Torque in HDD connections before and after wear

Dimitrios Katsareas
Mechanical Engineer, MSc, PhD for
PREMIER DRILL PIPE

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Summary

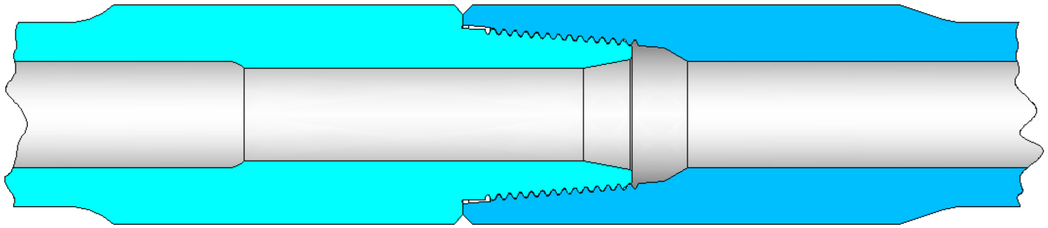
Make-up and *Yield* (*Maximum / Limit*) *torques* are two of the most important characteristics, that define the *load capacity of HDD*.

It is demonstrated how API drill pipe torque calculations can be adapted to calculate torque in HDD.

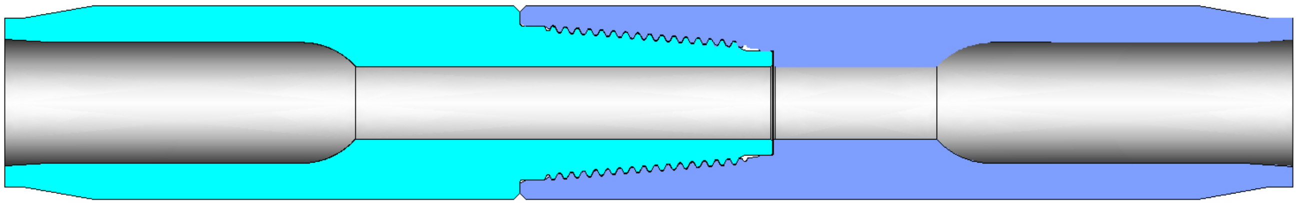
It is also shown how the torque formula can be modified to calculate torque in double-shouldered connections.

Finally, it is illustrated how tool joint outer diameter wear affects torque and how this information can be of use to the operator.

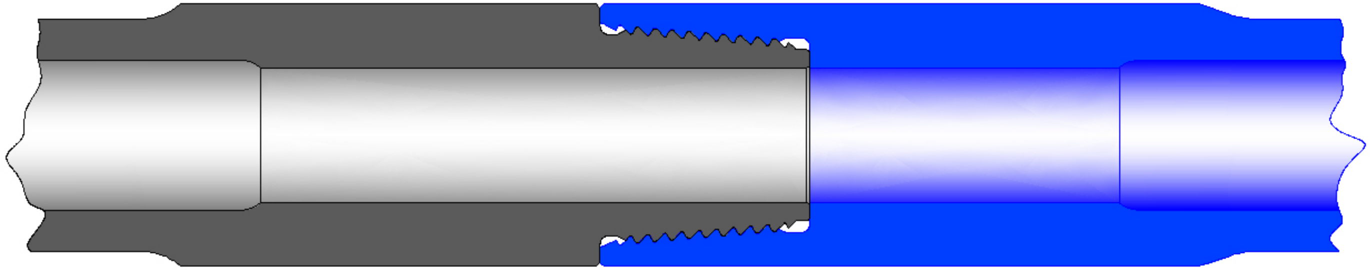
HDD connections vs. OCTG Drill Pipe connections



API Drill Pipe connection



DitchWitch HDD connection

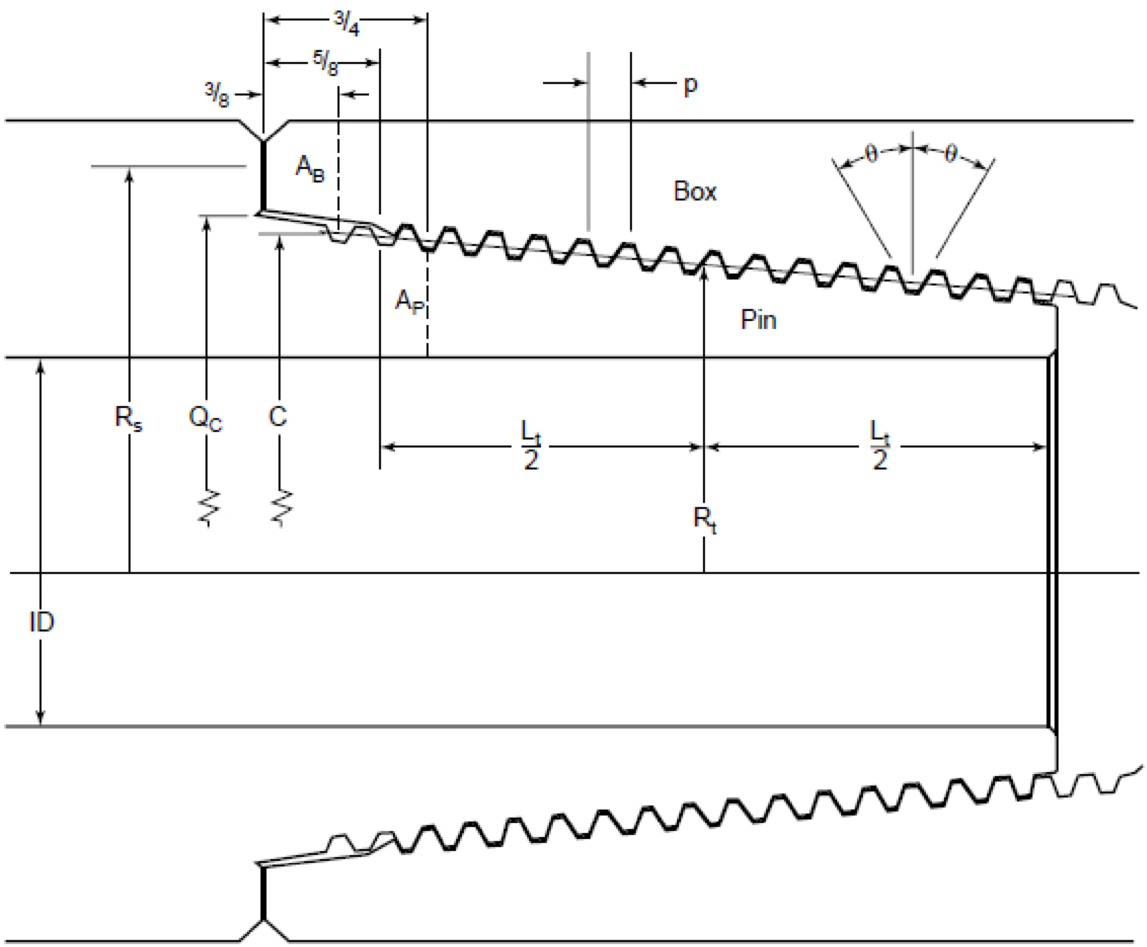


Vermeer HDD connection

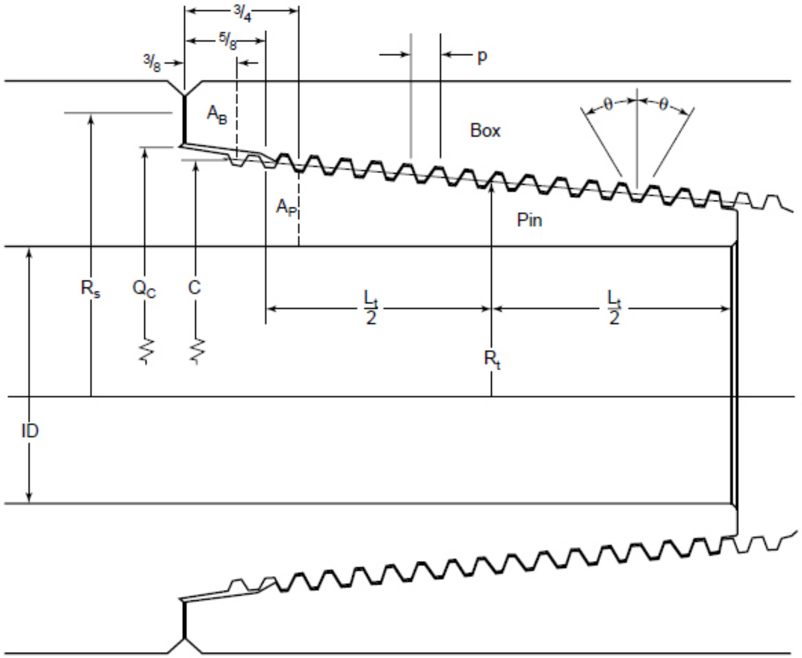
friction translates to torque

The screwjack formula

$$Ta = \frac{S}{12} A_M \left(\frac{p}{2\pi} + \frac{R_t f}{\cos\theta} + R_s f \right)$$



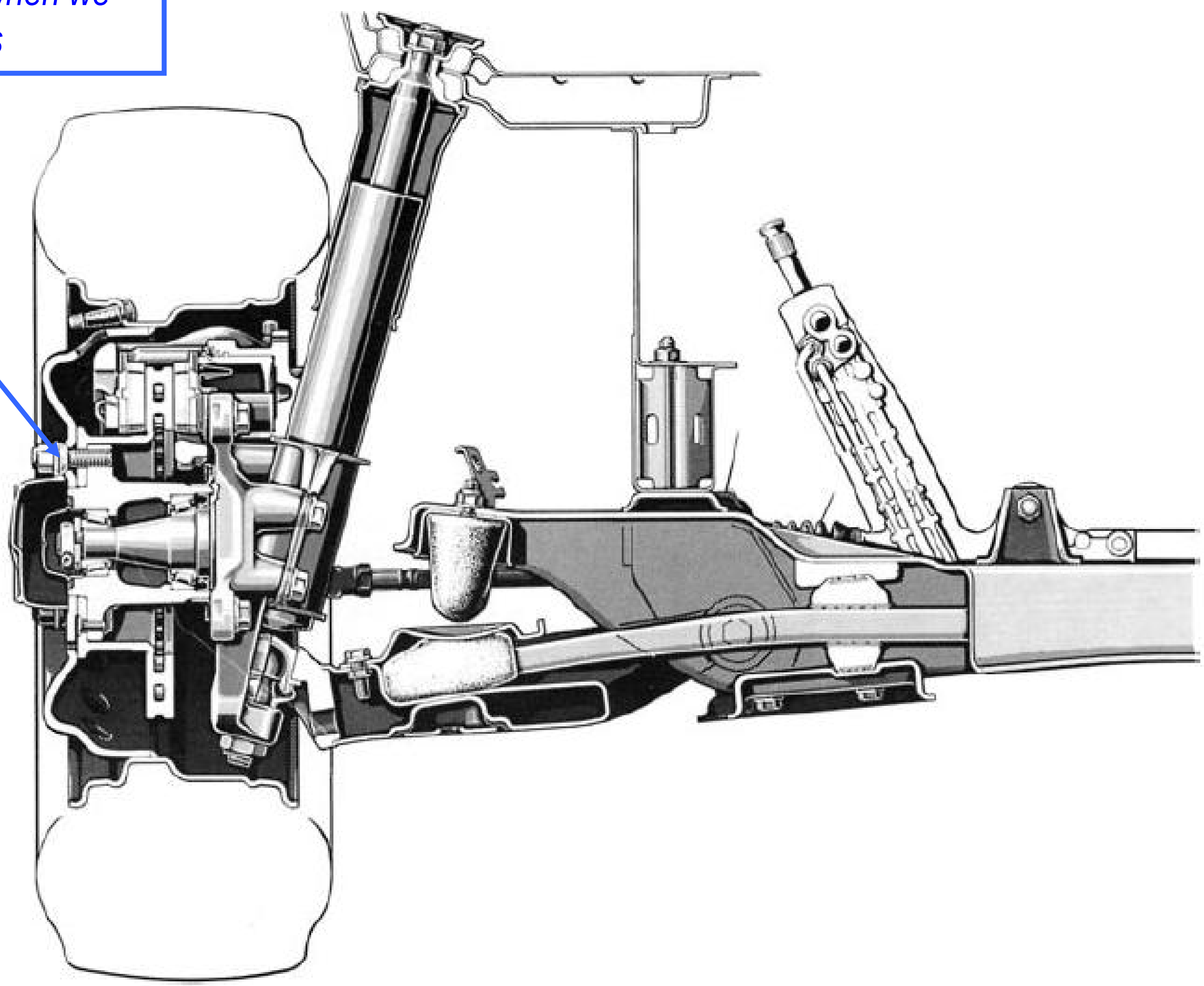
The screwjack formula



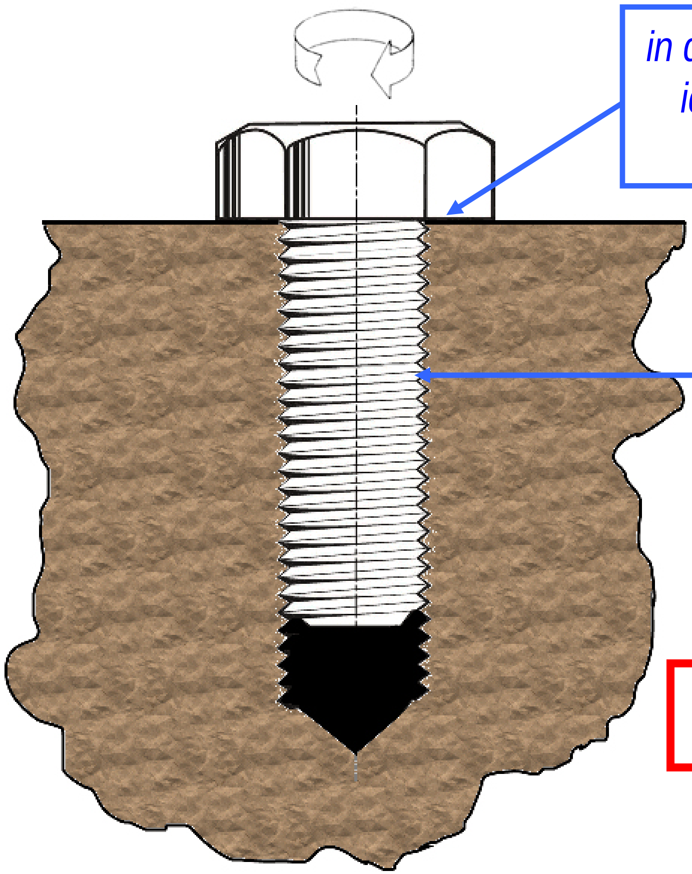
A_M is the smallest of the two load bearing cross-sectional areas A_B or A_P,
S is the recommended make-up stress level (S=72,000 psi),
p is the thread pitch,
f is the friction coefficient on mating surfaces, threads and shoulder(s),
θ is the thread angle,
A_B is the load bearing cross-sectional area of the box, calculated 3/8" from the shoulder contact surface,
A_P is the load bearing cross-sectional area of the pin, calculated 3/4" from the shoulder contact surface.

HDD connections and tire lug nuts

in drill pipe connections, shoulder contact is identical to wheel hub contact when we over-tighten the lug nuts



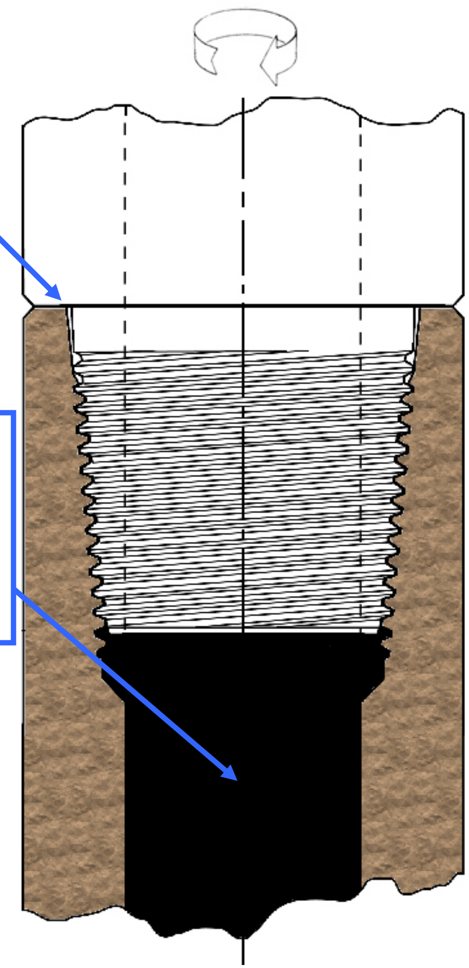
Pretensioning



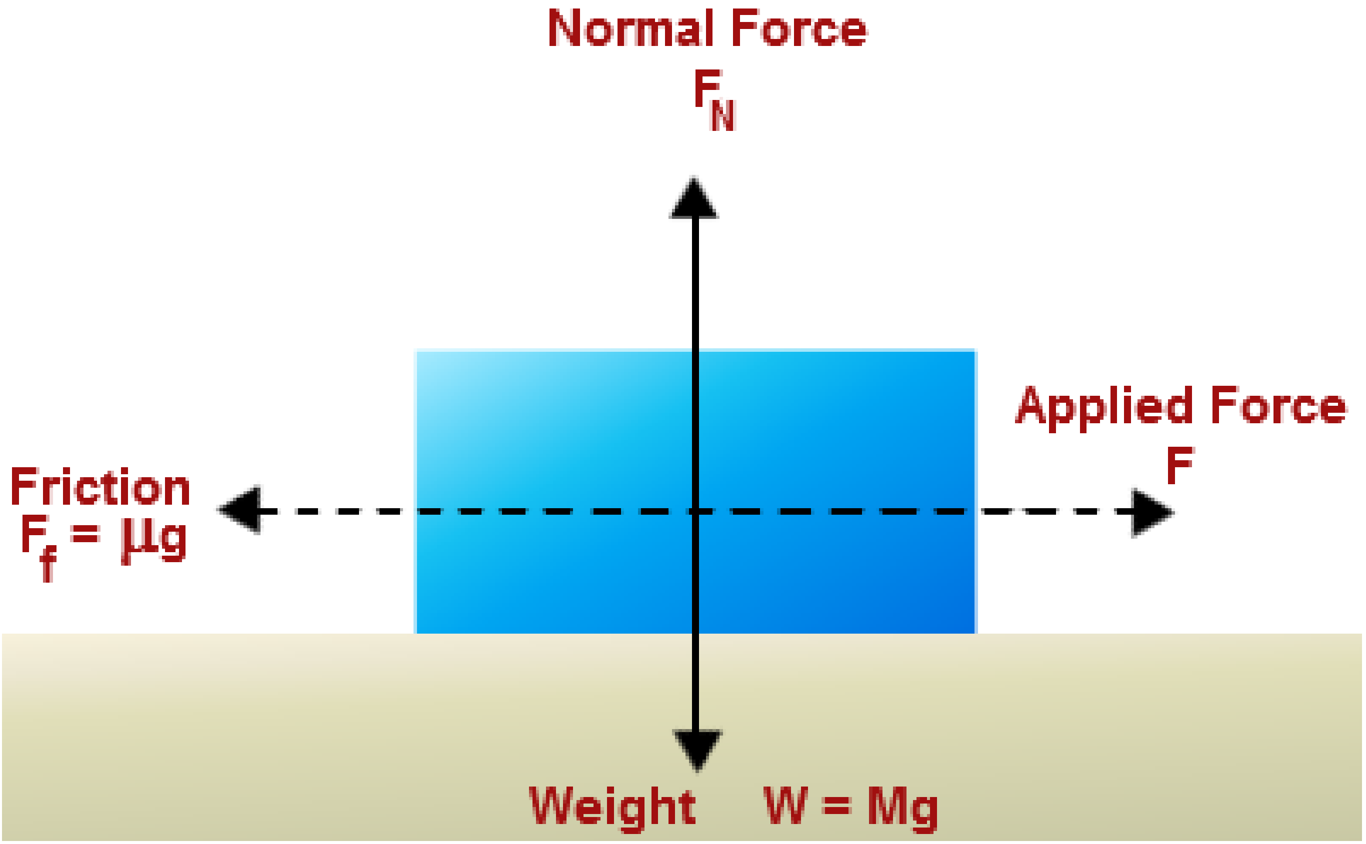
in drill pipe connections, shoulder contact is identical to the hexagonal head contact when we pre-load a cap screw

the only differences are: (1) the thread profile and (2) the fact that both the "screw" and the "nut" are hollow, in the case of the drill pipe

same mechanics



It's all about friction



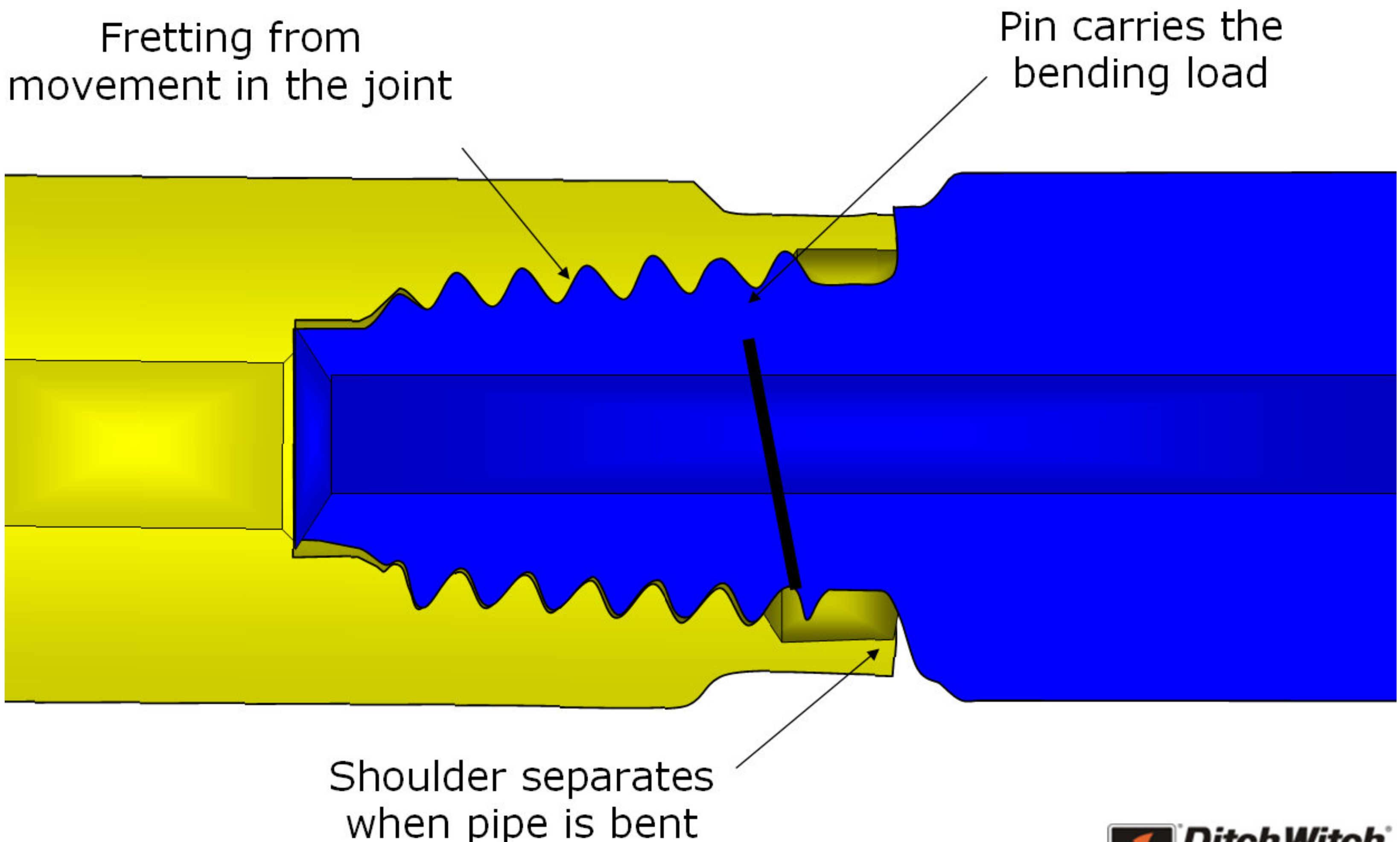
The more we pull the contact shoulders of the pin and the box against each other, the stronger the frictional force between them.
Overstretching the pin translates to a stronger pull of the contact shoulders.
Stronger friction translates to larger torque.

Modified screwjack formula for double-shoulder

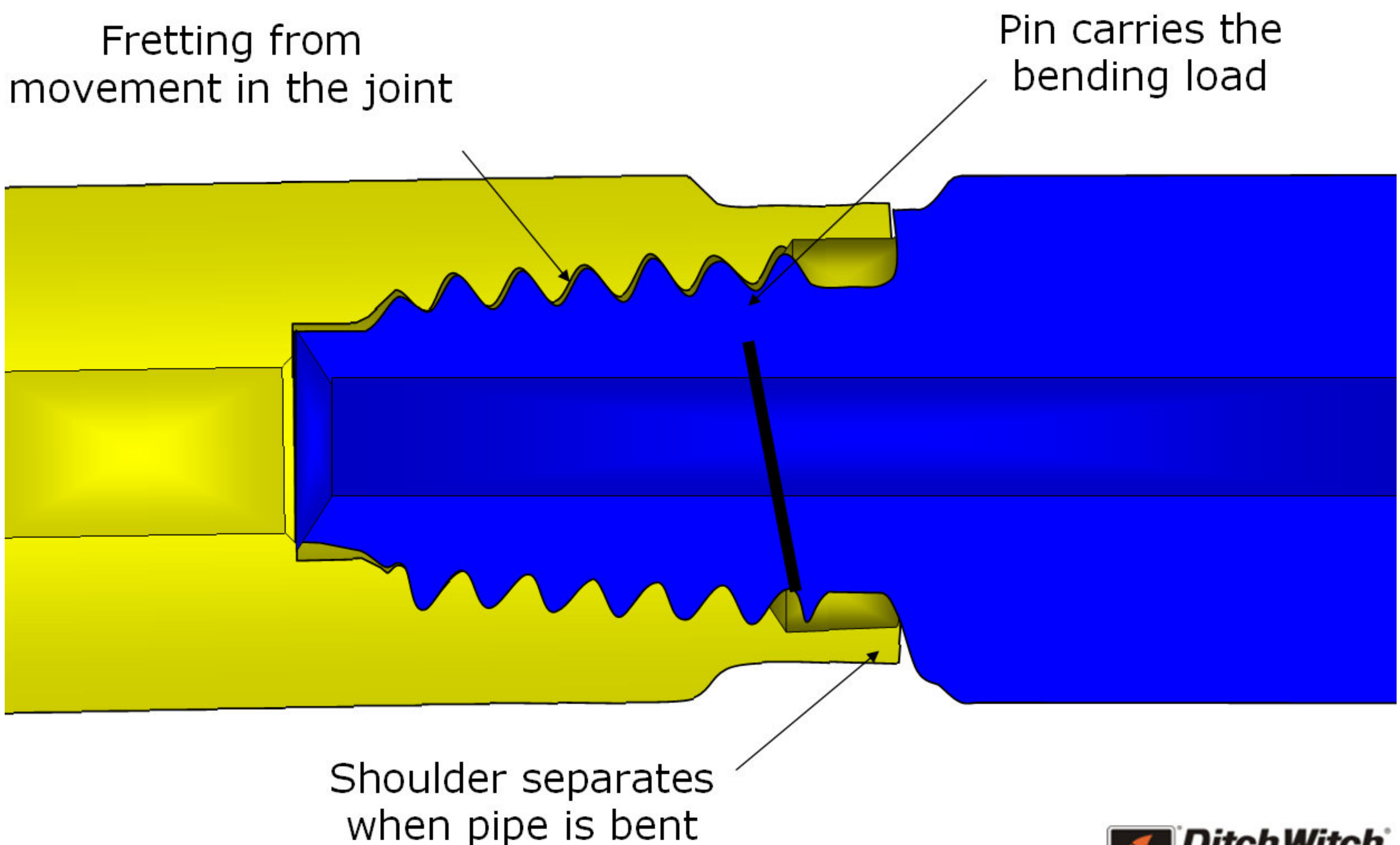
$$Ta = \frac{S}{12} A_M \left(\frac{p}{2\pi} + \frac{R_t f}{\cos\theta} + R_s f + R_{ss} f \right)$$

A_M is the smallest of the two load bearing cross-sectional areas A_B or A_P,
S is the recommended make-up stress level (S=72,000 psi),
p is the thread pitch,
f is the friction coefficient on mating surfaces, threads and shoulder(s),
θ is the thread angle,
A_B is the load bearing cross-sectional area of the box, calculated 3/8" from the shoulder contact surface,
A_P is the load bearing cross-sectional area of the pin, calculated 3/4" from the shoulder contact surface.

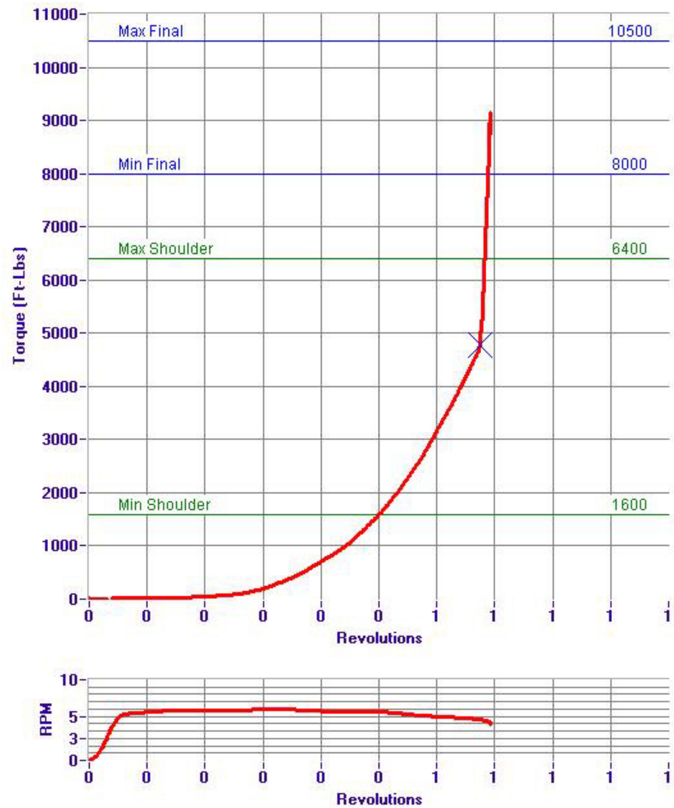
Insufficient make-up torque



Insufficient make-up torque



Make-up test



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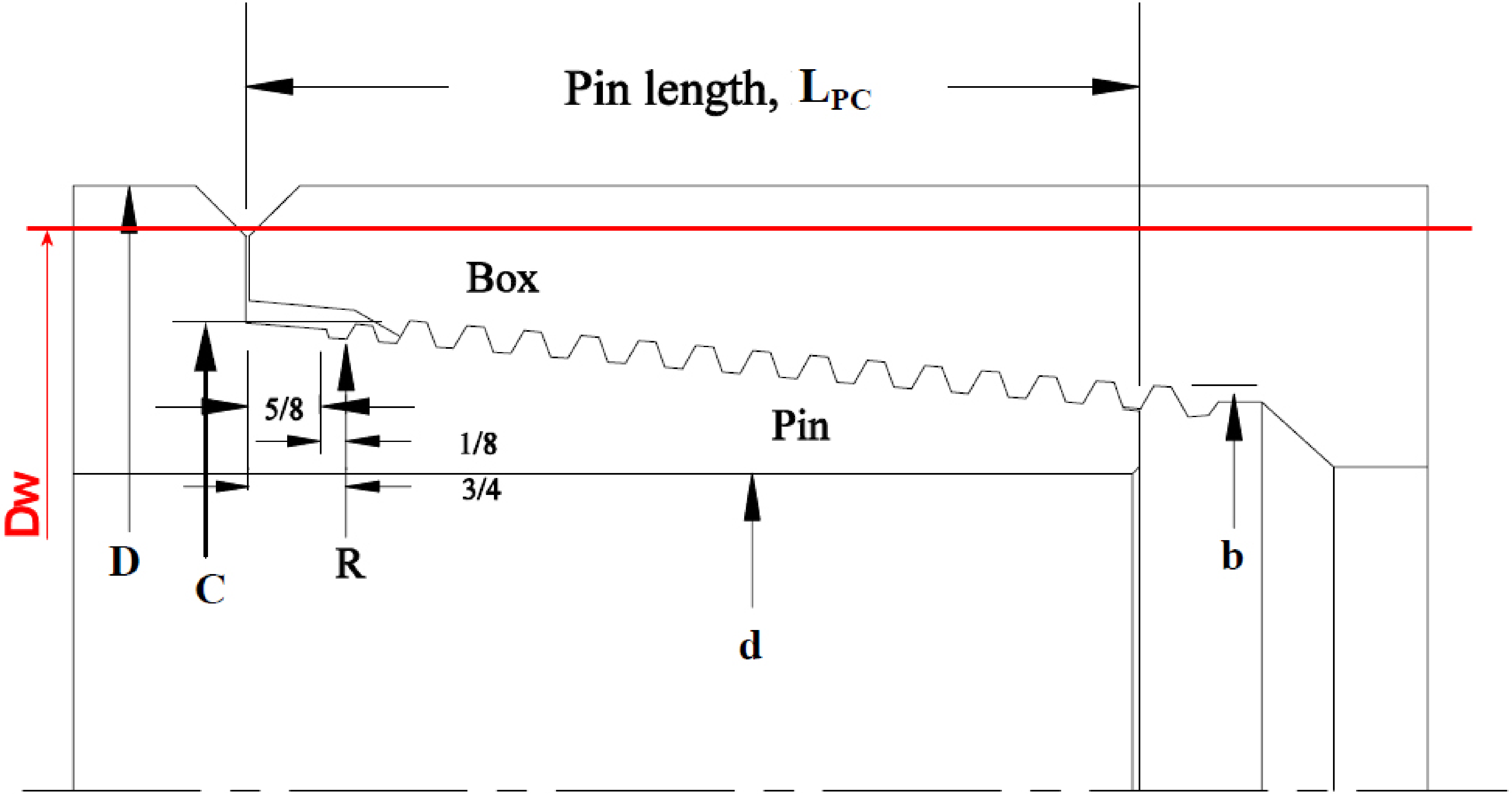
Date: 02-27-2014	Time: 08:47:21
Job: PTC120808NY1	Joint: 3
Cust:	
Rep:	
PO Number:	
Location:	THREAD LINE#2
Description:	[redacted]
Operator 1:	CARLOS
Max Final Torque:	10500 Ft-Lbs.
Min Final Torque:	8000 Ft-Lbs.
Max Shoulder Torque:	6400 Ft-Lbs.
Min Shoulder Torque:	1600 Ft-Lbs.
Dump Torque:	7800 Ft-Lbs.
Dump Torque Reset:	1755 Ft-Lbs.
Arm Length:	48.0 In.
Encoder Pulse/Rev:	24000.0
Final Torque:	**9158 Ft-Lbs.**
Peak Torque:	**9158 Ft-Lbs.**
Final Revolutions:	**0.692**
Average RPM:	**1.6**
Data Points:	**1489**
Ave Points/Rev:	**2153.0**
Turn Direction:	**Counter-Clockwise**
Shoulder Torque:	**4775 Ft-Lbs.**
Shoulder Revs:	**0.674**
Delta Torque:	**4383**
Delta Turn:	**0.017**
Result:	Accept
Comments:	JT#13 CPLG#3
Comments:	LIGHT DOPE BOX AND FACE
Comments:	CN#2721B

Torque capacity reduction due to wear



$$A_B = \frac{\pi}{4}\left[OD^2 - \left(Q_C - E\right)^2\right]$$

Wear chart

Dimensions	U.S.	Metric	U.S.	Metric	U.S.	Metric	U.S.	Metric	U.S.	Metric	U.S.	Metric	U.S.	Metric
Tube OD (in, mm)	1.660	42.2	1.900	48.3	2.063	52.4	2.375	60.3	2.875	73.0	3.500	88.9	3.500	88.9
Tool Joint OD (in, mm)	1.880	47.8	2.125	54.0	2.250	57.2	2.625	66.7	3.250	82.6	3.625	92.1	4.250	108.0
Tool Joint ID (in, mm)	0.750	19.1	0.750	19.1	0.875	22.2	0.875	22.2	1.250	31.8	1.500	38.1	1.625	41.3
Tool Joint WT (in, mm)	0.5650	14.4	0.6875	17.5	0.6875	17.5	0.8750	22.2	1.0000	25.4	1.0625	27.0	1.3125	33.3
TJ Cross Sectional Area (sq.in., sq.cm)	2.334	15.1	3.105	20.0	3.375	21.8	4.811	31.0	7.069	45.6	8.553	55.2	12.112	78.1
Box Load Section Area (sq.in., sq.cm)	1.2233	7.89	1.4226	9.18	1.2669	8.17	1.9635	12.67	3.6079	23.28	1.3990	9.03	9.1303	58.90
Load Section WT (in, mm)	0.1100	2.79	0.1125	2.86	0.0935	2.37	0.1250	3.18	0.1875	4.76	0.0625	1.59	0.3750	9.53
Load Section Wear Reduction (in, mm)	0.0110	0.28	0.0113	0.29	0.0093	0.24	0.0125	0.32	0.0188	0.48	0.0063	0.16	0.0375	0.95

Remaining Trq	TJOD	Torque	TJOD	Torque	TJOD	Torque	TJOD	Torque	TJOD	Torque	TJOD	Torque	TJOD	Torque
100	1.8800	1500	2.1250	2000	2.2500	2600	2.6250	4000	3.2500	9000	3.6250	10000	4.2500	10000
95	1.8690	1425	2.1138	1900	2.2407	2470	2.6125	3800	3.2313	8550	3.6188	9500	4.2125	9500
90	1.8580	1350	2.1025	1800	2.2313	2340	2.6000	3600	3.2125	8100	3.6125	9000	4.1750	9000
85	1.8470	1275	2.0913	1700	2.2220	2210	2.5875	3400	3.1938	7650	3.6063	8500	4.1375	8500
80	1.8360	1200	2.0800	1600	2.2126	2080	2.5750	3200	3.1750	7200	3.6000	8000	4.1000	8000
75	1.8250	1125	2.0688	1500	2.2033	1950	2.5625	3000	3.1563	6750	3.5938	7500	4.0625	7500
70	1.8140	1050	2.0575	1400	2.1939	1820	2.5500	2800	3.1375	6300	3.5875	7000	4.0250	7000
65	1.8030	975	2.0463	1300	2.1846	1690	2.5375	2600	3.1188	5850	3.5813	6500	3.9875	6500
60	1.7920	900	2.0350	1200	2.1752	1560	2.5250	2400	3.1000	5400	3.5750	6000	3.9500	6000
55	1.7810	825	2.0238	1100	2.1659	1430	2.5125	2200	3.0813	4950	3.5688	5500	3.9125	5500

THANK YOU

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