099	0.093	**0.096**
I	9.1	17	2836	30	5002				0.105	0.105	0.105
	9.2	15	2838	26	5012				0.090	0.088	0.089
	9.3	15	2841	26	5004	0.693	0.5295		0.090	0.088	0.089
	Avg	16	2838	27	5006	0.693	0.5295	0.61125	0.095	0.094	**0.094**
J	10.1	17.5	2837	28	5013				0.109	0.096	0.103
	10.2	14	2839	25	4999				0.083	0.084	0.083
	10.3	14.5	2836	27	5004	0.6925	0.5305		0.086	0.092	0.089
	Avg	15	2837	27	5005	0.6925	0.5305	0.6115	0.093	0.091	**0.092**
K	11.1	17.5	2842	29	5002				0.108	0.100	0.104
	11.2	16	2839	27	4999				0.097	0.092	0.094
	11.3	15.5	2837	25	5001	0.7105	0.528		0.093	0.084	0.088
	Avg	16	2839	27	5001	0.7105	0.528	0.61925	0.099	0.092	**0.096**
L	12.1	16	2841	29	5005				0.097	0.101	0.099
	12.2	16	2841	27.5	4998				0.097	0.095	0.096
	12.3	17.5	2850	28	5001	0.694	0.5285		0.108	0.097	0.102
	Avg	17	2844	28	5001	0.694	0.5285	0.61125	0.101	0.097	**0.099**
M	13.1	17.5	2837	29.5	5001				0.109	0.103	0.106
	13.2	15	2836	27.5	5000				0.090	0.095	0.092
	13.3	15	2840	28	5004	0.693	0.53		0.090	0.097	0.093
	Avg	16	2838	28	5002	0.693	0.53	0.6115	0.096	0.098	**0.097**
N	14.1	17.5	2840	29	5000				0.108	0.101	0.105
	14.2	15	2841	27	5001				0.090	0.092	0.091
	14.3	16	2839	28.5	5002	0.697	0.5305		0.097	0.099	0.098
	Avg	16	2840	28	5001	0.697	0.5305	0.61375	0.099	0.097	**0.098**
O	15.1	19	2842	33	5020				0.120	0.117	0.118
	15.2	16	2837	29.5	5000				0.098	0.103	0.100
	15.3	16	2837	28	5000	0.6975	0.527		0.098	0.097	0.097
	Avg	17	2839	30	5007	0.6975	0.527	0.61225	0.105	0.106	**0.105**
P	16.1	18	2840	29	5000				0.111	0.100	0.105
	16.2	15	2840	27.5	5000				0.089	0.094	0.091
	16.3	17.5	2837	26	5002	0.7195	0.53		0.107	0.087	0.097
	Avg	17	2839	28	5001	0.7195	0.53	0.62475	0.103	0.094	**0.098**
	AVG	16	2840	28	5002			0.615	0.099	0.095	**0.097**

Standard Deviation	0.010580693	0.00864671	0.00975073
95% +-	0.003072313	0.00251074	0.00197568
99% +-	0.00409983	0.00335044	0.0026159

DDS-COF-TP-0060 ENCLOSURE (1)								DATE:	1/17/2023	
LUBRICANT:	CHRISTOLUBE MCG111			BOLT PROPERTIES:				TARGETS:		
SIZE:	0.75-10UNC-2A	TPI:	10	Nominal Diameter (in):	0.75		LEAD ANGLE (Deg)(B1.1):			
BOLT MATERIAL:	INCONEL 625 MIL-DTL-1222/ASTM B446 GR 1			Yield Strength (ksi):	60	MIL-DTL-1222	2.660		1/3Y	2/3Y
NUT MATERIAL:	NICU GR 400 MIL-DTL-1222 / QQ-N-281 CL A			Tensile Stress Area (in^2):	0.334	ASME B1.1	Em (in) (B1.1):	PRELOAD (LBS)	6680	13360
WASHER MATERIAL:	NICU GR 400 FF-W-92			Torque Coefficient (assumed):	0.198	S9086-CJ-STM-010	0.685	EST. TORQUE (FT-LB)	83	165

Fastener No.	Trial	1/3 Yield Strength		2/3 Yield Strength		Crush Diameter			COF (Method 2)		
		Torque (ft lbs)	Preload (lbs)	Torque (ft lbs)	Preload (lbs)	Dco (in)	Dci (in)	Dc (in)	1/3Y	2/3Y	AVG
A	1.1	71	6683	125	13350				0.127	0.110	0.119
	1.2	71	6681	130	13364				0.127	0.115	0.121
	1.3	70	6676	130	13380	1.0995	0.811		0.125	0.115	0.120
	Avg	71	6680	128	13365	1.0995	0.811	0.95525	0.127	0.113	**0.120**
B	2.1	70	6686	125	13360				0.126	0.111	0.119
	2.2	60	6687	111	13359				0.106	0.096	0.101
	2.3	65	6689	122	13362	1.0715	0.8085		0.116	0.108	0.112
	Avg	65	6687	119	13360	1.0715	0.8085	0.94	0.116	0.105	**0.110**
C	3.1	68	6680	122	13360				0.122	0.108	0.115
	3.2	59	6678	122	13359				0.104	0.108	0.106
	3.3	74	6682	140	13360	1.0705	0.8095		0.135	0.126	0.130
	Avg	67	6680	128	13360	1.0705	0.8095	0.94	0.120	0.114	**0.117**
D	4.1	71	6680	125	13364				0.126	0.109	0.117
	4.2	69	6700	120	13357				0.121	0.104	0.113
	4.3	70	6678	133	13351	1.14	0.8105		0.124	0.117	0.120
	Avg	70	6686	126	13357	1.14	0.8105	0.97525	0.124	0.110	**0.117**
E	5.1	70	6680	133	13359				0.126	0.119	0.122
	5.2	71	6690	139	13369				0.128	0.125	0.126
	5.3	70	6678	130	13365	1.0795	0.811		0.126	0.116	0.121
	Avg	70	6683	134	13364	1.0795	0.811	0.94525	0.127	0.120	**0.123**
F	6.1	77	6740	111	13364				0.140	0.097	0.118
	6.2	62	6692	123	13361				0.110	0.109	0.109
	6.3	68	6698	128	13371	1.065	0.809		0.122	0.114	0.118
	Avg	69	6710	121	13365	1.065	0.809	0.937	0.124	0.107	**0.115**
G	7.1	71	6682	129	13360				0.127	0.114	0.121
	7.2	71	6685	133	13398				0.127	0.118	0.122
	7.3	70	6702	124	13356	1.103	0.8105		0.125	0.109	0.117
	Avg	71	6690	129	13371	1.103	0.8105	0.95675	0.126	0.113	**0.120**
H	8.1	70	6680	121	13378				0.126	0.106	0.116
	8.2	56	6687	118	13359				0.097	0.103	0.100
	8.3	60	6688	118	13359	1.0915	0.81		0.105	0.103	0.104
	Avg	62	6685	119	13365	1.0915	0.81	0.95075	0.109	0.104	**0.107**
I	9.1	78	6680	142	13375				0.143	0.128	0.135
	9.2	71	6685	130	13366				0.128	0.116	0.122
	9.3	64	6682	130	13360	1.086	0.8015		0.114	0.116	0.115
	Avg	71	6682	134	13367	1.086	0.8015	0.94375	0.128	0.120	**0.124**
J	10.1	66	6680	122	13361				0.117	0.107	0.112
	10.2	63	6687	121	13363				0.111	0.106	0.108
	10.3	68	6680	130	13362	1.11	0.81		0.121	0.115	0.118
	Avg	66	6682	124	13362	1.11	0.81	0.96	0.116	0.109	**0.113**
K	11.1	72	6681	130	13370				0.130	0.116	0.123
	11.2	69	6680	120	13363				0.124	0.105	0.115
	11.3	70	6699	129	13359	1.0775	0.8115		0.126	0.115	0.120
	Avg	70	6687	126	13364	1.0775	0.8115	0.9445	0.127	0.112	**0.119**
L	12.1	70	6684	120	13369				0.125	0.105	0.115
	12.2	61	6688	130	13364				0.106	0.115	0.111
	12.3	68	6683	119	13357	1.108	0.811		0.121	0.104	0.112
	Avg	66	6685	123	13363	1.108	0.811	0.9595	0.117	0.108	**0.113**
M	13.1	81	6684	130	13378				0.147	0.115	0.131
	13.2	73	6680	124	13361				0.131	0.109	0.120
	13.3	69	6681	118	13373	1.111	0.809		0.123	0.102	0.113
	Avg	74	6682	124	13371	1.111	0.809	0.96	0.134	0.109	**0.121**
N	14.1	77	6695	122	13380				0.138	0.106	0.122
	14.2	70	6689	120	13368				0.124	0.104	0.114
	14.3	64	6685	130	13363	1.1175	0.8115		0.112	0.114	0.113
	Avg	70	6690	124	13370	1.1175	0.8115	0.9645	0.125	0.108	**0.117**
O	15.1	65	6687	119	13381				0.115	0.104	0.109
	15.2	59	6683	119	13357				0.103	0.104	0.103
	15.3	60	6676	121	13360	1.096	0.8115		0.105	0.106	0.105
	Avg	61	6682	120	13366	1.096	0.8115	0.95375	0.108	0.105	**0.106**
P	16.1	64	6708	102	13384				0.112	0.086	0.099
	16.2	50	6709	92	13363				0.084	0.076	0.080
	16.3	50	7611	85	13364	1.1105	0.812		0.072	0.069	0.070
	Avg	55	7009	93	13370	1.1105	0.812	0.96125	0.088	0.077	**0.083**
	AVG	67	6706	123	13365			0.953	0.120	0.108	**0.114**

Standard Deviation	0.01392125	0.010793	0.0135941
95% +-	0.00404231	0.003134	0.0027544
99% +-	0.005394237	0.004182	0.003647

DDS-COF-TP-0060 ENCLOSURE (1)								DATE:	1/18/2023	
LUBRICANT:	CHRISTOLUBE MCG111			BOLT PROPERTIES:				TARGETS:		
SIZE:	1.00-8-UNC-2A	TPI:	8	Nominal Diameter (in):	1.00		LEAD ANGLE (Deg)(B1.1):		1/3Y	2/3Y
BOLT MATERIAL:	INCONEL 625 MIL-DTL-1222/ASTM B446 GR 1			Yield Strength (ksi):	60	MIL-DTL-1222	2.480			
NUT MATERIAL:	NICU GR 400 MIL-DTL-1222 / QQ-N-281 CL A			Tensile Stress Area (in^2):	0.606	ASME B1.1	Em (in) (B1.1):	PRELOAD (LBS)	12120	24240
WASHER MATERIAL:	NICU GR 400 FF-W-92			Torque Coefficient (assumed):	0.197	S9086-CJ-STM-010	0.919	EST. TORQUE (FT-LB)	199	398

Fastener No.	Trial	1/3 Yield Strength		2/3 Yield Strength		Crush Diameter			COF (Method 2)		
		Torque (ft lbs)	Preload (lbs)	Torque (ft lbs)	Preload (lbs)	Dco (in)	Dci (in)	Dc (in)	1/3Y	2/3Y	AVG
A	1.1	159	12222	273	24240				0.118	0.100	0.109
	1.2	158	12166	285	24241				0.118	0.105	0.111
	1.3	172	12120	289	24240	1.426	1.056		0.130	0.107	0.118
	Avg	163	12169	282	24240	1.426	1.056	1.241	0.122	0.104	**0.113**
B	2.1	152	12123	305	24241				0.112	0.113	0.112
	2.2	172	12120	342	24242				0.129	0.128	0.129
	2.3	189	12118	363	24240	1.4525	1.062		0.144	0.137	0.141
	Avg	171	12120	337	24241	1.4525	1.062	1.25725	0.128	0.126	**0.127**
C	3.1	161	12115	313	24240				0.120	0.116	0.118
	3.2	169	12132	321	24282				0.127	0.119	0.123
	3.3	169	12123	319	24240	1.4565	1.059		0.127	0.119	0.123
	Avg	166	12123	318	24254	1.4565	1.059	1.25775	0.124	0.118	**0.121**
D	4.1	141	12122	244	24242				0.103	0.087	0.095
	4.2	138	12119	253	24240				0.101	0.091	0.096
	4.3	132	12120	248	24241	1.445	1.061		0.095	0.089	0.092
	Avg	137	12120	248	24241	1.445	1.061	1.253	0.100	0.089	**0.094**
E	5.1	179	12124	330	24241				0.136	0.124	0.130
	5.2	171	12120	339	24240				0.129	0.128	0.128
	5.3	182	12121	333	24240	1.436	1.063		0.138	0.125	0.132
	Avg	177	12122	334	24240	1.436	1.063	1.2495	0.134	0.125	**0.130**
F	6.1	166	12120	299	24240				0.124	0.110	0.117
	6.2	166	12120	323	24240				0.124	0.120	0.122
	6.3	172	12123	333	24242	1.4485	1.061		0.129	0.125	0.127
	Avg	168	12121	318	24241	1.4485	1.061	1.25475	0.126	0.118	**0.122**
G	7.1	159	12126	305	24240				0.119	0.113	0.116
	7.2	161	12121	342	24239				0.120	0.129	0.125
	7.3	172	12133	336	24251	1.437	1.0625		0.130	0.126	0.128
	Avg	164	12127	328	24243	1.437	1.0625	1.24975	0.123	0.123	**0.123**
H	8.1	139	12160	245	24242				0.101	0.087	0.094
	8.2	130	12120	238	24240				0.094	0.085	0.089
	8.3	130	12117	237	24241	1.4385	1.061		0.094	0.084	0.089
	Avg	133	12132	240	24241	1.4385	1.061	1.24975	0.096	0.085	**0.091**
I	9.1	166	12121	310	24240				0.124	0.115	0.120
	9.2	172	12119	317	24258				0.130	0.118	0.124
	9.3	180	12121	310	24240	1.441	1.062		0.136	0.115	0.126
	Avg	173	12120	312	24246	1.441	1.062	1.2515	0.130	0.116	**0.123**
J	10.1	178	12122	310	24241				0.134	0.114	0.124
	10.2	179	12129	342	24240				0.134	0.128	0.131
	10.3	191	12128	341	24240	1.479	1.061		0.144	0.127	0.136
	Avg	183	12126	331	24240	1.479	1.061	1.27	0.137	0.123	**0.130**
K	11.1	173	12141	327	24240				0.130	0.122	0.126
	11.2	188	12149	343	24241				0.142	0.129	0.135
	11.3	190	12124	345	24241	1.462	1.062		0.144	0.129	0.137
	Avg	184	12138	338	24241	1.462	1.062	1.262	0.139	0.127	**0.133**
L	12.1	143	12119	257	24240				0.105	0.093	0.099
	12.2	139	12119	238	24240				0.102	0.085	0.093
	12.3	141	12119	241	24241	1.434	1.059		0.103	0.086	0.095
	Avg	141	12119	245	24240	1.434	1.059	1.2465	0.103	0.088	**0.096**
M	13.1	155	12130	284	24240				0.116	0.105	0.110
	13.2	158	12218	292	24243				0.117	0.108	0.113
	13.3	176	12121	308	24240	1.416	1.06		0.134	0.115	0.124
	Avg	163	12156	295	24241	1.416	1.06	1.238	0.122	0.109	**0.116**
N	14.1	179	12128	302	24240				0.135	0.111	0.123
	14.2	181	12138	347	24240				0.136	0.130	0.133
	14.3	189	12132	353	24259	1.472	1.06		0.143	0.132	0.138
	Avg	183	12133	334	24246	1.472	1.06	1.266	0.138	0.125	**0.131**
O	15.1	179	12134	335	24241				0.135	0.125	0.130
	15.2	185	12133	369	24242				0.140	0.140	0.140
	15.3	191	12115	375	24240	1.457	1.062		0.145	0.142	0.144
	Avg	185	12127	360	24241	1.457	1.062	1.2595	0.140	0.136	**0.138**
P	16.1	151	12186	269	24240				0.110	0.097	0.103
	16.2	150	12126	242	24242				0.110	0.085	0.098
	16.3	163	12115	279	24244	1.4805	1.0625		0.121	0.101	0.111
	Avg	155	12142	263	24242	1.4805	1.0625	1.2715	0.114	0.094	**0.104**
	AVG	165	12131	305	24242			1.255	0.124	0.113	**0.118**

Standard Deviation	0.014723709	0.01663	0.0164354
95% +-	0.00427532	0.004829	0.0033301
99% +-	0.005705176	0.006444	0.0044093

DDS-COF-TP-0060 ENCLOSURE (1)									DATE:	1/19/2023 & 1/20/2023	
LUBRICANT:	CHRISTOLUBE MCG111			BOLT PROPERTIES:					TARGETS:		
SIZE:	1.25-7UNC-2A	TPI:	7	Nominal Diameter (in):	1.25		LEAD ANGLE (Deg)(B1.1):	2.250		1/3Y	2/3Y
BOLT MATERIAL:	INCONEL 625 MIL-DTL-1222/ASTM B446 GR 1			Yield Strength (ksi):	60	MIL-DTL-1222					
NUT MATERIAL:	NICU GR 400 MIL-DTL-1222 / QQ-N-281 CL A			Tensile Stress Area (in^2):	0.969	ASME B1.1	Em (in) (B1.1):		PRELOAD (LBS)	19380	38760
WASHER MATERIAL:	NICU GR 400 FF-W-92			Torque Coefficient (assumed):	0.196	S9086-CJ-STM-010		1.157	EST. TORQUE (FT-LB)	396	791

Fastener No.	Trial	1/3 Yield Strength		2/3 Yield Strength		Crush Diameter			COF (Method 2)		
		Torque (ft lbs)	Preload (lbs)	Torque (ft lbs)	Preload (lbs)	Dco (in)	Dci (in)	Dc (in)	1/3Y	2/3Y	AVG
A	1.1	355	19381	761	38763				0.134	0.144	0.139
	1.2	285	19381	638	38772				0.104	0.118	0.111
	1.3	265	19380	565	38762	1.8315	1.3755		0.096	0.103	0.100
	Avg	302	19381	655	38766	1.8315	1.3755	1.6035	0.111	0.122	**0.117**
B	2.1	349	19381	643	38764				0.131	0.120	0.125
	2.2	277	19380	602	38761				0.101	0.111	0.106
	2.3	204	19379	490	38765	1.8265	1.375		0.070	0.088	0.079
	Avg	277	19380	578	38763	1.8265	1.375	1.60075	0.101	0.106	**0.104**
C	3.1	367	19412	698	38761				0.139	0.131	0.135
	3.2	274	19380	565	38760				0.100	0.103	0.102
	3.3	261	19380	592	38763	1.826	1.375		0.094	0.109	0.102
	Avg	301	19391	618	38761	1.826	1.375	1.6005	0.111	0.115	**0.113**
D	4.1	345	19382	629	38765				0.129	0.116	0.123
	4.2	294	19381	590	38761				0.108	0.108	0.108
	4.3	267	19380	588	38762	1.8525	1.375		0.096	0.108	0.102
	Avg	302	19381	602	38763	1.8525	1.375	1.61375	0.111	0.111	**0.111**
E	5.1	371	19380	693	38760				0.140	0.130	0.135
	5.2	309	19381	641	38762				0.114	0.119	0.116
	5.3	321	19380	704	38773	1.8525	1.374		0.119	0.132	0.125
	Avg	334	19380	679	38765	1.8525	1.374	1.61325	0.124	0.127	**0.126**
F	6.1	354	19379	693	38761				0.133	0.130	0.132
	6.2	297	19380	631	38761				0.109	0.117	0.113
	6.3	254	19380	583	38760	1.8365	1.374		0.091	0.107	0.099
	Avg	302	19380	636	38761	1.8365	1.374	1.60525	0.111	0.118	**0.115**
G	7.1	354	19380	674	38760				0.133	0.126	0.130
	7.2	355	19495	644	38762				0.133	0.120	0.126
	7.3	261	19380	578	38762	1.8235	1.3755		0.094	0.106	0.100
	Avg	323	19418	632	38761	1.8235	1.3755	1.5995	0.120	0.117	**0.119**
H	8.1	364	19380	721	38764				0.138	0.136	0.137
	8.2	272	19380	600	38850				0.099	0.111	0.105
	8.3	277	19380	589	38760	1.8185	1.3745		0.101	0.109	0.105
	Avg	304	19380	637	38791	1.8185	1.3745	1.5965	0.113	0.118	**0.116**
I	9.1	391	19380	737	38761				0.149	0.140	0.145
	9.2	288	19381	667	38763				0.106	0.125	0.116
	9.3	267	19381	653	38760	1.8	1.3755		0.097	0.122	0.110
	Avg	315	19381	686	38761	1.8	1.3755	1.58775	0.118	0.129	**0.123**
J	10.1	341	19380	664	38760				0.128	0.124	0.126
	10.2	299	19380	682	38761				0.110	0.128	0.119
	10.3	348	19380	730	38760	1.837	1.3745		0.131	0.138	0.134
	Avg	329	19380	692	38760	1.837	1.3745	1.60575	0.123	0.130	**0.126**
K	11.1	351	19380	699	38760				0.134	0.133	0.133
	11.2	258	19380	586	38759				0.094	0.109	0.102
	11.3	223	19381	576	38762	1.755	1.374		0.079	0.107	0.093
	Avg	277	19380	620	38760	1.755	1.374	1.5645	0.102	0.116	**0.109**
L	12.1	340	19381	596	38760				0.127	0.110	0.118
	12.2	252	19381	503	38764				0.090	0.090	0.090
	12.3	238	19382	526	38763	1.8445	1.3745		0.084	0.095	0.090
	Avg	277	19381	542	38762	1.8445	1.3745	1.6095	0.101	0.098	**0.099**
M	13.1	374	19380	713	38763				0.142	0.134	0.138
	13.2	288	19380	609	38762				0.106	0.113	0.109
	13.3	230	19380	535	38760	1.8235	1.374		0.081	0.097	0.089
	Avg	297	19380	619	38762	1.8235	1.374	1.59875	0.110	0.115	**0.112**
N	14.1	341	19383	715	38761				0.128	0.134	0.131
	14.2	295	19380	566	38761				0.108	0.103	0.106
	14.3	267	19523	499	38760	1.8435	1.3725		0.096	0.089	0.093
	Avg	301	19429	593	38761	1.8435	1.3725	1.608	0.111	0.109	**0.110**
O	15.1	374	19380	678	38760				0.142	0.128	0.135
	15.2	355	19380	697	38762				0.134	0.132	0.133
	15.3	352	19381	752	38761	1.7965	1.373		0.133	0.143	0.138
	Avg	360	19380	709	38761	1.7965	1.373	1.58475	0.137	0.134	**0.135**
P	16.1	377	19381	680	38762				0.143	0.127	0.135
	16.2	286	19380	568	38760				0.105	0.104	0.104
	16.3	252	19381	528	38760	1.8345	1.374		0.090	0.095	0.093
	Avg	305	19381	592	38761	1.8345	1.374	1.60425	0.113	0.109	**0.111**
	AVG	307	19386	631	38764			1.600	0.113	0.117	**0.115**
								Standard Deviation	0.020515575	0.01492232	0.01784585
								95% +-	0.005957102	0.00433299	0.0036159
								99% +-	0.007949421	0.00578213	0.00478765

CRES 316

DDS-COF-TP-0060 ENCLOSURE (1)								DATE:	1/9/2023 & 1/10/2023	
LUBRICANT:	CHRISTOLUBE MCG111			BOLT PROPERTIES:				TARGETS:		
SIZE:	0.50-13UNC-2A	TPI:	13	Nominal Diameter (in):	0.5		LEAD ANGLE (Deg)(B1.1):			
BOLT MATERIAL:	CRES 316 MIL-DTL-1222 / ASTM F593 GR 2 COND A			Yield Strength (ksi):	30	MIL-DTL-1222	3.114		1/3Y	2/3Y
NUT MATERIAL:	CRES 304 MIL-DTL-1222 / UNS S30400			Tensile Stress Area (in^2):	0.1419	ASME B1.1	Em (in) (B1.1):	PRELOAD (LBS)	1419	2838
WASHER MATERIAL:	CRES 316 FF-W-92			Torque Coefficient (assumed):	0.212	S9086-CJ-STM-010	0.450	EST. TORQUE (FT-LB)	13	25

Fastener No.	Trial	1/3 Yield Strength		2/3 Yield Strength		Crush Diameter			COF (Method 2)		
		Torque (ft lbs)	Preload (lbs)	Torque (ft lbs)	Preload (lbs)	Dco (in)	Dci (in)	Dc (in)	1/3Y	2/3Y	AVG
A	1.1	13	1421	25	2851				0.171	0.163	0.167
	1.2	12.5	1419	23	2831				0.163	0.149	0.156
	1.3	12	1436	22.5	2845	0.7065	0.5275		0.154	0.145	0.149
	Avg	13	1425	24	2842	0.7065	0.5275	0.617	0.163	0.152	**0.157**
B	2.1	14	1420	26	2855				0.183	0.167	0.175
	2.2	10	1414	23	2837				0.125	0.147	0.136
	2.3	11	1420	21.5	2845	0.7415	0.5265		0.139	0.135	0.137
	Avg	12	1418	24	2846	0.7415	0.5265	0.634	0.149	0.150	**0.149**
C	3.1	13.5	1419	26.5	2846				0.174	0.170	0.172
	3.2	12	1429	23	2848				0.151	0.144	0.148
	3.3	11.5	1431	22.5	2840	0.763	0.53		0.144	0.141	0.142
	Avg	12	1426	24	2845	0.763	0.53	0.6465	0.156	0.152	**0.154**
D	4.1	13.5	1424	26	2843				0.176	0.169	0.173
	4.2	11	1425	23	2858				0.140	0.146	0.143
	4.3	12	1435	22	2827	0.726	0.5265		0.153	0.141	0.147
	Avg	12	1428	24	2843	0.726	0.5265	0.62625	0.156	0.152	**0.154**
F	5.1	15	1430	26	2836				0.197	0.170	0.183
	5.2	12	1418	23	2837				0.155	0.148	0.151
	5.3	11	1419	22	2841	0.7215	0.529		0.140	0.140	0.140
	Avg	13	1422	24	2838	0.7215	0.529	0.62525	0.164	0.153	**0.158**
E	6.1	12	1418	23	2832				0.155	0.148	0.151
	6.2	11.5	1418	22	2837				0.147	0.140	0.144
	6.3	11	1423	19.5	2844	0.728	0.53		0.139	0.121	0.130
	Avg	12	1420	22	2838	0.728	0.53	0.629	0.147	0.136	**0.142**
G	7.1	12	1421	26	2840				0.153	0.168	0.161
	7.2	12	1425	24.5	2838				0.153	0.157	0.155
	7.3	11.5	1433	22	2841	0.7415	0.5315		0.145	0.139	0.142
	Avg	12	1426	24	2840	0.7415	0.5315	0.6365	0.150	0.155	**0.152**
H	8.1	14.5	1416	26	2835				0.191	0.169	0.180
	8.2	11.5	1424	22.5	2845				0.146	0.143	0.145
	8.3	11.5	1427	21	2844	0.733	0.5305		0.146	0.132	0.139
	Avg	13	1422	23	2841	0.733	0.5305	0.63175	0.161	0.148	**0.154**
I	9.1	13	1408	24	2831				0.170	0.154	0.162
	9.2	12	1430	23	2830				0.152	0.147	0.150
	9.3	11	1427	21	2845	0.7425	0.528		0.138	0.132	0.135
	Avg	12	1422	23	2835	0.7425	0.528	0.63525	0.153	0.144	**0.149**
J	10.1	13	1420	25	2846				0.171	0.163	0.167
	10.2	12	1432	23	2837				0.154	0.149	0.152
	10.3	10.5	1420	23	2831	0.707	0.529		0.134	0.149	0.141
	Avg	12	1424	24	2838	0.707	0.529	0.618	0.153	0.154	**0.153**
K	11.1	12.5	1419	25	2811				0.163	0.165	0.164
	11.2	11.5	1419	20	2854				0.149	0.126	0.137
	11.3	11	1421	20.5	2849	0.7065	0.529		0.141	0.130	0.135
	Avg	12	1420	22	2838	0.7065	0.529	0.61775	0.151	0.140	**0.146**
L	12.1	14	1416	24.5	2834				0.184	0.158	0.171
	12.2	12	1417	24	2848				0.154	0.154	0.154
	12.3	11.5	1424	21.5	2844	0.7375	0.524		0.146	0.136	0.141
	Avg	13	1419	23	2842	0.7375	0.524	0.63075	0.162	0.149	**0.155**
M	13.1	13	1420	25	2847				0.169	0.162	0.165
	13.2	12	1425	23	2847				0.154	0.147	0.151
	13.3	11	1425	21	2836	0.721	0.531		0.140	0.133	0.136
	Avg	12	1423	23	2843	0.721	0.531	0.626	0.154	0.147	**0.151**
N	14.1	13	1422	25	2856				0.167	0.159	0.163
	14.2	13	1442	24	2850				0.164	0.152	0.158
	14.3	12.5	1418	19	2830	0.7545	0.526		0.160	0.117	0.139
	Avg	13	1427	23	2845	0.7545	0.526	0.64025	0.164	0.143	**0.153**
O	15.1	16	1436	28	2850				0.209	0.182	0.195
	15.2	12	1417	25.5	2836				0.154	0.165	0.159
	15.3	11.5	1415	22.5	2850	0.742	0.5305		0.147	0.142	0.144
	Avg	13	1423	25	2845	0.742	0.5305	0.63625	0.170	0.163	**0.166**
P	16.1	14	1430	27	2830				0.180	0.175	0.178
	16.2	10	1422	24	2835				0.124	0.153	0.139
	16.3	12	1511	22	2841	0.75	0.53		0.142	0.138	0.140
	Avg	12	1454	24	2835	0.75	0.53	0.64	0.149	0.156	**0.152**
	AVG	12	1425	23	2841			0.631	0.156	0.150	**0.153**

Standard Deviation	0.017850907	0.0145828	0.01648944
95% +-	0.005183363	0.0042344	0.00334107
99% +-	0.006916909	0.0056506	0.00442375

DDS-COF-TP-0060 ENCLOSURE (1)									DATE:	1/5/2023	
LUBRICANT:	CHRISTOLUBE MCG111			BOLT PROPERTIES:					TARGETS:		
SIZE:	0.75-10UNC-2A	TPI:	10	Nominal Diameter (in):	0.75		LEAD ANGLE (Deg)(B1.1):				
BOLT MATERIAL:	CRES 316 MIL-DTL-1222 / ASTM F593 GR 2 COND A			Yield Strength (ksi):	30	MIL-DTL-1222	2.660			1/3Y	2/3Y
NUT MATERIAL:	CRES 304 MIL-DTL-1222 / UNS S30400			Tensile Stress Area (in^2):	0.334	ASME B1.1	Em (in) (B1.1):		PRELOAD (LBS)	3340	6680
WASHER MATERIAL:	CRES 316 FF-W-92			Torque Coefficient (assumed):	0.21	S9086-CJ-STM-010	0.685		EST. TORQUE (FT-LB)	44	88

Fastener No.	Trial	1/3 Yield Strength		2/3 Yield Strength		Crush Diameter			COF (Method 2)		
		Torque (ft lbs)	Preload (lbs)	Torque (ft lbs)	Preload (lbs)	Dco (in)	Dci (in)	Dc (in)	1/3Y	2/3Y	AVG
A	1.1	61	4031	88	6665				0.190	0.163	0.177
	1.2	55	4000	84	6685				0.171	0.155	0.163
	1.3	51	4005	88	6691	1.076	0.813		0.157	0.163	0.160
	Avg	56	4012	87	6680	1.076	0.813	0.9445	0.173	0.160	**0.166**
B	2.1	61	4018	92	6710				0.191	0.171	0.181
	2.2	57	3985	90	6684				0.179	0.168	0.174
	2.3	52	4020	81	6710	1.062	0.811		0.160	0.149	0.155
	Avg	57	4008	88	6701	1.062	0.811	0.9365	0.177	0.163	**0.170**
C	3.1	62	4043	98	6698				0.191	0.181	0.186
	3.2	51	4007	84	6684				0.155	0.153	0.154
	3.3	52	4554	78	6660	1.11	0.814		0.138	0.142	0.140
	Avg	55	4201	87	6681	1.11	0.814	0.962	0.160	0.159	**0.159**
D	4.1	72	4592	94	6692				0.198	0.176	0.187
	4.2	60	4550	90	6660				0.164	0.169	0.166
	4.3	60	4527	81	6674	1.06	0.811		0.165	0.150	0.157
	Avg	64	4556	88	6675	1.06	0.811	0.9355	0.176	0.165	**0.170**
E	5.1	62	4484	85	6701				0.171	0.156	0.164
	5.2	55	4495	83	6687				0.150	0.152	0.151
	5.3	50	4493	72	6678	1.087	0.812		0.135	0.130	0.132
	Avg	56	4491	80	6689	1.087	0.812	0.9495	0.152	0.146	**0.149**
F	6.1	75	4499	99	6719				0.210	0.183	0.197
	6.2	66	4517	91	6737				0.182	0.167	0.174
	6.3	61	4501	90	6667	1.096	0.8125		0.167	0.167	0.167
	Avg	67	4506	93	6708	1.096	0.8125	0.95425	0.186	0.172	**0.179**
G	7.1	70	4508	100	6688				0.195	0.187	0.191
	7.2	69	4763	90	6715				0.180	0.166	0.173
	7.3	50	4510	85	6669	1.0885	0.8115		0.134	0.157	0.145
	Avg	63	4594	92	6691	1.0885	0.8115	0.95	0.170	0.170	**0.170**
H	8.1	70	4540	95	6684				0.193	0.177	0.185
	8.2	58	4507	80	6702				0.158	0.146	0.152
	8.3	60	4547	80	6689	1.0925	0.8095		0.163	0.146	0.154
	Avg	63	4531	85	6692	1.0925	0.8095	0.951	0.171	0.156	**0.164**
I	9.1	72	4519	100	6679				0.200	0.187	0.193
	9.2	65	4516	91	6700				0.179	0.168	0.173
	9.3	58	4502	86	6689	1.097	0.813		0.158	0.158	0.158
	Avg	65	4512	92	6689	1.097	0.813	0.955	0.179	0.171	**0.175**
J	10.1	79	4482	100	6692				0.223	0.186	0.204
	10.2	65	4542	90	6670				0.178	0.166	0.172
	10.3	55	4529	82	6693	1.097	0.812		0.148	0.150	0.149
	Avg	66	4518	91	6685	1.097	0.812	0.9545	0.183	0.167	**0.175**
K	11.1	70	4556	99	6707				0.193	0.185	0.189
	11.2	59	4563	89	6681				0.160	0.165	0.163
	11.3	57	4563	73	6670	1.07	0.812		0.154	0.133	0.143
	Avg	62	4561	87	6686	1.07	0.812	0.941	0.169	0.161	**0.165**
L	12.1	68	4526	98	6689				0.189	0.184	0.186
	12.2	52	4509	81	6668				0.141	0.149	0.145
	12.3	50	4538	78	6654	1.07	0.813		0.134	0.143	0.139
	Avg	57	4524	86	6670	1.07	0.813	0.9415	0.154	0.159	**0.157**
M	13.1	68	4498	91	6707				0.188	0.167	0.178
	13.2	53	4504	81	6692				0.143	0.147	0.145
	13.3	50	4504	80	6711	1.1025	0.8135		0.134	0.145	0.139
	Avg	57	4502	84	6703	1.1025	0.8135	0.958	0.155	0.153	**0.154**
N	14.1	61	4484	90	6723				0.166	0.163	0.164
	14.2	56	4499	81	6680				0.150	0.146	0.148
	14.3	50	4516	79	6717	1.145	0.81		0.132	0.141	0.136
	Avg	56	4500	83	6707	1.145	0.81	0.9775	0.149	0.150	**0.150**
O	15.1	70	4541	94	6661				0.194	0.176	0.185
	15.2	60	4513	87	6692				0.165	0.161	0.163
	15.3	52	4514	79	6701	1.0785	0.8105		0.140	0.144	0.142
	Avg	61	4523	87	6685	1.0785	0.8105	0.9445	0.166	0.160	**0.163**
P	16.1	69	4521	90	6697				0.191	0.166	0.179
	16.2	60	4519	86	6683				0.164	0.158	0.161
	16.3	59	4555	82	6697	1.086	0.8115		0.160	0.150	0.155
	Avg	63	4532	86	6692	1.086	0.8115	0.94875	0.172	0.158	**0.165**
	AVG	60	4442	87	6690			0.950	0.168	0.161	**0.164**

Standard Deviation	0.022560667	0.01481	0.019275
95% +-	0.006550935	0.0043	0.0039055
99% +-	0.008741857	0.005739	0.0051711

DDS-COF-TP-0060 ENCLOSURE (1)									DATE:	1/4/2023 & 1/5/2023	
LUBRICANT:	CHRISTOLUBE MCG111			BOLT PROPERTIES:					TARGETS:		
SIZE:	1.00-8UNC-2A	TPI:	8	Nominal Diameter (in):	1.00		LEAD ANGLE (Deg)(B1.1):				
BOLT MATERIAL:	CRES 316 MIL-DTL-1222 / ASTM F593 GR 2 COND A			Yield Strength (ksi):	30	MIL-DTL-1222	2.480			1/3Y	2/3Y
NUT MATERIAL:	CRES 304 MIL-DTL-1222 / UNS S30400			Tensile Stress Area (in^2):	0.606	ASME B1.1	Em (in) (B1.1):		PRELOAD (LBS)	6060	12120
WASHER MATERIAL:	CRES 316 FF-W-92			Torque Coefficient (assumed):	0.209	S9086-CJ-STM-010	0.919		EST. TORQUE (FT-LB)	106	211

Fastener No.	Trial	1/3 Yield Strength		2/3 Yield Strength		Crush Diameter			COF (Method 2)		
		Torque (ft lbs)	Preload (lbs)	Torque (ft lbs)	Preload (lbs)	Dco (in)	Dci (in)	Dc (in)	1/3Y	2/3Y	AVG
A	1.1	126	6044	238	12140				0.199	0.186	0.193
	1.2	99	6083	209	12154				0.152	0.161	0.157
	1.3	95	6081	200	12154	1.4215	1.06		0.145	0.154	0.149
	Avg	107	6069	216	12149	1.4215	1.06	1.24075	0.165	0.167	**0.166**
B	2.1	132	6050	244	12135				0.208	0.190	0.199
	2.2	111	6092	222	12114				0.171	0.172	0.171
	2.3	102	6061	209	12147	1.4495	1.059		0.157	0.160	0.159
	Avg	115	6068	225	12132	1.4495	1.059	1.25425	0.178	0.174	**0.176**
C	3.1	125	6068	240	12125				0.195	0.186	0.191
	3.2	101	6109	216	12159				0.153	0.166	0.159
	3.3	99	6092	192	12139	1.462	1.061		0.150	0.146	0.148
	Avg	108	6090	216	12141	1.462	1.061	1.2615	0.166	0.166	**0.166**
D	4.1	131	6058	254	12150				0.206	0.198	0.202
	4.2	111	6083	225	12126				0.171	0.174	0.173
	4.3	119	6435	218	12136	1.444	1.068		0.174	0.168	0.171
	Avg	120	6192	232	12137	1.444	1.068	1.256	0.183	0.180	**0.182**
E	5.1	130	6034	243	12160				0.205	0.189	0.197
	5.2	105	6054	215	12166				0.162	0.165	0.163
	5.3	105	6069	210	12163	1.454	1.06		0.161	0.161	0.161
	Avg	113	6052	223	12163	1.454	1.06	1.257	0.176	0.172	**0.174**
F	6.1	121	6078	242	12233				0.191	0.190	0.190
	6.2	100	6067	205	12074				0.155	0.161	0.158
	6.3	93	6125	194	12120	1.376	1.0615		0.142	0.150	0.146
	Avg	105	6090	214	12142	1.376	1.0615	1.21875	0.163	0.167	**0.165**
G	7.1	128	6067	235	12148				0.201	0.183	0.192
	7.2	104	6077	200	12118				0.160	0.153	0.157
	7.3	98	6090	200	12198	1.443	1.061		0.149	0.152	0.151
	Avg	110	6078	212	12155	1.443	1.061	1.252	0.170	0.163	**0.166**
H	8.1	130	6084	254	12150				0.203	0.198	0.201
	8.2	104	6054	209	12107				0.160	0.161	0.161
	8.3	92	6046	184	12085	1.45	1.06		0.140	0.140	0.140
	Avg	109	6061	216	12114	1.45	1.06	1.255	0.168	0.167	**0.167**
I	9.1	115	6031	225	12109				0.179	0.174	0.176
	9.2	112	6074	202	12294				0.172	0.152	0.162
	9.3	100	6102	192	12154	1.4725	1.059		0.151	0.145	0.148
	Avg	109	6069	206	12186	1.4725	1.059	1.26575	0.167	0.157	**0.162**
J	10.1	129	6071	235	12122				0.202	0.182	0.192
	10.2	110	6043	213	12158				0.170	0.163	0.167
	10.3	100	6084	200	12162	1.456	1.0625		0.152	0.152	0.152
	Avg	113	6066	216	12147	1.456	1.0625	1.25925	0.175	0.166	**0.170**
K	11.1	130	6073	250	12161				0.203	0.194	0.199
	11.2	110	6037	227	12161				0.170	0.175	0.173
	11.3	109	6049	218	12141	1.46	1.0605		0.168	0.168	0.168
	Avg	116	6053	232	12154	1.46	1.0605	1.26025	0.181	0.179	**0.180**
L	12.1	148	6056	270	12102				0.233	0.211	0.222
	12.2	119	6085	231	12119				0.183	0.178	0.180
	12.3	108	6080	210	12112	1.4935	1.056		0.165	0.160	0.163
	Avg	125	6074	237	12111	1.4935	1.056	1.27475	0.193	0.183	**0.188**
M	13.1	140	6101	279	12131				0.219	0.220	0.219
	13.2	129	6058	248	12161				0.202	0.193	0.198
	13.3	130	6070	246	12136	1.454	1.0595		0.203	0.192	0.198
	Avg	133	6076	258	12143	1.454	1.0595	1.25675	0.208	0.201	**0.205**
N	14.1	138	6052	267	12145				0.218	0.210	0.214
	14.2	106	8080	222	12139				0.119	0.172	0.145
	14.3	99	6102	198	12138	1.4415	1.06		0.151	0.151	0.151
	Avg	114	6745	229	12141	1.4415	1.06	1.25075	0.158	0.178	**0.168**
O	15.1	133	6039	259	12127				0.210	0.203	0.206
	15.2	110	6053	227	12142				0.170	0.176	0.173
	15.3	101	6103	208	12157	1.451	1.059		0.154	0.159	0.157
	Avg	115	6065	231	12142	1.451	1.059	1.255	0.178	0.179	**0.179**
P	16.1	134	6065	255	12173				0.210	0.198	0.204
	16.2	100	6085	210	12145				0.152	0.161	0.156
	16.3	90	6052	187	12141	1.461	1.06		0.136	0.142	0.139
	Avg	108	6067	217	12153	1.461	1.06	1.2605	0.166	0.167	**0.167**
	AVG	114	6120	224	12144			1.255	0.175	0.173	**0.174**

Standard Deviation	0.026491657	0.019868	0.023195173
95% +-	0.007692375	0.005769	0.004699779
99% +-	0.010265046	0.007698	0.006222752

DDS-COF-TP-0060 ENCLOSURE (1)								DATE:	1/6/2023	
LUBRICANT:	CHRISTOLUBE MCG111			BOLT PROPERTIES:				TARGETS:		
SIZE:	1.25-7UNC-2A	TPI:	7	Nominal Diameter (in):	1.25		LEAD ANGLE (Deg)(B1.1):			
BOLT MATERIAL:	CRES 316 MIL-DTL-1222 / ASTM F593 GR 2 COND A			Yield Strength (ksi):	30	MIL-DTL-1222	2.250		1/3Y	2/3Y
NUT MATERIAL:	CRES 304 MIL-DTL-1222 / UNS S30400			Tensile Stress Area (in^2):	0.969	ASME B1.1	Em (in) (B1.1):	PRELOAD (LBS)	9690	19380
WASHER MATERIAL:	CRES 316 FF-W-92			Torque Coefficient (assumed):	0.208	S9086-CJ-STM-010	1.157	EST. TORQUE (FT-LB)	210	420

Fastener No.	Trial	1/3 Yield Strength		2/3 Yield Strength		Crush Diameter			COF (Method 2)		
		Torque (ft lbs)	Preload (lbs)	Torque (ft lbs)	Preload (lbs)	Dco (in)	Dci (in)	Dc (in)	1/3Y	2/3Y	AVG
A	1.1	235	9704	476	19379				0.182	0.185	0.184
	1.2	212	9740	416	19386				0.162	0.160	0.161
	1.3	219	9707	388	19381	1.8075	1.369		0.169	0.148	0.159
	Avg	222	9717	427	19382	1.8075	1.369	1.58825	0.171	0.164	**0.168**
B	2.1	240	9691	459	19381				0.186	0.177	0.182
	2.2	229	9715	407	19381				0.177	0.156	0.166
	2.3	210	9667	392	19381	1.8215	1.374		0.162	0.149	0.155
	Avg	226	9691	419	19381	1.8215	1.374	1.59775	0.175	0.161	**0.168**
C	3.1	251	9694	490	19380				0.196	0.191	0.193
	3.2	239	9709	462	19381				0.185	0.179	0.182
	3.3	227	9690	455	19381	1.806	1.378		0.176	0.176	0.176
	Avg	239	9698	469	19381	1.806	1.378	1.592	0.186	0.182	**0.184**
D	4.1	263	9742	492	19379				0.205	0.192	0.198
	4.2	223	9694	436	19381				0.172	0.168	0.170
	4.3	204	9710	379	19381	1.8	1.3775		0.156	0.144	0.150
	Avg	230	9715	436	19380	1.8	1.3775	1.58875	0.178	0.168	**0.173**
E	5.1	233	9724	459	19381				0.180	0.177	0.178
	5.2	226	9678	427	19380				0.175	0.164	0.169
	5.3	210	9727	416	19451	1.822	1.378		0.160	0.159	0.160
	Avg	223	9710	434	19404	1.822	1.378	1.6	0.172	0.167	**0.169**
F	6.1	221	9727	442	19381				0.169	0.170	0.170
	6.2	201	9705	406	19383				0.153	0.155	0.154
	6.3	215	9739	388	19379	1.83	1.3745		0.164	0.147	0.156
	Avg	212	9724	412	19381	1.83	1.3745	1.60225	0.162	0.158	**0.160**
G	7.1	250	9695	469	19380				0.194	0.181	0.188
	7.2	219	9683	433	19380				0.168	0.166	0.167
	7.3	227	9681	436	19380	1.8355	1.3735		0.175	0.167	0.171
	Avg	232	9686	446	19380	1.8355	1.3735	1.6045	0.179	0.172	**0.175**
H	8.1	251	9709	474	19380				0.195	0.184	0.189
	8.2	217	10062	410	19380				0.160	0.157	0.159
	8.3	187	9694	356	19381	1.8155	1.3775		0.142	0.134	0.138
	Avg	218	9822	413	19380	1.8155	1.3775	1.5965	0.166	0.158	**0.162**
I	9.1	241	9700	476	19383				0.187	0.185	0.186
	9.2	240	9693	454	19381				0.187	0.176	0.181
	9.3	245	9705	444	19381	1.8055	1.376		0.191	0.172	0.181
	Avg	242	9699	458	19382	1.8055	1.376	1.59075	0.188	0.177	**0.183**
J	10.1	254	9703	486	19381				0.199	0.190	0.194
	10.2	206	9675	417	19380				0.159	0.161	0.160
	10.3	200	9699	379	19380	1.7885	1.373		0.153	0.145	0.149
	Avg	220	9692	427	19380	1.7885	1.373	1.58075	0.170	0.165	**0.168**
K	11.1	261	9699	475	19381				0.205	0.185	0.195
	11.2	221	9690	405	19380				0.171	0.156	0.163
	11.3	206	9707	398	19384	1.793	1.3705		0.158	0.153	0.156
	Avg	229	9699	426	19382	1.793	1.3705	1.58175	0.178	0.165	**0.171**
L	12.1	279	9726	535	19380				0.218	0.209	0.213
	12.2	301	9684	594	19480				0.237	0.232	0.235
	12.3	281	9806	501	19408	1.827	1.3725		0.218	0.195	0.206
	Avg	287	9739	543	19423	1.827	1.3725	1.59975	0.224	0.212	**0.218**
M	13.1	276	9837	492	19379				0.213	0.192	0.203
	13.2	225	9729	411	19380				0.173	0.158	0.166
	13.3	215	9729	380	19383	1.8055	1.377		0.165	0.145	0.155
	Avg	239	9765	428	19381	1.8055	1.377	1.59125	0.184	0.165	**0.174**
N	14.1	265	9697	448	19380				0.209	0.174	0.192
	14.2	225	9707	421	19381				0.175	0.163	0.169
	14.3	201	9691	403	19382	1.777	1.3695		0.155	0.155	0.155
	Avg	230	9698	424	19381	1.777	1.3695	1.57325	0.179	0.164	**0.172**
O	15.1	251	9699	462	19380				0.195	0.179	0.187
	15.2	229	9688	431	19380				0.177	0.166	0.171
	15.3	199	9701	392	19380	1.819	1.378		0.152	0.149	0.151
	Avg	226	9696	428	19380	1.819	1.378	1.5985	0.175	0.165	**0.170**
P	16.1	245	9700	448	19381				0.191	0.174	0.182
	16.2	218	9800	405	19380				0.167	0.156	0.161
	16.3	211	9690	416	19381	1.7885	1.3765		0.163	0.160	0.162
	Avg	225	9730	423	19381	1.7885	1.3765	1.5825	0.174	0.163	**0.168**
	AVG	231	9718	438	19385			1.592	0.179	0.169	**0.174**

Standard Deviation	0.020492473	0.018683	0.0200008
95% +-	0.005950394	0.005425	0.0040525
99% +-	0.007940469	0.007239	0.0053658

MONEL

DDS-COF-TP-0060 ENCLOSURE (1)								DATE:	1/10/2023 & 1/11/2023	
LUBRICANT:	CHRISTOLUBE MCG111			BOLT PROPERTIES:				TARGETS:		
SIZE:	0.50-13UNC-2A	TPI:	13	Nominal Diameter (in):	0.5		LEAD ANGLE (Deg)(B1.1):			
BOLT MATERIAL:	NICU GR 400 MIL-DTL-1222 / QQ-N-281 CL A			Yield Strength (ksi):	40	MIL-DTL-1222	3.114		1/3Y	2/3Y
NUT MATERIAL:	NICU GR 400 MIL-DTL-1222 / QQ-N-281 CL A			Tensile Stress Area (in^2):	0.1419	ASME B1.1	Em (in) (B1.1):	PRELOAD (LBS)	1892	3784
WASHER MATERIAL:	NICU GR 400 FF-W-92			Torque Coefficient (assumed):	0.188	S9086-CJ-STM-010	0.450	EST. TORQUE (FT-LB)	15	30

Fastener No.	Trial	1/3 Yield Strength		2/3 Yield Strength		Crush Diameter			COF (Method 2)		
		Torque (ft lbs)	Preload (lbs)	Torque (ft lbs)	Preload (lbs)	Dco (in)	Dci (in)	Dc (in)	1/3Y	2/3Y	AVG
A	1.1	11.5	1898	17	3783				0.106	0.073	0.089
	1.2	11.5	1932	20	3794				0.103	0.089	0.096
	1.3	10	1892	20	3781	0.71	0.53		0.089	0.090	0.090
	Avg	11	1907	19	3786	0.71	0.53	0.62	0.100	0.084	**0.092**
B	2.1	10.5	1896	24	3786				0.095	0.112	0.104
	2.2	11	1896	22	3780				0.101	0.101	0.101
	2.3	11	1919	18	3794	0.697	0.5275		0.099	0.079	0.089
	Avg	11	1904	21	3787	0.697	0.5275	0.61225	0.099	0.097	**0.098**
C	3.1	13	1897	23	3782				0.123	0.107	0.115
	3.2	11.5	1898	22	3786				0.106	0.101	0.103
	3.3	10.5	1929	20.5	3790	0.7	0.531		0.093	0.092	0.093
	Avg	12	1908	22	3786	0.7	0.531	0.6155	0.107	0.100	**0.104**
D	4.1	12	1890	24.5	3781				0.112	0.115	0.114
	4.2	12	1893	22.5	3784				0.112	0.104	0.108
	4.3	10.5	1884	20.5	3791	0.6969	0.528		0.096	0.093	0.094
	Avg	12	1889	23	3785	0.6969	0.528	0.61245	0.107	0.104	**0.105**
E	5.1	12.5	1894	23	3787				0.117	0.106	0.112
	5.2	12	1914	21	3788				0.111	0.095	0.103
	5.3	11	1902	21	3789	0.699	0.531		0.100	0.095	0.098
	Avg	12	1903	22	3788	0.699	0.531	0.615	0.109	0.099	**0.104**
F	6.1	12.5	1894	23.5	3807				0.117	0.108	0.112
	6.2	10.5	1896	21	3795				0.095	0.095	0.095
	6.3	11	1901	20	3799	0.711	0.532		0.100	0.089	0.094
	Avg	11	1897	22	3800	0.711	0.532	0.6215	0.104	0.097	**0.100**
G	7.1	13	1890	24.5	3784				0.124	0.115	0.119
	7.2	11.5	1903	23	3791				0.106	0.107	0.106
	7.3	10	1893	21	3782	0.694	0.529		0.090	0.096	0.093
	Avg	12	1895	23	3786	0.694	0.529	0.6115	0.107	0.106	**0.106**
H	8.1	12	1928	20.5	3779				0.109	0.092	0.100
	8.2	10.5	1900	20	3778				0.094	0.089	0.092
	8.3	10	1889	18.5	3781	0.7195	0.53		0.089	0.081	0.085
	Avg	11	1906	20	3779	0.7195	0.53	0.62475	0.097	0.087	**0.092**
I	9.1	14.5	1890	27	3784				0.139	0.128	0.134
	9.2	12.5	1898	22.5	3795				0.117	0.103	0.110
	9.3	12.5	1914	23	3780	0.711	0.53		0.115	0.106	0.111
	Avg	13	1901	24	3786	0.711	0.53	0.6205	0.124	0.112	**0.118**
J	10.1	12.5	1893	23	3784				0.117	0.106	0.111
	10.2	11	1892	23	3825				0.100	0.104	0.102
	10.3	11	1902	22	3783	0.7195	0.528		0.100	0.100	0.100
	Avg	12	1896	23	3797	0.7195	0.528	0.62375	0.105	0.103	**0.104**
K	11.1	10.5	1913	23	3796				0.094	0.106	0.100
	11.2	11	1899	21	3783				0.100	0.095	0.098
	11.3	10	1899	20.5	3789	0.6985	0.532		0.089	0.092	0.091
	Avg	11	1904	22	3789	0.6985	0.532	0.61525	0.095	0.098	**0.096**
L	12.1	14	1893	23.5	3785				0.134	0.109	0.122
	12.2	13	1909	23.5	3780				0.122	0.109	0.116
	12.3	11	1893	23.5	3781	0.6985	0.53		0.101	0.109	0.105
	Avg	13	1898	24	3782	0.6985	0.53	0.61425	0.119	0.109	**0.114**
M	13.1	12	1889	22	3785				0.112	0.101	0.107
	13.2	11.5	1899	21.5	3789				0.106	0.098	0.102
	13.3	10.5	1955	20	3780	0.6995	0.526		0.092	0.090	0.091
	Avg	11	1914	21	3785	0.6995	0.526	0.61275	0.103	0.097	**0.100**
N	14.1	12.5	1908	22	3784				0.116	0.101	0.108
	14.2	10.5	1892	20.5	3785				0.095	0.092	0.094
	14.3	11.5	1906	20.5	3781	0.7095	0.53		0.105	0.092	0.099
	Avg	12	1902	21	3783	0.7095	0.53	0.61975	0.105	0.095	**0.100**
O	15.1	13	1896	23.5	3790				0.122	0.109	0.116
	15.2	13	2133	21.5	3809				0.107	0.097	0.102
	15.3	11	2018	18.5	3793	0.708	0.529		0.093	0.081	0.087
	Avg	12	2016	21	3797	0.708	0.529	0.6185	0.107	0.096	**0.101**
P	16.1	14	1902	25	3782				0.133	0.117	0.125
	16.2	10	1902	24	3786				0.089	0.112	0.100
	16.3	12	1895	22	3786	0.7065	0.528		0.112	0.101	0.106
	Avg	12	1900	24	3785	0.7065	0.528	0.61725	0.111	0.110	**0.111**
	AVG	12	1909	22	3788			0.617	0.106	0.100	**0.103**

Standard Deviation	0.0126485	0.01079366	0.0120897
95% +-	0.003672742	0.00313415	0.0024496
99% +-	0.004901069	0.00418235	0.0032434

DDS-COF-TP-0060 ENCLOSURE (1)								DATE:	1/9/2023	
LUBRICANT:	CHRISTOLUBE MCG111			BOLT PROPERTIES:				TARGETS:		
SIZE:	0.75-10UNC-2A	TPI:	10	Nominal Diameter (in):	0.75		LEAD ANGLE (Deg)(B1.1):		1/3Y	2/3Y
BOLT MATERIAL:	NICU GR 400 MIL-DTL-1222 / QQ-N-281 CL A			Yield Strength (ksi):	40	MIL-DTL-1222	2.660			
NUT MATERIAL:	NICU GR 400 MIL-DTL-1222 / QQ-N-281 CL A			Tensile Stress Area (in^2):	0.334	ASME B1.1	Em (in) (B1.1):	PRELOAD (LBS)	4453	8907
WASHER MATERIAL:	NICU GR 400 FF-W-92			Torque Coefficient (assumed):	0.186	S9086-CJ-STM-010	0.685	EST. TORQUE (FT-LB)	52	104

Fastener No.	Trial	1/3 Yield Strength		2/3 Yield Strength		Crush Diameter			COF (Method 2)		
		Torque (ft lbs)	Preload (lbs)	Torque (ft lbs)	Preload (lbs)	Dco (in)	Dci (in)	Dc (in)	1/3Y	2/3Y	AVG
A	1.1	71	5101	108	8929				0.172	0.147	0.160
	1.2	52	5101	80	8913				0.121	0.105	0.113
	1.3	51	5103	91	8905	1.102	0.8085		0.119	0.122	0.120
	Avg	58	5102	93	8916	1.102	0.8085	0.95525	0.137	0.125	**0.131**
B	2.1	60	5409	84	8903				0.133	0.110	0.121
	2.2	51	5411	71	8910				0.110	0.090	0.100
	2.3	51	5399	80	8931	1.1295	0.8095		0.110	0.104	0.107
	Avg	54	5406	78	8915	1.1295	0.8095	0.9695	0.118	0.101	**0.109**
C	3.1	64	5405	93	8900				0.143	0.124	0.134
	3.2	51	5406	78	8907				0.110	0.101	0.106
	3.3	56	5398	81	8910	1.121	0.806		0.123	0.106	0.115
	Avg	57	5403	84	8906	1.121	0.806	0.9635	0.126	0.110	**0.118**
D	4.1	79	5492	102	8919				0.180	0.139	0.160
	4.2	59	5398	81	8920				0.132	0.107	0.120
	4.3	61	5420	91	8919	1.088	0.7965		0.137	0.122	0.130
	Avg	66	5437	91	8919	1.088	0.7965	0.94225	0.150	0.123	**0.136**
E	5.1	69	5411	96	8902				0.157	0.130	0.143
	5.2	50	5406	75	8908				0.109	0.098	0.103
	5.3	49	6017	72	8904	1.085	0.81		0.094	0.093	0.093
	Avg	56	5611	81	8905	1.085	0.81	0.9475	0.119	0.107	**0.113**
F	6.1	67	5412	86	8917				0.152	0.114	0.133
	6.2	51	5414	72	8916				0.111	0.093	0.102
	6.3	48	5443	71	8903	1.09	0.81		0.103	0.091	0.097
	Avg	55	5423	76	8912	1.09	0.81	0.95	0.122	0.099	**0.111**
G	7.1	80	6522	103	8943				0.150	0.140	0.145
	7.2	70	6549	81	8933				0.129	0.107	0.118
	7.3	60	6547	89	8953	1.08	0.812		0.108	0.119	0.113
	Avg	70	6539	91	8943	1.08	0.812	0.946	0.129	0.122	**0.125**
H	8.1	72	6510	99	8896				0.134	0.135	0.134
	8.2	51	6514	77	8950				0.090	0.100	0.095
	8.3	60	6506	81	8935	1.079	0.812		0.109	0.107	0.108
	Avg	61	6510	86	8927	1.079	0.812	0.9455	0.111	0.114	**0.112**
I	9.1	83	6497	110	8905				0.156	0.151	0.154
	9.2	70	6523	90	8914				0.129	0.120	0.124
	9.3	75	6496	100	8907	1.106	0.8085		0.140	0.135	0.138
	Avg	76	6505	100	8909	1.106	0.8085	0.95725	0.142	0.135	**0.138**
J	10.1	84	6501	109	8906				0.159	0.150	0.155
	10.2	69	6525	84	8902				0.127	0.112	0.119
	10.3	68	6511	98	8928	1.079	0.8125		0.125	0.133	0.129
	Avg	74	6512	97	8912	1.079	0.8125	0.94575	0.137	0.132	**0.134**
K	11.1	89	6505	113	8909				0.170	0.156	0.163
	11.2	62	6501	98	8904				0.113	0.133	0.123
	11.3	80	6516	109	8915	1.0835	0.811		0.150	0.150	0.150
	Avg	77	6507	107	8909	1.0835	0.811	0.94725	0.144	0.146	**0.145**
L	12.1	90	6492	120	8911				0.171	0.166	0.168
	12.2	70	6504	99	8902				0.129	0.134	0.131
	12.3	70	6496	101	8925	1.1065	0.8115		0.129	0.136	0.133
	Avg	77	6497	107	8913	1.1065	0.8115	0.959	0.143	0.145	**0.144**
M	13.1	90	6507	118	8908				0.171	0.163	0.167
	13.2	80	6512	110	8918				0.150	0.151	0.150
	13.3	79	6527	102	8921	1.101	0.8105		0.147	0.138	0.143
	Avg	83	6515	110	8916	1.101	0.8105	0.95575	0.156	0.151	**0.153**
N	14.1	80	6500	99	8903				0.151	0.135	0.143
	14.2	70	6481	100	8915				0.130	0.136	0.133
	14.3	76	6508	101	8912	1.0835	0.807		0.142	0.138	0.140
	Avg	75	6496	100	8910	1.0835	0.807	0.94525	0.141	0.136	**0.139**
O	15.1	80	6499	110	8895				0.150	0.151	0.150
	15.2	71	6505	96	8908				0.131	0.129	0.130
	15.3	79	6537	102	8892	1.111	0.808		0.147	0.138	0.143
	Avg	77	6514	103	8898	1.111	0.808	0.9595	0.143	0.139	**0.141**
P	16.1	83	6510	101	8920				0.155	0.135	0.145
	16.2	75	6515	100	8911				0.138	0.134	0.136
	16.3	74	6512	103	8910	1.1445	0.804		0.136	0.139	0.137
	Avg	77	6512	101	8914	1.1445	0.804	0.97425	0.143	0.136	**0.139**
	AVG	68	6093	94	8914			0.954	0.135	0.126	**0.131**
								Standard Deviation	0.021507184	0.020092	0.0210478
								95% +-	0.006245035	0.005834	0.0042647
								99% +-	0.008333652	0.007785	0.0056467

DDS-COF-TP-0060 ENCLOSURE (1)								DATE:	1/11/2023 & 1/12/2023	
LUBRICANT:	CHRISTOLUBE MCG111			BOLT PROPERTIES:				TARGETS:		
SIZE:	1.00-8UNC-2A	TPI:	8	Nominal Diameter (in):	1.00		LEAD ANGLE (Deg)(B1.1):		1/3Y	2/3Y
BOLT MATERIAL:	NICU GR 400 MIL-DTL-1222 / QQ-N-281 CL A			Yield Strength (ksi):	40	MIL-DTL-1222	2.480			
NUT MATERIAL:	NICU GR 400 MIL-DTL-1222 / QQ-N-281 CL A			Tensile Stress Area (in^2):	0.606	ASME B1.1	Em (in) (B1.1):	PRELOAD (LBS)	8080	16160
WASHER MATERIAL:	NICU GR 400 FF-W-92			Torque Coefficient (assumed):	0.185	S9086-CJ-STM-010	0.919	EST. TORQUE (FT-LB)	125	249

Fastener No.	Trial	1/3 Yield Strength		2/3 Yield Strength		Crush Diameter			COF (Method 2)		
		Torque (ft lbs)	Preload (lbs)	Torque (ft lbs)	Preload (lbs)	Dco (in)	Dci (in)	Dc (in)	1/3Y	2/3Y	AVG
A	1.1	123	8101	232	16165				0.140	0.131	0.136
	1.2	118	8098	220	16196				0.134	0.124	0.129
	1.3	125	8078	244	16154	1.432	1.062		0.143	0.139	0.141
	Avg	122	8092	232	16172	1.432	1.062	1.247	0.139	0.131	**0.135**
B	2.1	120	8079	231	16160				0.137	0.132	0.134
	2.2	120	8084	232	16160				0.137	0.132	0.135
	2.3	141	8070	257	16162	1.4155	1.0565		0.164	0.148	0.156
	Avg	127	8078	240	16161	1.4155	1.0565	1.2360	0.146	0.137	**0.142**
C	3.1	111	8073	237	16160				0.125	0.135	0.130
	3.2	112	8113	215	16160				0.126	0.121	0.123
	3.3	112	8071	224	16294	1.4395	1.061		0.126	0.125	0.126
	Avg	112	8086	225	16205	1.4395	1.061	1.25025	0.126	0.127	**0.126**
D	4.1	142	8035	240	16161				0.165	0.136	0.151
	4.2	135	8088	235	16160				0.155	0.133	0.144
	4.3	149	8079	254	16160	1.4495	1.06		0.173	0.145	0.159
	Avg	142	8067	243	16160	1.4495	1.06	1.25475	0.164	0.138	**0.151**
E	5.1	130	8082	255	16160				0.150	0.146	0.148
	5.2	129	8093	226	16160				0.148	0.128	0.138
	5.3	142	8081	256	16185	1.426	1.061		0.165	0.147	0.156
	Avg	134	8085	246	16168	1.426	1.061	1.2435	0.154	0.140	**0.147**
F	6.1	140	8111	252	16162				0.162	0.145	0.153
	6.2	132	8078	237	16160				0.153	0.135	0.144
	6.3	141	8082	247	16160	1.4135	1.063		0.164	0.142	0.153
	Avg	138	8090	245	16161	1.4135	1.063	1.23825	0.160	0.141	**0.150**
G	7.1	110	8084	209	16161				0.124	0.117	0.120
	7.2	108	8080	201	16832				0.121	0.106	0.114
	7.3	112	8072	204	16161	1.439	1.061		0.126	0.113	0.120
	Avg	110	8079	205	16385	1.439	1.061	1.25	0.124	0.112	**0.118**
H	8.1	112	8108	201	16714				0.125	0.107	0.116
	8.2	105	8081	202	16701				0.117	0.108	0.112
	8.3	109	8093	210	16250	1.4485	1.0615		0.122	0.116	0.119
	Avg	109	8094	204	16555	1.4485	1.0615	1.255	0.122	0.110	**0.116**
I	9.1	110	8088	202	16161				0.123	0.112	0.118
	9.2	102	8085	203	16711				0.113	0.108	0.111
	9.3	107	8080	217	16739	1.4475	1.059		0.120	0.117	0.118
	Avg	106	8084	207	16537	1.4475	1.059	1.25325	0.119	0.112	**0.116**
J	10.1	108	8089	202	16168				0.121	0.112	0.116
	10.2	108	8086	202	16210				0.121	0.111	0.116
	10.3	109	8088	208	16301	1.452	1.063		0.122	0.115	0.118
	Avg	108	8088	204	16226	1.452	1.063	1.2575	0.121	0.113	**0.117**
K	11.1	112	8078	200	16160				0.127	0.112	0.119
	11.2	109	8083	200	17218				0.123	0.104	0.113
	11.3	112	8085	200	16160	1.4145	1.06		0.127	0.112	0.119
	Avg	111	8082	200	16513	1.4145	1.06	1.23725	0.126	0.109	**0.117**
L	12.1	118	8086	203	16160				0.134	0.113	0.124
	12.2	101	8080	202	16283				0.113	0.112	0.112
	12.3	109	8080	200	16913	1.42	1.063		0.123	0.106	0.114
	Avg	109	8082	202	16452	1.42	1.063	1.2415	0.123	0.110	**0.117**
M	13.1	110	8079	206	16160				0.123	0.114	0.118
	13.2	106	8079	200	16667				0.118	0.106	0.112
	13.3	109	8133	200	16412	1.4675	1.063		0.121	0.108	0.114
	Avg	108	8097	202	16413	1.4675	1.063	1.26525	0.120	0.110	**0.115**
N	14.1	110	8086	208	16160				0.123	0.116	0.120
	14.2	99	8076	199	16159				0.109	0.110	0.110
	14.3	109	8072	206	16161	1.4465	1.064		0.122	0.114	0.118
	Avg	106	8078	204	16160	1.4465	1.064	1.25525	0.118	0.113	**0.116**
O	15.1	108	8084	195	16165				0.121	0.108	0.114
	15.2	102	8098	201	16158				0.113	0.112	0.112
	15.3	111	8129	205	16165	1.4435	1.0595		0.124	0.114	0.119
	Avg	107	8104	200	16163	1.4435	1.0595	1.2515	0.119	0.111	**0.115**
P	16.1	107	8066	201	16180				0.120	0.112	0.116
	16.2	100	8082	196	16179				0.111	0.108	0.110
	16.3	105	8114	196	16161	1.429	1.0615		0.117	0.109	0.113
	Avg	104	8087	198	16173	1.429	1.0615	1.24525	0.116	0.110	**0.113**
	AVG	116	8086	216	16288			1.249	0.131	0.120	**0.126**

Standard Deviation	0.016798924	0.01341826	0.015984222
95% +-	0.004877899	0.00389626	0.003238704
99% +-	0.006509285	0.00519934	0.004288213

DDS-COF-TP-0060 ENCLOSURE (1)								DATE:	1/12/2023	
LUBRICANT:	CHRISTOLUBE MCG111			BOLT PROPERTIES:				TARGETS:		
SIZE:	1.25-7UNC-2A	TPI:	7	Nominal Diameter (in):	1.25		LEAD ANGLE (Deg)(B1.1):		1/3Y	2/3Y
BOLT MATERIAL:	NICU GR 400 MIL-DTL-1222 / QQ-N-281 CL A			Yield Strength (ksi):	40	MIL-DTL-1222	2.250			
NUT MATERIAL:	NICU GR 400 MIL-DTL-1222 / QQ-N-281 CL A			Tensile Stress Area (in^2):	0.969	ASME B1.1	Em (in) (B1.1):	PRELOAD (LBS)	12920	25840
WASHER MATERIAL:	NICU GR 400 FF-W-92			Torque Coefficient (assumed):	0.184	S9086-CJ-STM-010	1.157	EST. TORQUE (FT-LB)	248	495

Fastener No.	Trial	1/3 Yield Strength		2/3 Yield Strength		Crush Diameter			COF (Method 2)		
		Torque (ft lbs)	Preload (lbs)	Torque (ft lbs)	Preload (lbs)	Dco (in)	Dci (in)	Dc (in)	1/3Y	2/3Y	AVG
A	1.1	261	12919	502	25927				0.149	0.142	0.145
	1.2	246	12922	444	25840				0.139	0.124	0.132
	1.3	258	12920	517	25841	1.836	1.3715		0.147	0.147	0.147
	Avg	255	12920	488	25869	1.836	1.3715	1.60375	0.145	0.138	**0.142**
B	2.1	235	12921	456	25841				0.133	0.129	0.131
	2.2	222	12930	436	25857				0.125	0.122	0.124
	2.3	276	12920	520	25841	1.8	1.374		0.159	0.149	0.154
	Avg	244	12924	471	25846	1.8	1.374	1.587	0.139	0.133	**0.136**
C	3.1	238	12920	549	25841				0.135	0.158	0.146
	3.2	232	12921	412	25842				0.131	0.115	0.123
	3.3	219	12921	429	25840	1.814	1.3735		0.123	0.120	0.121
	Avg	230	12921	463	25841	1.814	1.3735	1.59375	0.130	0.131	**0.130**
D	4.1	256	12921	502	25843				0.146	0.143	0.145
	4.2	263	12920	486	25840				0.151	0.138	0.144
	4.3	278	12920	531	25840	1.8115	1.375		0.160	0.152	0.156
	Avg	266	12920	506	25841	1.8115	1.375	1.59325	0.152	0.144	**0.148**
E	5.1	248	12920	460	25840				0.141	0.130	0.135
	5.2	225	12920	428	25840				0.127	0.120	0.123
	5.3	219	12920	440	25840	1.818	1.3735		0.123	0.123	0.123
	Avg	231	12920	443	25840	1.818	1.3735	1.59575	0.130	0.124	**0.127**
F	6.1	254	12920	506	25840				0.145	0.144	0.144
	6.2	262	12920	521	25841				0.150	0.149	0.149
	6.3	306	12921	581	25840	1.83	1.3755		0.177	0.167	0.172
	Avg	274	12920	536	25840	1.83	1.3755	1.60275	0.157	0.153	**0.155**
G	7.1	267	12920	495	25841				0.153	0.141	0.147
	7.2	287	12920	524	25840				0.166	0.150	0.158
	7.3	295	12920	529	25840	1.8225	1.3685		0.171	0.151	0.161
	Avg	283	12920	516	25840	1.8225	1.3685	1.5955	0.163	0.147	**0.155**
H	8.1	278	12920	513	25841				0.159	0.146	0.153
	8.2	250	12920	463	25840				0.142	0.130	0.136
	8.3	283	12920	549	25841	1.8345	1.375		0.163	0.157	0.160
	Avg	270	12920	508	25841	1.8345	1.375	1.60475	0.155	0.145	**0.150**
I	9.1	226	12921	428	25844				0.127	0.120	0.123
	9.2	230	12922	435	25840				0.130	0.122	0.126
	9.3	256	12920	481	25842	1.821	1.374		0.146	0.136	0.141
	Avg	237	12921	448	25842	1.821	1.374	1.5975	0.134	0.126	**0.130**
J	10.1	232	12921	437	25840				0.131	0.123	0.127
	10.2	208	12930	396	25842				0.116	0.110	0.113
	10.3	217	12921	438	25841	1.805	1.375		0.122	0.123	0.122
	Avg	219	12924	424	25841	1.805	1.375	1.59	0.123	0.119	**0.121**
K	11.1	256	13020	483	25841				0.145	0.137	0.141
	11.2	243	12969	463	25841				0.137	0.131	0.134
	11.3	227	12928	430	25845	1.8155	1.375		0.128	0.120	0.124
	Avg	242	12972	459	25842	1.8155	1.375	1.59525	0.137	0.129	**0.133**
L	12.1	248	12920	493	25842				0.142	0.141	0.141
	12.2	241	12970	464	25842				0.137	0.131	0.134
	12.3	263	12984	505	25841	1.8	1.37		0.150	0.144	0.147
	Avg	251	12958	487	25842	1.8	1.37	1.585	0.143	0.139	**0.141**
M	13.1	237	12921	449	25841				0.135	0.127	0.131
	13.2	222	12921	393	25841				0.125	0.109	0.117
	13.3	207	12922	424	25844	1.7915	1.375		0.116	0.119	0.117
	Avg	222	12921	422	25842	1.7915	1.375	1.58325	0.125	0.118	**0.122**
N	14.1	212	12922	389	25841				0.120	0.109	0.114
	14.2	204	12920	371	25845				0.115	0.103	0.109
	14.3	263	12921	435	25841	1.7385	1.374		0.153	0.124	0.138
	Avg	226	12921	398	25842	1.7385	1.374	1.55625	0.129	0.112	**0.121**
O	15.1	243	13153	481	25848				0.136	0.137	0.136
	15.2	230	12920	447	25840				0.130	0.126	0.128
	15.3	251	12920	477	25840	1.795	1.375		0.144	0.136	0.140
	Avg	241	12998	468	25843	1.795	1.375	1.585	0.136	0.133	**0.135**
P	16.1	254	12919	515	25840				0.145	0.147	0.146
	16.2	293	12920	546	25840				0.169	0.157	0.163
	16.3	305	12920	531	25841	1.8235	1.3745		0.177	0.152	0.164
	Avg	284	12920	531	25840	1.8235	1.3745	1.599	0.164	0.152	**0.158**
	AVG	248	12931	473	25843			1.592	0.141	0.134	**0.138**
								Standard Deviation	0.016122038	0.015007	0.0158525
								95% +-	0.004681352	0.004357	0.003212
								99% +-	0.006247003	0.005815	0.0042529

Fall Recommendations

This document consists of recommendations based on the testing that occurred over the summer. These recommendations are split into two categories: a procedural change and a few changes that do not affect the procedure. This document will be split into these two categories.

PROCEDURAL CHANGE

1)

The one procedural change that was investigated was decreasing the number of bolts that need to be tested while maintaining a high level of confidence. Through statistical analysis, it was determined that the number of bolts could be decreased. The following equation was used:

$$CI = \frac{t(s)}{\sqrt{n}}$$

Where CI is the confidence interval, t is the t-value for the specific percentage and for 96 tests, s is the standard deviation, and n is the number of tests. By confidence interval, I am solely referring to the value that is added to or subtracted from the average. This can be rewritten as:

$$n = \left(\frac{t(s)}{CI}\right)^2$$

CI is unknown because it must be chosen. In this circumstance, 5% of the average COF was determined to be a valid choice. This is because in most calculations, having a 5% error is still a reasonable answer. If that is not a reasonable choice, this can be a quick change to the MATLAB code that completed the calculations. n was determined for each of the 16 set of bolts, but since the standard deviation is based on all 96 calculations of COF, n must then be divided by six to get the sample size. Then that value was averaged for all 16 sets to get a final number of bolts. To have a 95%, 97.5%, and 99% confidence over the interval there must be 5, 6, and 9 bolts, respectively, to be tested. I am hoping to find similar results after testing more bolts in January.

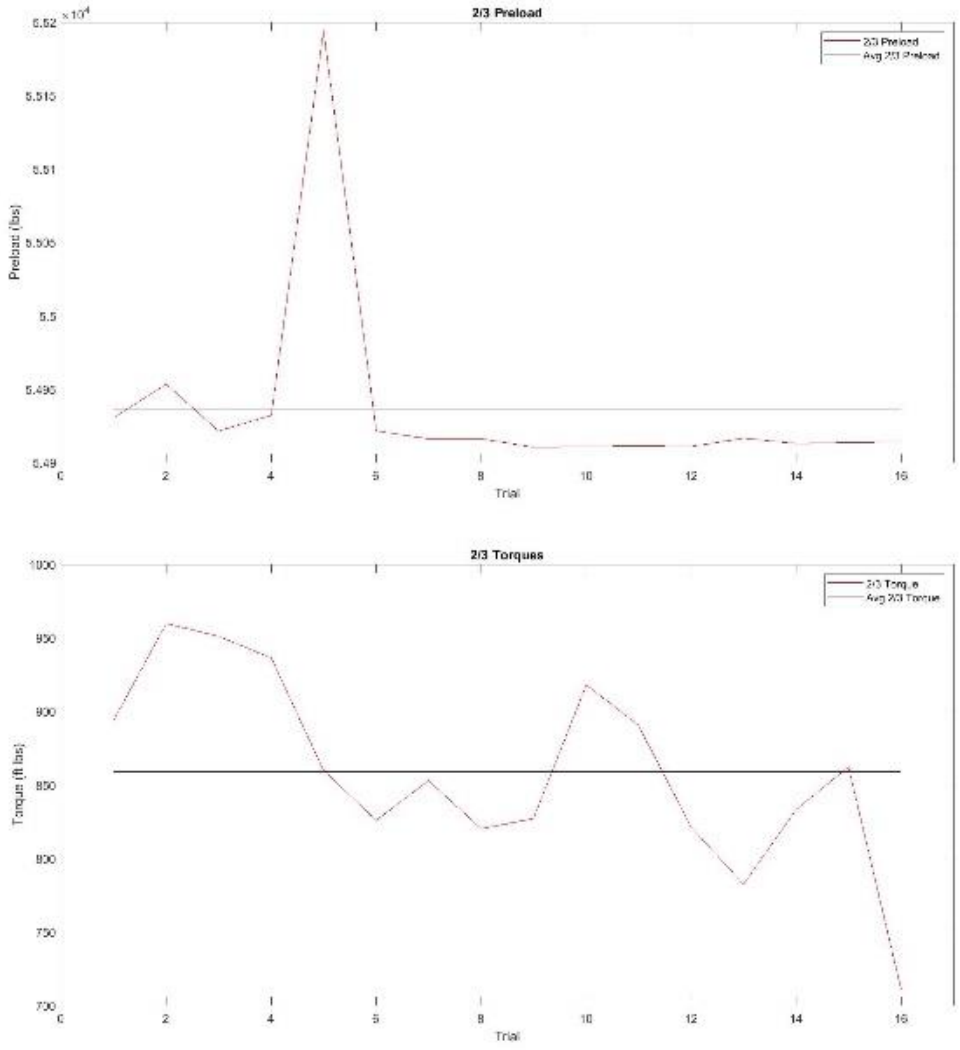
DO NOT AFFECT PROCEDURE

2)

Always have two people watching the Skidmore-Wilhelm gauge due to its rapid changes. With one person watching the gauge, they might miss the maximum preload that was reached. Two people are able to decrease the likelihood of a missed value occurring. If there is a disagreement between the two people, always go with the higher value since the maximum preload is required for COF calculations. This idea drives other recommendations, and they will be based off the requirement of two people watching the gauge.

3)

After creating graphs for all 16 set of bolts, it was shown that there was not a strong correlation between the consistency of the preloads and the calculated coefficient of friction value. Graphs of the 1/3 torque, 1/3 preload, 2/3 torque, 2/3 preload, 1/3 and 2/3 COF values, and the Average COF values were created through a MATLAB code. With these graphs and the standard deviation values on the Excel sheet, a lower standard deviation did not necessarily come from a more consistent preload value. This could be because consistent preloads do not correspond to consistent torques. An example of this is with the 1 1/4 KMONEL bolts:



The standard deviation of the COF was 0.01666 for the 2/3 yield for this type of bolt. This is on the middle to high side for the standard deviation values, yet the preload values were consistent. There was one strong outlier preload, but this did not correlate to a higher torque or a higher COF. With this information, purchasing torque wrenches, which are used for more consistent preloads, is not necessary; however, making the purchases have other benefits. Torque wrenches cause less fatigue for those involved and allow for the user to also look at the Skidmore-Wilhelm gauge. This means that a third person is not needed to run the experiment since the person using

the torque multiplier can be one of the two people who watch the gauge. I am hoping to find similar results in January after testing the second lubricant.

4)

Try to get the person who is typing the data into the excel sheet to be the main reader of the Skidmore-Wilhelm gauge when the torque multiplier is being used. This will require only two people to be testing the bolts while maintaining two set of eyes on the gauge. With the torque wrenches, it does not matter if the one typing is the main reader of the gauge because a third person must be there to test the bolts. There are two possibilities that will accomplish this goal: use a laptop that connects to the network or move the computer that is already out in the high bay for a better view of the gauge.

5)

If the expected torque falls between two wrench's ranges, choose a torque/preload value that falls into one wrench's range. The chosen 1/3 yield and 2/3 yield preload values are arbitrary, so changing the values should not alter the results of the experiment. They are arbitrary because it is the relationship between the preload and the torque that is important, not the values themselves. Making this choice before the testing begins will allow for more accuracy and consistency with the data since there is a difference in torque readings between the torque wrenches and multipliers.

6)

Once all the bolts are lubricated, which could be finished before the testing begins by those who show up first, place all the bolts on the shelf next to the testing apparatus. This will allow for easy access to the bolts, and the ones being tested will be easy distinguishable from other sets of bolts.

7)

Buy a step stool to use with the larger torque wrenches instead of using the I-beam. The I-beam works but it might not be the safest choice since it has unstable footing. A step stool will allow for more stable footing, and if it has a second step, it will grant for a larger range of movement for the torque wrench. There are multiple choices for folding step stools on McMaster, and I believe that number 3 or 4 would be the best choices. This is because it has a second step, but it also does not have anything that restricts the range of motion such as the handle on number 1 or 2. Also, I would most likely choose aluminum over fiberglass. Besides these ideas on narrowing down the choices, I do not know which aluminum step stool to choose.

Recommendation number 7 is a priority since it involves the purchasing of equipment that can easily be done before testing resumes in January. Recommendation number 3 also mentions purchasing torque multipliers, but that might not be able to be accomplished before January. Also, the torque multipliers might not be needed if a torque testing machine is purchased, but I will not have time to research those until after the January testing. The other five

recommendations do not need to be prioritized since they are small changes, for recommendations 4-6, or they need more data to make a stronger argument, for recommendation 1.

If you need more information on the data analysis arguments or wanted to discuss any of these recommendations further, please reach out with any questions.

Spring Recommendations

The first section of this document details changes during the January testing that was effective and should be continued.

1)

Using a laptop instead of a desktop. This allowed for the person who is typing to also watch the Skidmore-Wilhelm gauge which made it easier to have two people reading off the preload values. Depending on how the torque testing machine is set up and saves the data that it collects, a laptop might not be necessary, but in the meantime, it is the best option. Also, this does not require a CAC to login to and use, so interns who are waiting for their computer access can run tests.

2)

Having a clearly defined system to represent which fasteners are unwashed, washed but not cleaned with isopropyl alcohol, clean but not lubricated, lubricated but not tested, and tested. Since not every employee arrives and leaves at the same time, a system allows for an understanding with all those involved. One person could stay late washing the fasteners, but they might not have time to clean them. The person who shows up early in the morning can now continue where the other person left off without any delay or repetition of steps.

3)

Using a radio. Due to the repetitive nature of this testing, it can become mundane which can cause errors or mistakes. At the beginning of the testing in January, there was not a radio in the high bay, but during the second half, there was one. This minor addition allowed for a change of setting which helped all those participating with the testing continue to stay focused and productive for longer. It does not have to be a radio that is being used, but this type of distraction was very beneficial.

4)

Having the same core group of people. For most employees, this testing comes second to some of their other work, so those who are part of the testing can not remain completely consistent. Also, others in the office might want to participate, even if they are not able to do this every day. Having some members rotate is beneficial since it is another action that causes a change of

setting. The reason for keeping the same core group is it will cause less errors or mistakes. If there is only one person in the high bay who knows the testing procedure, then they might forget to mention one step of the process, and they can not watch over everyone's actions during testing to make sure no mistakes were made. Having two or more people who know the test well allows for new people to help while reducing the chance of mistakes.

These were not the only effective changes that were made during the January testing, but they are the less obvious to continue. The larger ultrasonic cleaner, as an example, is a very beneficial change that was made, but the continued use of this equipment is clear. I tried to make a list above of the ones that could be forgotten or changed without much thought.

The rest of this document consists of recommendations based on the testing that occurred over the summer. These recommendations are split into two categories: a procedural change and a few changes that do not affect the procedure. This document will be split into these two categories.

PROCEDURAL CHANGE

1)

From the Fall Recommendations:

The one procedural change that was investigated was decreasing the number of bolts that need to be tested while maintaining a high level of confidence. Through statistical analysis, it was determined that the number of bolts could be decreased. The following equation was used:

$$CI = \frac{t(s)}{\sqrt{n}}$$

Where CI is the confidence interval, t is the t-value for the specific percentage and for 96 tests, s is the standard deviation, and n is the number of tests. By confidence interval, I am solely referring to the value that is added to or subtracted from the average. This can be rewritten as:

$$n = \left(\frac{t(s)}{CI}\right)^2$$

CI is unknown because it must be chosen. In this circumstance, 5% of the average COF was determined to be a valid choice. This is because in most calculations, having a 5% error is still a reasonable answer. If that is not a reasonable choice, this can be a quick change to the MATLAB code that completed the calculations. n was determined for each of the 16 set of bolts, but since the standard deviation is based on all 96 calculations of COF, n must then be divided by six to get the sample size. Then that value was averaged for all 16 sets to get a final number of bolts. To have a 95%, 97.5%, and 99% confidence over the interval there must be 5, 6, and 9 bolts, respectively, to be tested. I am hoping to find similar results after testing more bolts in January.

After the January testing, the previous findings were reaffirmed. For the 95%, 97.5%, and 99%, the number of bolts that can be tested were 4, 5, and 7 bolts, respectively. This trend shows that with the 5% error, there is no need to test the full 16 bolts; 10 bolts would be more than enough. With less bolts, it would cost less money to run the test because of a decrease in man-hours and purchasing funds.

DO NOT AFFECT PROCEDURE

2)

Purchase an impact wrench such as the one in the following URL: https://www.homedepot.com/p/Milwaukee-M18-FUEL-18V-Lithium-Ion-Brushless-Cordless-1-2-in-Impact-Wrench-with-Friction-Ring-Tool-Only-2767-20/302654201#overlay. I tried to find one on McMaster, but I was unable to do so. The link above is from The Home Depot, and it goes to a Milwaukee drill which is one of brands used in the high bay. This would make it easier since the battery packs should be the same. For this purchase to be even more helpful, the 3D printed piece which holds the bolts head in place would also be used. I was unable to find this during the January testing, but Connor said this was very helpful during the summer testing. If this piece was thrown away or misplaced, it might need to be reprinted.

The reason this purchase would help the lubrication process is because of the difference from the drills in the high bay now. The current drills in the high bay have too small of an initial socket attachment which makes the sockets fall off and unsteady during drilling. A larger drill that is better built for the size of the fasteners being used would increase the stability while lubricating. Also, the air compressor has this attachment, but the air compressor would be too much power and torque which could cause damage to the bolt. The impact drill would allow for the bolt to be safely lubricated.

3)

Buy the larger size lubricant containers. The toothpaste size tubes made it much more difficult to lubricate the bolts since it was not easy to put the lubricant on the threads. The pint size container allowed for easy access to the lubricant and easy application to the bolts using a knife. I understand that there is still a large amount of TRI Marine left over from the January testing, but it might be worth dealing with an excess amount of lubricant rather than struggling to lubricate for testing.

4)

Have one of the work benches marked off for the fasteners and the testing materials. The high bay is used for various projects, so it would be helpful to have a designated space for testing. In the previous two tests, any available space was claimed for the testing, but this caused the bolts to be spread throughout the high bay. If there was one specific area, it would allow for better organization during the preparatory work and testing. Also, the bolts would not need to be moved around the high bay, so they would be less likely to be dropped or damaged in any way. For the

January testing, there was the table designated for the bolts, but it would be helpful to have the bolts, ultrasonic cleaners, and any other items in one location. With the new work bench in the high bay, this could be done much easier.

These are either new recommendations or previous recommendations which now include the new data from the January testing. Because of this, previous recommendations should also be remembered and incorporated or continued into the testing process.