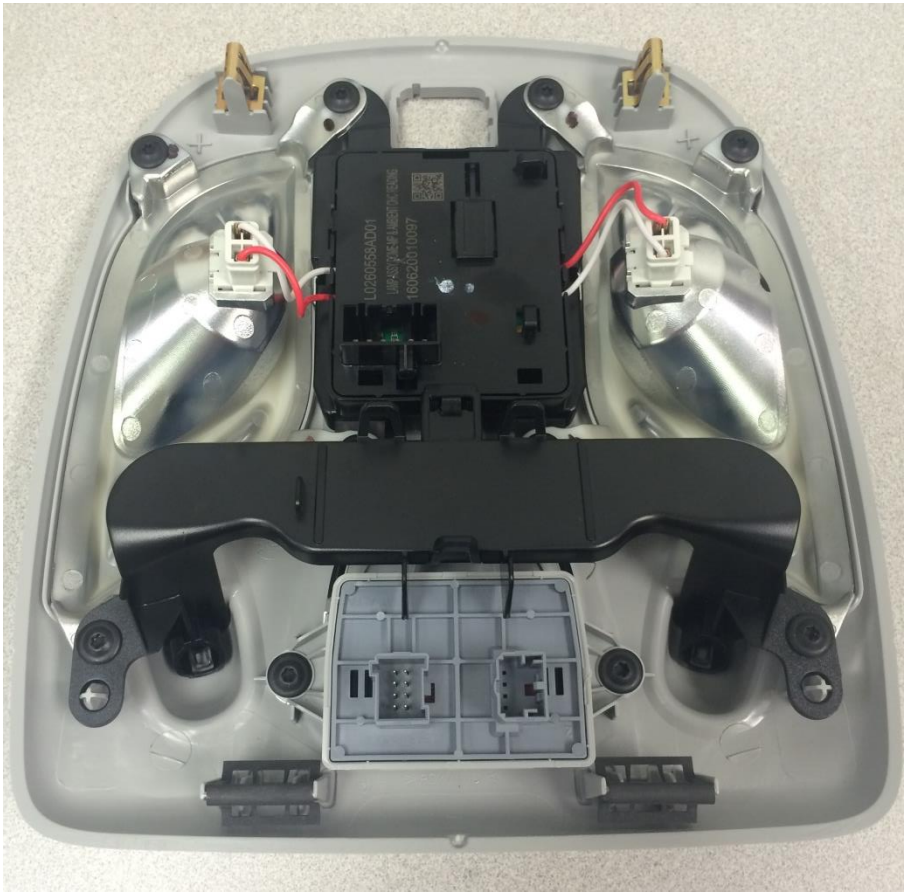
Applications Laboratory Testing Report

Tightening Torque Validation for ------ Overhead Module



Project Number: 16029

Submitted To:

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Table of Contents

INTRODUCTION **3**
PARTS TESTED **4**
Delta® 40 x 11.5 4
Figure 1: Delta® 40 x 11.5 Torx® Large Round Washer Head with T15 Torx® Recess *4*
APPLICATION **5**
Overhead Modules 5
Figure 2: Overhead Module 5211 Cavity 1(Left) and Cavity 2(Right) *5*
Table 1: Boss Dimensions and Clamp Material for 5211 Cav. 1 and 2 ..... *5*
Figure 3: Overhead Module 5212 ..... *6*
Table 2: Boss Dimensions and Clamp Material for 5212 ..... *6*
Figure 4: Overhead Module 5213 ..... *7*
Table 3: Boss Dimensions and Clamp Material for 5213 ..... *7*
Figure 5: Overhead Module 5210 Cavity 1(Left) and Cavity 2(Right) *8*
Table 4: Boss Dimensions and Clamp Material for 5210 Cav. 1 and 2 ..... *8*
TEST PREPARATION **9**
Drive & Strip Torque 9
Tightening Torque 9
Drive and Strip Torque Explanation 10
Figure 6: Drive and Strip Torque Explanation *10*
TEST RESULTS **11**
Drive and Strip Torque 11
5211 Cavity 1 and 2 11
Table 5: Drive/Strip values for 5211 Cavity 1 ..... *11*
Figure 7: Torque Over Angle for 5211 Cavity 1 ..... *12*
Table 6: Drive/Strip Values for 5211 Cavity 2 ..... *13*
Figure 8: Torque Over Angle for 5211 Cavity 2 ..... *14*
5212 15
Table 7: Drive/Strip Values for 5212 ..... *15*
Figure 9: Torque Over Angle for 5212 ..... *16*
5213 17
Table 8: Drive/Strip Values for 5213 ..... *17*
Figure 10: Torque Over Angle for 5213 ..... *18*
5210 Cavity 1 and 2 19
Table 9: Drive/Strip Values for 5210 Cavity 1 ..... *19*
Figure 10: Torque Over Angle for 5210 Cavity 1 ..... *20*
Table 10: Drive/Strip Values for 5210 Cavity 2 ..... *21*
Figure 11: Torque Over Angle For 5210 Cavity 2 ..... *22*
CONCLUSIONS **23**
RECOMMENDATIONS **24**
Table 11: Final Tightening Torque Recommendations *24*

Introduction

The ATF, Inc. Applications Lab, on behalf of ------, initiated project number 16029. The objective was to validate a tightening torque strategy for P2705137 in the overhead module. The various overhead modules, internal components of the system, and screws were provided to ATF by ------. Drive and strip torque tests were conducted to determine and validate the tightening torques. The testing procedure, results, and recommendations from ATF are described in this document.

Parts Tested

Delta® 40 x 11.5

- **ATF Part:** #P2705137
- **------ Part:** #------
- **Size**: 4 mm diameter, 11.5 mm length
- **Head Style**: Torx® Round Washer Head
- **Head Diameter**: 10.5 mm
- **Drive Style**: T15 Torx® Recess

Figure 1: Delta® 40 x 11.5 Torx® Large Round Washer Head with T15 Torx® Recess

Application

Overhead Modules

Carrier Material For All Overhead Modules (Boss): PC/ABS (Polycarbonate plus Acrylonitrile Butadiene Styrene)

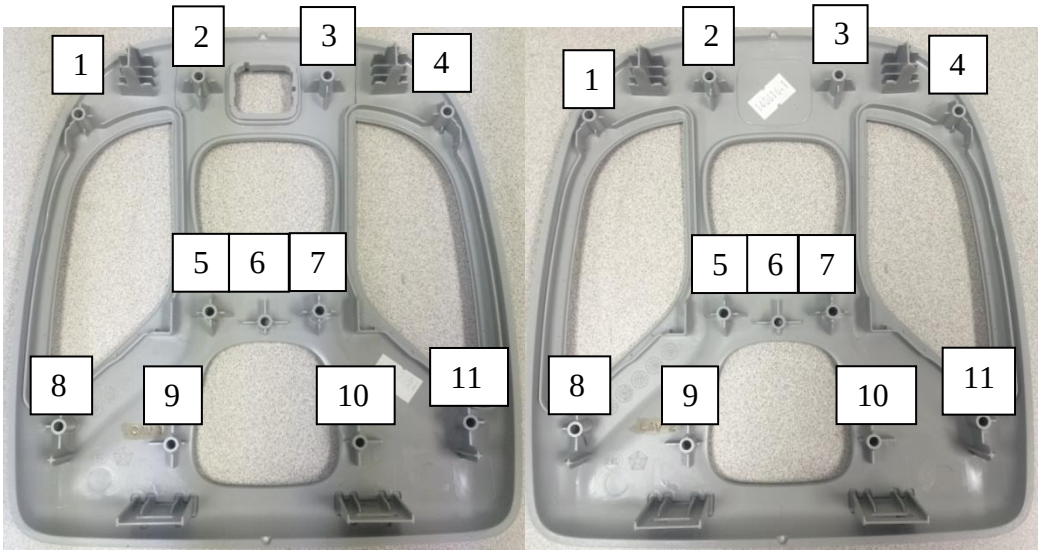

Figure 2: Overhead Module 5211 Cavity 1(Left) and Cavity 2(Right)

Table 1: Boss Dimensions and Clamp Material for 5211 Cav. 1 and 2

Part/Hole	Hole Depth	Hole Dia.	C'bore Depth	C'bore Dia.	Clamp Material
5211 Cav. 1					
1	14.21	3.44	3.29	3.90	Unknown
2	15.33	3.42	3.11	3.90	Unknown
3	15.67	3.46	3.36	3.90	Unknown
4	14.81	3.46	3.47	3.88	Unknown
5	14.80	3.46	4.47	3.90	Unknown
6	8.60	3.48	1.00	3.88	ABS/PBT-6F20
7	15.50	3.46	3.34	3.90	Unknown
8	14.74	3.40	4.50	3.90	Unknown
9	9.75	3.42	1.03	3.88	ABS/PBT-6F20
10	10.15	3.40	1.05	3.88	ABS/PBT-6F20
11	15.14	3.44	4.70	3.90	Unknown
5211 Cav. 2					
1	14.40	3.46	2.90	3.88	Unknown
2	15.56	3.46	4.38	3.90	Unknown
3	15.55	3.46	4.41	3.88	Unknown
4	14.05	3.44	2.80	3.90	Unknown
5	15.05	3.46	5.04	3.90	Unknown
6	8.42	3.44	1.50	3.88	ABS/PBT-6F20
7	15.94	3.42	4.90	3.90	Unknown
8	14.54	3.46	4.37	3.88	Unknown
9	10.40	3.46	1.25	3.88	ABS/PBT-6F20
10	9.72	3.44	1.29	3.88	ABS/PBT-6F20
11	14.84	3.46	3.75	3.90	Unknown

Figure 3: Overhead Module 5212

Table 2: Boss Dimensions and Clamp Material for 5212

Part/Hole	Hole Depth	Hole Dia.	C'bore Depth	C'bore Dia.	Clamp Material
5212					
1	14.15	3.52	4.82	3.90	Unknown
2	16.20	3.48	4.56	3.90	Unknown
3	16.02	3.46	3.36	3.90	Unknown
4	14.25	3.52	4.16	3.88	Unknown
5	15.15	3.52	4.34	3.90	Unknown
6	15.17	3.50	4.56	3.90	Unknown
7	14.20	3.44	3.43	3.88	Unknown
8	14.80	3.44	3.37	3.88	Unknown

Figure 4: Overhead Module 5213

Table 3: Boss Dimensions and Clamp Material for 5213

Part/Hole	Hole Depth	Hole Dia.	C'bore Depth	C'bore Dia.	Clamp Material
5213					
1	14.20	3.44	4.99	3.90	Unknown
2	15.74	3.46	4.84	3.90	Unknown
3	15.78	3.48	4.83	3.90	Unknown
4	14.24	3.50	4.79	3.90	Unknown
5	15.40	3.50	4.46	3.90	Unknown
6	8.24	3.52	4.35	3.88	ABS/PBT-6F20
7	16.08	3.48	4.50	3.90	Unknown
8	14.92	3.46	2.42	3.90	Unknown
9	11.05	3.42	1.19	3.88	ABS/PBT-6F20
10	10.78	3.46	2.25	3.88	ABS/PBT-6F20
11	14.92	3.44	3.12	3.88	Unknown

Figure 5: Overhead Module 5210 Cavity 1(Left) and Cavity 2(Right)

Table 4: Boss Dimensions and Clamp Material for 5210 Cav. 1 and 2

Part/Hole	Hole Depth	Hole Dia.	C'bore Depth	C'bore Dia.	Clamp Material
5210 Cav. 1					
1	14.81	3.46	4.59	3.90	Unknown
2	16.25	3.46	4.42	3.90	Unknown
3	15.71	3.44	3.32	3.90	Unknown
4	13.86	3.48	3.79	3.92	Unknown
5	15.50	3.46	3.84	3.90	Unknown
6	14.95	3.46	3.07	3.90	Unknown
7	14.28	3.42	3.28	3.90	Unknown
8	13.91	3.46	3.34	3.88	Unknown
5210 Cav. 2					
1	13.91	3.46	4.51	3.90	Unknown
2	15.78	3.46	3.51	3.90	Unknown
3	15.75	3.42	3.44	3.90	Unknown
4	14.27	3.44	4.19	3.90	Unknown
5	15.08	3.44	4.38	3.90	Unknown
6	15.05	3.46	4.49	3.90	Unknown
7	14.57	3.46	3.56	3.88	Unknown
8	14.86	3.42	3.39	3.90	Unknown

Test Preparation

Drive & Strip Torque

Driving torque and stripping torque are important in determining a joint's safety of assembly. Drive and strip torque testing is conducted by driving the fasteners into the pilot holes of each boss with an Atlas Copco electric driver, turning at a free speed of 400 rpm, until the joint fails. The torque is measured continuously throughout the driving process. The measuring apparatus consists of an Atlas Copco Tensor S4/S7 running ToolsTalk PF3000 for data acquisition. The software then collects and translates signals from the transducer into a torque vs. rotation graph. This graph is interpreted to determine the precise maximum driving and stripping torque.

Tightening Torque

The tightening torque is the torque at which it is recommended the application be assembled. The tightening torque should be sufficiently high so as to fully drive the screw and generate clamp load, yet low enough to avoid stripping and long term boss damage. An adequate safety factor to compensate for the repeat accuracy of the driver system must also be considered.

Drive and Strip Torque Explanation

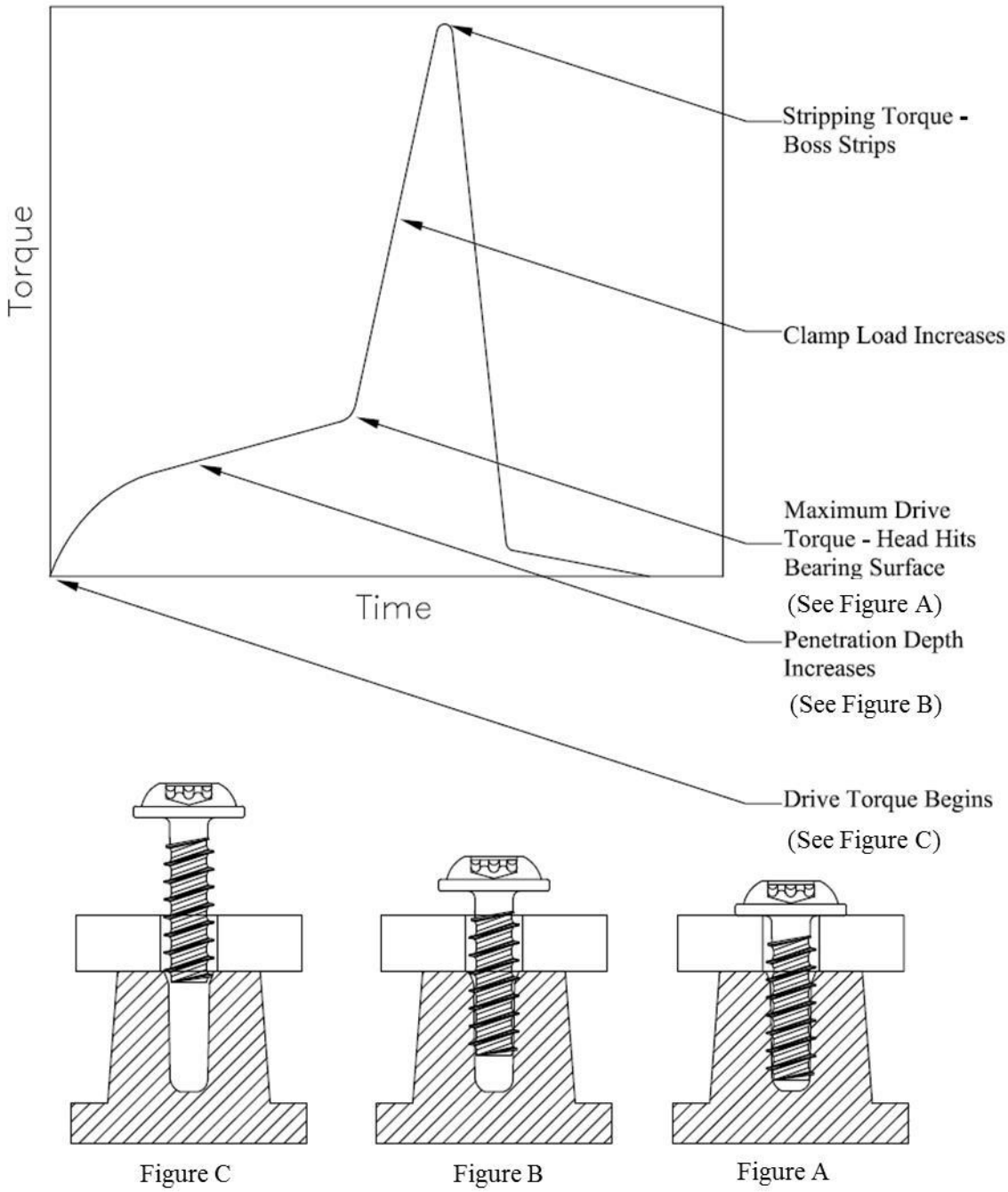

Figure 6: Drive and Strip Torque Explanation

Test Results

Drive and Strip Torque

5211 Cavity 1 and 2

Table 5: Drive/Strip values for 5211 Cavity 1

Part/Hole	Drive(N-m)	Strip(N-m)
5211 Cav. 1		
A1	0.13	2.04
A2	0.12	1.97
A3	0.13	2.15
A4	0.16	2.25
A5	0.31	2.02
A6	0.30	2.40
A7	0.17	2.08
A8	0.32	2.28
A9	0.26	2.66
A10	0.37	2.76
A11	0.25	2.44
B1	0.17	2.24
B2	0.24	2.12
B3	0.14	2.17
B4	0.98	XX
B5	XX	2.17
B6	0.30	2.69
B7	0.25	1.90
B8	0.36	2.33
B9	0.29	2.93
B10	0.28	3.03
B11	0.17	2.42
C1	0.17	2.03
C2	0.36	2.07
C3	0.29	2.42
C4	0.28	2.18
C5	0.22	2.12
C6	0.17	2.37
C7	0.17	2.34
C8	0.24	2.27
C9	0.30	2.50
C10	0.18	2.71
C11	0.13	2.45
Average	0.26	2.33
3s Max	0.7053	3.154
3s Min	0.0000	1.502
St Dev	0.1496	0.2753

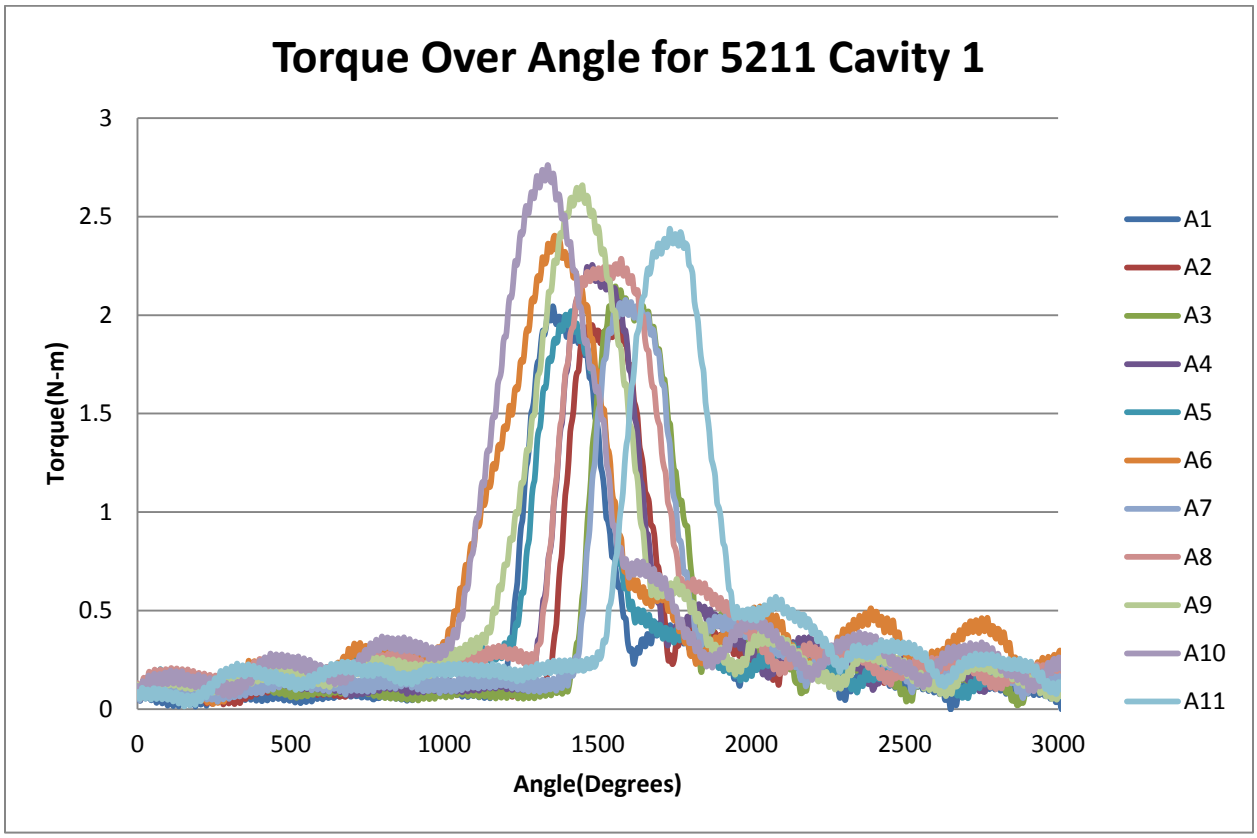

Figure 7: Torque Over Angle for 5211 Cavity 1

Table 6: Drive/Strip Values for 5211 Cavity 2

Part/Hole	Drive(N-m)	Strip(N-m)
5211 Cav. 2		
D1	0.09	2.03
D2	0.24	2.37
D3	0.20	2.36
D4	0.13	2.29
D5	0.30	1.89
D6	0.30	2.71
D7	0.25	2.14
D8	0.17	2.00
D9	0.13	2.57
D10	0.25	2.62
D11	0.17	2.13
E1	0.17	2.25
E2	0.28	2.58
E3	0.19	2.52
E4	0.14	2.44
E5	0.23	2.27
E6	0.33	2.56
E7	0.22	2.37
E8	0.26	2.40
E9	0.18	2.82
E10	0.27	2.50
E11	0.21	2.40
F1	0.31	2.26
F2	0.39	2.16
F3	0.15	2.26
F4	0.17	2.18
F5	0.14	2.29
F6	0.31	2.52
F7	0.33	2.20
F8	0.40	2.29
F9	0.34	2.44
F10	0.32	2.46
F11	0.17	2.13
Average	0.23	2.35
3s Max	0.4728	2.962
3s Min	0.0000	1.730
St Dev	0.0794	0.2053

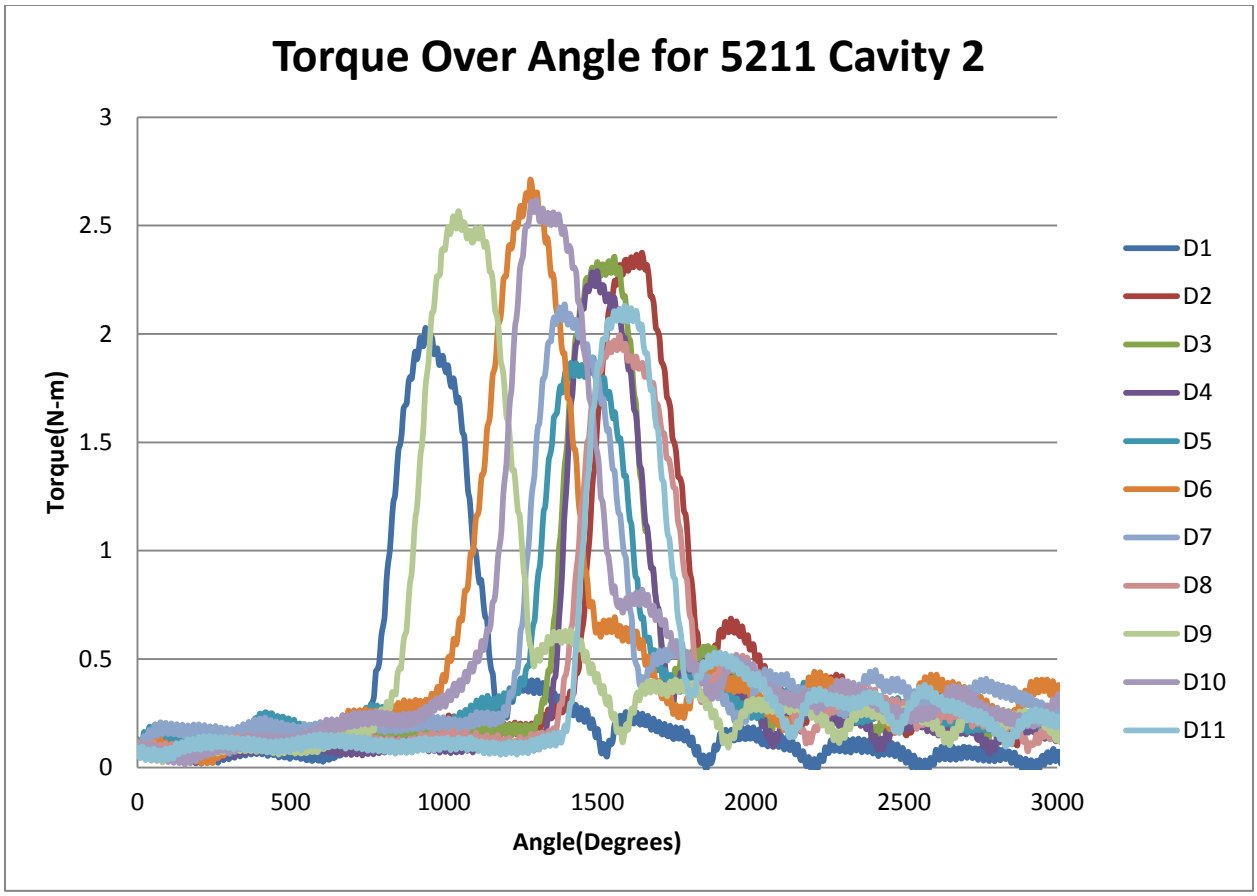

Figure 8: Torque Over Angle for 5211 Cavity 2

5212

Table 7: Drive/Strip Values for 5212

Part/Hole	Drive(N-m)	Strip(N-m)
5212		
G1	0.19	1.77
G2	0.28	2.17
G3	0.33	2.22
G4	0.38	2
G5	0.36	2.08
G6	0.24	1.85
G7	0.4	2.23
G8	0.2	2.34
H1	0.37	1.92
H2	0.23	2.05
H3	0.19	2.29
H4	0.23	2.09
H5	0.43	2.23
H6	0.42	2
H7	0.32	2.72
H8	0.26	2.48
I1	0.36	2.07
I2	0.34	1.98
I3	0.26	2.39
I4	0.38	2.21
I5	0.18	2.23
I6	0.29	2.11
I7	0.27	2.53
I8	0.22	2.64
Average	0.30	2.19
3s Max	0.5278	2.891
3s Min	0.0664	1.492
St Dev	0.0769	0.2332

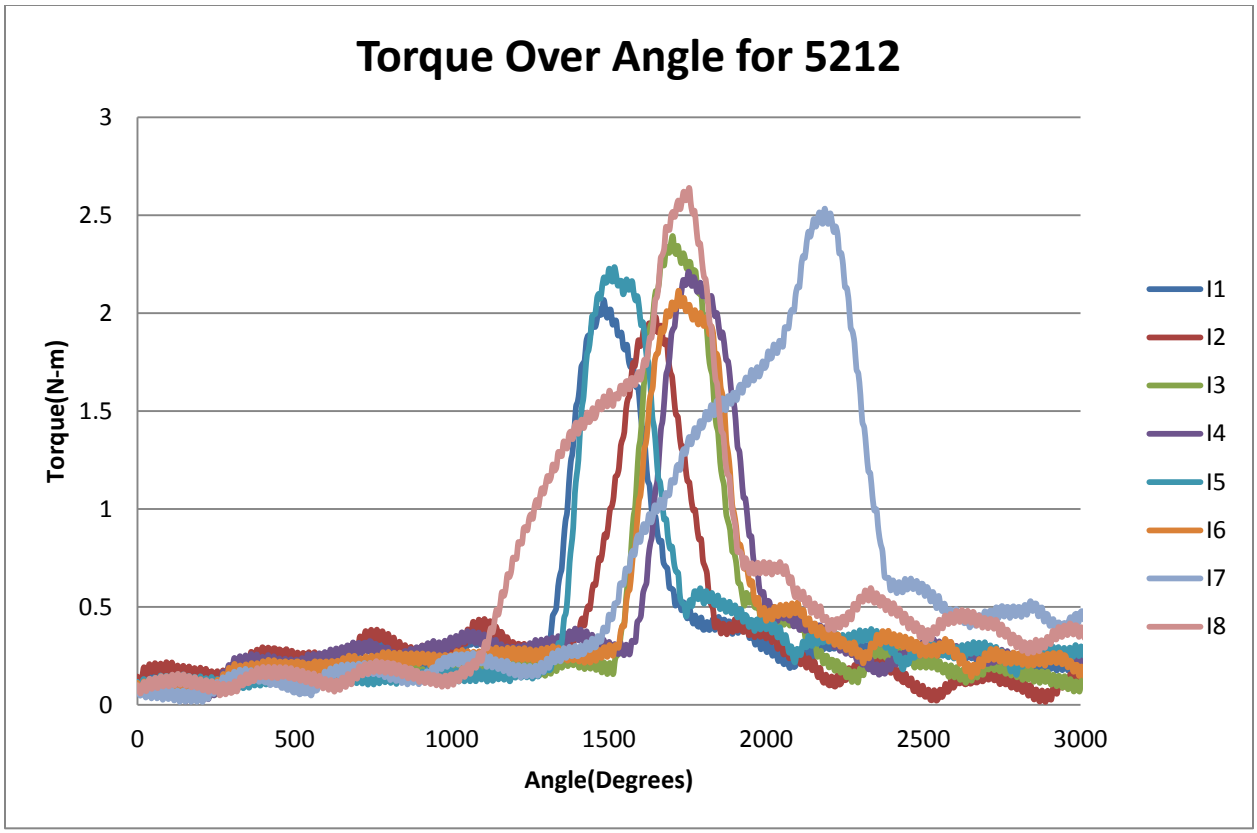

Figure 9: Torque Over Angle for 5212

5213

Table 8: Drive/Strip Values for 5213

Part/Hole	Drive(N-m)	Strip(N-m)
5213		
J1	0.26	2.36
J2	0.35	2.21
J3	0.31	2.2
J4	0.18	2.21
J5	0.33	2.47
J6	0.28	2.5
J7	0.28	2.27
J8	0.19	2.69
J9	0.21	2.55
J10	0.32	2.72
J11	0.36	2.67
K1	0.29	2.27
K2	0.43	2.42
K3	0.41	2.5
K4	0.23	2.25
K5	0.46	2.38
K6	0.4	2.3
K7	0.33	2.06
K8	0.32	2.59
K9	0.26	2.2
K10	0.42	2.28
K11	0.3	2.91
L1	0.24	2.3
L2	0.21	2.17
L3	0.13	2.35
L4	0.17	2.25
L5	0.33	2.25
L6	0.27	2.49
L7	0.24	2.12
L8	0.34	2.63
L9	0.34	2.77
L10	0.29	2.5
L11	0.2	2.73
Average	0.29	2.40
3s Max	0.5304	3.046
3s Min	0.0562	1.747
St Dev	0.0790	0.2166

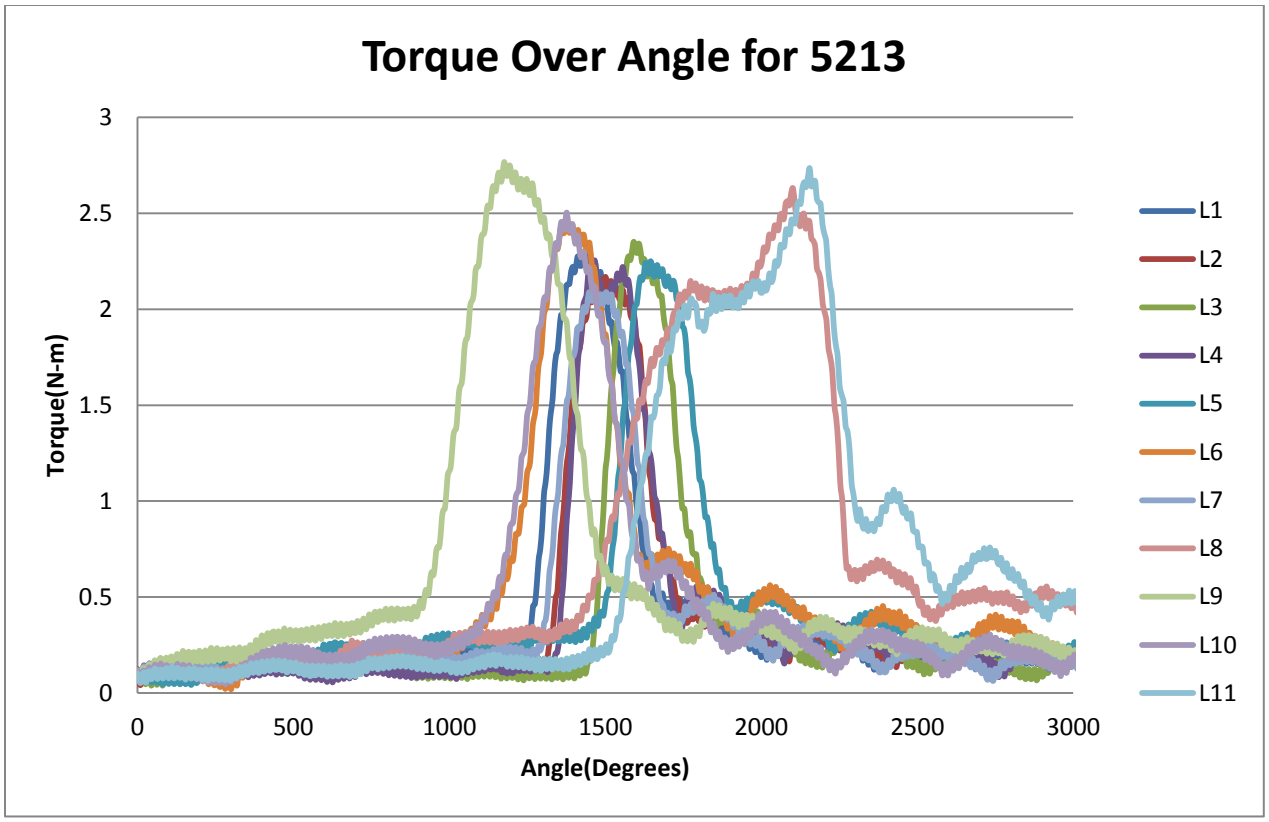

Figure 10: Torque Over Angle for 5213

5210 Cavity 1 and 2

Table 9: Drive/Strip Values for 5210 Cavity 1

Part/Hole	Drive(N-m)	Strip(N-m)
5210 Cav. 1		
M1	0.17	1.81
M2	0.25	2.01
M3	0.27	2.31
M4	0.24	2.01
M5	0.22	2.05
M6	0.23	2.03
M7	0.35	1.81
M8	0.24	1.88
N1	0.27	1.91
N2	0.30	2.13
N3	0.35	2.46
N4	0.28	2.08
N5	0.30	2.18
N6	0.26	1.95
N7	0.41	1.97
N8	0.29	2.06
O1	0.37	1.94
O2	0.39	2.29
O3	0.44	2.6
O4	0.36	2.44
O5	0.32	1.93
O6	0.38	2.21
O7	0.36	2.05
O8	0.29	1.87
Average	0.31	2.08
3s Max	0.5041	2.699
3s Min	0.1076	1.466
St Dev	0.0661	0.2057

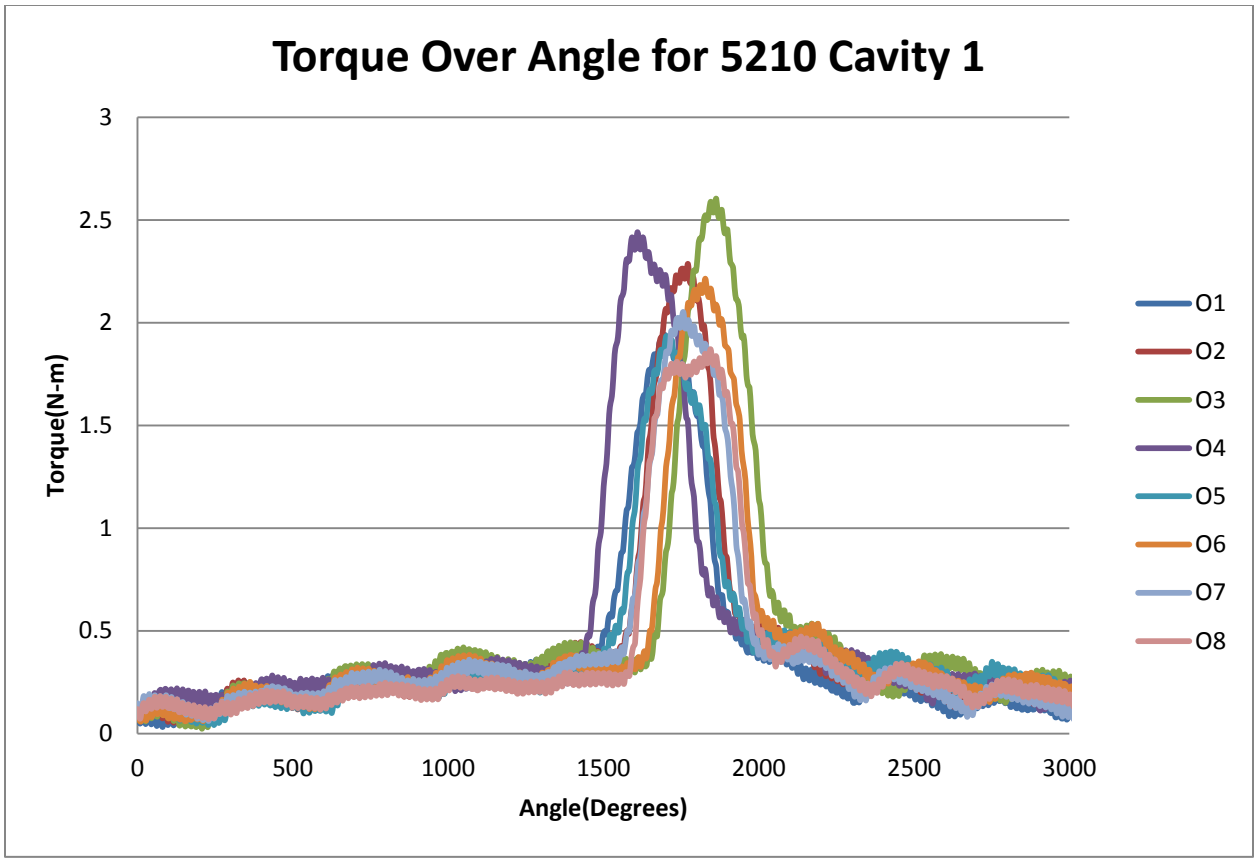

Figure 10: Torque Over Angle for 5210 Cavity 1

Table 10: Drive/Strip Values for 5210 Cavity 2

Part/Hole	Drive(N-m)	Strip(N-m)
5210 Cav. 2		
P1	0.42	2.10
P2	0.45	2.01
P3	0.37	2.11
P4	0.31	1.91
P5	0.37	1.96
P6	0.31	1.93
P7	0.36	2.21
P8	0.35	1.98
Q1	0.40	1.98
Q2	0.30	1.93
Q3	0.31	2.21
Q4	0.33	2.03
Q5	0.32	2.21
Q6	0.26	1.87
Q7	0.41	2.31
Q8	0.25	1.90
R1	0.36	1.99
R2	0.33	2.05
R3	0.37	1.96
R4	0.36	1.95
R5	0.31	2.37
R6	0.37	1.68
R7	0.30	2.10
R8	0.24	1.91
Average	0.34	2.03
3s Max	0.4947	2.479
3s Min	0.1853	1.576
St Dev	0.0516	0.1506

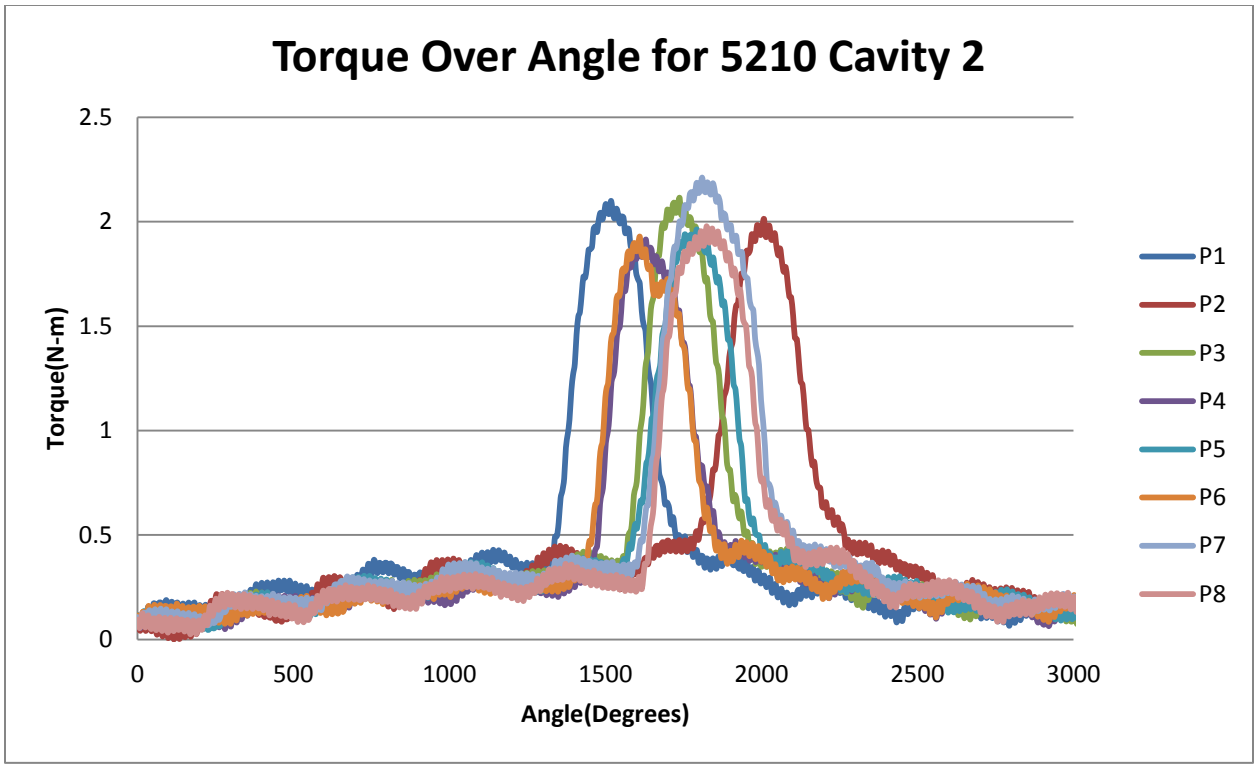

Figure 11: Torque Over Angle For 5210 Cavity 2

Conclusions

The objective for this series of testing was to validate the tightening torques of ATF P2705137 fastener in the ------ overhead modules. Initially the boss dimensions and tightening torques were recommended using Delta Calc to ------ by ATF. ------ made changes to the original design to correct issues found during fastener installation. The results shown from the drive/strip testing and from gaging the holes of the new parts were favorable and met the initial recommendations of ATF.

Based on the performance of the screws, the ATF Applications Lab feels that optimal performance will be achieved if the recommendations stated in the next section are met.

Recommendations

Upon completion of all testing and analysis the ATF, Inc. Applications Lab has made the following recommendations:

Table 11: Final Tightening Torque Recommendations

Driver Speed=400 RPM
Recommended Tightening Torque (Nm)
1.10 ±0.11

LIABILITY STATEMENT

The information and technical advice contained herein is given to the best of our knowledge according to the state of technology at the time of this test. It is presented to our customers with the intention of aiding them in improving their product. However, please understand that since differences exist between the laboratory and mass production, we cannot guarantee a specific performance or accept any liability.