DETERMINATION AND QUALIFICATION OF ALTERNATIVE FLANGE ASSEMBLY PROCEDURES

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Railroad Tankcar General Purpose (GP) Manways

22% Of All Railcar Non-Accidental Releases (NARs)

Cited By FRA As #1 Source Of Railcar NARs

Contributing Causes:

Flexibility of Cover
Low Bolt Load
Large Gasket/Bolt Area Ratio
(117X vs 7X NPS 20 x 150)
Poor Surface Conditions

Assembly Procedures/Tools
(Securement)

Manway Securement

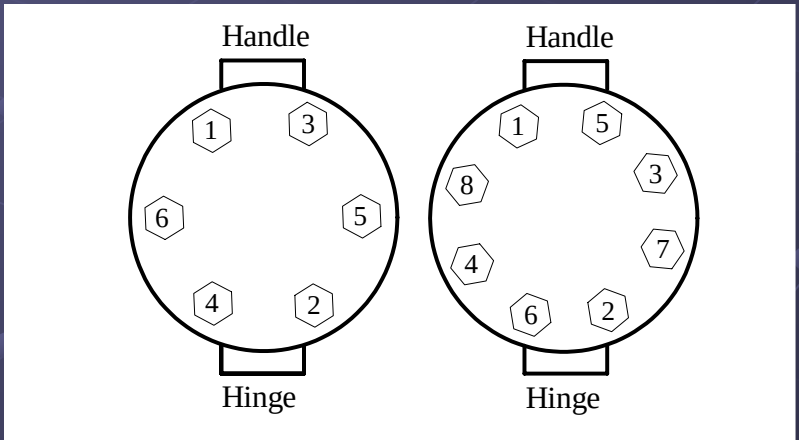
Specifications: Star Pattern, Multi-Step w/ Defined Torque Increments

	VSP CYCLETIGHT®/Hard Gasket		Elastomer Gasket	
Sequence	**6 Bolt**	**8 Bolt**	**6 Bolt**	**8 Bolt**
Snug Pass (Star Pattern)	**Snug**	**Snug**	**Snug**	**Snug**
1ST Pass (Star Pattern)	**75 ft-lbs**	**70 ft-lbs**	**50 ft-lbs**	**45 ft-lbs**
2ND Pass (Star Pattern)	**160 ft-lbs**	**140 ft-lbs**	**80 ft-lbs**	**70 ft-lbs**
3RD Pass (Star Pattern)	**250 ft-lbs**	**200 ft-lbs**	**115 ft-lbs**	**90 ft-lbs**
4TH Pass (Clockwise/Rotational)	**250 ft-lbs**	**200 ft-lbs**	**115 ft-lbs**	**90 ft-lbs**

At Manufacturer (Trained Mechanic)

At Repair Facility (Trained Mechanic)

At Loading Rack (Chemical Operator)



Manway Securement At Loading Rack

Outdoors (Weather)

Poor Working Conditions

Limited Space On Work Platform (Safety)

Different Skill-Set
(Operators, not Mechanics)

Repetition
(15 – 20 cars/shift)

Easier, Less Time Consuming Assembly Procedure Using Air Tools Desired

4 Step Evaluation

Phase 1: Tool Characteristics & Capabilities and Lubrication Effect

Phase 2: Gasket Compression & Alternative Procedures/Tools

Phase 3: Sealing Performance of Alternative Procedures/Tools

Phase 4: In-Plant Evaluation On Railcar

Phase 1- Tool Characteristics & Capabilities and Lubrication Effect

Skidmore-Wilhelm Load Tension Tester

Lubricated vs Un-Lubricated Bolts

"As-Is" Condition, Cleaned & Threads Lubed, Cleaned & Thread/Nut Lubed

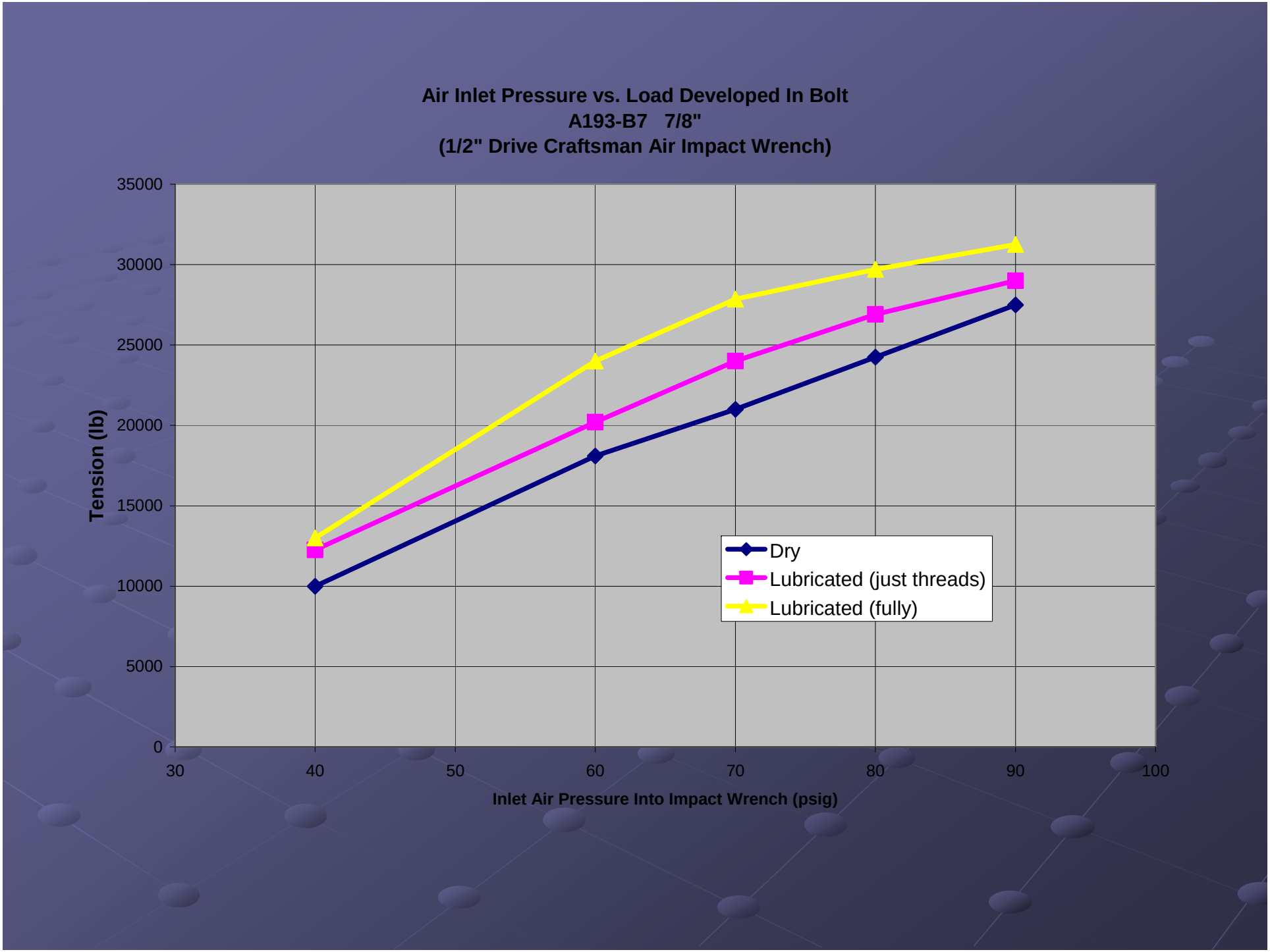
-Load Developed

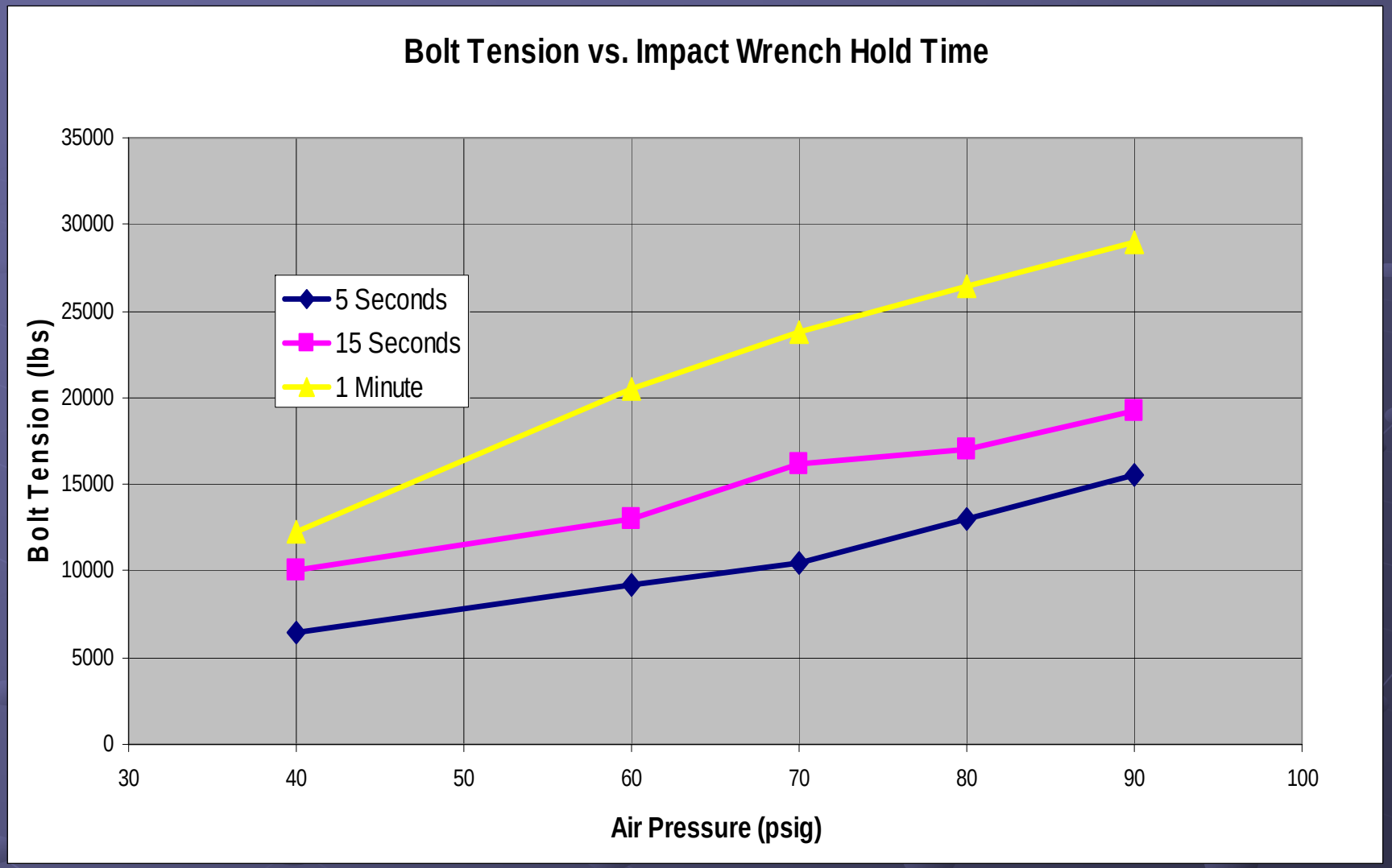
Dwell Time With Impact Wrench

5 sec, 15 sec, 1 minute

-Load Developed

Bolt Torque vs. Tension
A193 B7 7/8"
Tension (lb)
30000
25000
20000
15000
10000
5000
0
0
50
100
150
200
250
300
Torque (ft-lb)
As Is
Cleaned
Lubricated (just threads)
Lubricated (threads, nut, and washer)


Air Inlet Pressure vs. Load Developed In Bolt
A193-B7 7/8"
(1/2" Drive Craftsman Air Impact Wrench)
Tension (lb)
35000
30000
25000
20000
15000
10000
5000
0
30
40
50
60
70
80
90
100
Inlet Air Pressure Into Impact Wrench (psig)
Dry
Lubricated (just threads)
Lubricated (fully)


Bolt Tension vs. Impact Wrench Hold Time
Bolt Tension (lbs)
35000
30000
25000
20000
15000
10000
5000
0
5 Seconds
15 Seconds
1 Minute
30
40
50
60
70
80
90
100
Air Pressure (psig)

Phase 2- Gasket Compression and Alternative Procedures/Tools

Railcar GP Manway Test Fixture

Impact Wrench vs Torque Wrench:

"Legacy" Star Pattern

-Time, Work

- Load Developed, Uniformity

Assembly Patterns:

- Time, Work
- Load Developed, Load Uniformity
- Sealing Performance

Assembly Procedures Evaluated Stage 1: Load/Uniformity Assessment

Assembly Procedure ID	Assembly Procedure
2-T-S (Current Assembly Method)	**4 step star pattern w/final rotational passes until tight** snug, 60 ft-lb, 120 ft-lb, 200 ft-lb Torque Wrench
3-I-S	**3 step star pattern w/final rotational passes until tight** no snug, 45 psig, 60 psig, 90 psig Impact Wrench
4-I-R	**One Pass Rotational at 90 psig, with 5 second hold** no snug, 90 psig Impact Wrench
5-I-RR	**Three Pass Rotational at 90 psig, with 5 second hold** no snug, 90 psig Impact Wrench
6-I-RR	**Two Pass Rotational, Incrementally, with Final Rotational Passes Until Tight, with 5 second hold** no snug, 45 psig, 90 psig Impact Wrench
7-I-XR	**Single Cross Pattern (NSEW), Then 90 psig Rotational Until Tight, with 5 second hold** no snug, 45 psig, 90 psig Impact Wrench

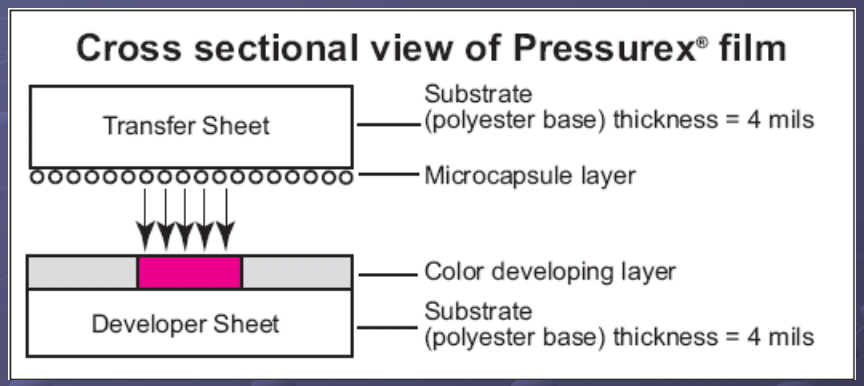
Unique Assembly Aspects

1) Condition Of Bolts/Inspection

2) “Snug”

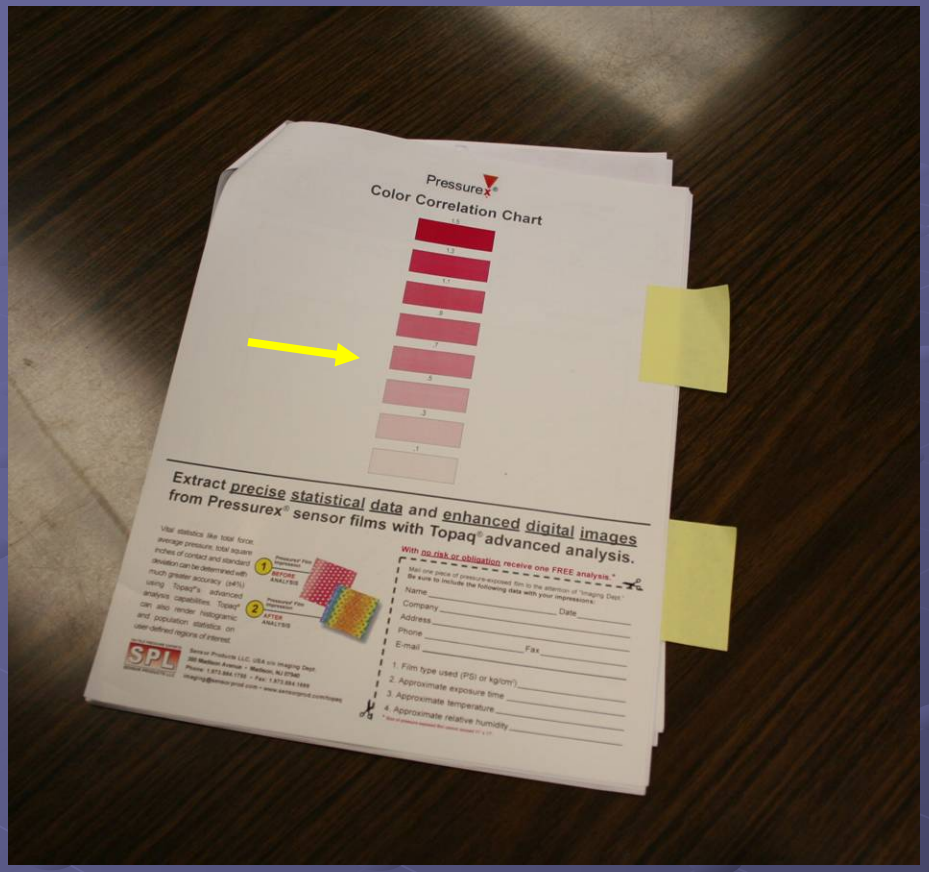
Load & Load Uniformity Determination

Medium Density Pressure Film Applied To Gasket

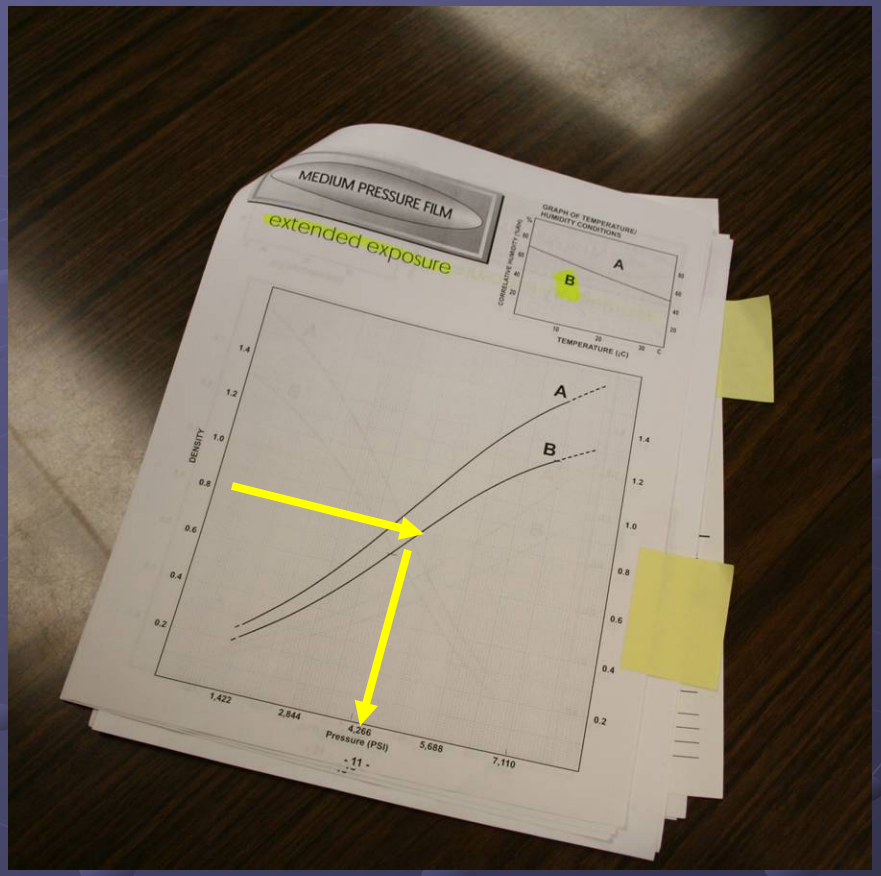


FILM TYPE PRESSURE RANGE

MICRO *(Shows relative pressure distribution only)* 2 - 20 PSI (0.14 - 1.4 kg/cm2)
ULTRA LOW 28 - 85 PSI (2 - 6 kg/cm2)
SUPER LOW 70 - 350 PSI (5 - 25 kg/cm2)
LOW 350 - 1,400 PSI (25 - 100 kg/cm2)
→ **MEDIUM** 1,400 - 7,100 PSI (100 - 500 kg/cm2)
HIGH 7,100 - 18,500 PSI (500 - 1,300 kg/cm2)
SUPER HIGH 18,500 - 43,200 PSI (1,300 - 3,000 kg/cm2)



#1- Identify Color Density



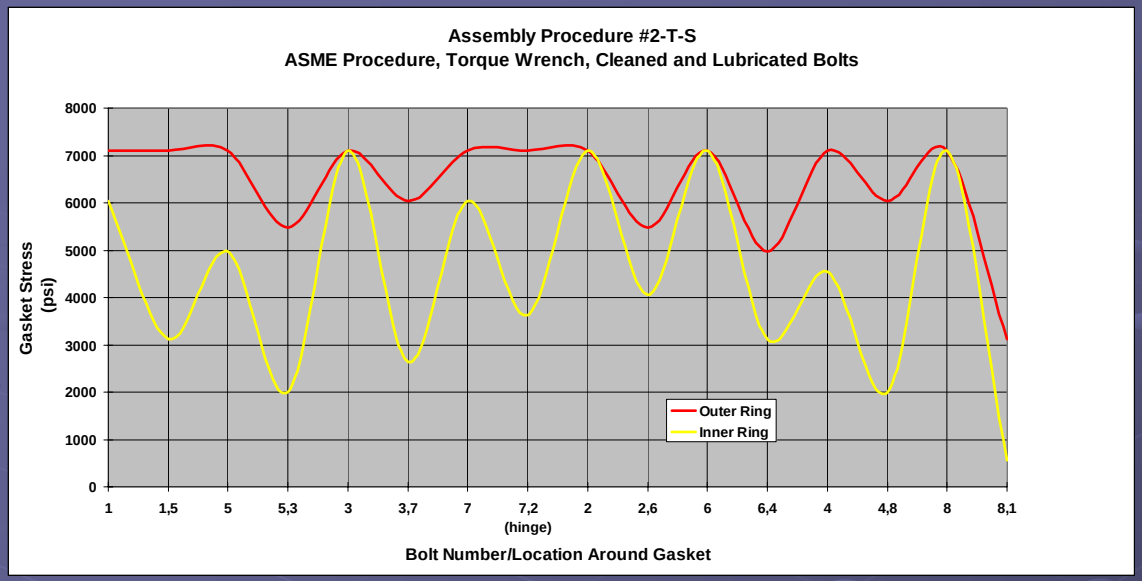
#2- Convert Color Density To Compressive Stress

Visual Assessments

High, Fairly Uniform Loading

Low Stress, Poor Uniformity

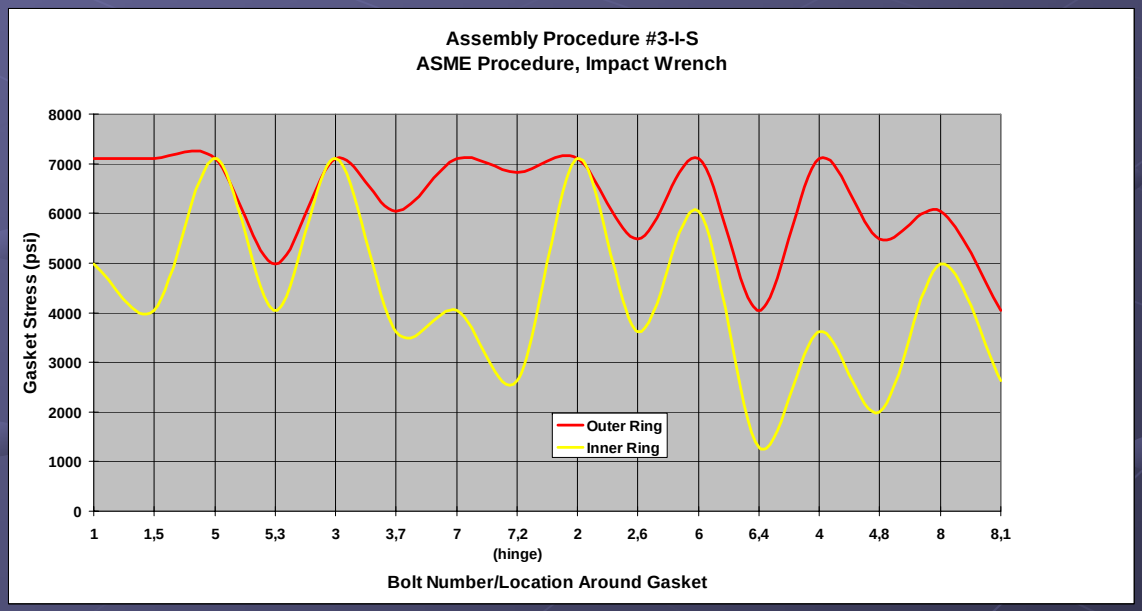
Comparison Star Pattern Torque Wrench vs Impact Wrench



Star Pattern- Torque Wrench

6,400 psi (avg) @ OD

4,450 psi (avg) @ ID

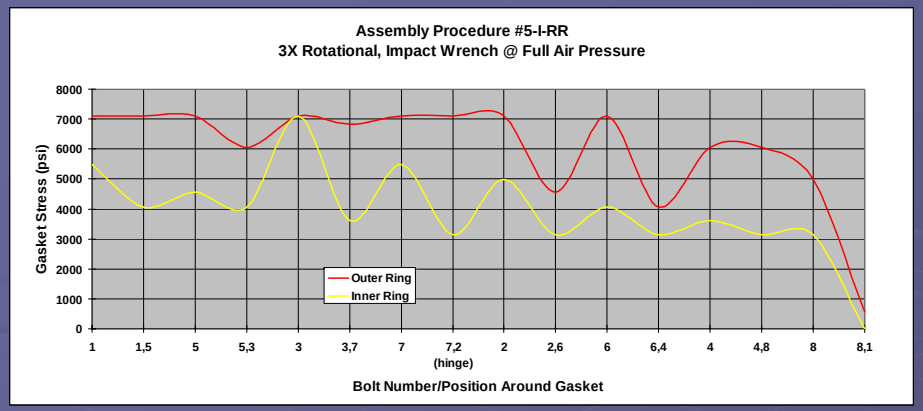


Star Pattern- Impact Wrench

6,200 psi (avg) @ OD

4,300 psi (avg) @ ID

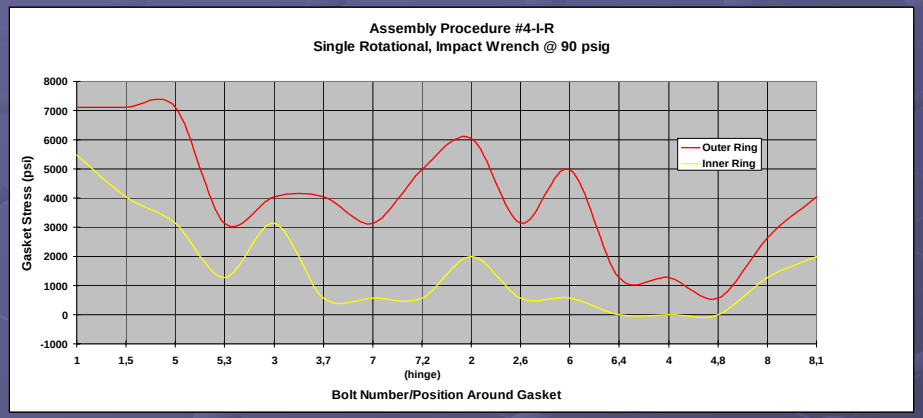
Comparison Alternative Patterns



3X Rotational w/Impact

4,000 psi (avg) @ OD

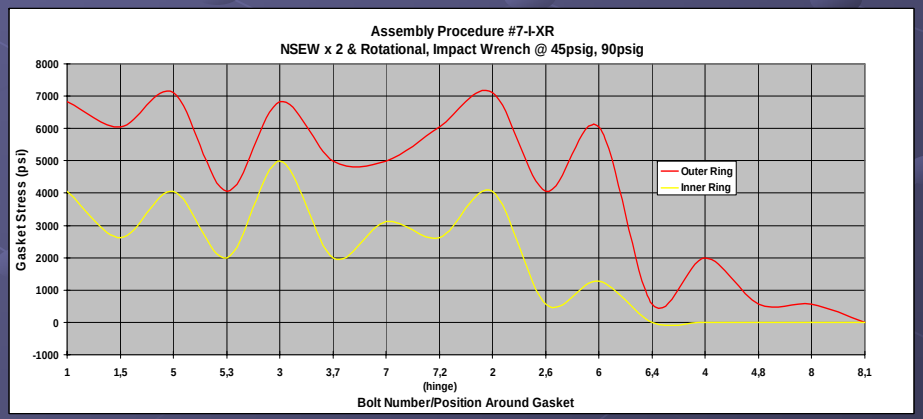
1,675 psi (avg) @ ID



1X Rotational w/Impact

6,000 psi (avg) at OD

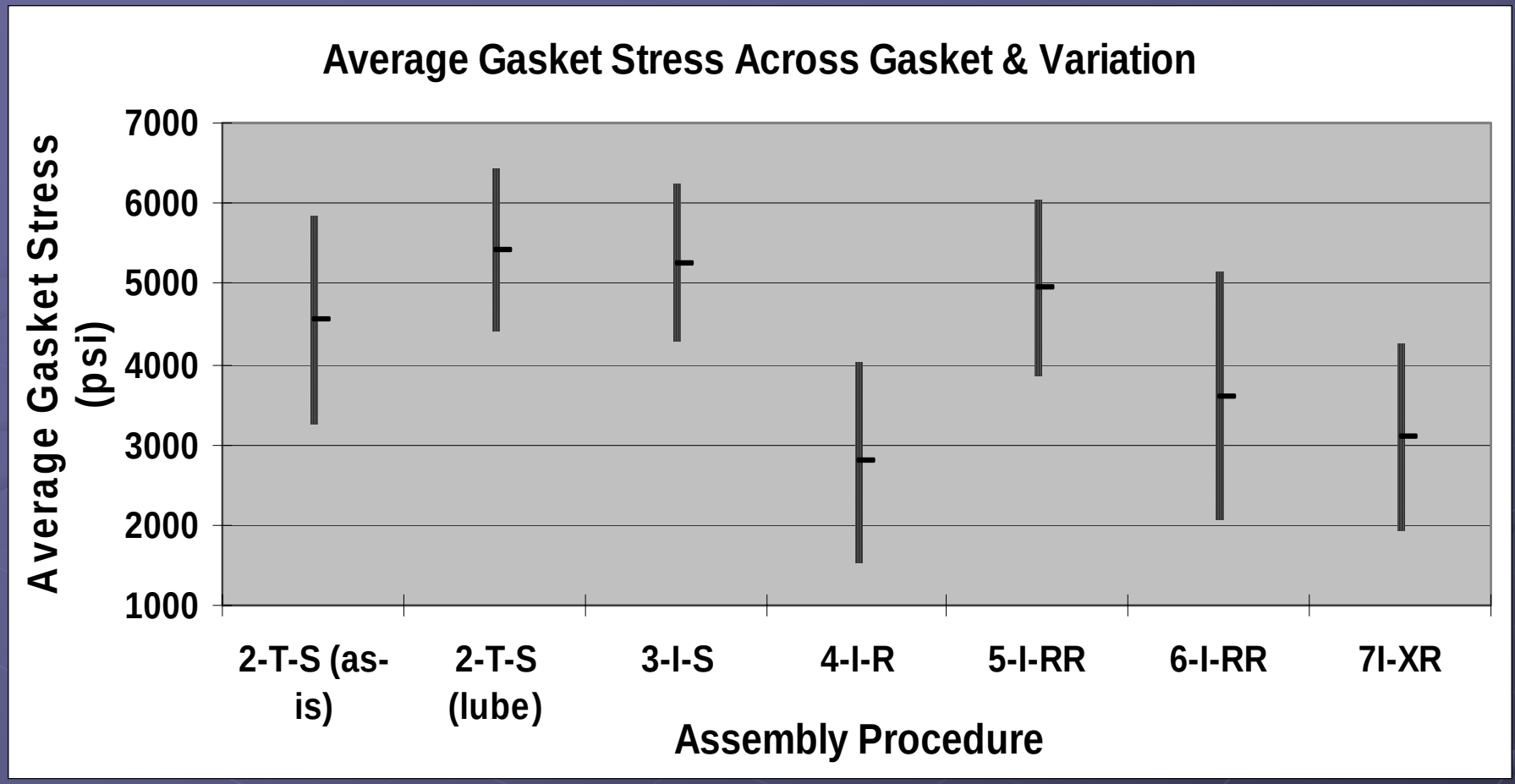
3,900 psi (avg) @ ID



NSEW x2 & 1X Rotational w/Impact

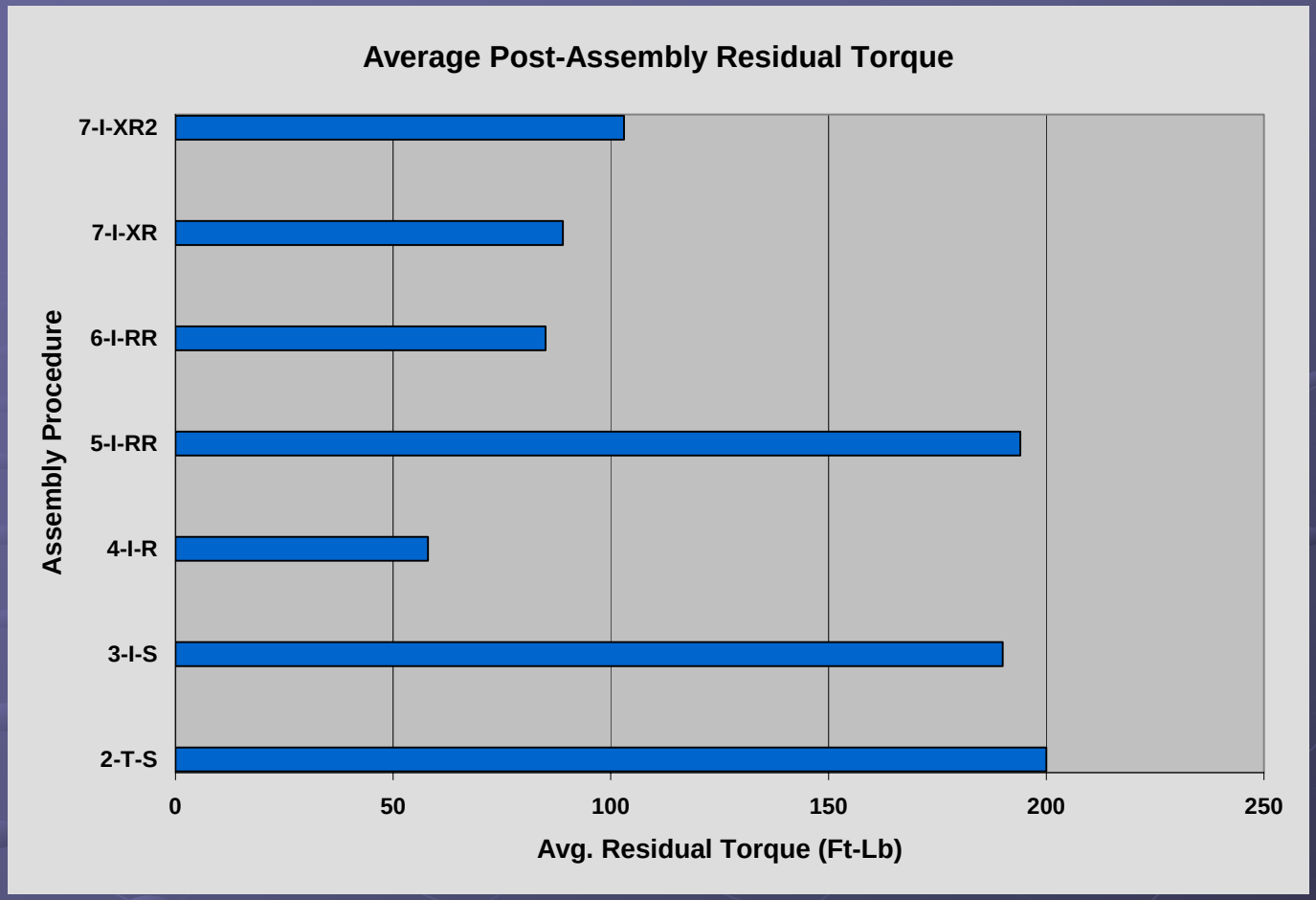
4,200 psi (avg) @ OD

1,960 psi (avg) @ ID



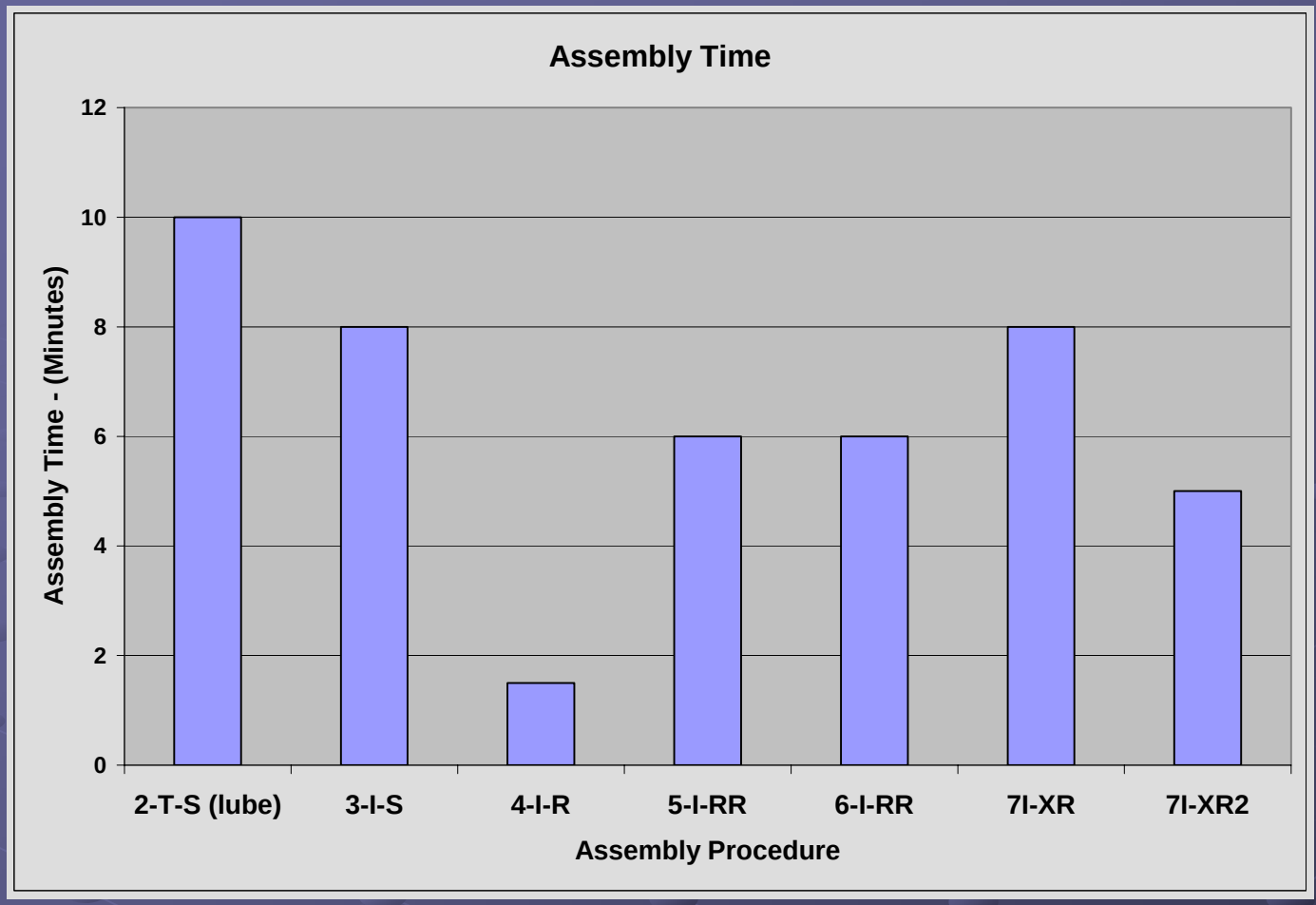
Best: Average Stress Level & Stress Range

#1 = Star Pattern, Torque Wrench (2-T-S)
#2 = Star Pattern, Impact Wrench (3-I-S)
#3 = 3X Rotational, Impact Wrench (5-I-RR)



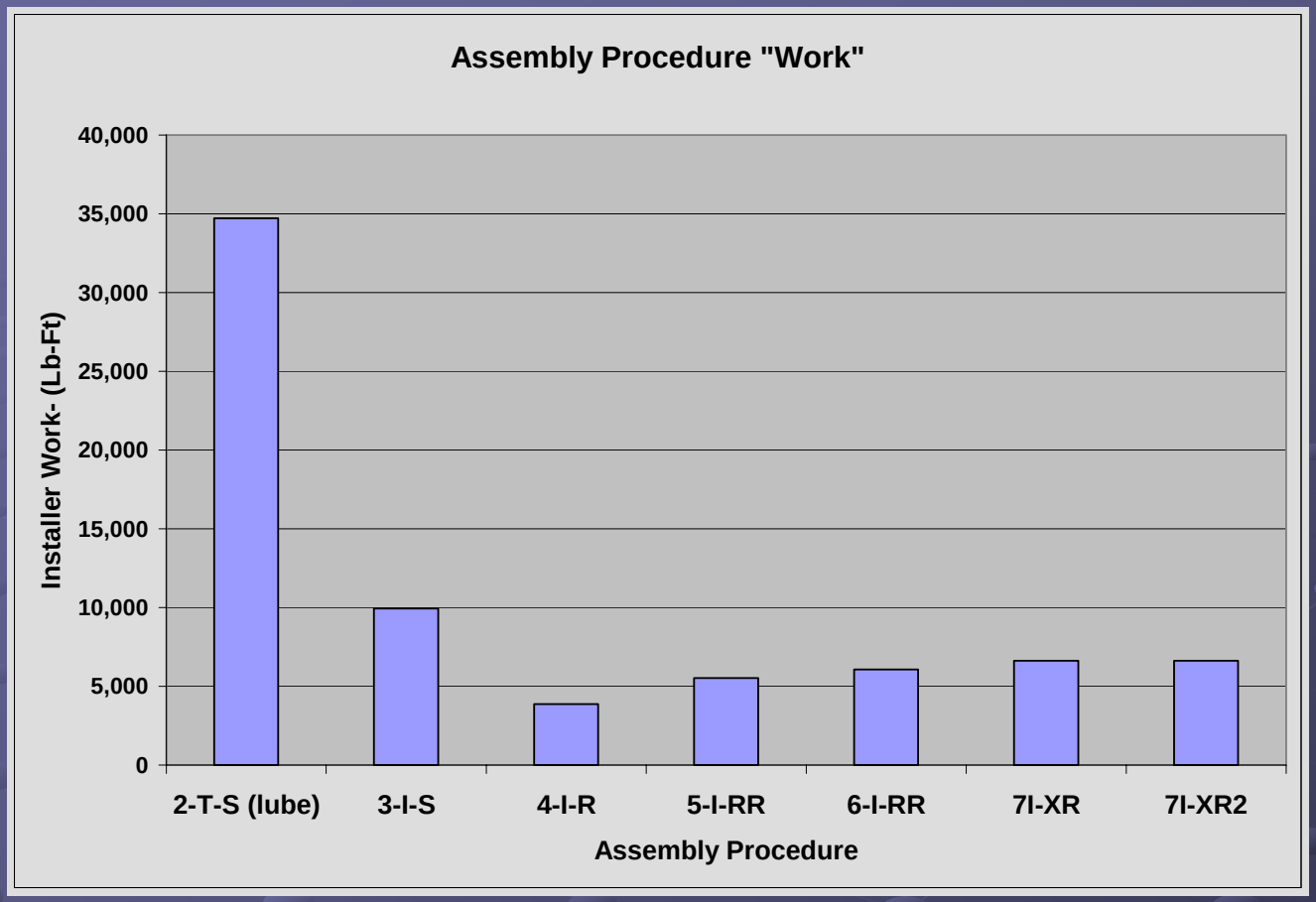
Best: Residual Torque

#1 = Star Pattern, Torque Wrench (2-T-S)
#2 = 3X Rotational, Impact Wrench (5-I-RR)
#3 = Star Pattern, Impact Wrench (3-I-S)



Best: Assembly Time

#1 = 1X Rotational, Impact Wrench (4-I-R)
#2 = NSEW x2 & 1X Rotational, Impact Wrench, One Pressure (7-I-XR2)
#3 = 3X Rotational, Impact Wrench (5-I-RR)
2X Rotational, Impact Wrench, Rotational Until Tight (6-I-RR)



Best: Lowest Assembly Effort (Work)

#1 = 1X Rotational, Impact Wrench (4-I-R)
#2 = 3X Rotational, Impact Wrench (5-I-RR)
#3 = 2X Rotational, Impact Wrench, Rotational Until Tight (6-I-RR)

Phase 3- Sealing Performance of Alternative Procedures/Tools

Procedure ID	Procedure Description	Leak
8-I-XR-PT	NSEW at 60psig, 80psig, then 2 Rotational Passes at 80psig. Impact Wrench	YES
10-I-RR-PT	Rotational Passes at 80psig until tight (3 passes). Impact Wrench	NO
11-I-R-PT	2 Rotational Passes at 90psig. Impact Wrench	YES
11-I-R-PT2	1 Rotational Pass at 80psig. Impact Wrench	YES
12-I-S-PT	Star pattern at 50psig, 80psig then 2 Rotational Passes at 80psig. Impact Wrench	NO

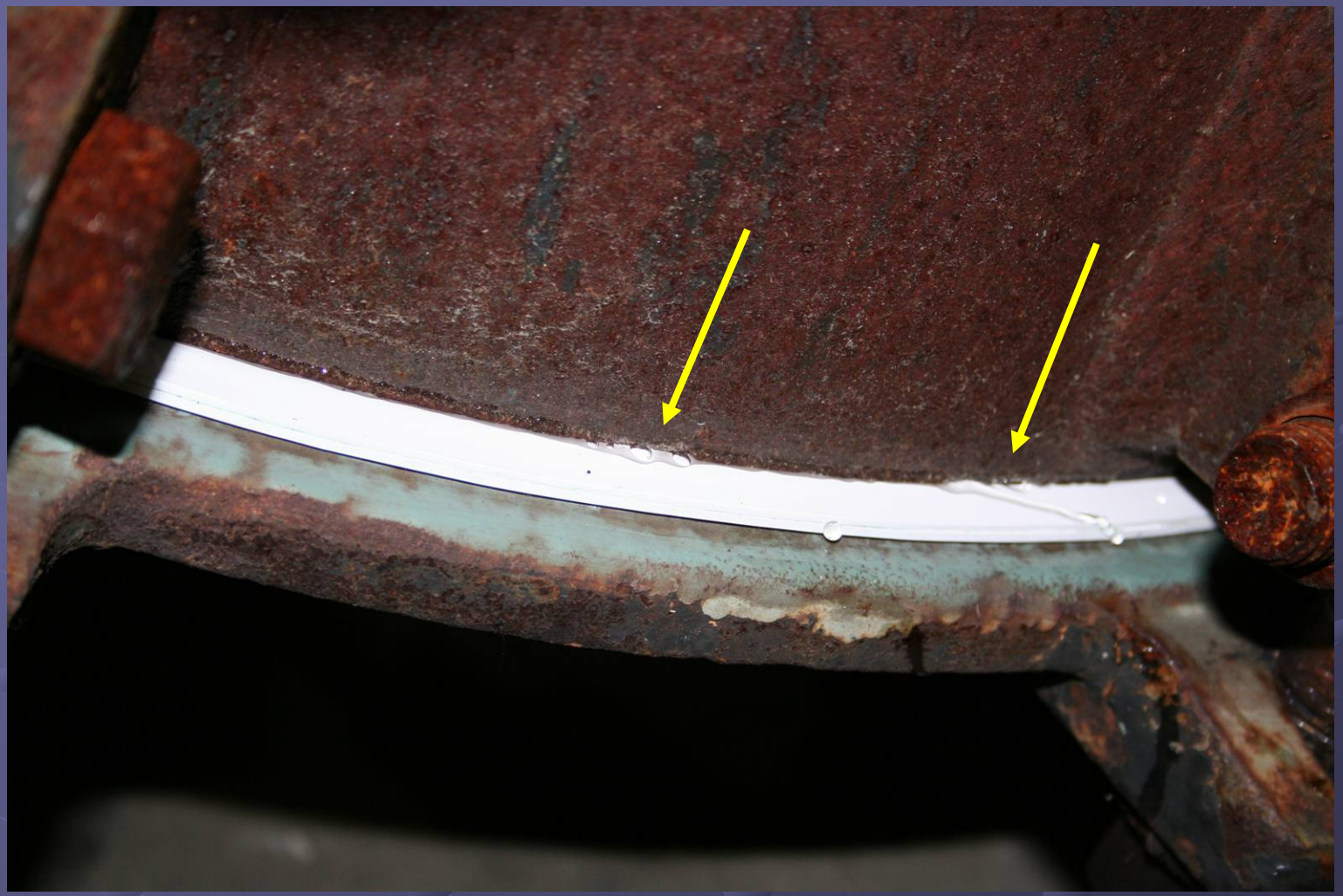
Optimized Alternative Procedures Based Upon Phase 2 Findings

Liquid Leakage Tests

30 Minute @ 30 psig, 50 psig and 75 psig

Visible Leakage = Failure

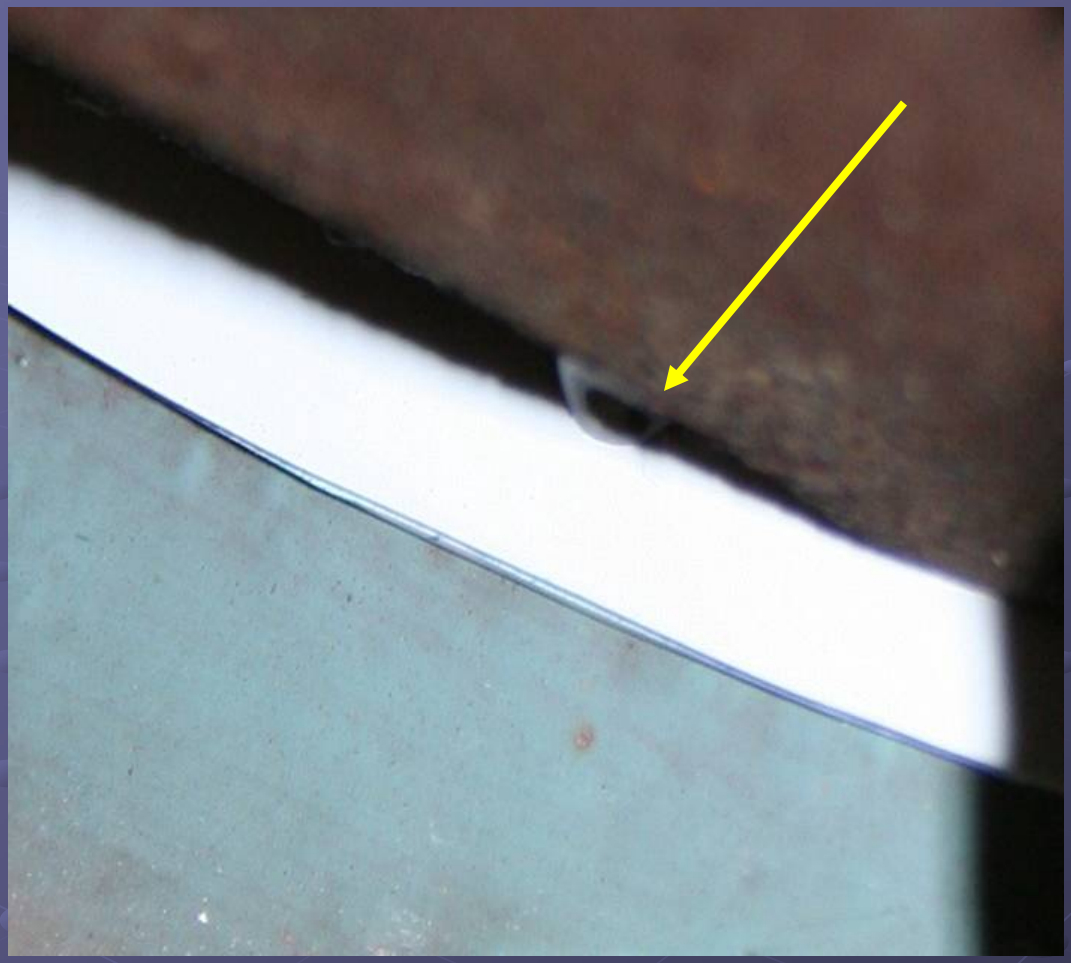
Pressure Test FAILURES



1X Rotational, Impact Wrench (11-I-R-PT2)

(Confirmation Of Screening Capability)

Pressure Test FAILURES



NSEW Incremental Pressure, 2X Rotational, Impact Wrench (8-I-XR-PT)

Procedure ID	Procedure Description	Leak
8-I-XR-PT	NSEW at 60psig, 80psig, then 2 Rotational Passes at 80psig. Impact Wrench	YES
10-I-RR-PT	Rotational Passes at 80psig until tight (3 passes). Impact Wrench	NO
11-I-R-PT	2 Rotational Passes at 90psig. Impact Wrench	YES
11-I-R-PT2	1 Rotational Pass at 80psig. Impact Wrench	YES
12-I-S-PT	Star pattern at 50psig, 80psig then 2 Rotational Passes at 80psig. Impact Wrench	NO

Best Alternative Procedures Phase 2 and Phase 3

Phase 4: Railcar Manway Field Evaluation

3 Pass Rotational, 80 psig, ½" Drive Impact Wrench, 5 Sec Hold

Phase 1 Torque Expected = 190 ft-lb

Actual Residual Torque = 150 – 225 ft-lb

CURRENT

Alternative Method, ½" Drive Impact Wrench @ 85 psig Air

	VSP CYCLETIGHT®/Hard Gasket	Elastomer Gasket
Sequence	6 or 8 Bolts	DO NOT INSTALL ELASTOMER GASKETS WITH AN IMPACT WRENCH
Snug Pass (Star Pattern)	1 Second Count	
1st Pass (Star Pattern)	5 Second Count	
2nd Pass (Clockwise/Rotational)	5 Second Count	

GOAL

Alternative Method, ½" Drive Impact Wrench @ 85 psig Air

Step 1	Clean & lubricate eyebolt threads and nut bearing surfaces
Step 2	Starting with bolt #1, directly opposite from hinge, tighten nuts, until just snug, in a rotational pattern. Do not tighten past snug.
Step 3	Continue tightening in a rotational pattern for two complete rotations around manway, applying load for 5 seconds on each nut