Quality.Together

Update on Southern Pine Resource Monitoring

History

- Original IGT Published: 1991
- Monitoring: 1994-2010
- Destructive Testing: 2011
    - #2 2x4
    - MOE, MOR, UTS
- Significant decreases observed

2012

- Reduced 2x4 #2 & lower design values
- Conducted New IGT
    - 2 grades, 3 sizes
    - MOE, MOR, UTS, UCS

2013-2016

- New design values published
- Monitoring:
  - #1 2x6 MOR in 2013
  - #2 2x4 MOR in 2014
  - #2 2x4 UTS in 2015
  - #2 2x4 & 2x8 MOR in 2016

InGrade Testing Standards

- Two main standards written during original IGT process to document procedures as they evolved.
- Extensive collaboration from FPL, Forintek, industry technical experts, and North American grading agencies

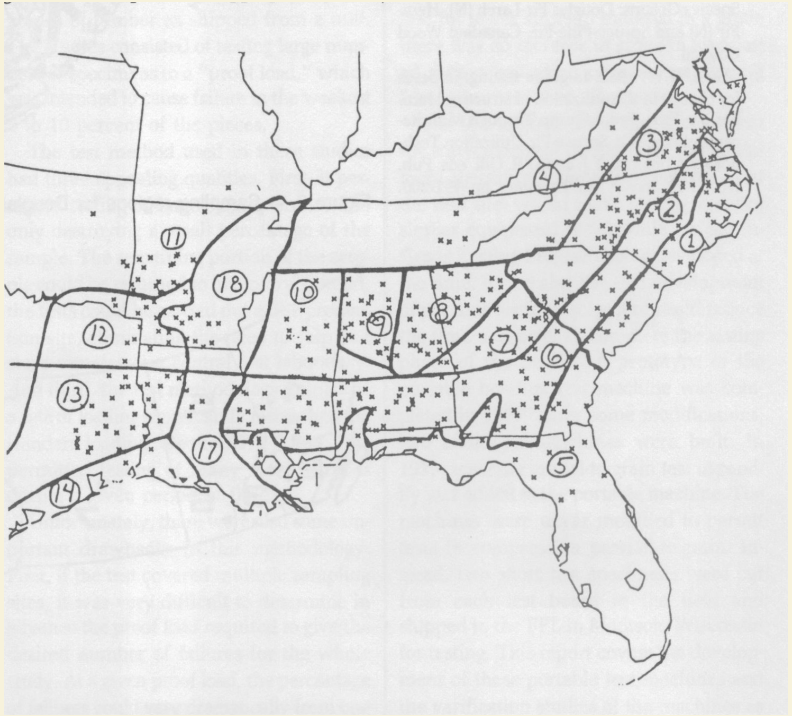
InGrade Testing Standards

- ASTM D4761- testing procedures
- ASTM D1990 – data adjustments, modeling procedures, design value development

Sampling

- Mills assigned to one of 16 homogeneous Southern Pine growing regions
- Includes SPIB and TP mills
- Randomly select mills in proportion to regional production
- Target sample size: 360 pieces per "cell"
- Test 10-12 pieces from each selected mill

Southern Pine Regions



Nonparametric Statistics

- We do not assume a “normal” (or any other) statistical distribution.
- Use “order statistics” to estimate values of interest.
- Permits analysis without actually breaking every piece.

5TH PERCENTILE

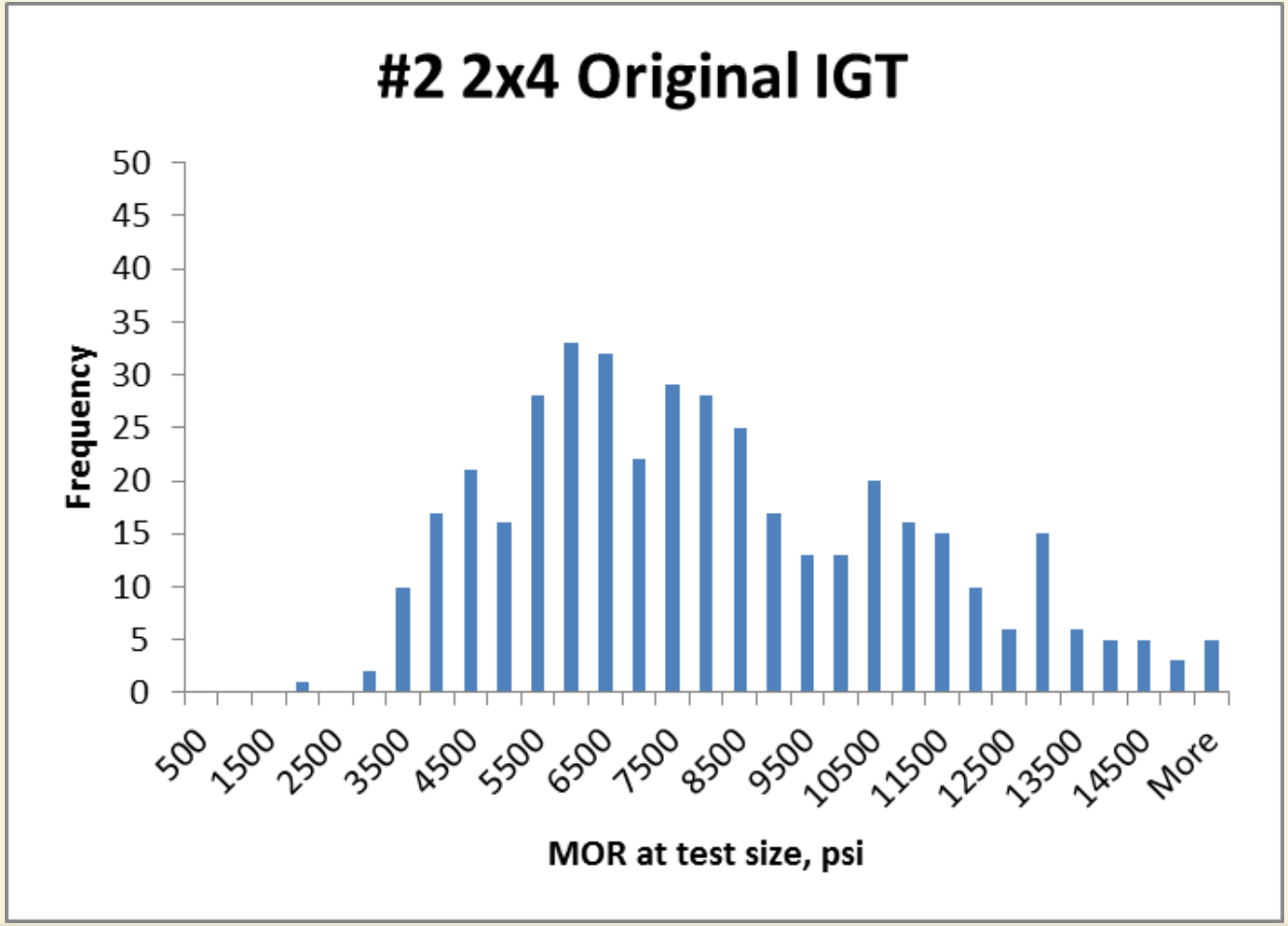
- Rank order all data from lowest to highest.
- (5% * sample size) is approximately the order statistic of the 5th percentile "point estimate".
- Example: 100 pieces broken in bending. Use the 5th weakest piece to estimate the 5th percentile.

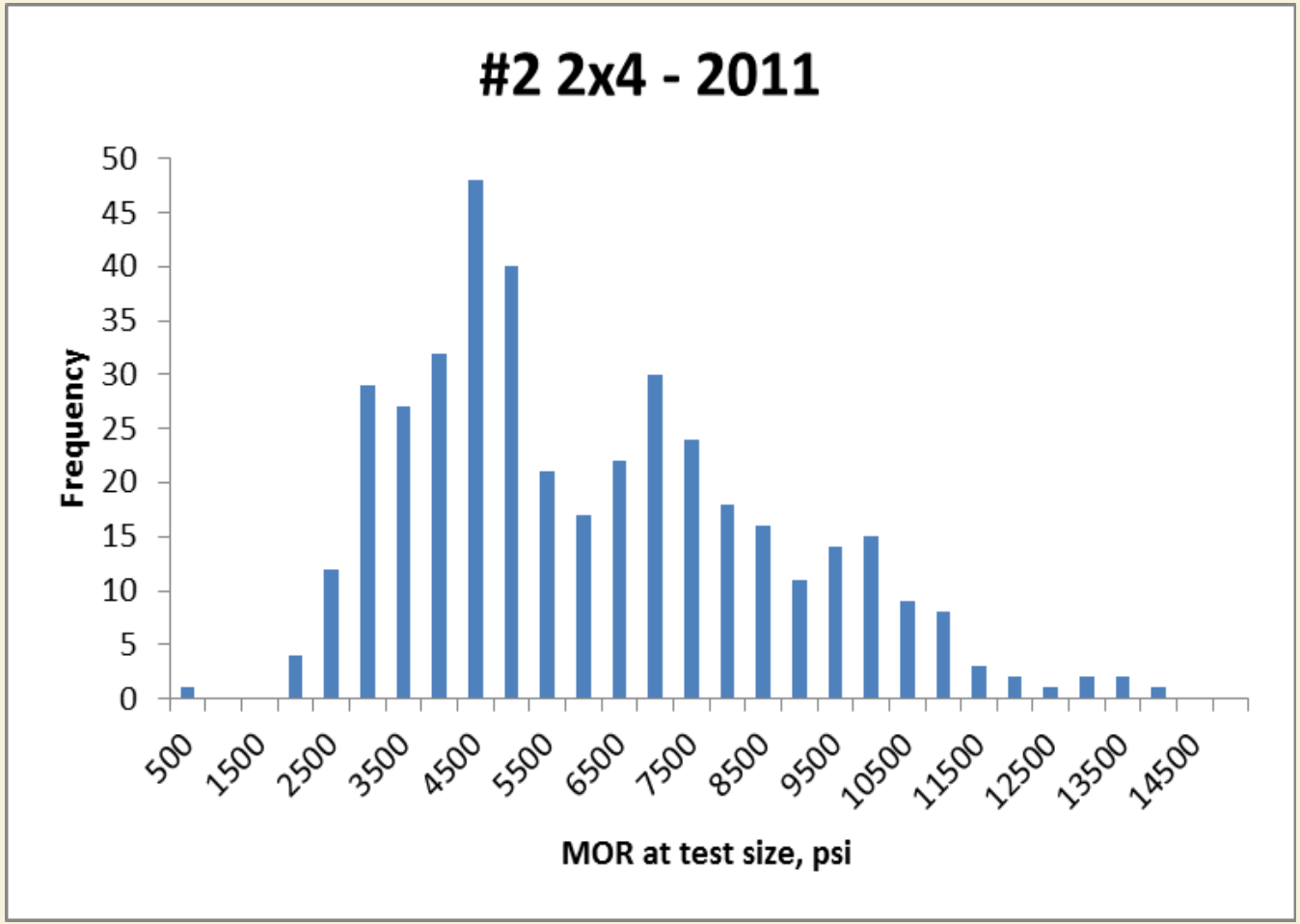
Tolerance Limits

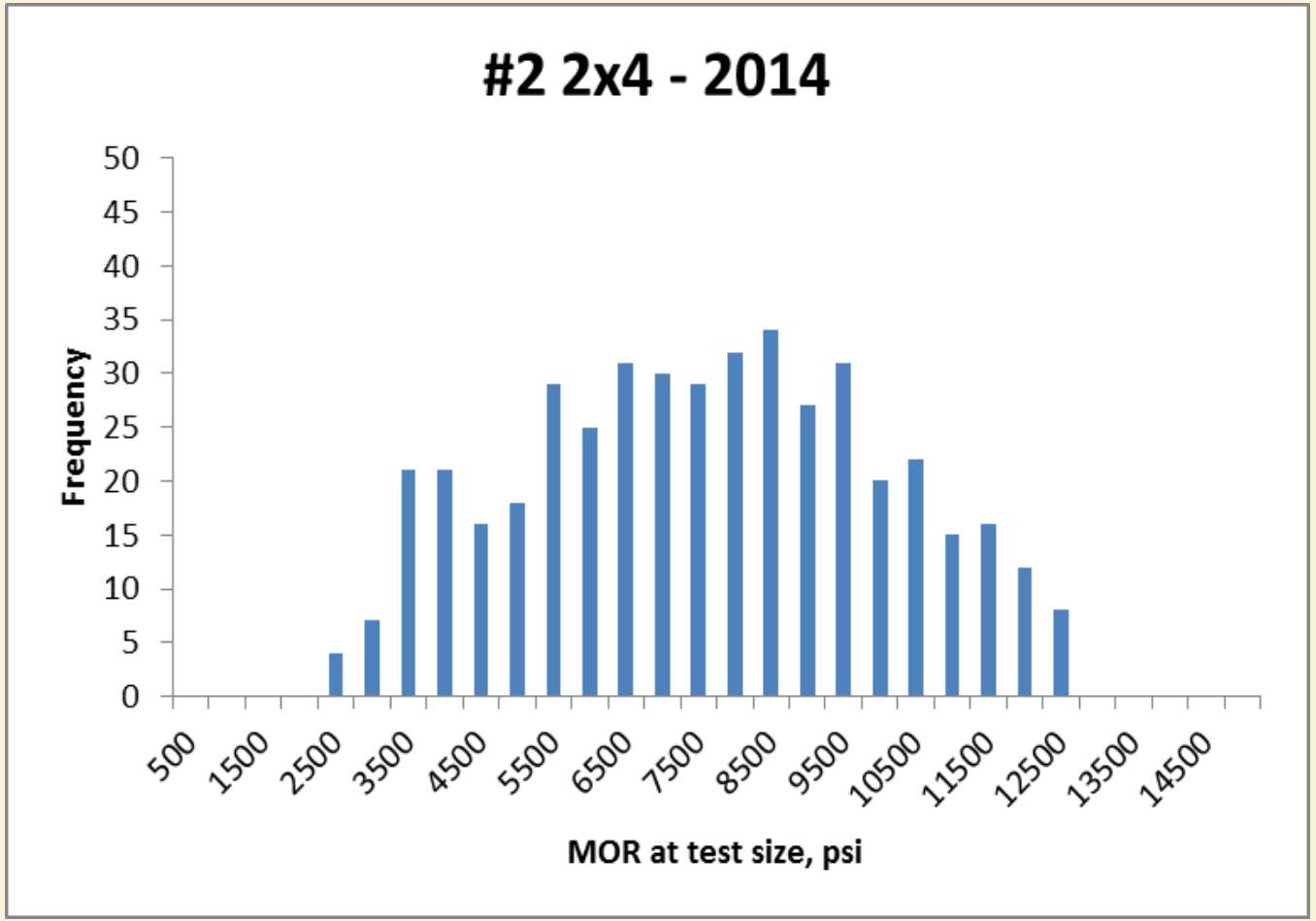
- ASTM D1990 uses the 75% confidence tolerance limit on the 5th percentile.
- Uses data from a piece weaker than actual 5th percentile "point estimate".
- Provides increased confidence that true 5th percentile is equal to or greater than our estimate.

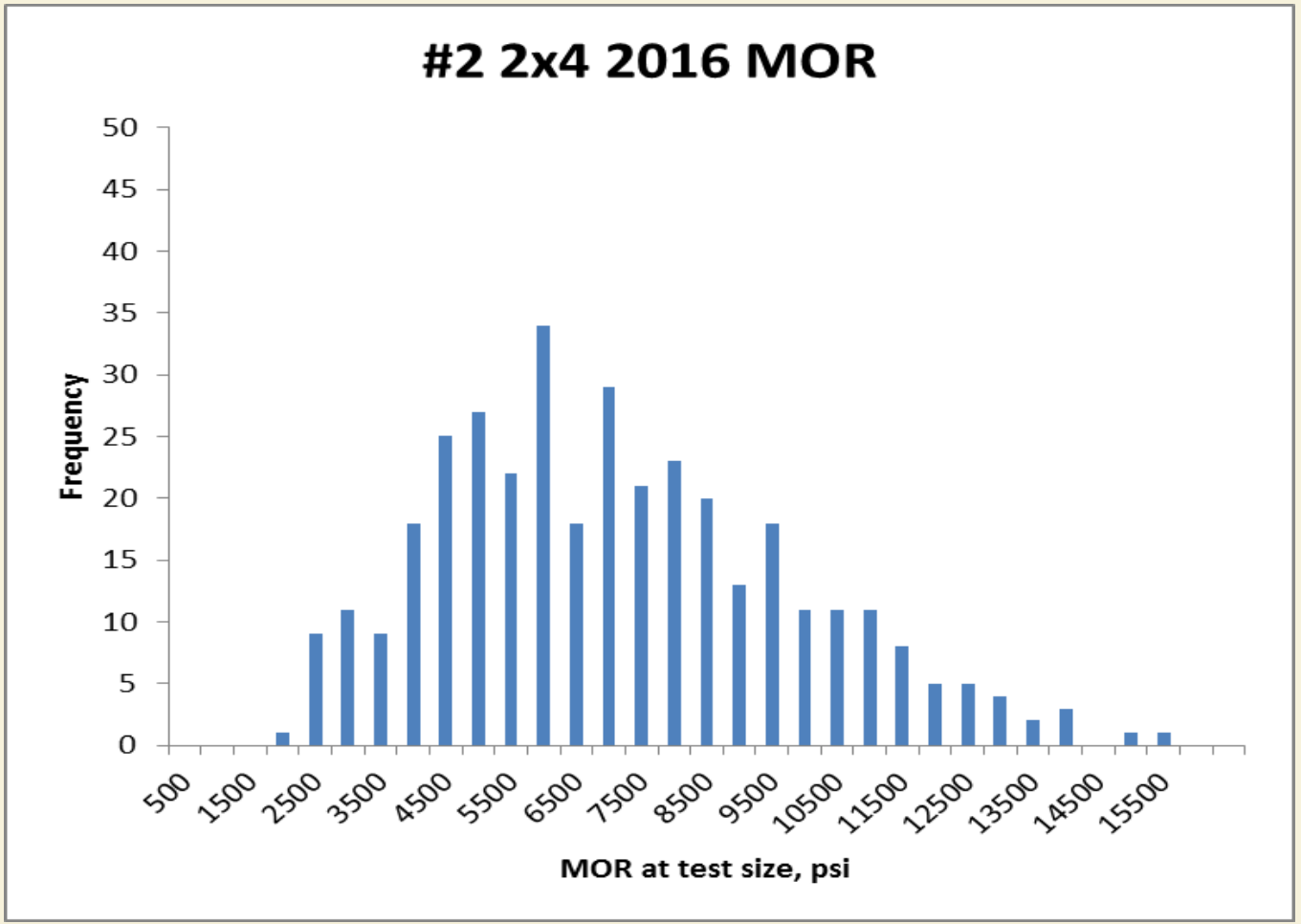
2x4 Results

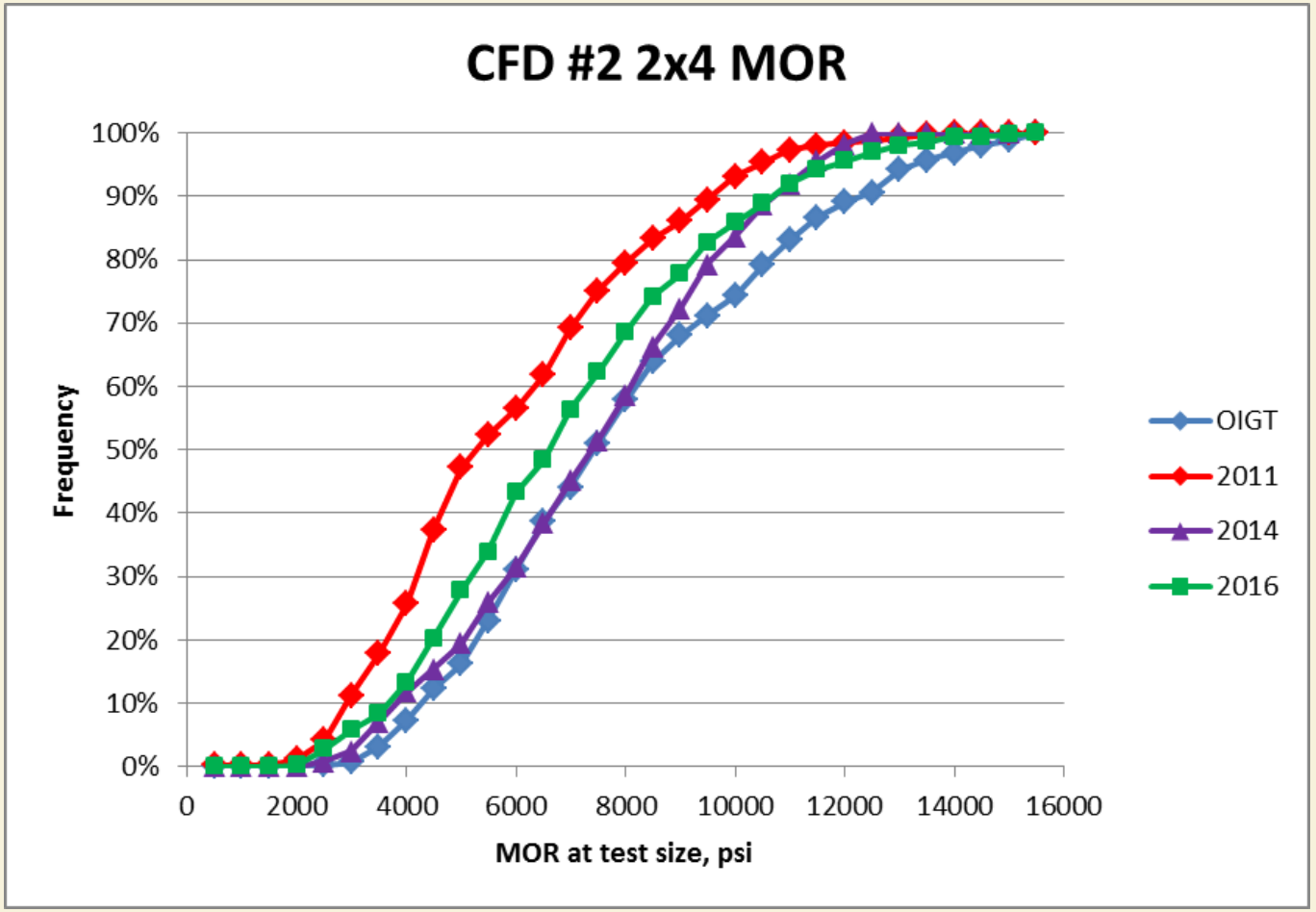
MOR Results

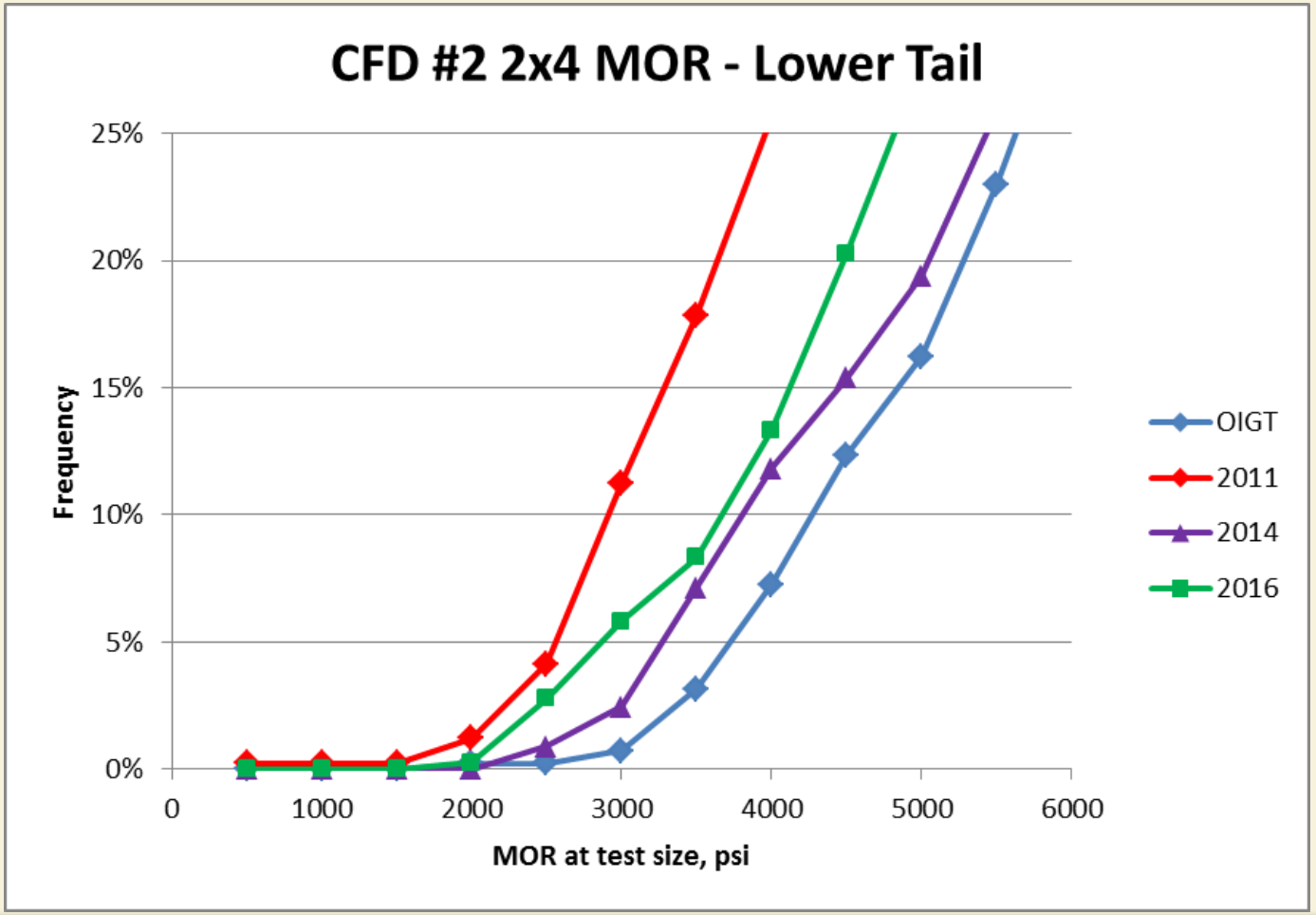

#2 2x4 Original IGT
Frequency
50
45
40
35
30
25
20
15
10
5
0
500
1500
2500
3500
4500
5500
6500
7500
8500
9500
10500
11500
12500
13500
14500
More
MOR at test size, psi


#2 2x4 - 2011
Frequency
50
45
40
35
30
25
20
15
10
5
0
500
1500
2500
3500
4500
5500
6500
7500
8500
9500
10500
11500
12500
13500
14500
MOR at test size, psi

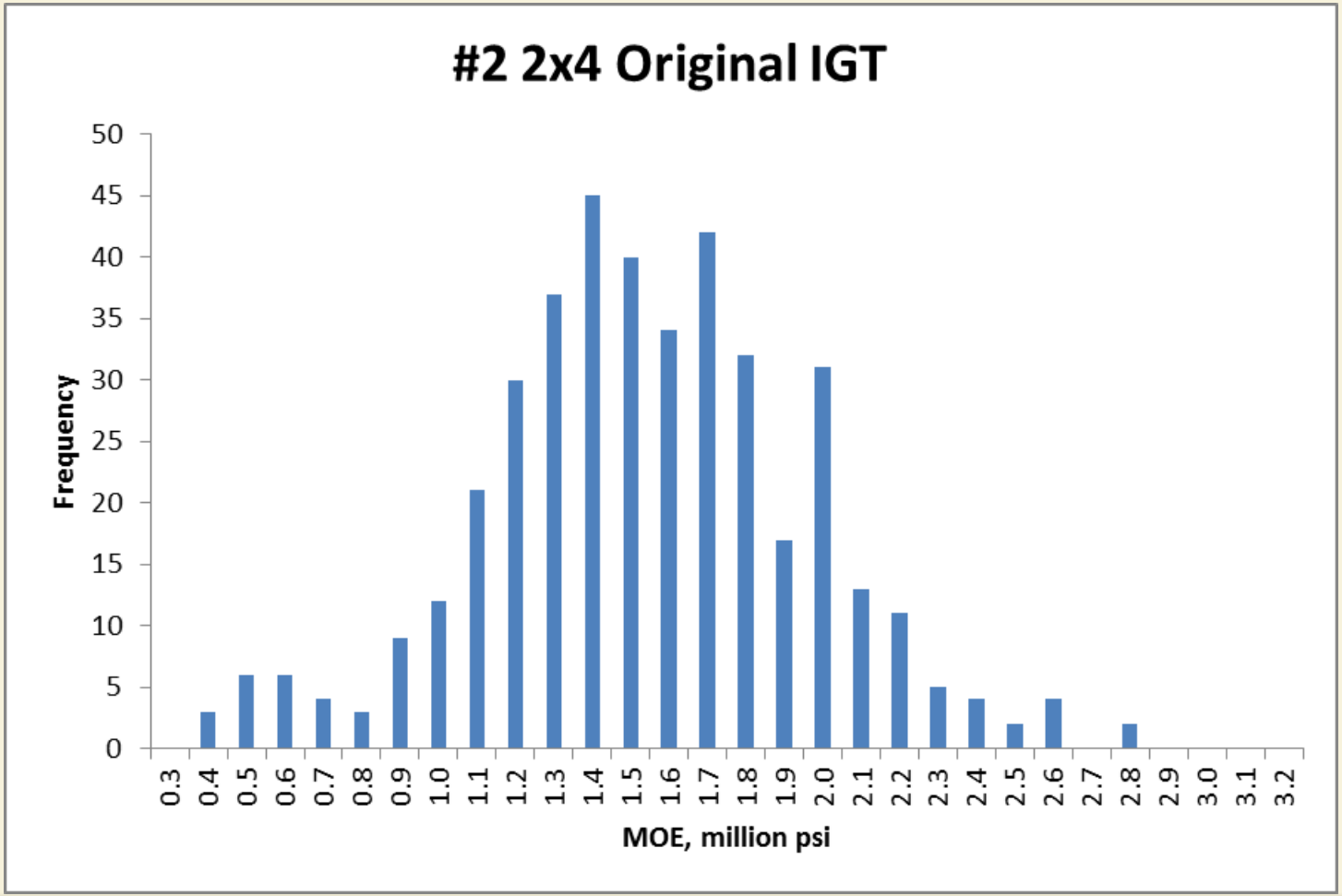

#2 2x4 - 2014
Frequency
50
45
40
35
30
25
20
15
10
5
0
500
1500
2500
3500
4500
5500
6500
7500
8500
9500
10500
11500
12500
13500
14500
MOR at test size, psi

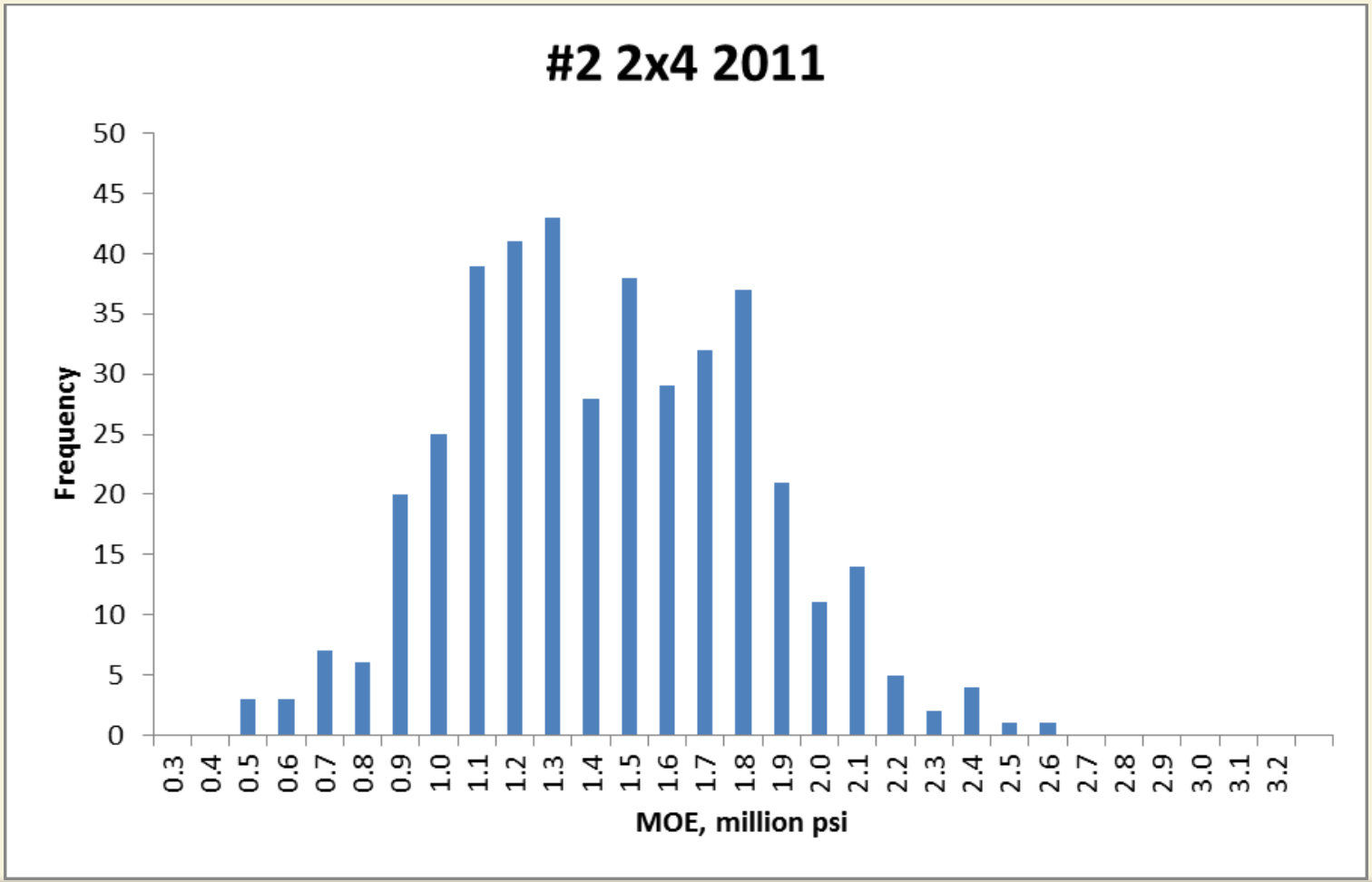

#2 2x4 2016 MOR
Frequency
0
5
10
15
20
25
30
35
40
45
50
500
1500
2500
3500
4500
5500
6500
7500
8500
9500
10500
11500
12500
13500
14500
15500
MOR at test size, psi

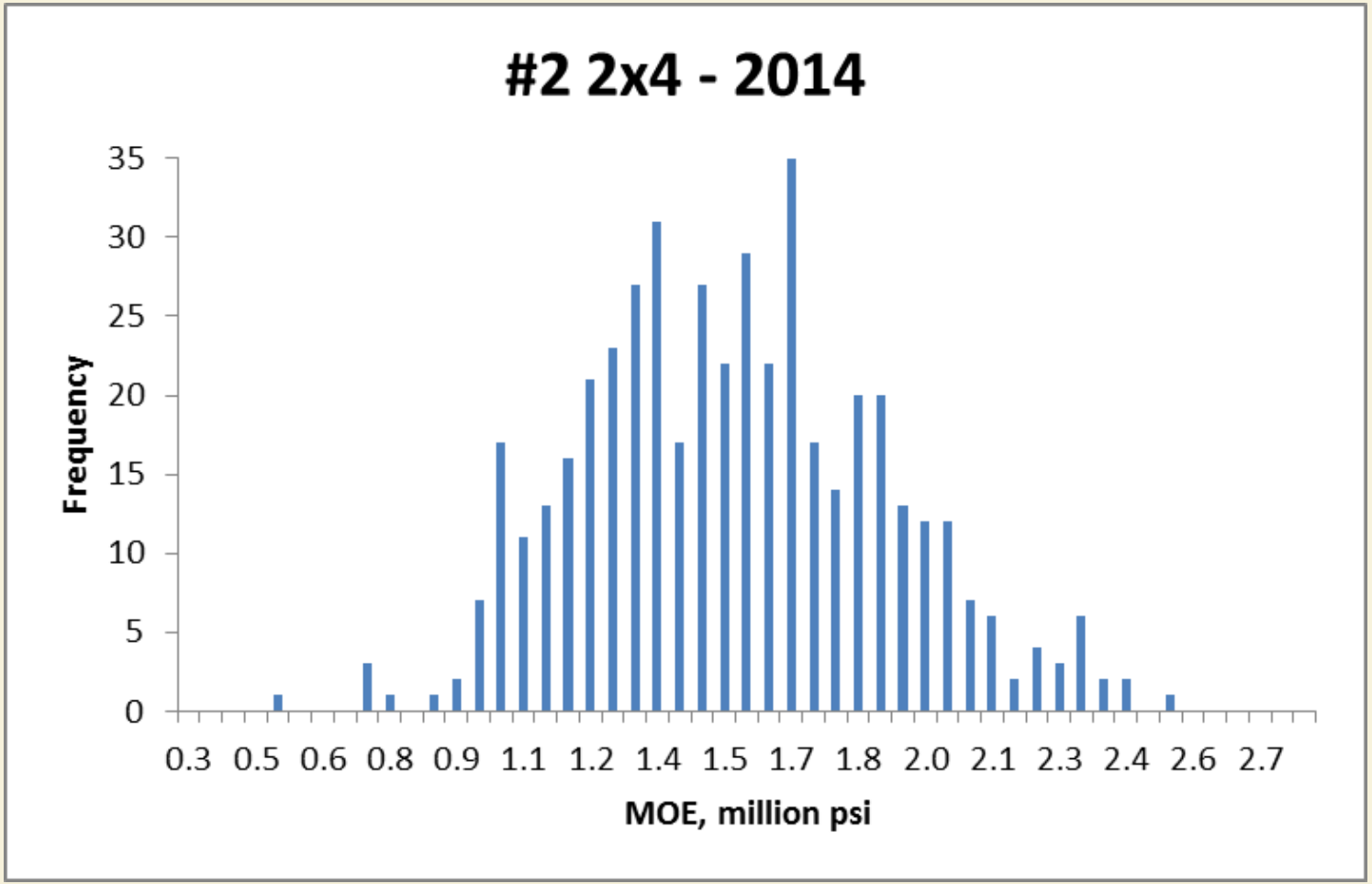

CFD #2 2x4 MOR
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Frequency
0
2000
4000
6000
8000
10000
12000
14000
16000
MOR at test size, psi
OIGT
2011
2014
2016

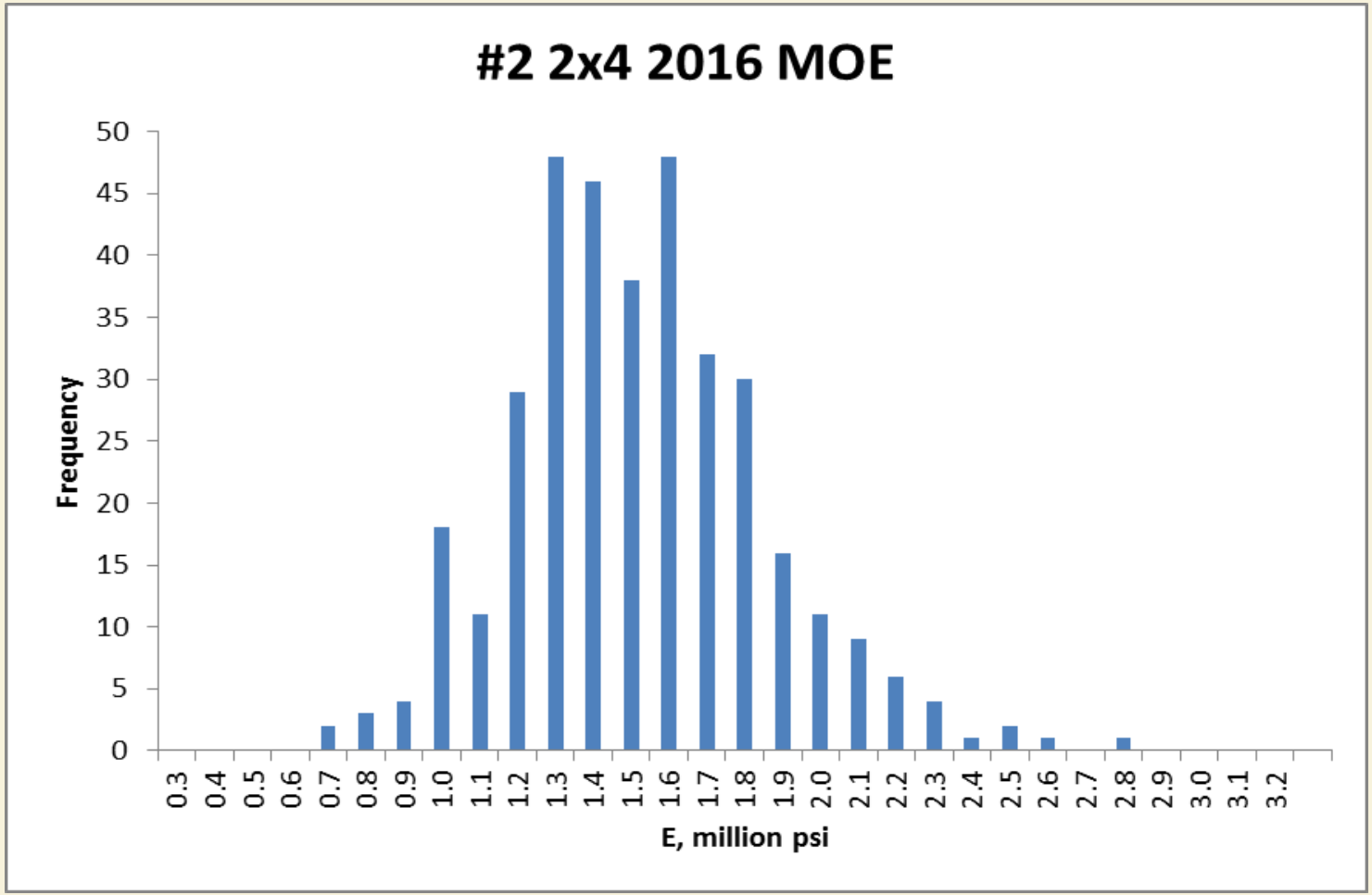

CFD #2 2x4 MOR - Lower Tail
25%
20%
15%
10%
5%
0%
Frequency
0
1000
2000
3000
4000
5000
6000
MOR at test size, psi
OIGT
2011
2014
2016

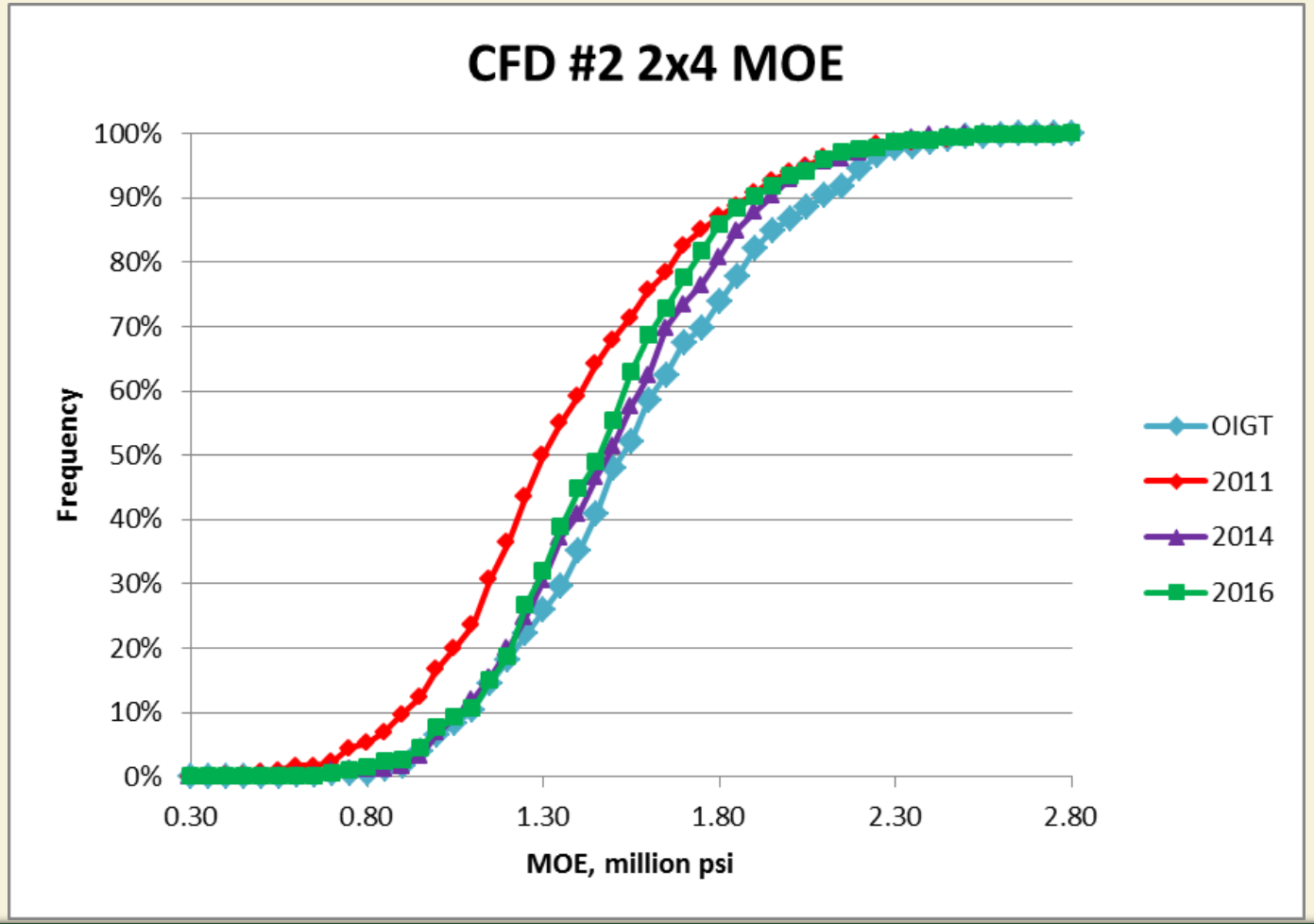
MOE Results

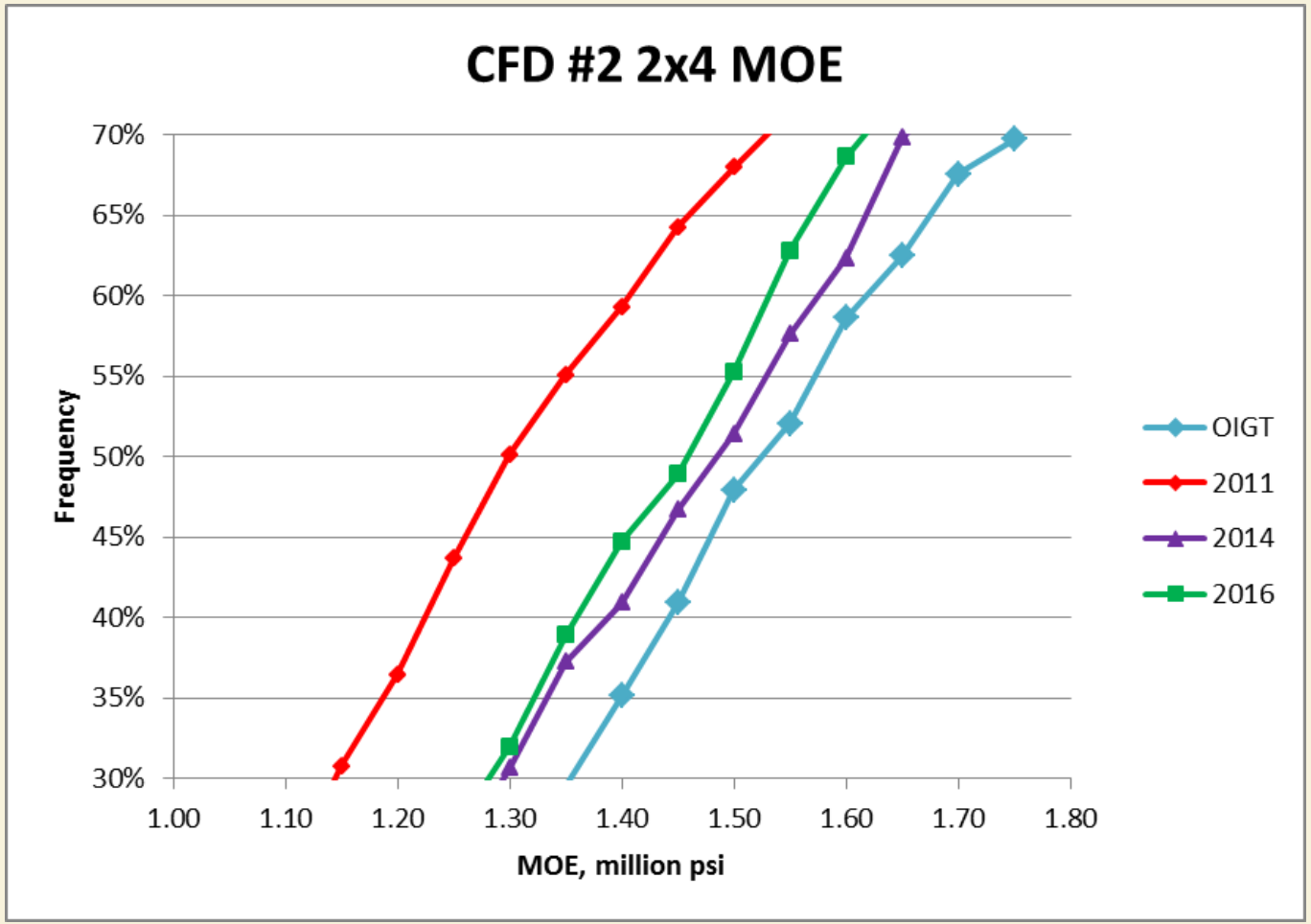

#2 2x4 Original IGT
Frequency
50
45
40
35
30
25
20
15
10
5
0
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
2.0
2.1
2.2
2.3
2.4
2.5
2.6
2.7
2.8
2.9
3.0
3.1
3.2
MOE, million psi


#2 2x4 2011
Frequency
50
45
40
35
30
25
20
15
10
5
0
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
2.0
2.1
2.2
2.3
2.4
2.5
2.6
2.7
2.8
2.9
3.0
3.1
3.2
MOE, million psi


#2 2x4 - 2014
Frequency
35
30
25
20
15
10
5
0
0.3 0.5 0.6 0.8 0.9 1.1 1.2 1.4 1.5 1.7 1.8 2.0 2.1 2.3 2.4 2.6 2.7
MOE, million psi


#2 2x4 2016 MOE
Frequency
50
45
40
35
30
25
20
15
10
5
0
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
2.0
2.1
2.2
2.3
2.4
2.5
2.6
2.7
2.8
2.9
3.0
3.1
3.2
E, million psi


CFD #2 2x4 MOE
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Frequency
0.30
0.80
1.30
1.80
2.30
2.80
MOE, million psi
OIGT
2011
2014
2016


CFD #2 2x4 MOE
70%
65%
60%
55%
50%
45%
40%
35%
30%
Frequency
1.00
1.10
1.20
1.30
1.40
1.50
1.60
1.70
1.80
MOE, million psi
OIGT
2011
2014
2016

Comparing 2x4 Samples

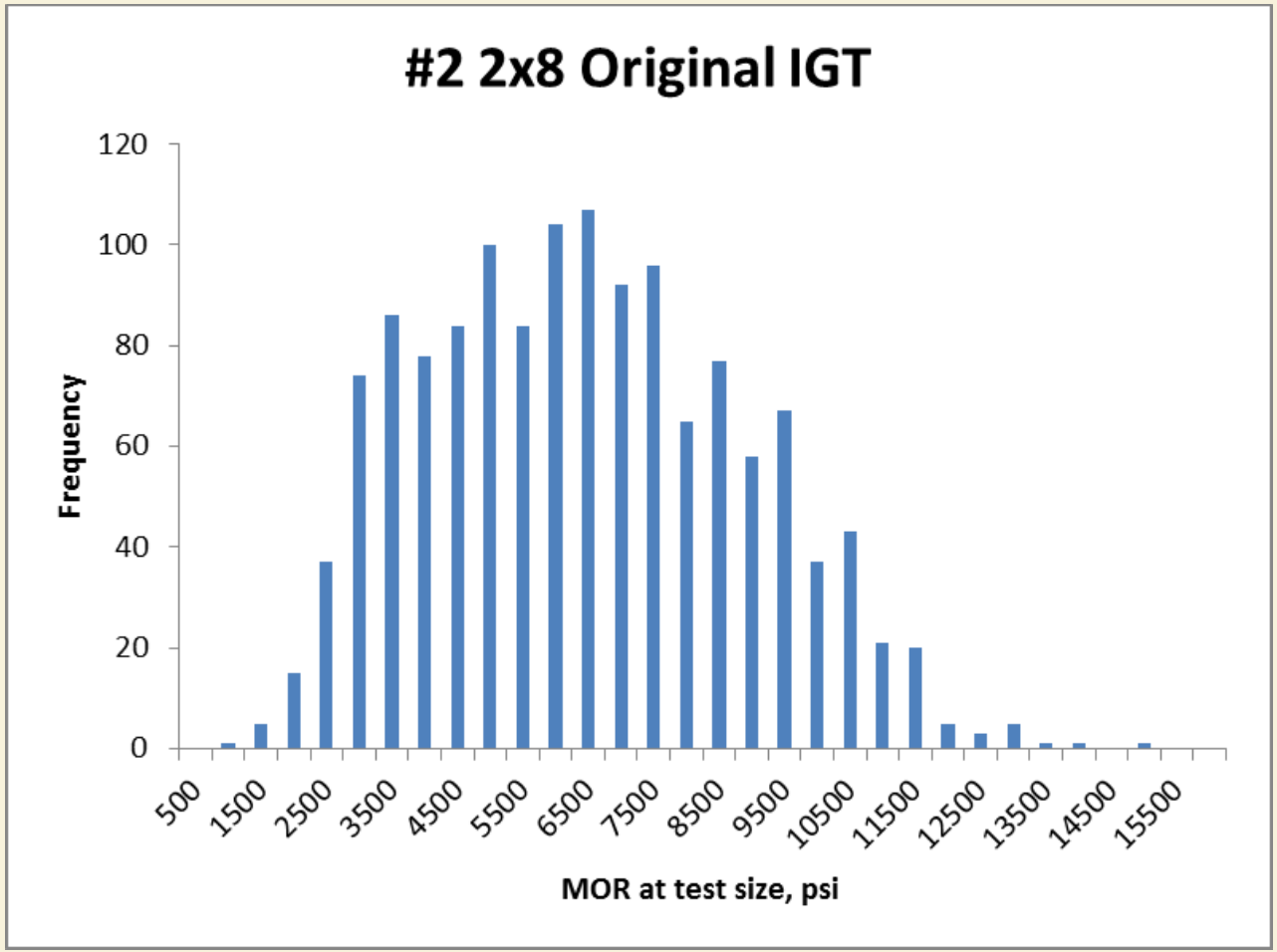
	OIGT	2011	2014	2016
MOR, TL psi	3621	2547	3265	2926
Avg E	1.56	1.35	1.50	1.47
Avg MC	14.2%	11.1%	14.7%	14.0%
% Dense	55%	39%	59%	50%
% Comb. Kt	0%	22%	5%	12%
RPI	na	5.7	5.7	5.8
%Summerwood	na	38%	51%	44%
% Prime	na	29%	19%	22%

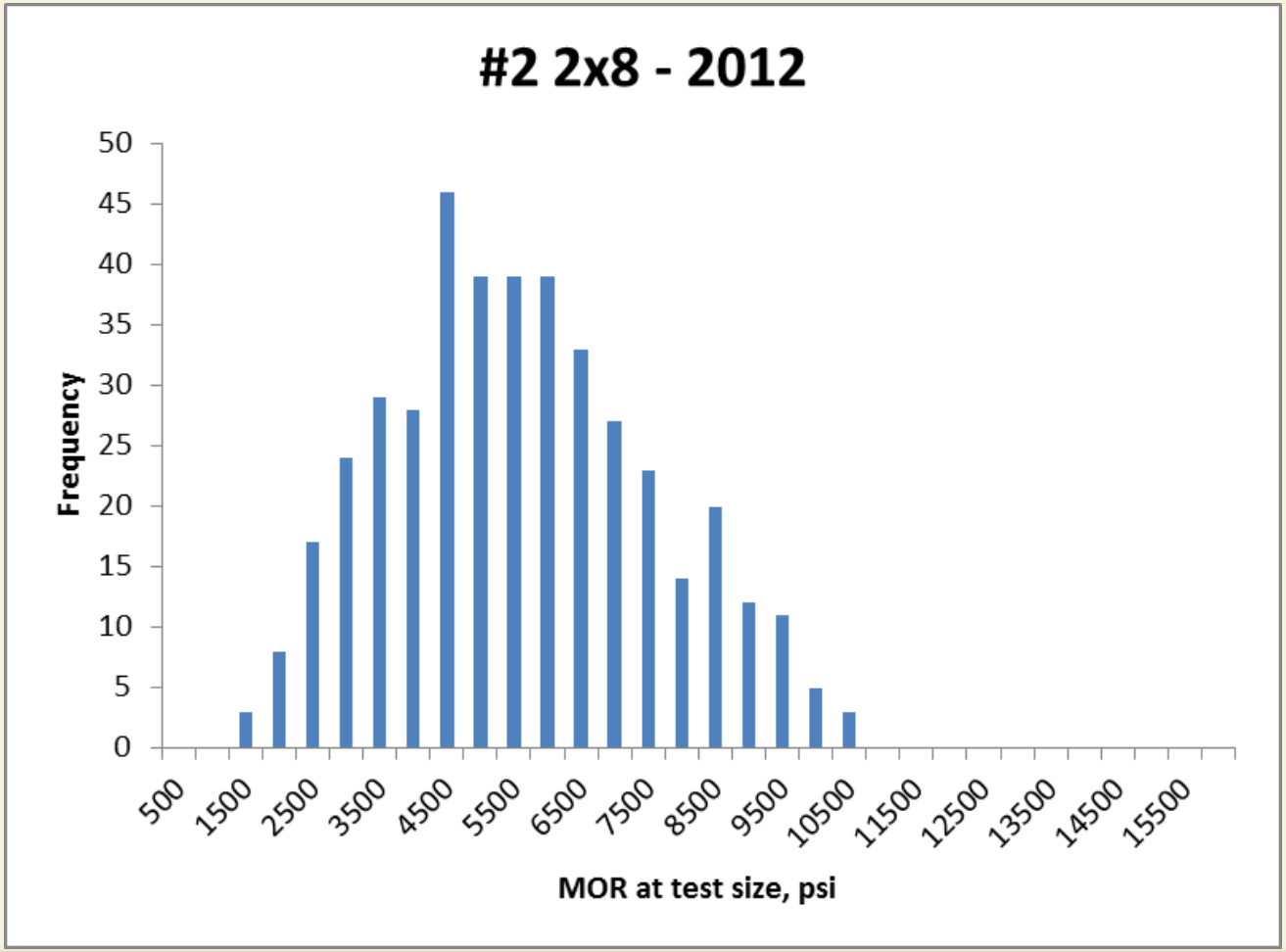
Observations

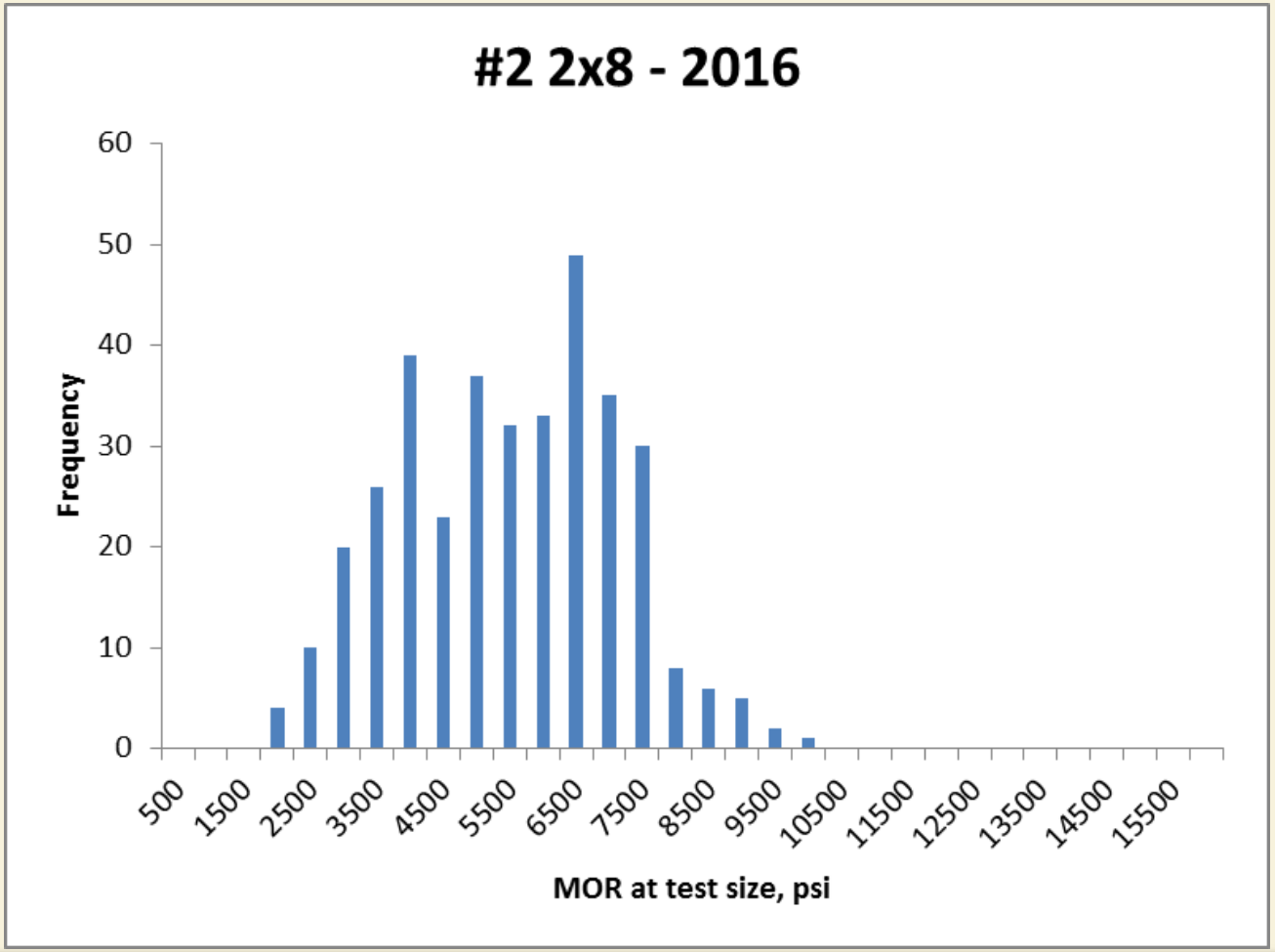
- 2016 2x4 sample falls between 2011 and 2014 samples for both MOR and MOE
- 2016 values meet or exceed published design values

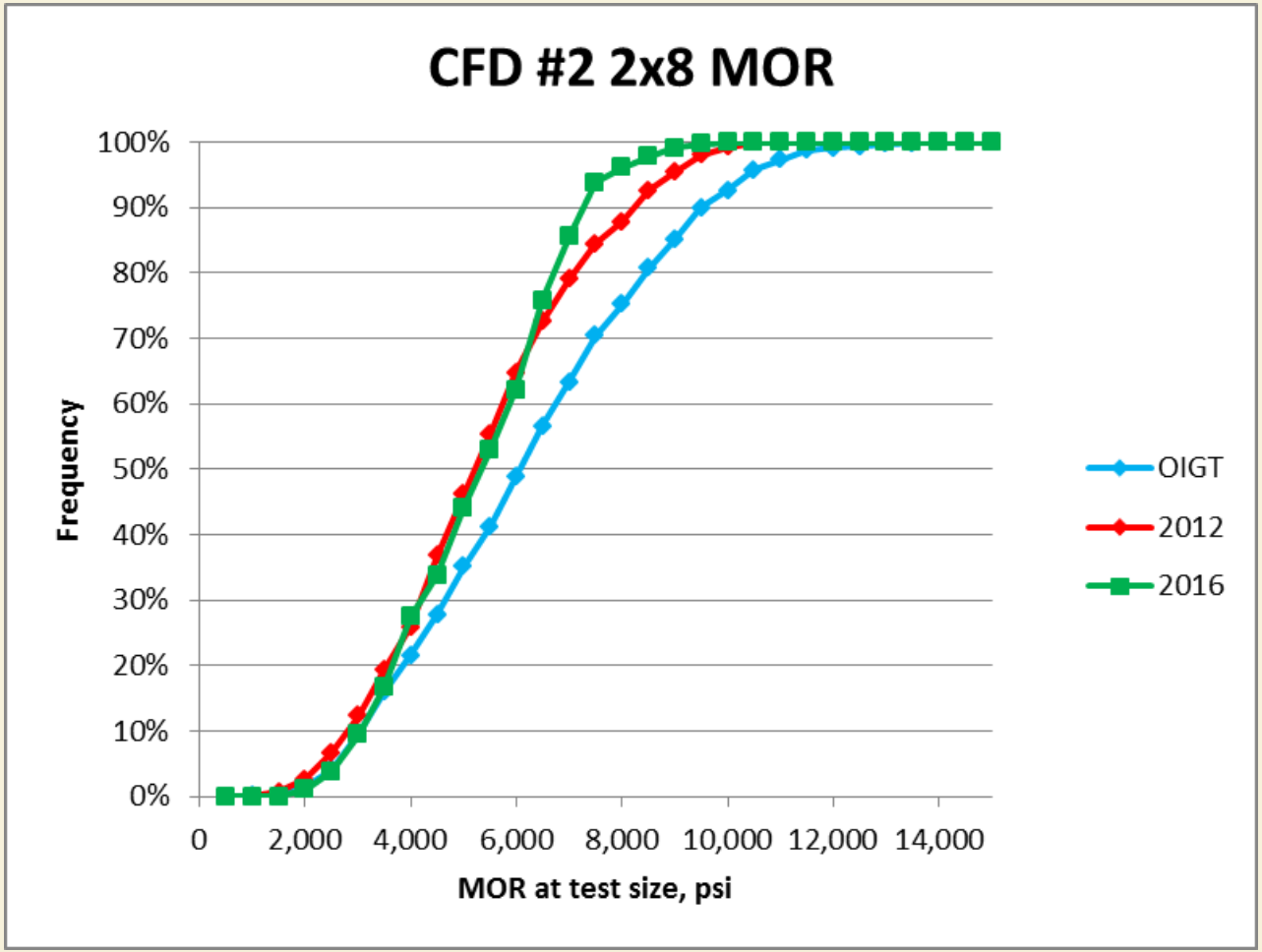
2x8 Results

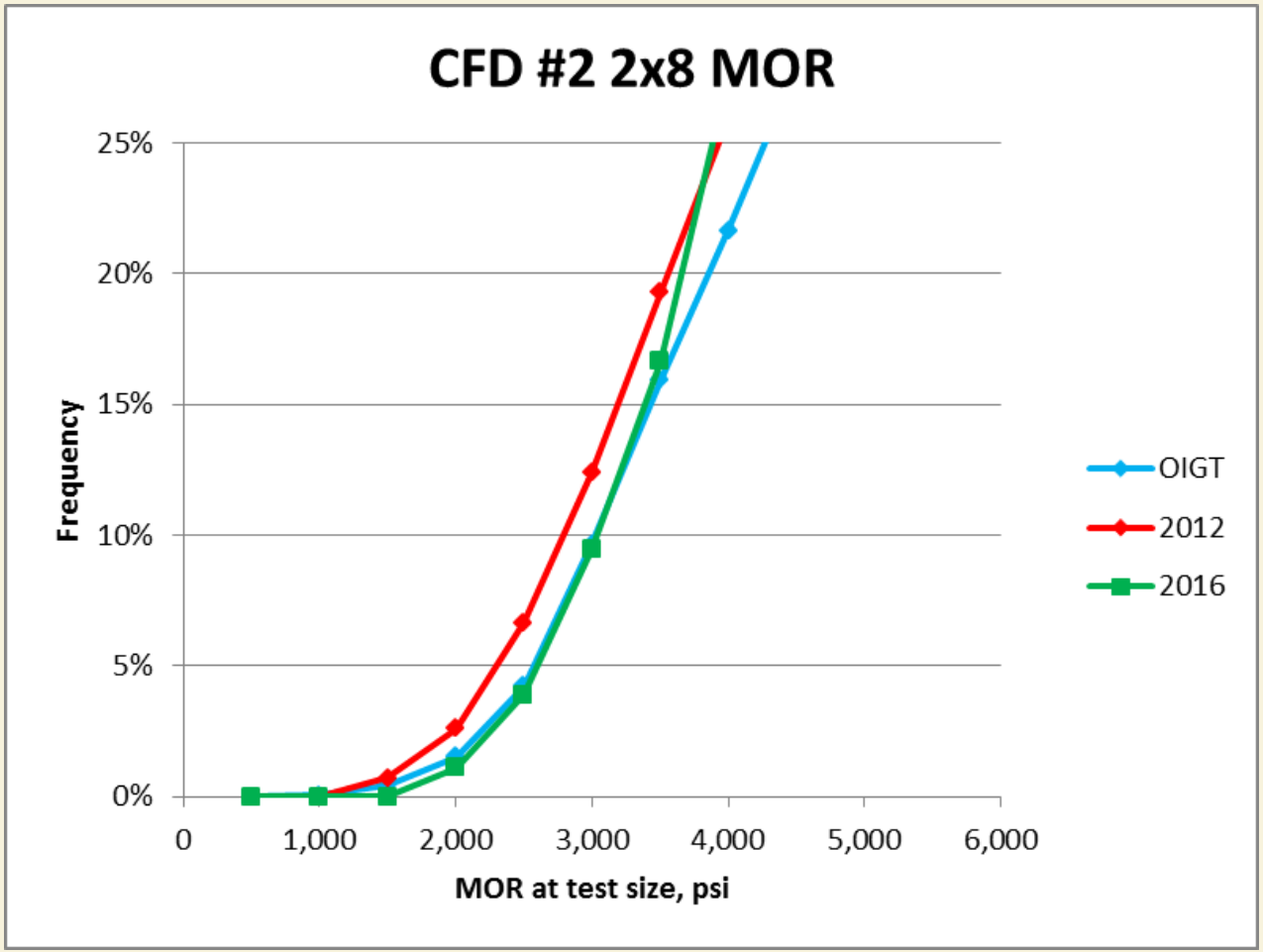
MOR Results


#2 2x8 Original IGT
Frequency
120
100
80
60
40
20
0
500
1500
2500
3500
4500
5500
6500
7500
8500
9500
10500
11500
12500
13500
14500
15500
MOR at test size, psi

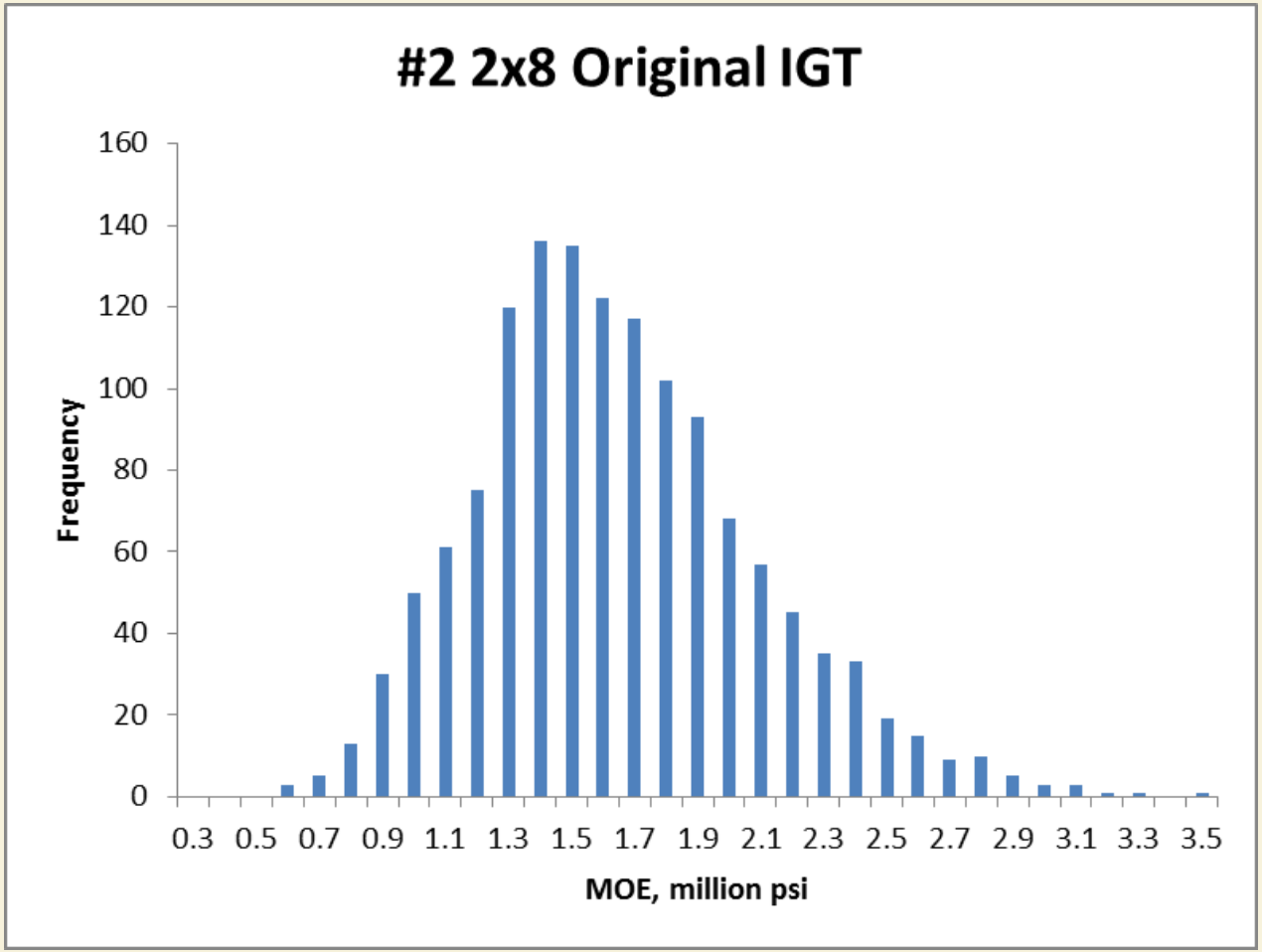

#2 2x8 - 2012
Frequency
0
5
10
15
20
25
30
35
40
45
50
500
1500
2500
3500
4500
5500
6500
7500
8500
9500
10500
11500
12500
13500
14500
15500
MOR at test size, psi

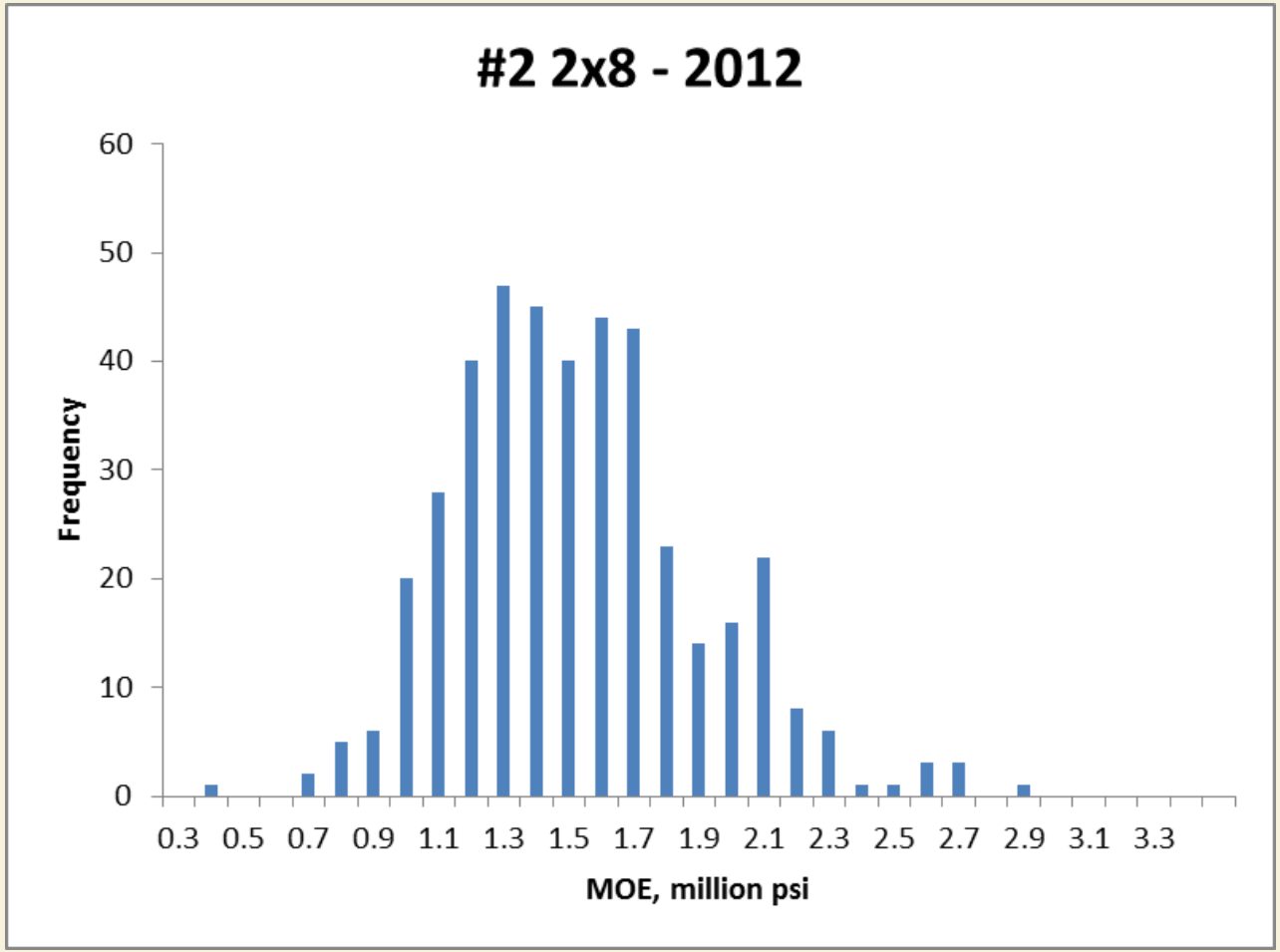

#2 2x8 - 2016
Frequency
60
50
40
30
20
10
0
500
1500
2500
3500
4500
5500
6500
7500
8500
9500
10500
11500
12500
13500
14500
15500
MOR at test size, psi

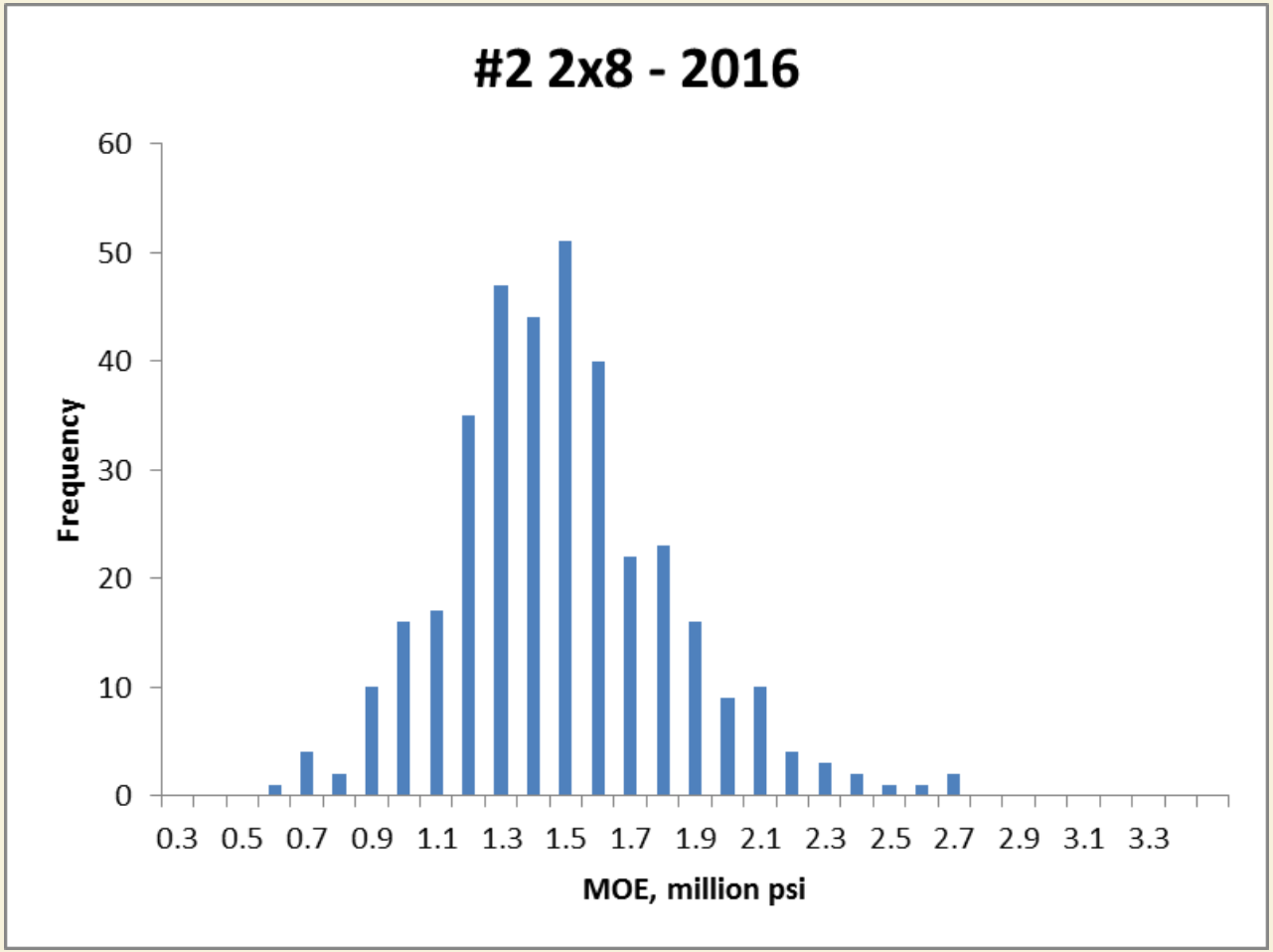

CFD #2 2x8 MOR
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Frequency
0
2,000
4,000
6,000
8,000
10,000
12,000
14,000
MOR at test size, psi
OIGT
2012
2016

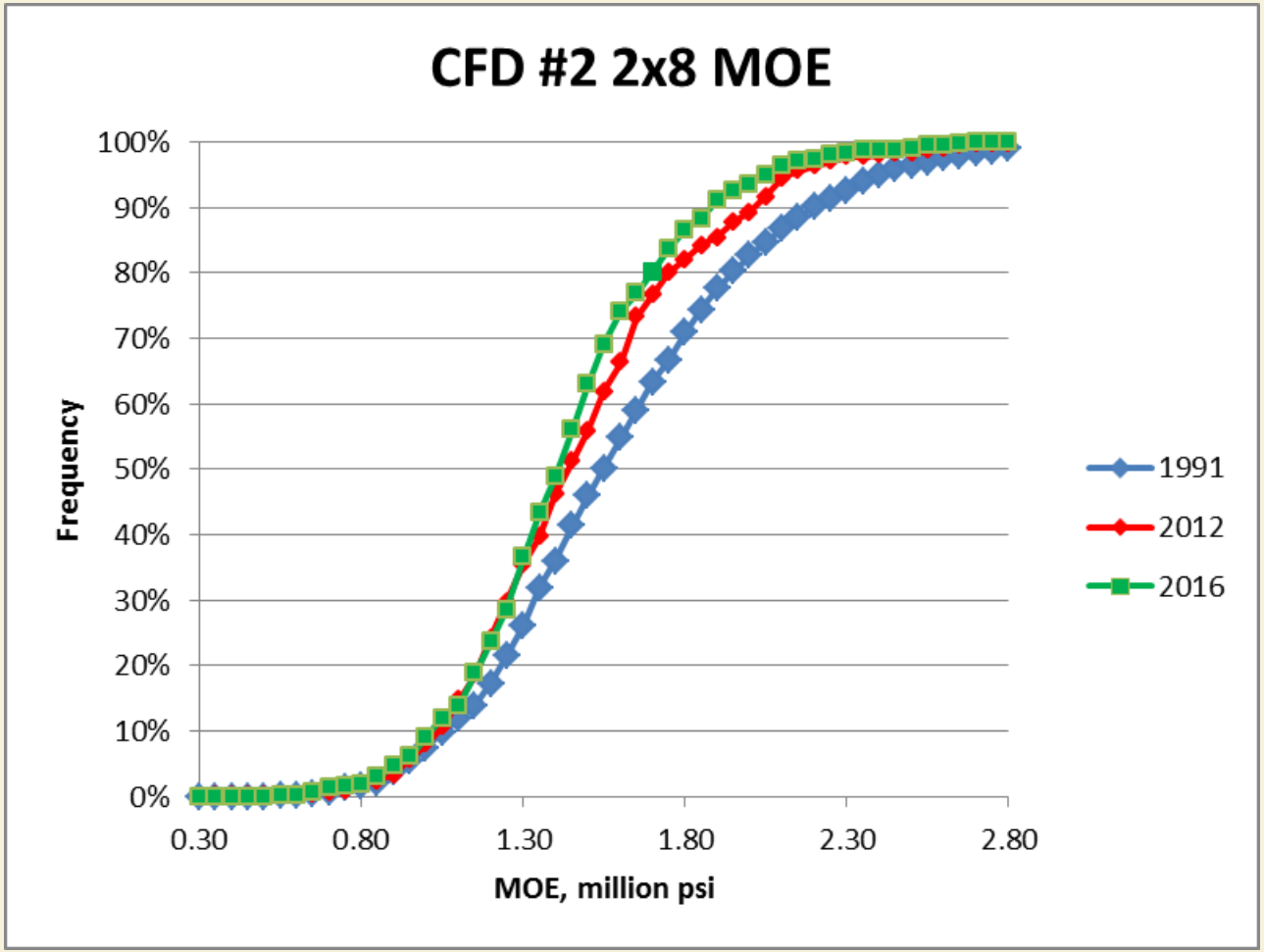

CFD #2 2x8 MOR
25%
20%
15%
10%
5%
0%
Frequency
0
1,000
2,000
3,000
4,000
5,000
6,000
MOR at test size, psi
OIGT
2012
2016

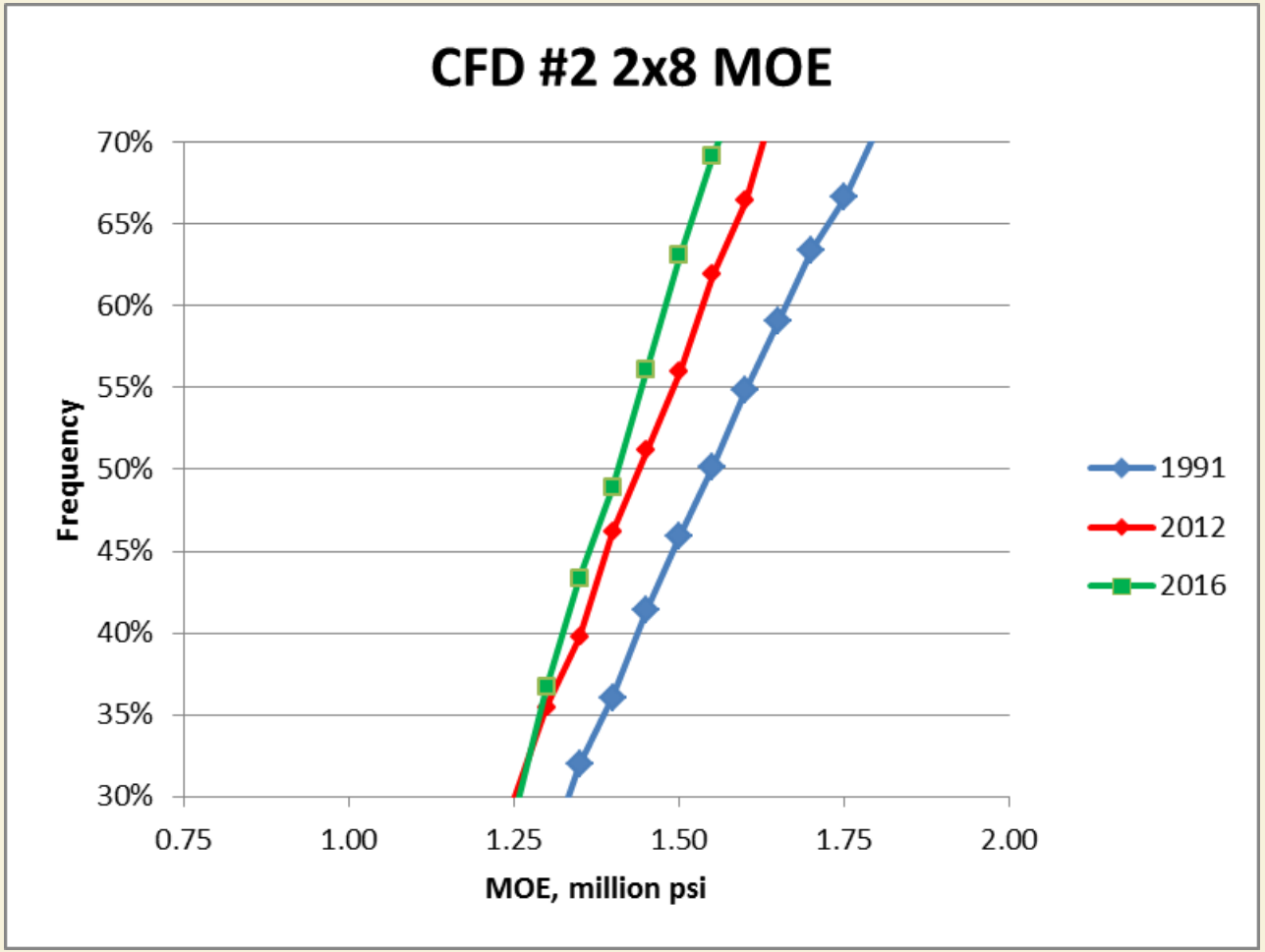
MOE Results


#2 2x8 Original IGT
Frequency
160
140
120
100
80
60
40
20
0
0.3 0.5 0.7 0.9 1.1 1.3 1.5 1.7 1.9 2.1 2.3 2.5 2.7 2.9 3.1 3.3 3.5
MOE, million psi


#2 2x8 - 2012
Frequency
60
50
40
30
20
10
0
0.3 0.5 0.7 0.9 1.1 1.3 1.5 1.7 1.9 2.1 2.3 2.5 2.7 2.9 3.1 3.3
MOE, million psi


#2 2x8 - 2016
Frequency
60
50
40
30
20
10
0
0.3 0.5 0.7 0.9 1.1 1.3 1.5 1.7 1.9 2.1 2.3 2.5 2.7 2.9 3.1 3.3
MOE, million psi


CFD #2 2x8 MOE
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Frequency
0.30
0.80
1.30
1.80
2.30
2.80
MOE, million psi
1991
2012
2016


CFD #2 2x8 MOE
70%
65%
60%
55%
50%
45%
40%
35%
30%
Frequency
0.75
1.00
1.25
1.50
1.75
2.00
MOE, million psi
1991
2012
2016

Comparing 2x8 Samples

	OIGT	2012	2016
MOR, TL psi	2519	2128	2496
Avg E	1.60	1.50	1.43
Avg MC	14.5%	15.1%	14.7%
% Dense	na	34%	38%
% Comb. Kt	na	22%	11%
RPI	na	5.4	5.3
%Summerwood	na	38%	45%
% Prime	na	27%	25%

Observations

- MOR of 2016 sample is higher than 2012 and very close to 1991 (Original IGT)
- Possibly due to lower number of combination knots
- MOE of 2016 sample is lower than 2012 and 1991
- 2016 MOE is close to published MOE value

Observations

- Significant variability between samples from year to year
- Present design values represent lower end of what could be included in the grade.
- 2016 samples confirm that present DV are appropriate.

Data on Prime Lumber

- Smaller sample sizes
- Averages meaningful
- Use tolerance limits with caution
- May not represent regions proportional to production

2X4 Prime Results

	2011	Prime	2014	Prime	2016	Prime
n	409	118	362	70	360	80
MOR, TL psi	2547	2246	3265	2355	2926	2355
Avg E	1.35	1.20	1.50	1.39	1.47	1.35
Avg MC	11.1%	11.5%	14.7%	14.8%	14.0%	14.3%
% Dense	39%	25%	59%	46%	50%	36%
% Comb. Kt	22%	36%	5%	11%	12%	26%
RPI	5.7	5.0	5.7	5.2	5.8	5.1
%Summerwood	38%	34%	51%	46%	44%	39%

2X8 Prime Results

	2012	Prime	2016	Prime
n	420	112	360	91
MOR, TL psi	2128	2018	2496	2172
Avg E	1.50	1.41	1.43	1.34
Avg MC	15.1	15.6%	14.7%	14.7%
% Dense	34%	26%	38%	25%
% Comb. Kt	22%	14%	11%	24%
RPI	5.4	4.7	5.3	4.6
%Summerwood	38%	34%	45%	41%

Prime Design Values?

- For 2x4 and 2x8 samples, MOR TL for Prime ranges from 72% to 95% of unclassified.
- Compared to unclassified MOR TL used in 2013 DV, Prime ranges from 92% to 102%.
- Significant issues surrounding Prime having separate design values.
- Production of Prime varies based on market

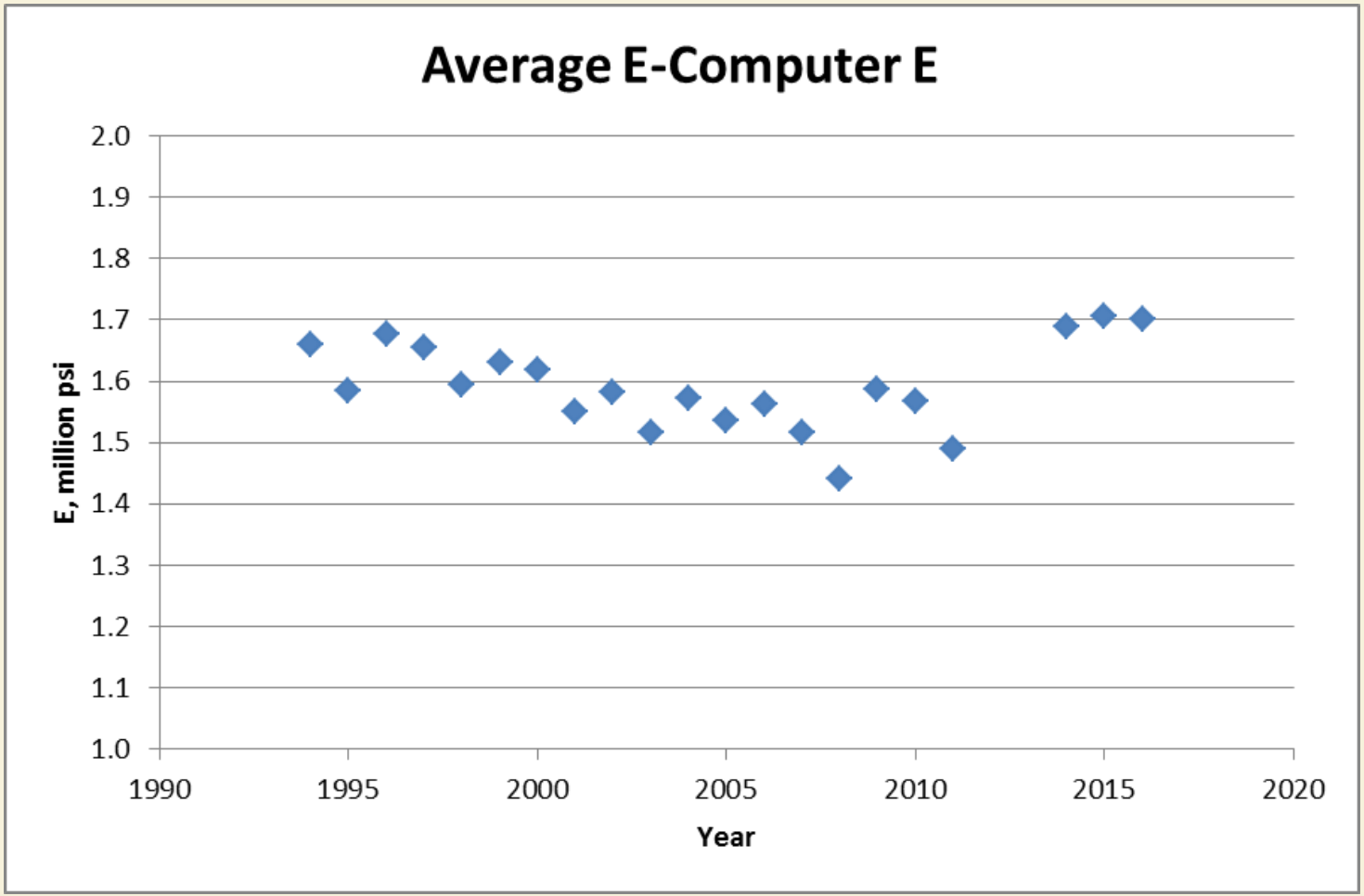
Historical RMP Data

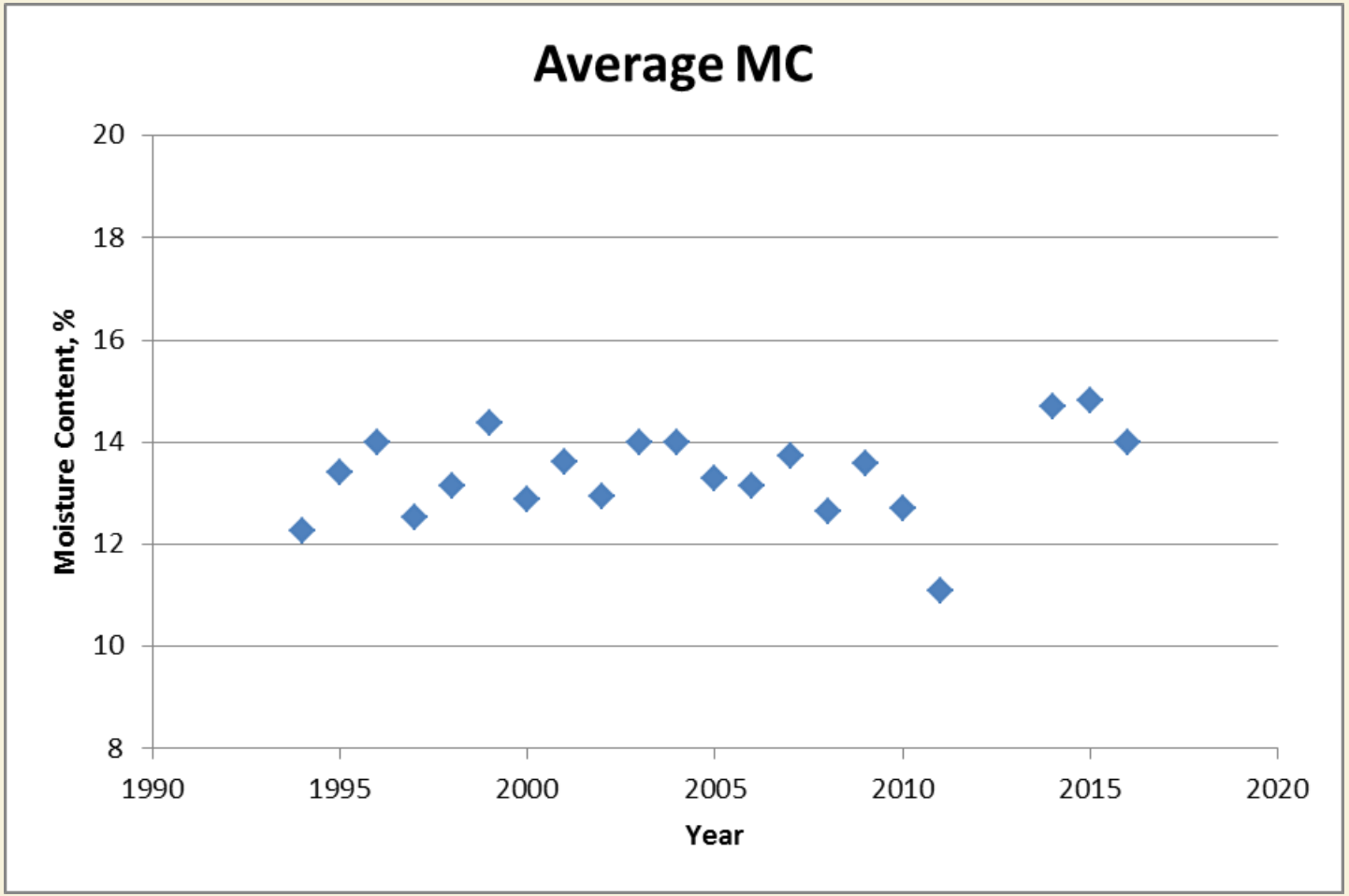
Historical RMP Data

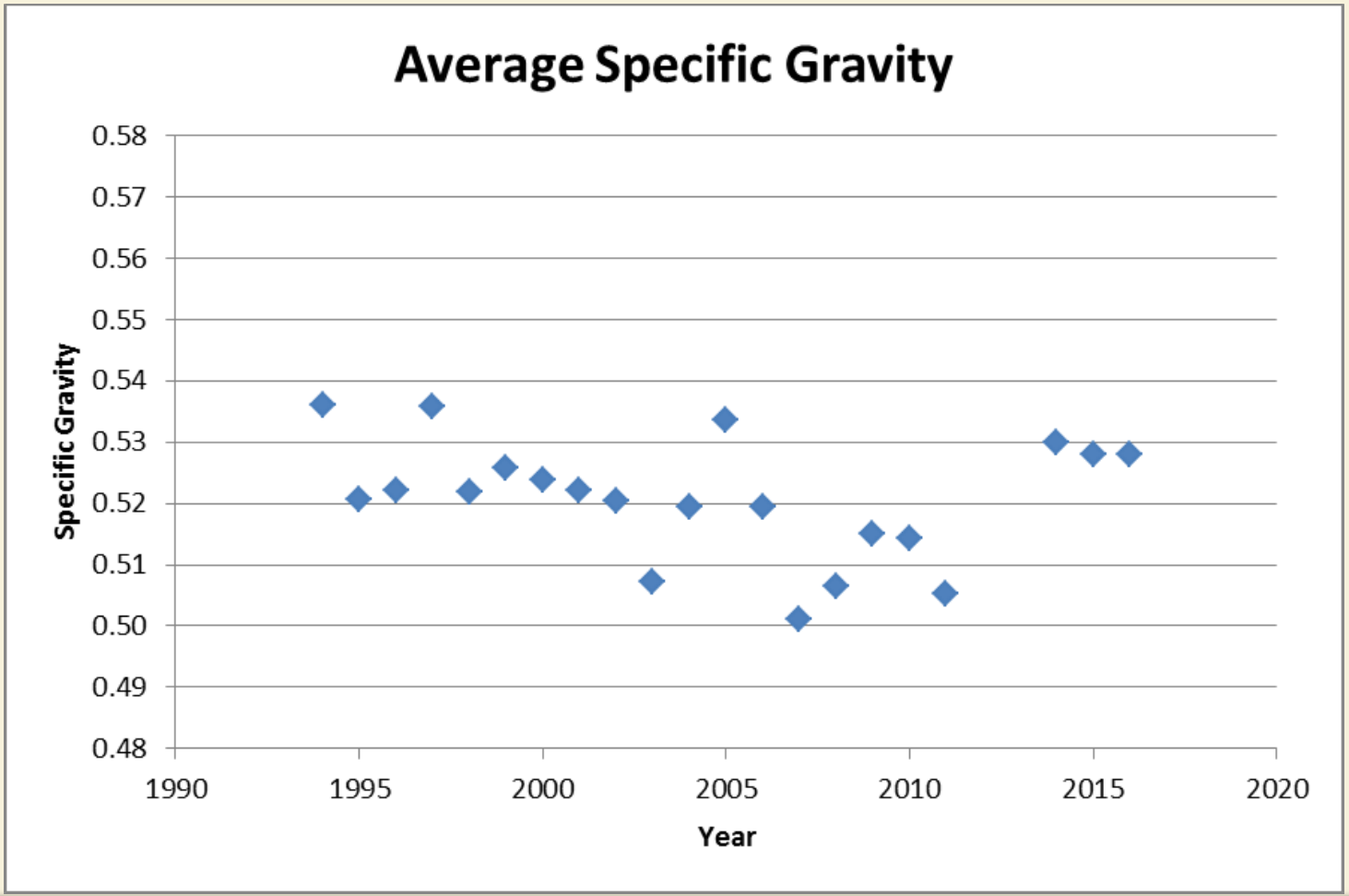
- Since 1994, a non-destructive monitoring program had been conducted by SPIB
- From 1994-2010, a portable E-Computer was used at mill sites to collect data
- Flatwise, transverse vibration E is not as correlated to third-point Edge E as we would like

Historical RMP Data

- #2 2x4 sampled by regions
- Data was useful to detect trends over time
- Continue collecting E-Computer data in recent/future monitoring samples


Average E-Computer E
E, million psi
2.0
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
1990
1995
2000
2005
2010
2015
2020
Year


Average MC
Moisture Content, %
20
18
16
14
12
10
8
1990
1995
2000
2005
2010
2015
2020
Year


Average Specific Gravity
Specific Gravity
0.58
0.57
0.56
0.55
0.54
0.53
0.52
0.51
0.50
0.49
0.48
1990
1995
2000
2005
2010
2015
2020
Year

Observations

- Recent monitoring samples are consistent
- Specific Gravity determined on full-size lumber pieces (not approved in ASTM D2395)
- RMP SG not a 1:1 relation with published SG

Future Testing

- Monitoring procedures added to ASTM D1990
- Requirement: Test most commonly produced size/grade every 5 years
- SPIB: Test #2 2x4 approximately every 18 months, test a wider width every 3rd year.
- Vary between bending and tension tests.

Year	"Season"	Size	Grade	Property
2011		2x4	#2	E, MOR, UTS
2012		2x4, 2x8, 2x10	SS, #2	E, MOR, UTS, UCS
2013	Summer	2x6	#1	E, MOR
2014	Winter	2x4	#2	E, MOR
2015	Winter	2x4	#2	E, UTS
2016	Late Fall '15	2x4,2x8	#2	E, MOR
2018	Summer '17	2x4	#2	E, MOR
2020	Winter '19	2x4, 2x8	#2	E, UTS
2022	Summer '21	2x4	#2	E, MOR
2024	Winter '23	2x4, 2x8	#2	E, MOR