SUB SECTION 6

REPORT 2

Burst Pressure Analyses Before Field Test
November 9, 2001

POP Project Meeting Report

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Performance of Offshore Pipelines Project
A Joint Industry Project

Presentation Outline

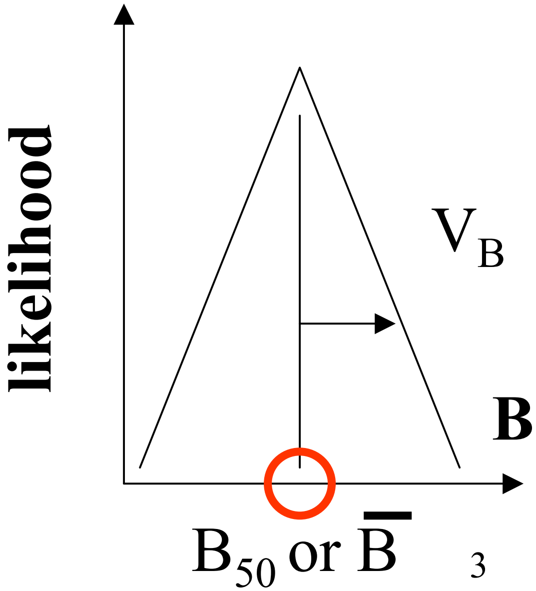
- **Burst pressure analyses before field test**
- **Burst pressure analyses after field test**
  - **After Rosen in-line instrumentation data**
  - **After Stress materials testing data**
  - **After Winmar field test data**
- **Observations**

Burst Pressure Analyses

- **B 31G, DNV RP F101, ABS, RAM Pipe**
- **Deterministic Pb (with, without Bias)**
- **Probabilistic Pb, P[Pb ≤ Ptest] (uncertainties)**

- ***Bias = B***

  = Pb test / Pb predicted



ASME B-31G

$$P' = 1.1P\left[\frac{1-\frac{2}{3}\left(\frac{d}{t}\right)}{1-\frac{2}{3}\left(\frac{d}{t\sqrt{A^2+1}}\right)}\right]$$

$$A = 0.893\left(\frac{Lm}{\sqrt{Dt}}\right) \leq 4$$

P’ = safe maximum pressure for the corroded area ≤ P

Lm = measured longitudinal extent of the corroded area, inches

D = nominal outside diameter of the pipe, inches

t = nominal wall thickness of the pipe, inches

d = measured depth of the corroded area

P = the greater of either the established MAOP or P = SMYS*2t*F/D

(F = design factor, usually equal to .72, = 1.0 for Pb analyses)

DNV RP-F101

$$\mathrm{Pf} = \frac{2 \cdot \mathrm{t} \cdot \mathrm{UTS}\left(1 - (\mathrm{d}/\mathrm{t})\right)}{(\mathrm{D} - \mathrm{t})\left(1 - \frac{(\mathrm{d}/\mathrm{t})}{\mathrm{Q}}\right)}$$

$$Q = \sqrt{1 + .31\left(\frac{L}{\sqrt{D \cdot t}}\right)^2}$$

Pf = **failure pressure of the corroded pipe**

t = uncorroded, measured, pipe wall thickness

d = depth of corroded region

D = nominal outside diameter

L = length of corroded region

Q = length correction factor

UTS = ultimate tensile strength

ABS formulation *(modified design)*

- **$Pb = \eta \, SMYS \, (t - tc) / Ro$**
  - **$Ro = (D - t) / 2$**
  - **SMYS - specified minimum yield strength**

    η - utilization factor = 1.0
  - **t - pipe nominal wall thickness**
  - **tc - pipe corrosion thickness**
  - **D - pipe nominal outer diameter**

RAM Pipe #1 *(SMYS)*

$$p_{bd} = \frac{3.2 \cdot t_{nom} \cdot SMYS}{D_o \cdot SCF}$$

p_{bd} = burst pressure of corroded pipeline

t_{nom} = pipe wall nominal thickness

D_o = mean pipeline diameter (D-t)

SMYS = Specified Minimum Yield Strength of pipeline material

SCF = Stress Concentration Factor

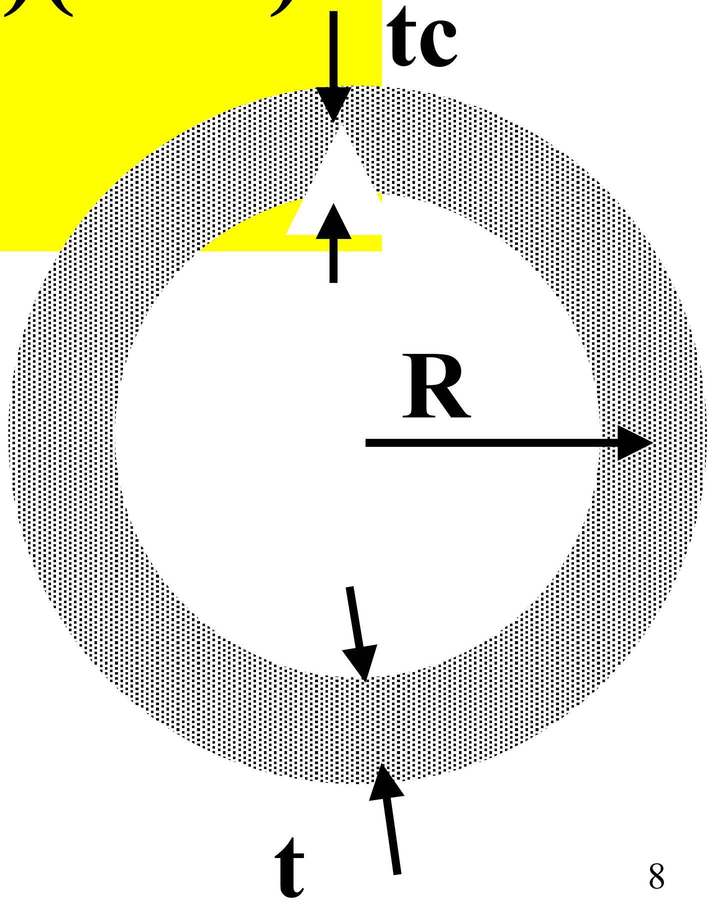
$$SCF = 1 + 2 \cdot (d / R)^{.5}$$

d = tc = depth of corrosion **R = Do/2**

RAM Pipe #2 *(SMTS)*

$$p_B = (1.2\ SMTS\ /\ SCF\ )(t\ /\ R)$$

$$SCF = 1+2(tc/R)^{0.5}$$

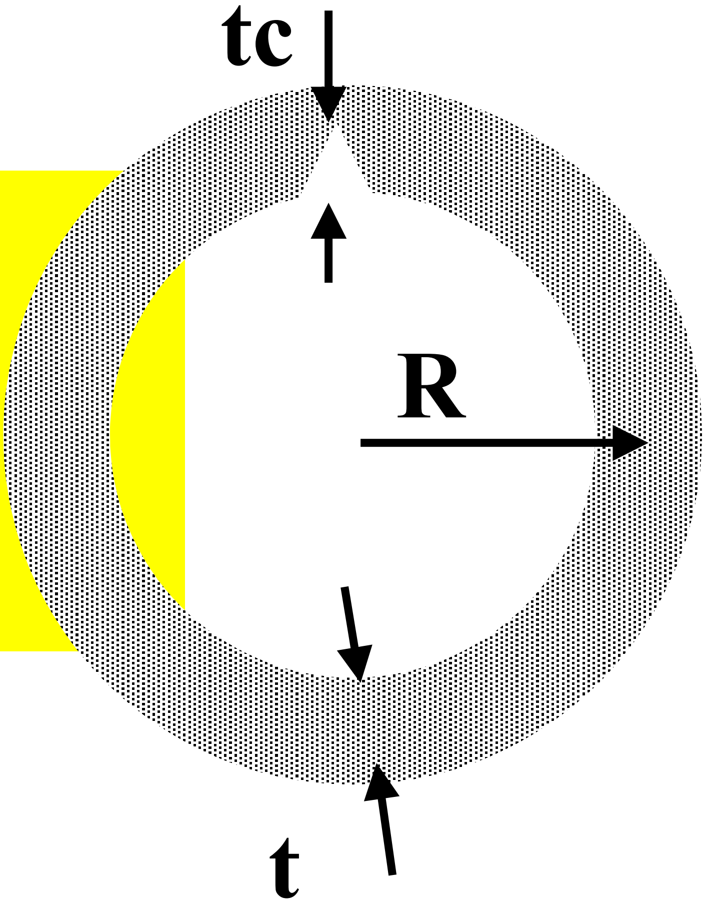


RAM Pipe #3 *(UTS)*

$$p_B = (\overline{UTS} / SCF)(t / R)$$

$$SCF = 1+2\,(tc/R)^{0.5}$$

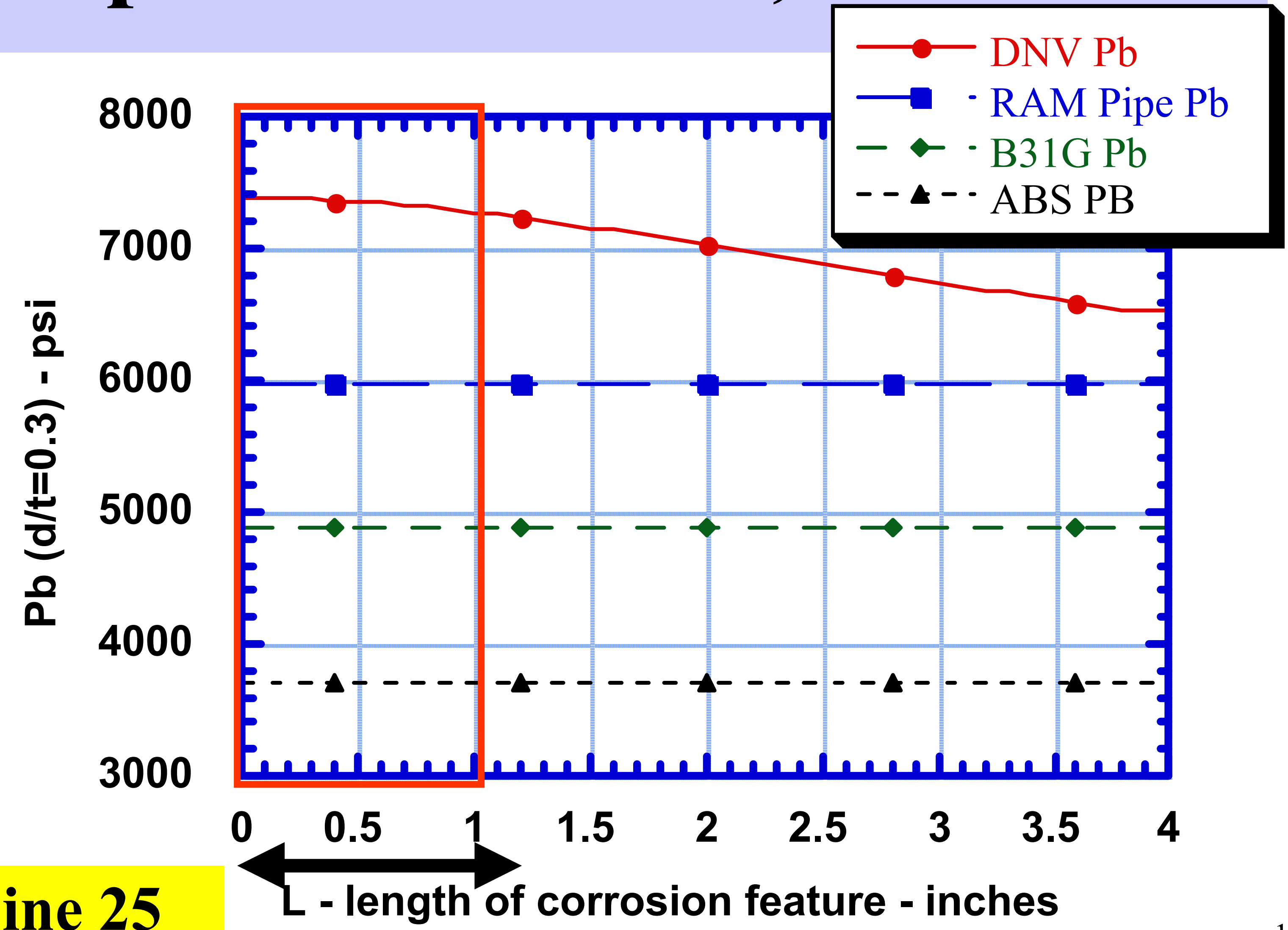
UTS = mean longitudinal



Comparison of alternative methods - *no corrosion*

Method	Pb - psi
B31G	4,900
DNV	7,400
ABS	5,200
RAM Pipe #1	8,300
RAM Pipe #2	8,900

Comparison Line 25, d/t=30%



Line 25

Stage #1 - Pb Biases

- **B31 G** $B_{Pb} = 1.40$
- **DNV** $B_{Pb} = 0.97$
- **ABS** $B_{Pb} = 1.79$
- **RAM** $B_{Pb} = 1.19$

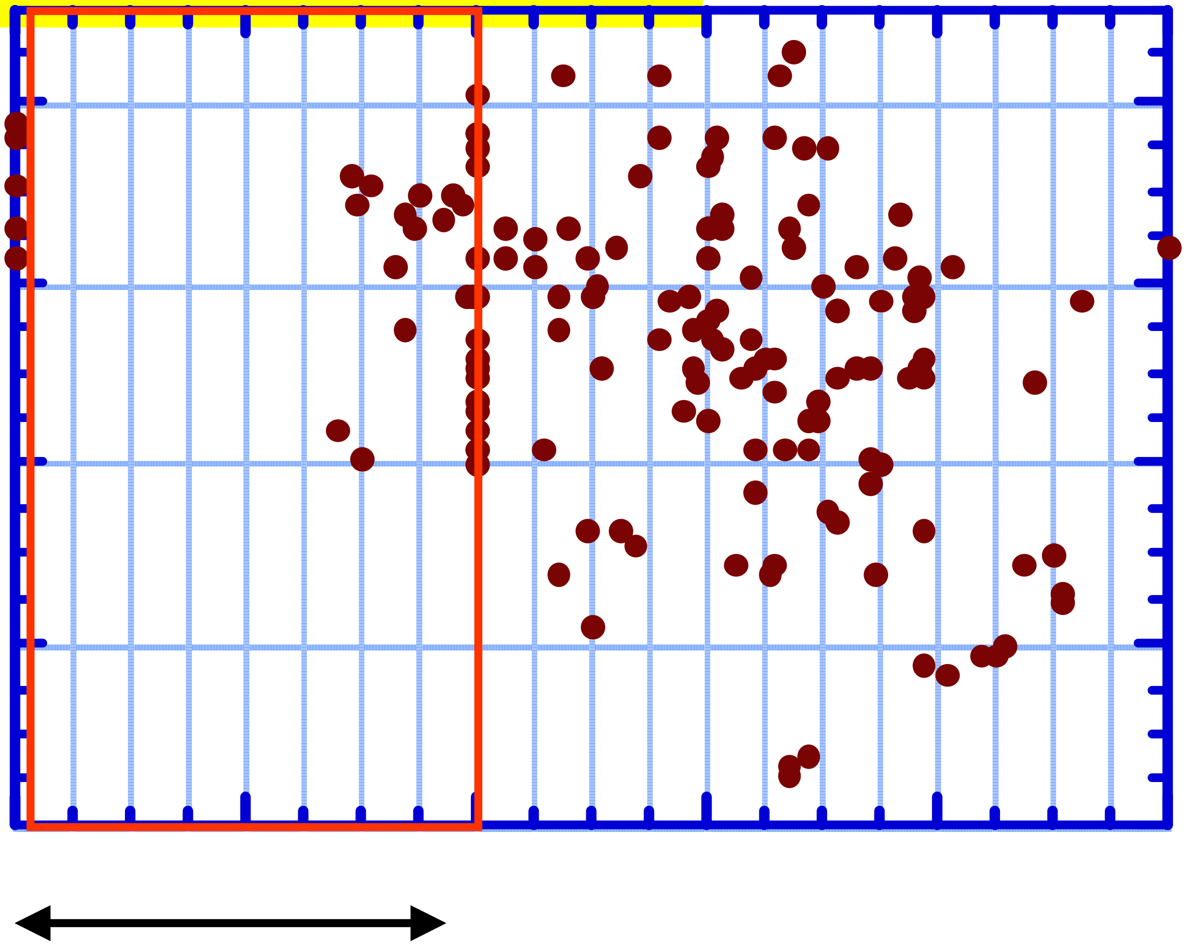
Results: Bias analysis from MSL database - *Spring POP report*

	ASME B-31G		DNV RP-F101		RAMPIPE	
	POP Report	MSL	POP Report	MSL	POP Report	MSL
Median	1.52	1.4	1.48	1.72	1.0	N/A
Mean	1.53	1.49	1.73	1.78	0.91	N/A
Std. Dev.	0.55	0.35	0.98	0.27	0.31	N/A
COV	0.36	0.23	0.57	0.15	0.34	N/A

RAM PIPE database: *lab tests on natural & machined corrosion defects - 151 tests*

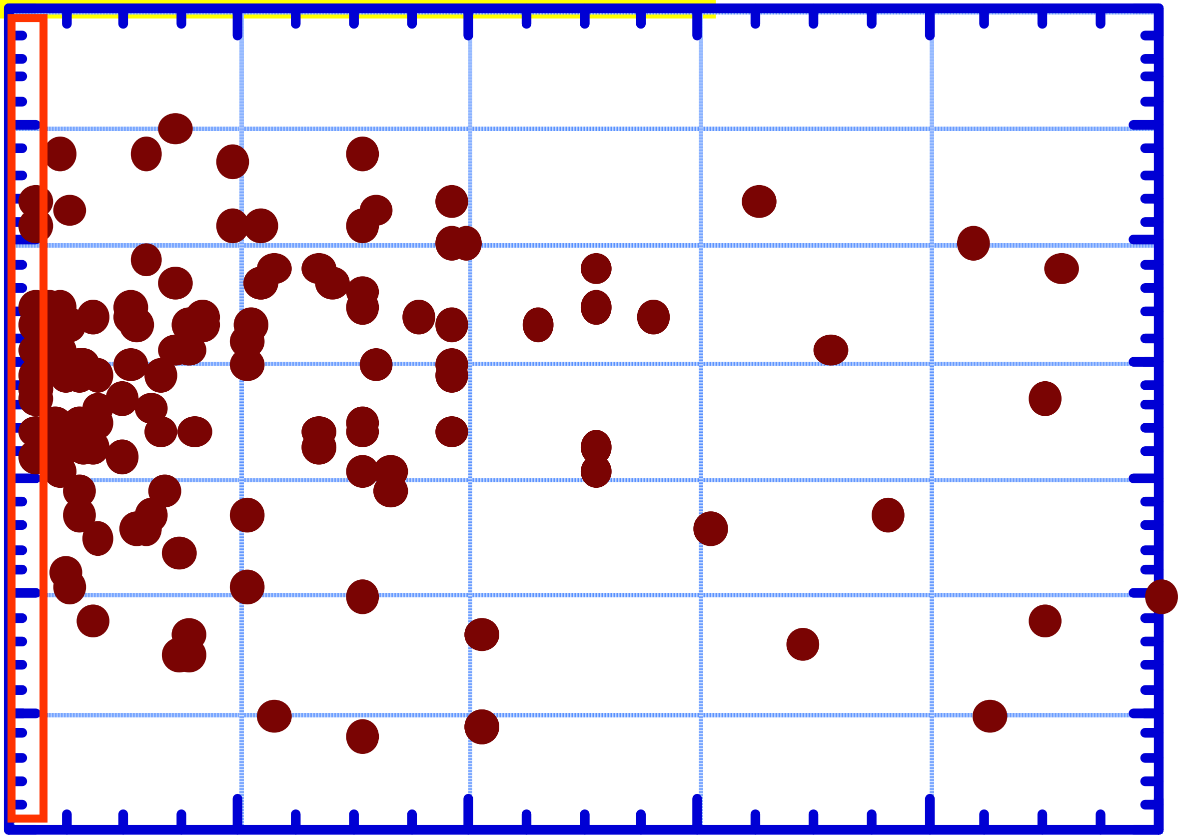
prediction	B mean	B_{50}	V_B %
DNV 99	1.46	1.22	56
B 31 G effect area	1.71	1.48	54
RAM PIPE	1.01	1.03	22

RAM Pipe Database



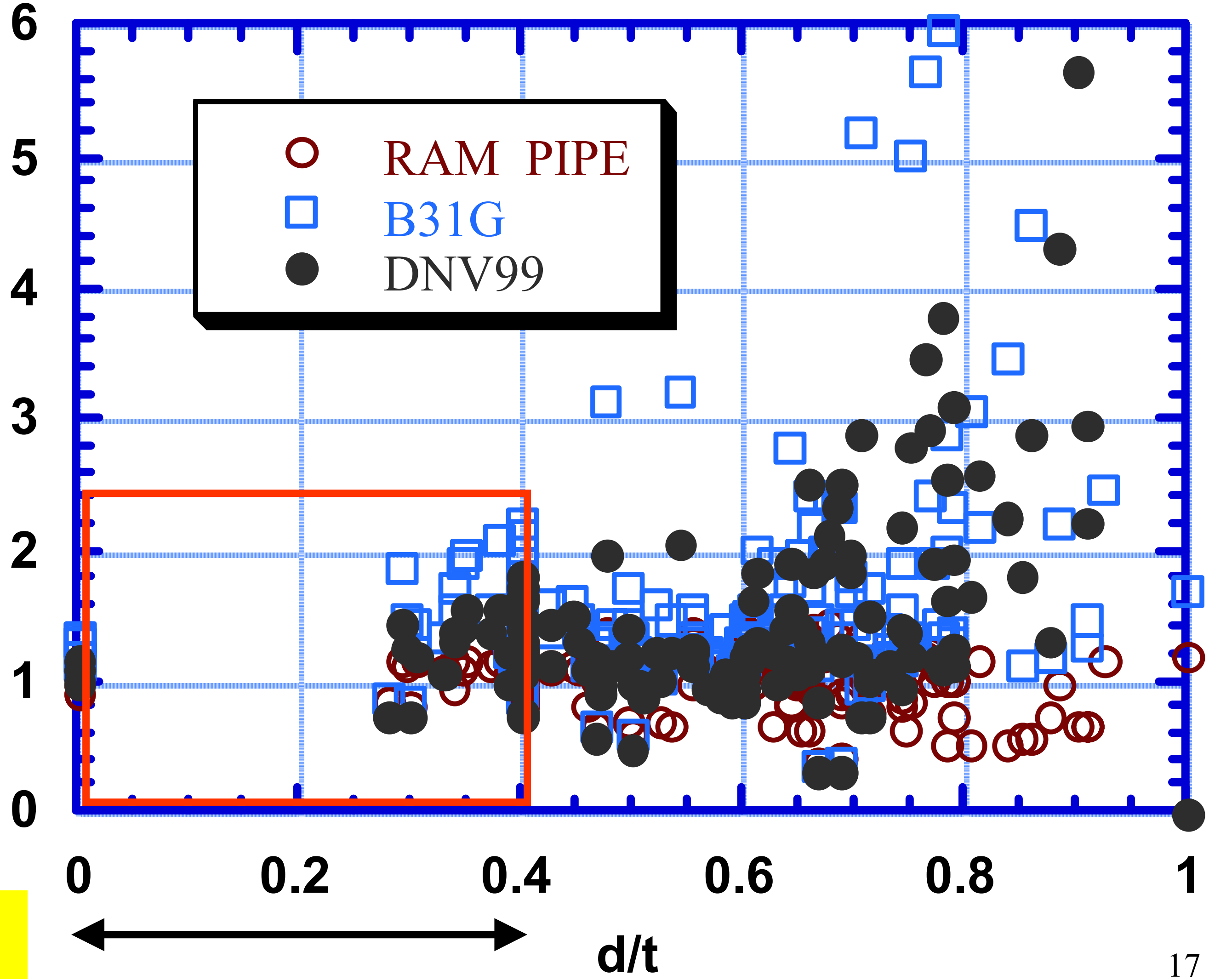
Line 25

RAM Pipe Database



Line 25

RAM Pipe Database



Line 25

RAM PIPE database: *lab tests on natural corrosion defects*

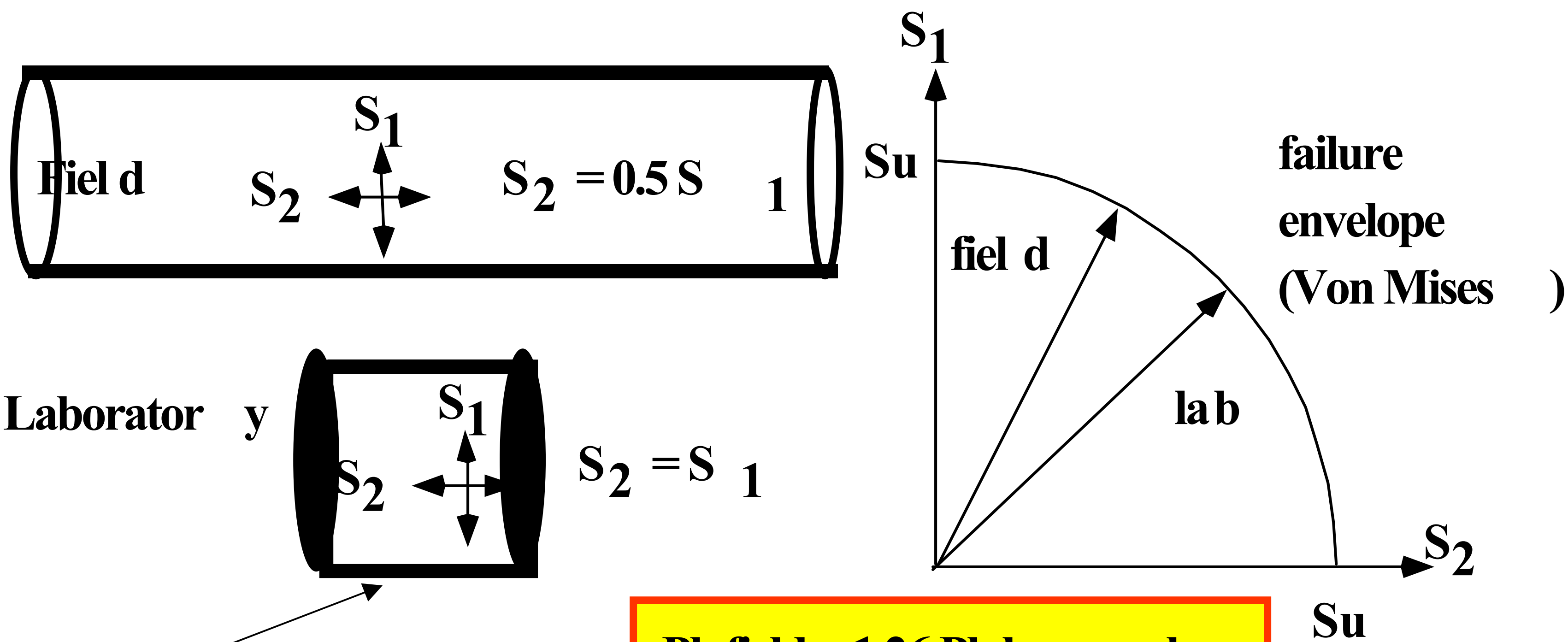
Formulation	B mean	B_{50}	V_B %
DNV 99	2.10	1.83	46
B 31 G	2.51	2.01	52
RAM Pipe	1.00	1.1	26

natural

machined

finite element analysis?

Lab test burst pressure bias ?



Pb field = 1.26 Pb lab

near ends of pipeline in field

removed from ends ?

Pipeline 25 burst pressure 'staged' analyses - *progressively 'more' information*

 # 1 Before test - ***based on knowledge of pipeline D, t, age, general condition and speculation on materials, products (Spring POP report)***

#2 After Rosen in-line data - ***interpreted results***

#3 After Stress Engineering materials data - ***diameters, thickness, stress-strain, failed section pictures***

#4 After Winmar field test reports - ***given failure pressure data, locations, test history***

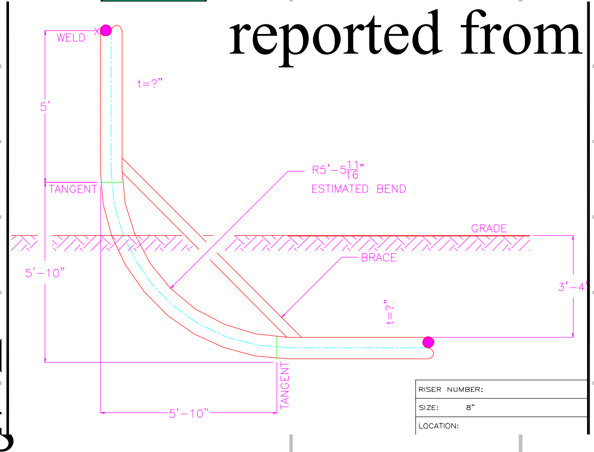
#1 Analysis: predicted burst pressures of pipeline 25- characteristics of pipeline

Pipeline 25 Characteristics: (as of 2/18/01)				
	Diameter, D	*Wall Thickness, t*	*SMYS*	*SMTS*
	Inches	Inches	ksi	ksi
Main Section (9200 ft.)	8.63	0.5	42	52
Riser Section (100 ft.)	8.63	0.322	42	52
Other Information:				
ANSI 900 System				
Material Type: Grade B steel				
Length of Time in Service: 22 years (1974-19				
Location: Gulf of Mexico				
Assume: 1) Zero External Corrosion on Riser (				
2) Known values of SMYS and SMTS				

60 ksi

0.5 in.

error found in result reported from field



#1 - Before test analyses

Corroded Analysis Composed of Three Corrosion Scenarios:

1) Internal (total) corrosion is 30% of wall thickness

best estimate

2) Internal corrosion is 60% of wall thickness

3) Internal corrosion is 90% of wall thickness

Assumption: No external corrosion on riser or mainline

#1 Before test - *RAM Pipe Pb*

Pipeline 25: Summary of Failure Predictions			
		Deterministic	**Probability of Failure**
		PSI	P_f
Uncorroded (New)			
	Mainline	**6033**	**0.501**
	~~**Riser**~~	~~**3885**~~	~~**0.501**~~
Internally Corroded			
Mainline	**d/t**		
	30%	**5674**	**0.55**

B_{Pb} = 1.19

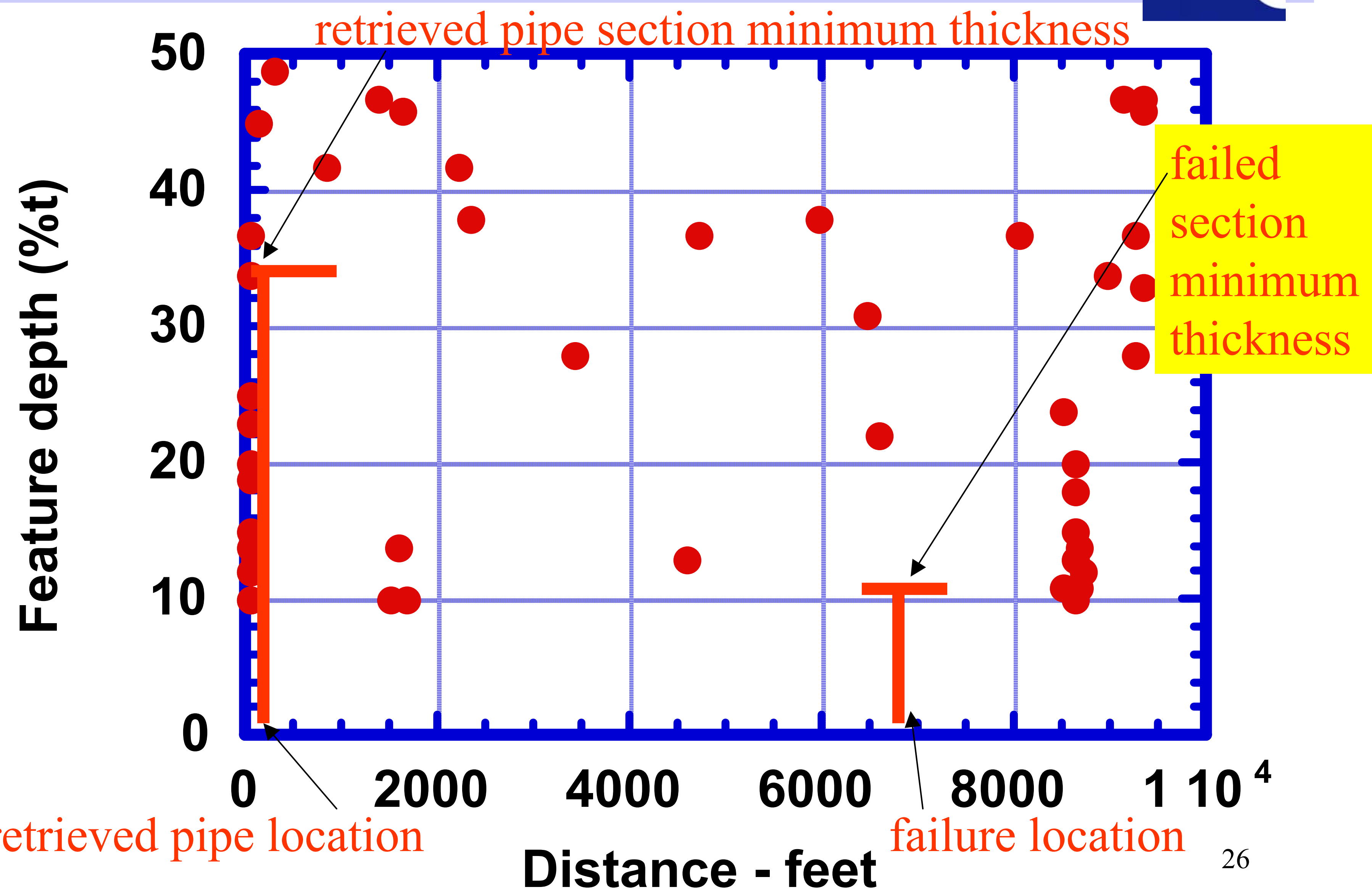
#1 Before test - *All Methods Pb 30% d/t*

Method	Pb - psi	B_{Pb}
B31G	5,000	1.35
DNV	7,000	0.97
ABS	3,800	1.79
RAM Pipe	5,700	1.19

#2 After Rosen Data Test Analyses

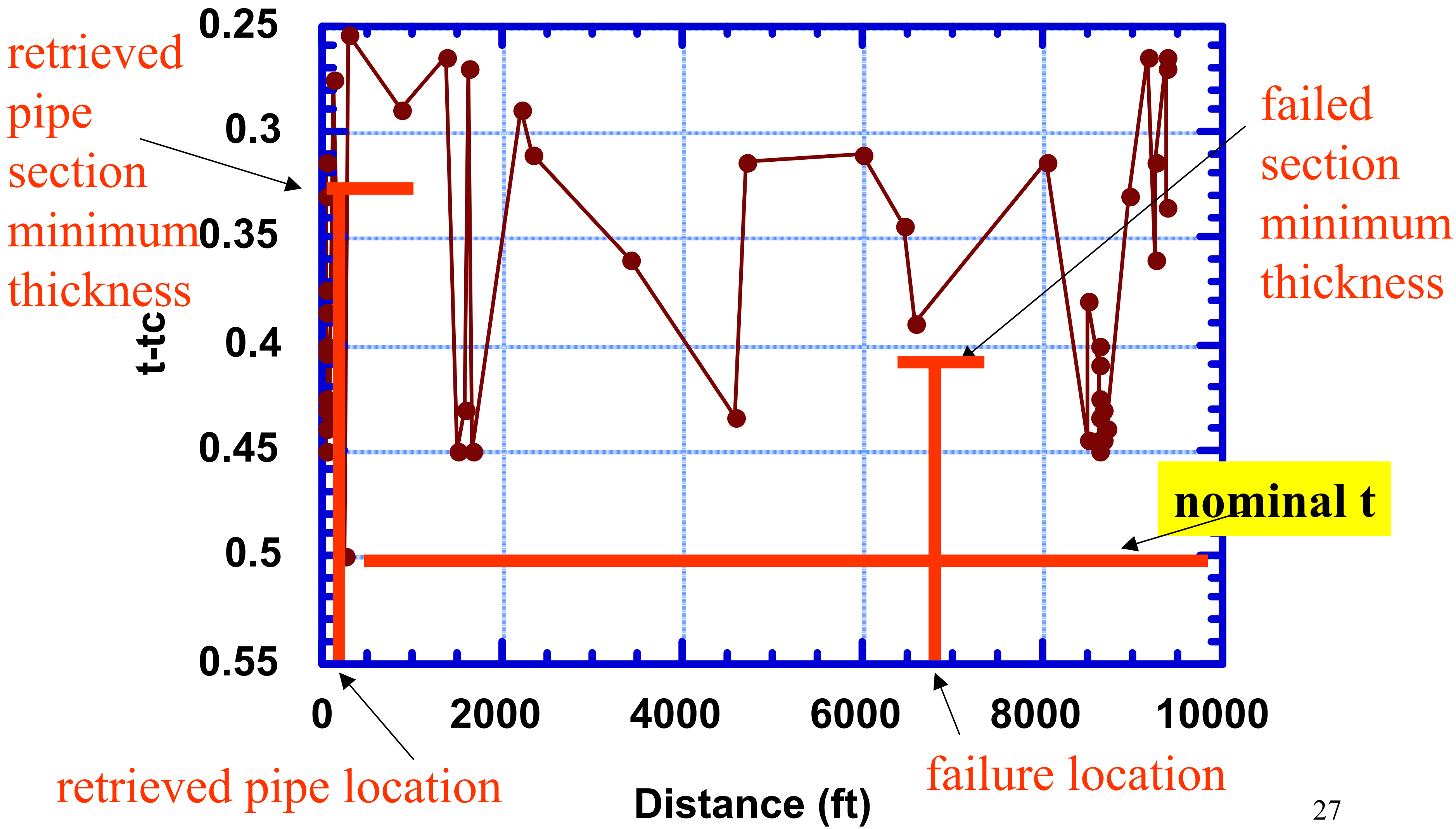
S-LOG DISTANCE [ft.]	TYPE	DESCR	CAUSE	S-POS. [hr.]	MAX. DEPTH [%.]	LEN [in.]	WID [in.]	AT INT. PIPEWALL	WELD TO FEATURE	WELD LOG DISTANCE	MARKER TO WELD
39.505	MELO	GEPI	CORR	10:20	25	1.063	1.654	YES	10.845	28.660	-126.410
39.739	MELO	GEPI	CORR	03:40	12	1.024	1.654	YES	11.079	28.660	-126.410
39.781	MELO	GEPI	CORR	10:00	10	0.866	1.339	YES	11.121	28.660	-126.410
40.124	MELO	GEPI	CORR	03:40	15	1.142	2.165	YES	11.464	28.660	-126.410
40.138	MELO	GEPI	CORR	08:50	23	1.220	1.575	YES	11.478	28.660	-126.410
40.195	MELO	GEPI	CORR	08:00	19	1.457	1.890	YES	11.535	28.660	-126.410
40.199	MELO	GEPI	CORR	04:40	12	1.142	1.378	YES	11.539	28.660	-126.410
40.439	MELO	GEPI	CORR	06:30	12	0.984	1.417	YES	11.779	28.660	-126.410
40.454	MELO	GEPI	CORR	08:30	37	1.102	1.693	YES	11.794	28.660	-126.410
40.696	MELO	GEPI	CORR	03:10	12	1.378	2.087	YES	12.036	28.660	-126.410
40.717	MELO	GEPI	CORR	07:30	10	0.906	0.866	YES	12.057	28.660	-126.410
41.945	MELO	GEPI	CORR	04:50	20	0.984	1.575	YES	13.285	28.660	-126.410
42.185	MELO	GEPI	CORR	04:30	10	0.984	1.220	YES	13.525	28.660	-126.410
42.371	MELO	PITT	CORR	05:00	14	0.945	1.260	YES	13.711	28.660	-126.410
43.692	MELO	WEDE		10:30	34	1.102	3.780	n/a	0.005	43.687	-111.383
44.441	MELO	GEPI	CORR	00:30	23	1.339	1.614	YES	0.754	43.687	-111.383
92.421	MELO	WEDE		04:00	13	1.339	0.551	n/a	5.530	86.891	-68.179
111.863	MELO	PWDE		09:50	45	0.748	2.362	n/a	0.054	111.809	-43.261
233.649	WEFE	PWDE		05:50				n/a	41.479	192.170	37.100
275.545	MELO	WEDE		00:00	49	1.181	5.984	n/a	41.752	233.793	78.723
856.807	MELO	WEDE		00:40	42	1.417	1.772	n/a	42.053	814.754	659.684
1361.224	MELO	WEDE		07:10	47	1.142	2.205	n/a	42.194	1319.030	1163.960
1486.085	MELO	WEDE		00:20	10	1.063	1.299	n/a	41.650	1444.435	1289.365
1569.664	MELO	WEDE		04:20	14	0.433	2.520	n/a	41.594	1528.070	1373.000
1611.383	MELO	WEDE		01:00	46	1.378	1.575	n/a	41.590	1569.793	1414.723
1653.234	MELO	WEDE		10:10	10	1.102	1.260	n/a	41.851	1611.383	1456.313
2194.626	MELO	WEDE		02:10	42	1.260	1.575	n/a	41.690	2152.936	1997.866
2320.538	MELO	WEDE		02:40	38	0.945	1.417	n/a	42.448	2278.090	2123.020
3427.530	MELO	PWDE		11:50	28	0.630	1.220	n/a	0.012	3427.518	3272.448
4592.774	MELO	WEDE		03:20	13	0.906	1.181	n/a	41.630	4551.144	4396.074
4717.281	MELO	WEDE		10:40	37	1.220	1.654	n/a	40.152	4677.129	4522.059
5983.869	MELO	WEDE		11:00	38	0.827	1.575	n/a	41.820	5942.049	5786.979
6475.969	MELO	WEDE		11:30	31	0.984	1.693	n/a	41.424	6434.545	6279.475
6597.481	MELO	WEDE		03:30	22	0.591	1.417	n/a	0.038	6597.443	6442.373
8052.064	MELO	WEDE		11:50	37	0.748	1.811	n/a	41.068	8010.996	7855.926
8506.312	MELO	GEPI	CORR	05:00	11	0.709	0.827	YES	37.831	8468.481	8313.411
8506.404	MELO	GEPI	CORR	05:40	24	0.709	0.866	YES	37.923	8468.481	8313.411
8643.035	MELO	GEPI	CORR	06:50	18	0.472	0.827	YES	5.837	8637.198	8482.128
8643.807	MELO	GEPI	CORR	06:50	15	0.551	1.181	YES	6.609	8637.198	8482.128
8643.955	MELO	GEPI	CORR	05:40	11	0.591	0.906	YES	6.757	8637.198	8482.128
8644.392	MELO	GEPI	CORR	06:40	13	0.512	0.709	YES	7.194	8637.198	8482.128
8644.596	MELO	GEPI	CORR	05:50	20	0.709	1.063	YES	7.398	8637.198	8482.128
8645.677	MELO	GEPI	CORR	06:40	10	0.906	0.630	YES	8.479	8637.198	8482.128
8647.784	MELO	GEPI	CORR	06:40	10	0.906	1.024	YES	10.586	8637.198	8482.128
8648.032	MELO	GEPI	CORR	06:30	10	0.551	0.827	YES	10.834	8637.198	8482.128
8648.291	MELO	GEPI	CORR	05:20	13	0.787	0.945	YES	11.093	8637.198	8482.128
8649.605	MELO	GEPI	CORR	06:50	11	0.433	0.866	YES	12.407	8637.198	8482.128
8675.925	MELO	GEPI	CORR	05:00	11	0.394	0.709	YES	38.727	8637.198	8482.128
8676.029	MELO	GEPI	CORR	05:00	14	0.827	0.945	YES	38.831	8637.198	8482.128
8719.087	MELO	WEDE		05:40	12	0.984	1.496	n/a	40.479	8678.608	8523.538
8956.595	MELO	WEDE		04:10	34	0.709	1.575	n/a	0.005	8956.590	8801.520
9158.235	MELO	WEDE		06:20	47	1.339	1.614	n/a	0.018	9158.217	9003.147
9245.991	MELO	WEDE		08:40	28	0.827	1.496	n/a	4.921	9241.070	9086.000
9245.998	MELO	WEDE		02:50	37	0.551	1.614	n/a	4.928	9241.070	9086.000
9364.101	MELO	GEPI	CORR	04:20	47	0.709	2.087	NO	7.315	9356.786	9201.716
9364.195	MELO	GEPI	CORR	00:40	46	0.591	3.465	NO	7.409	9356.786	9201.716
9364.195	MELO	GEPI	CORR	04:40	33	1.102	1.969	NO	7.409	9356.786	9201.716

‘Feature depths’ from in-line

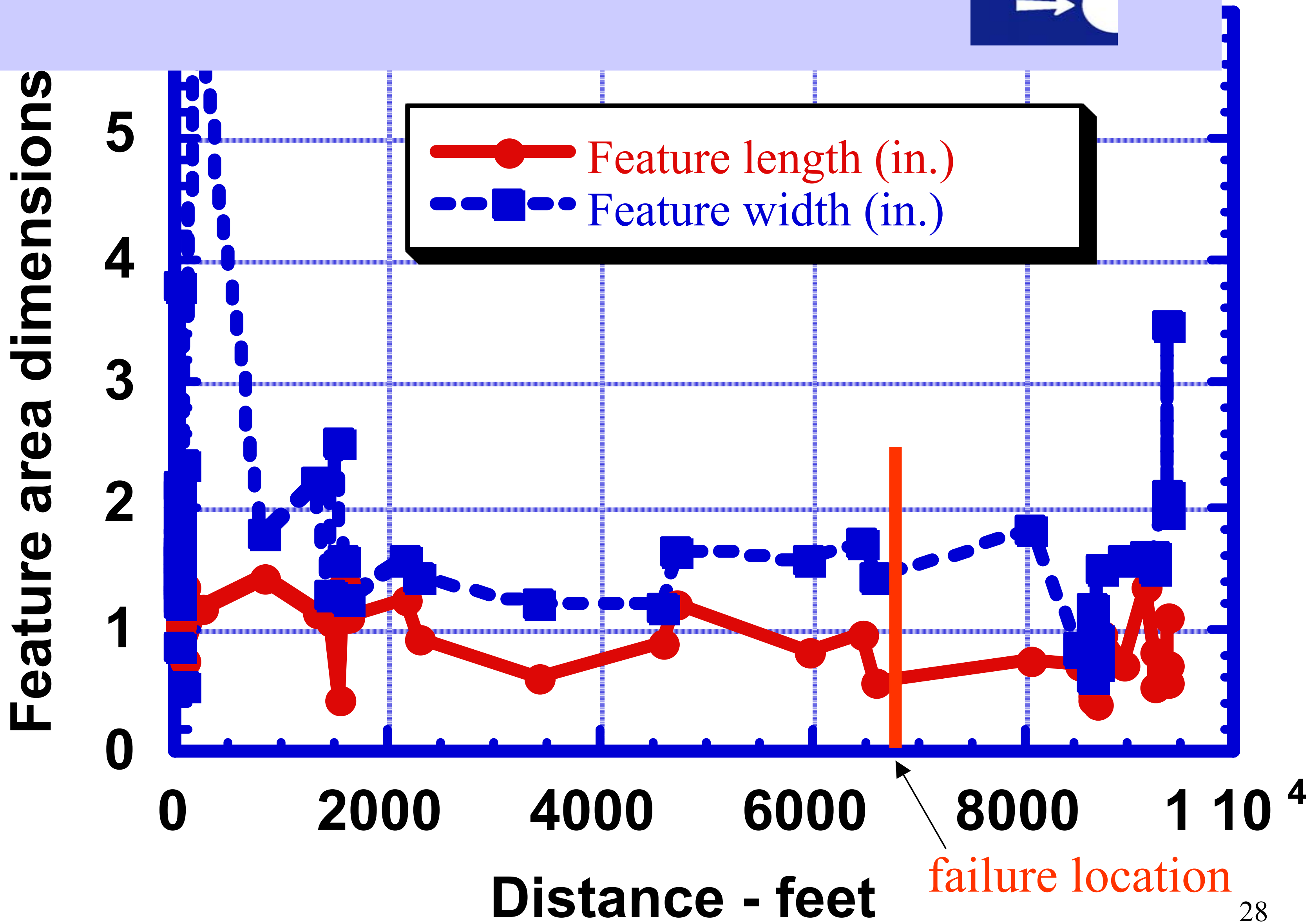


Thickness from in-line

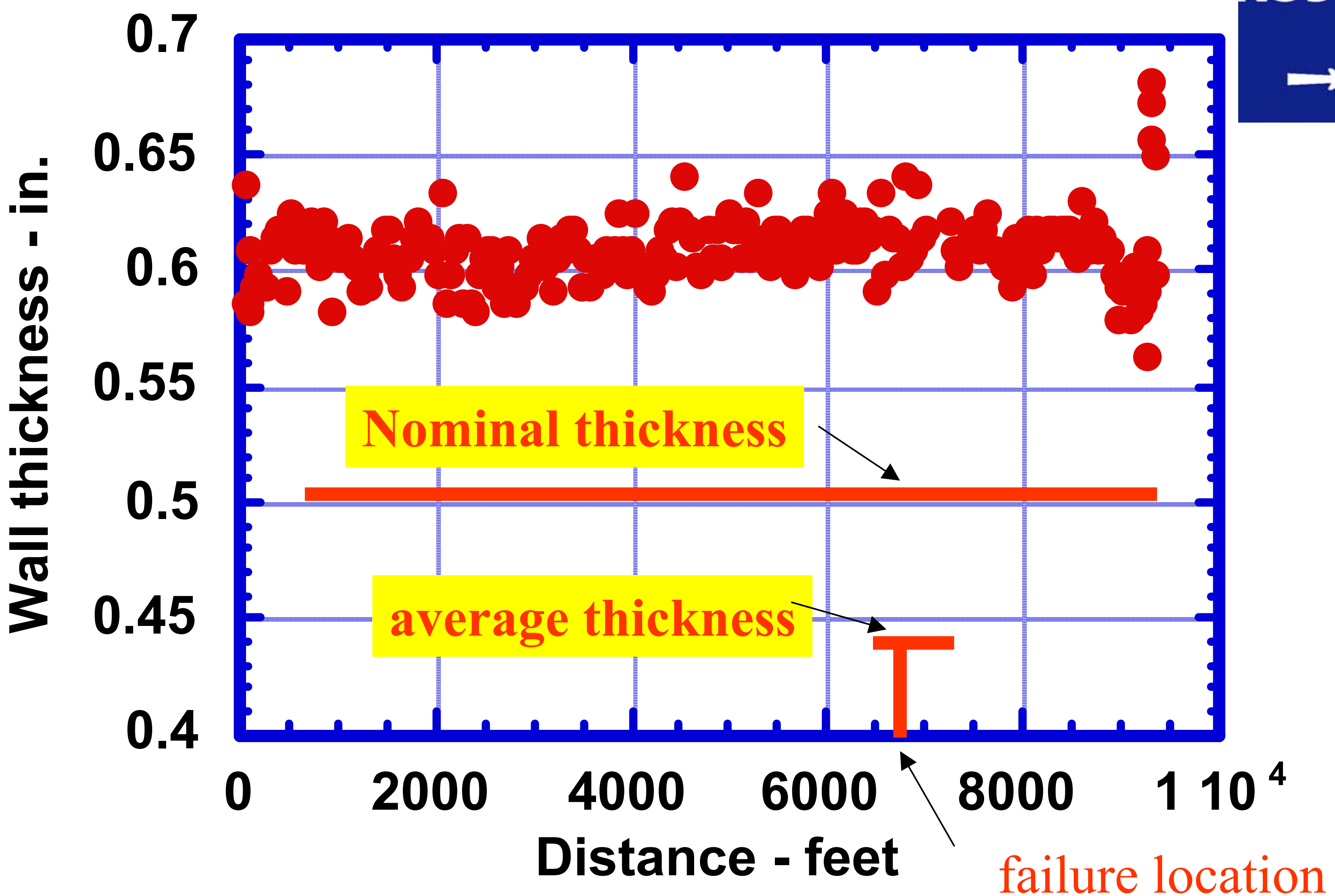
note reversed vertical scale



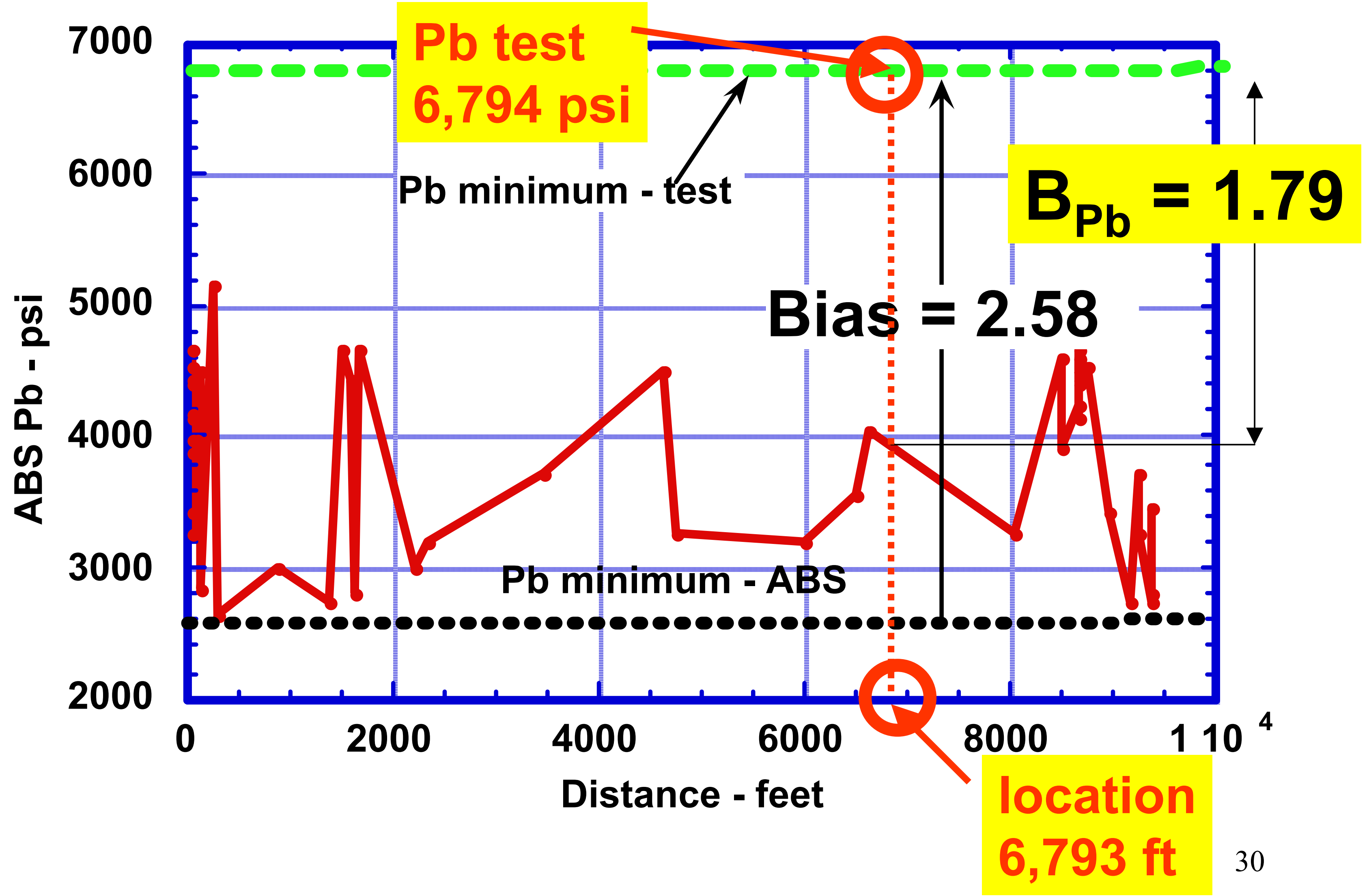
Feature area dimensions



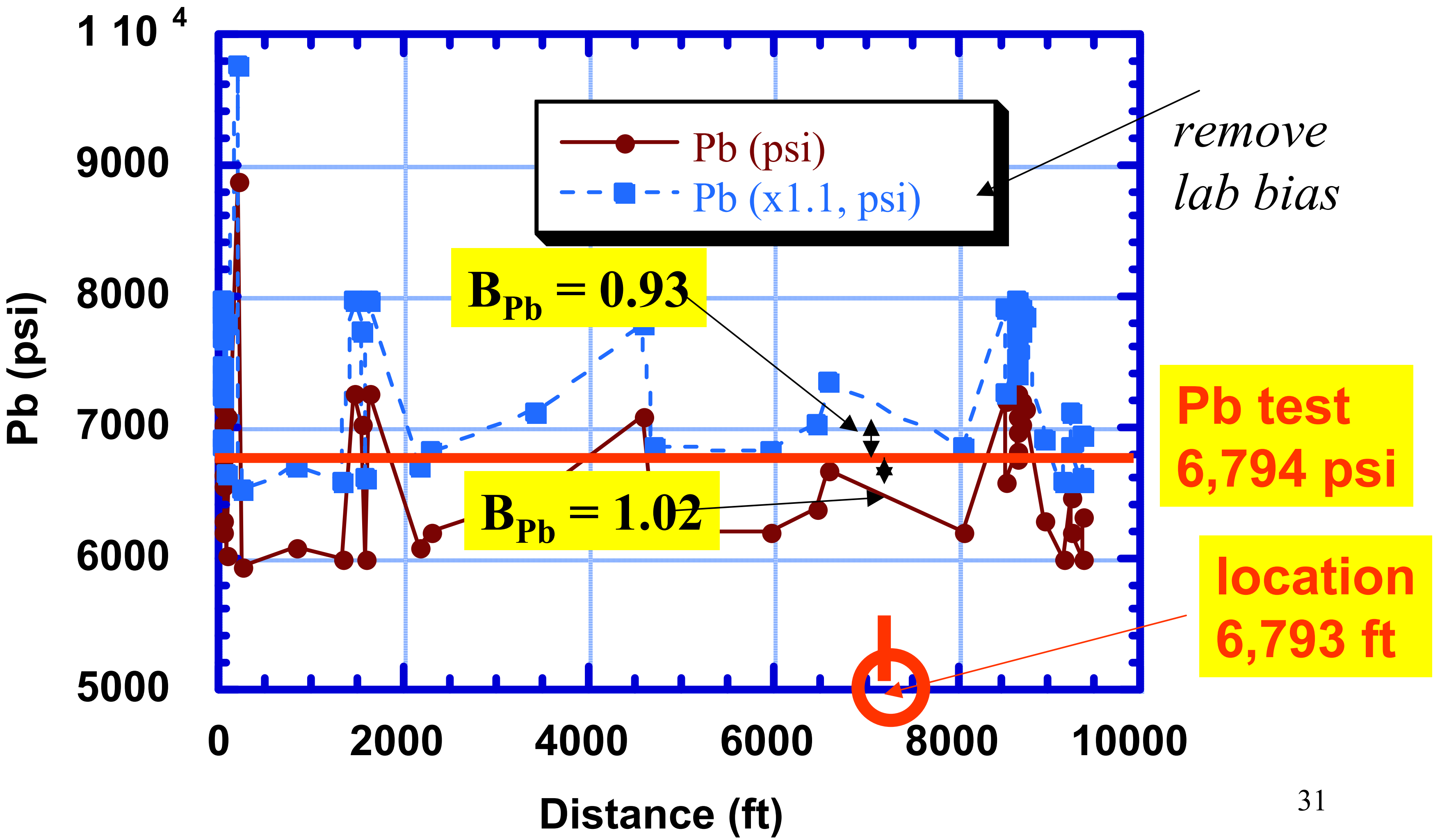
Pipe thickness *100% magnetization*



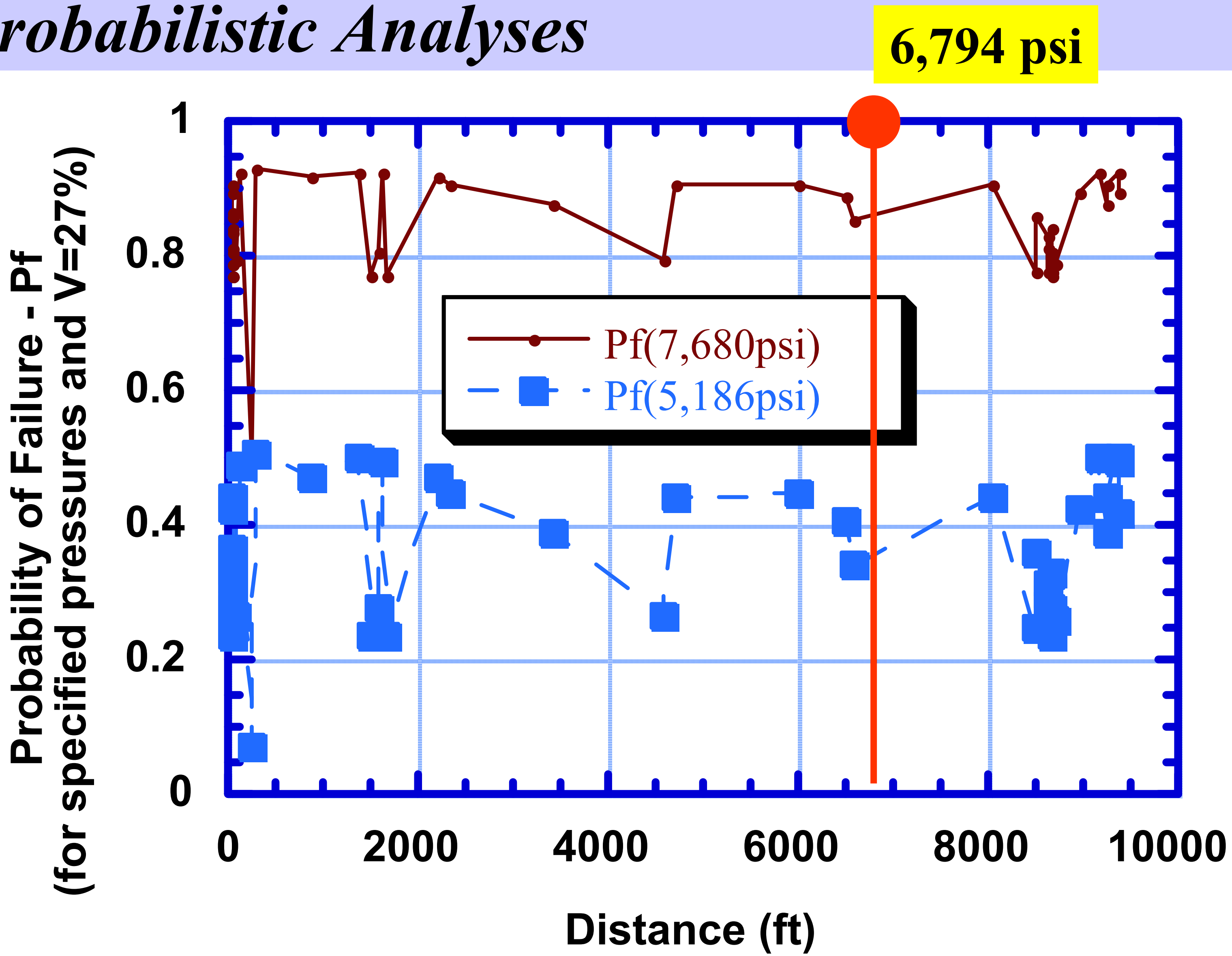
#2 After test analyses - *ABS Pb*



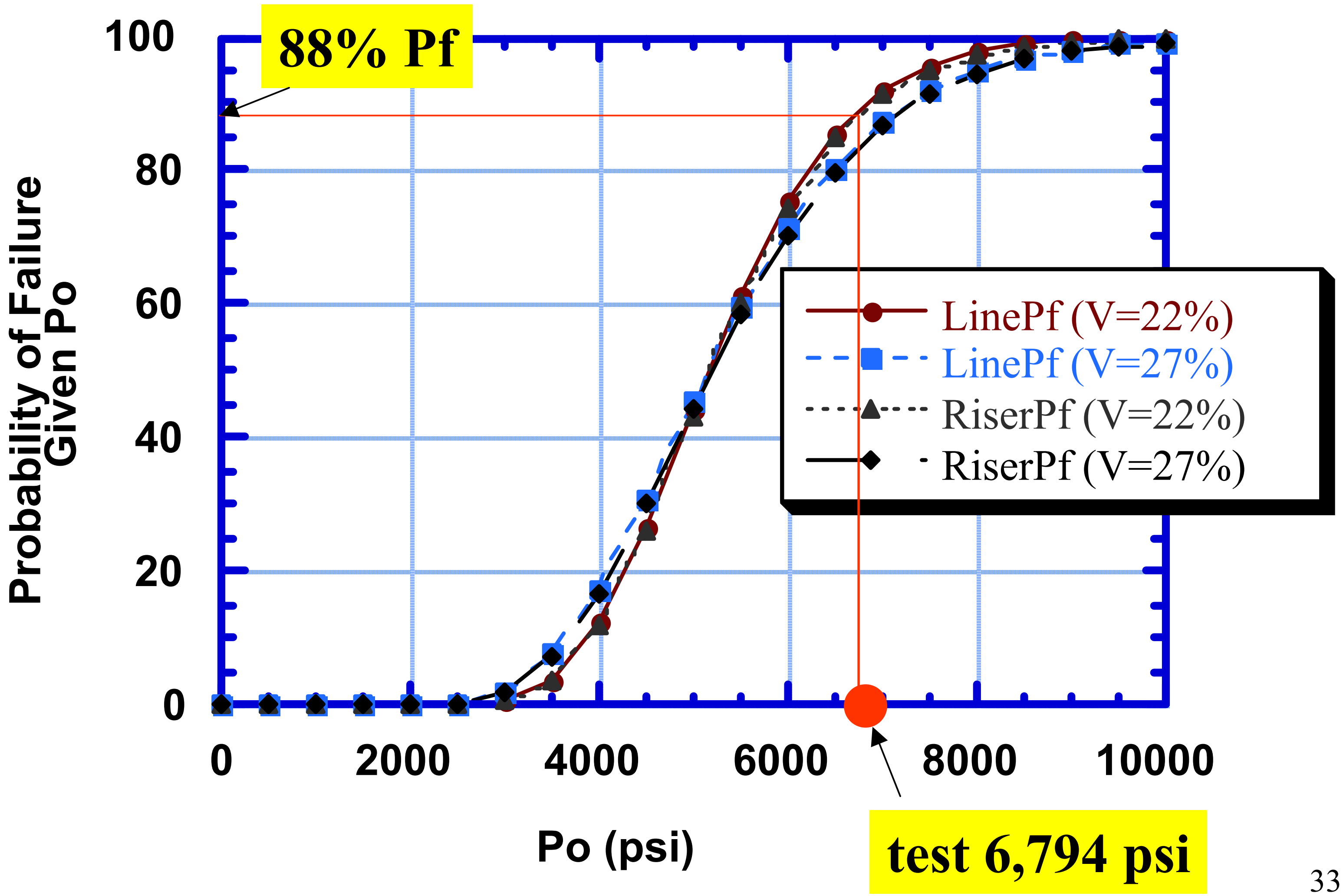
#2 After test analyses - *RAM Pipe Pb*

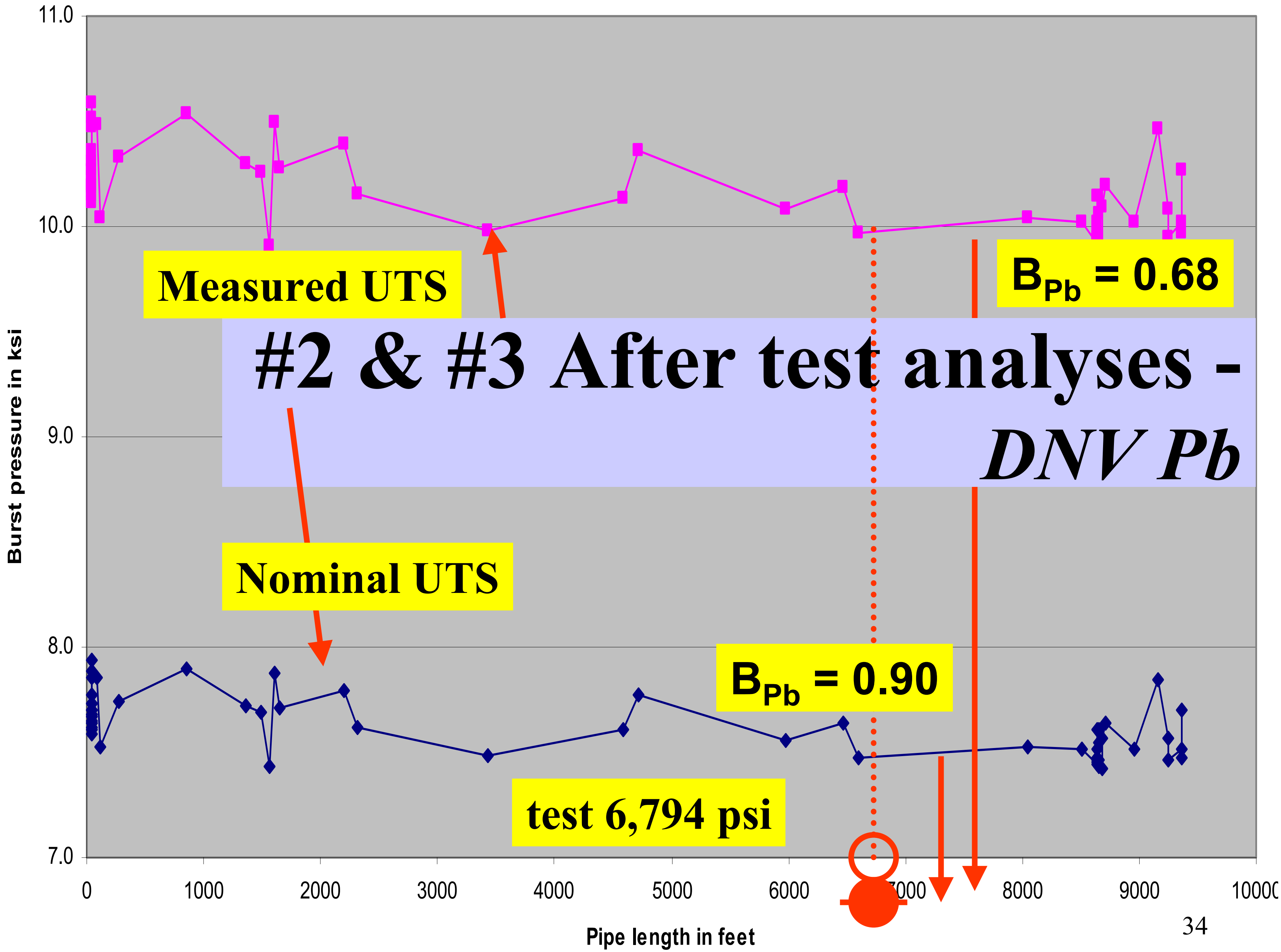


#2 After test analyses - *RAM Pipe Pb Probabilistic Analyses*

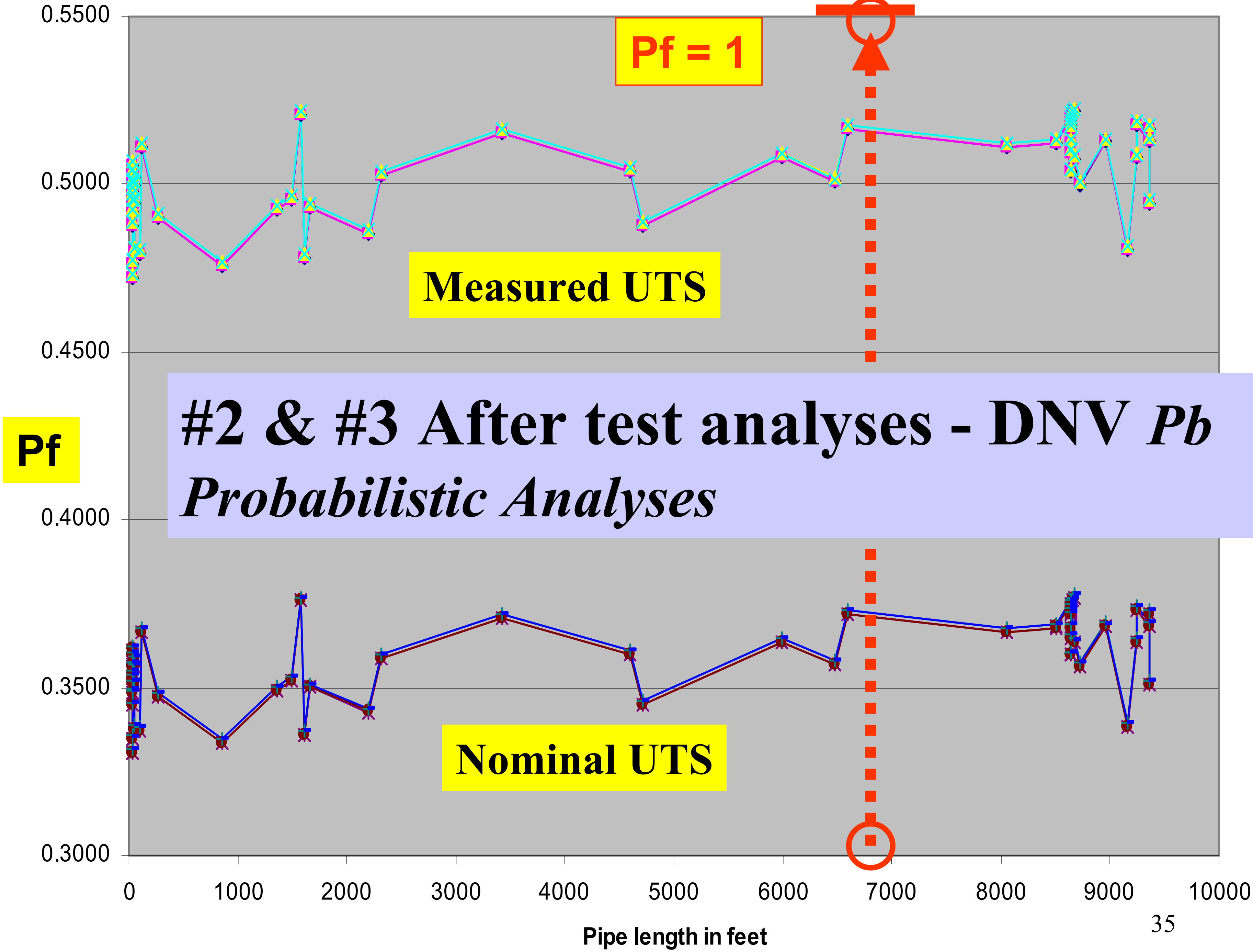


#2 After test analyses - *RAM Pipe Pb*
Probabilistic Analyses - 'Fragility Curves'

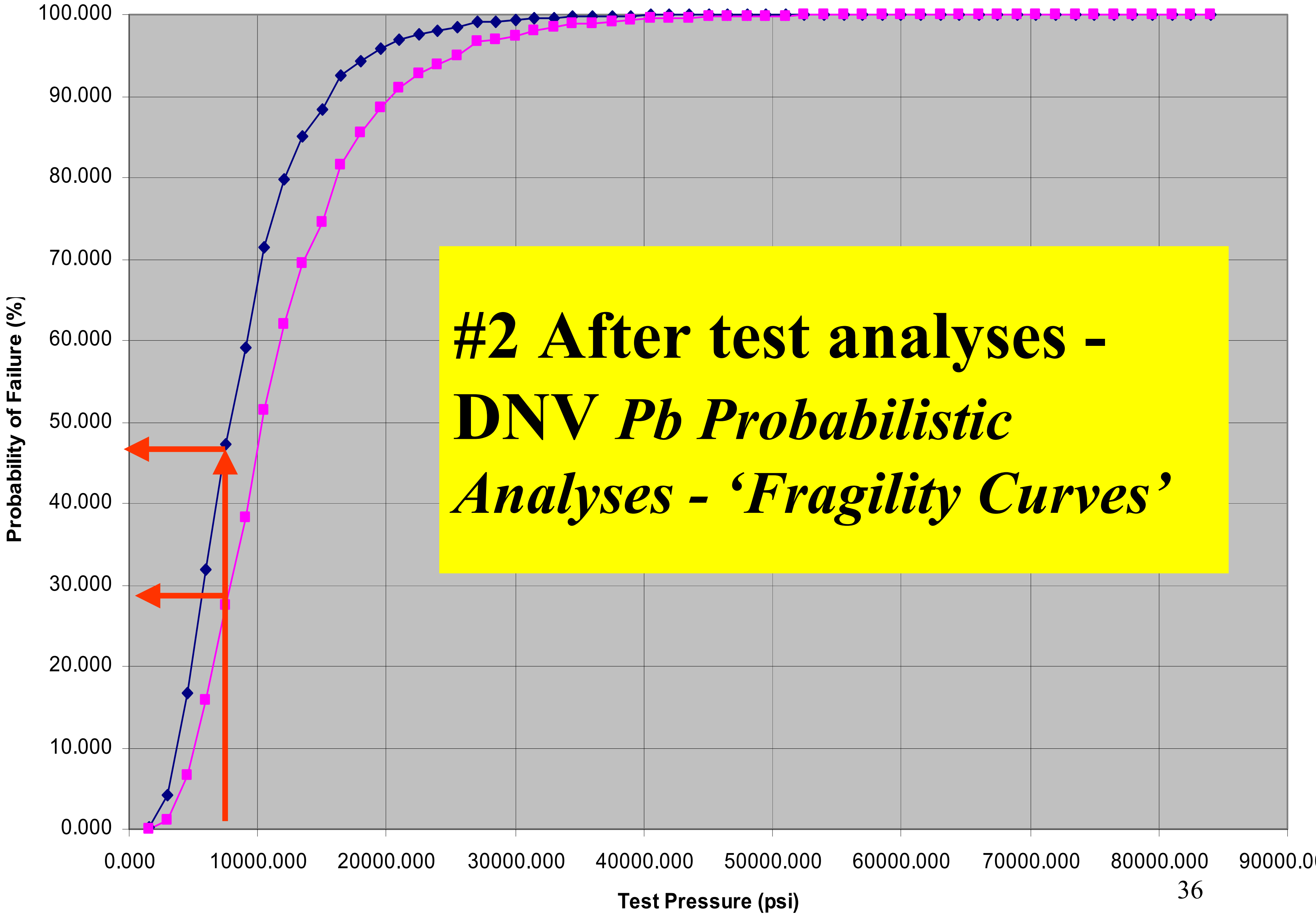



#2 & #3 After test analyses - DNV Pb
Measured UTS
Nominal UTS
B Pb = 0.68
B Pb = 0.90
test 6,794 psi
Burst pressure in ksi
Pipe length in feet
11.0
10.0
9.0
8.0
7.0
0
1000
2000
3000
4000
5000
6000
8000
9000
10000

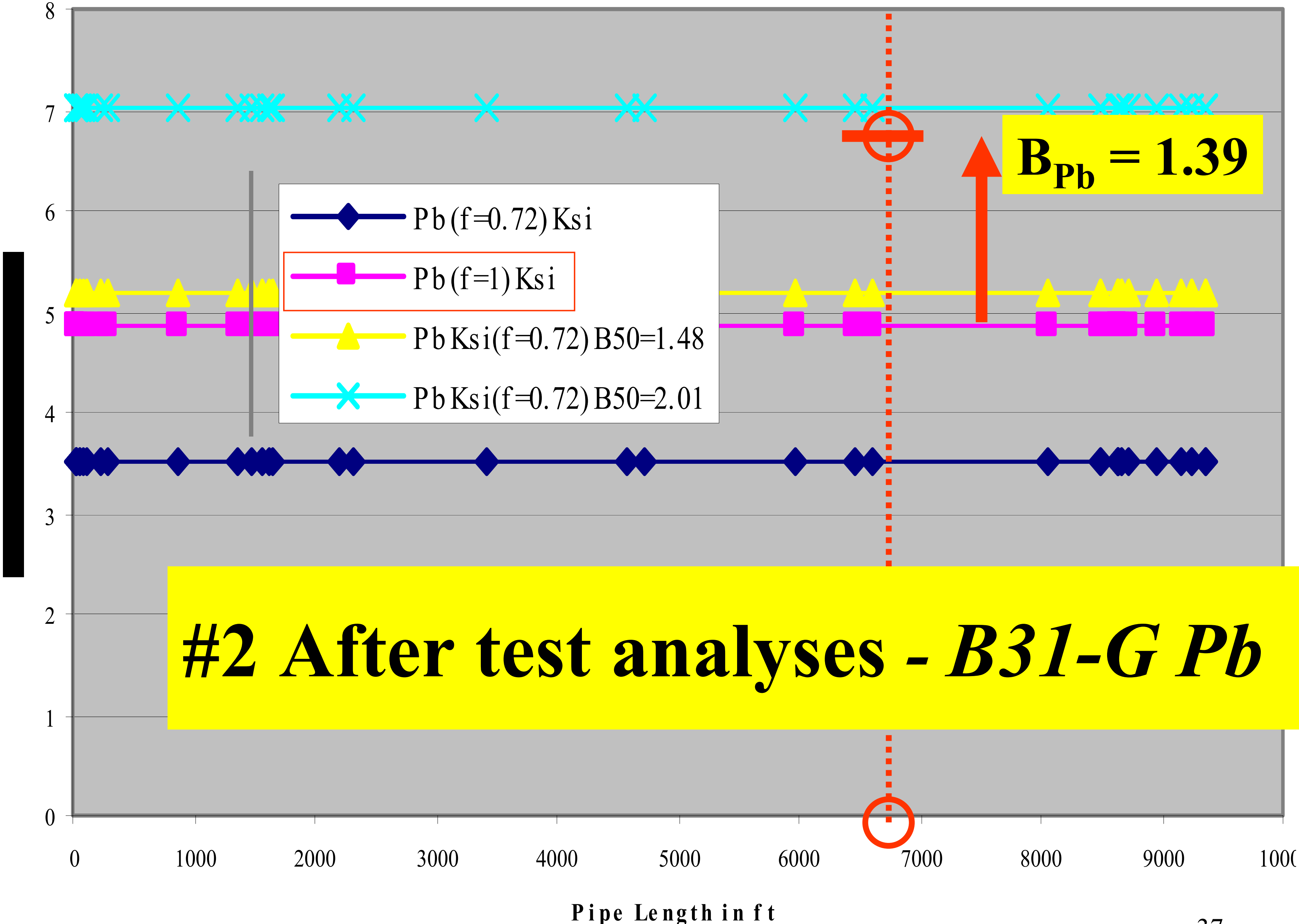
#2 & #3 After test analyses - DNV *Pb* *Probabilistic Analyses*



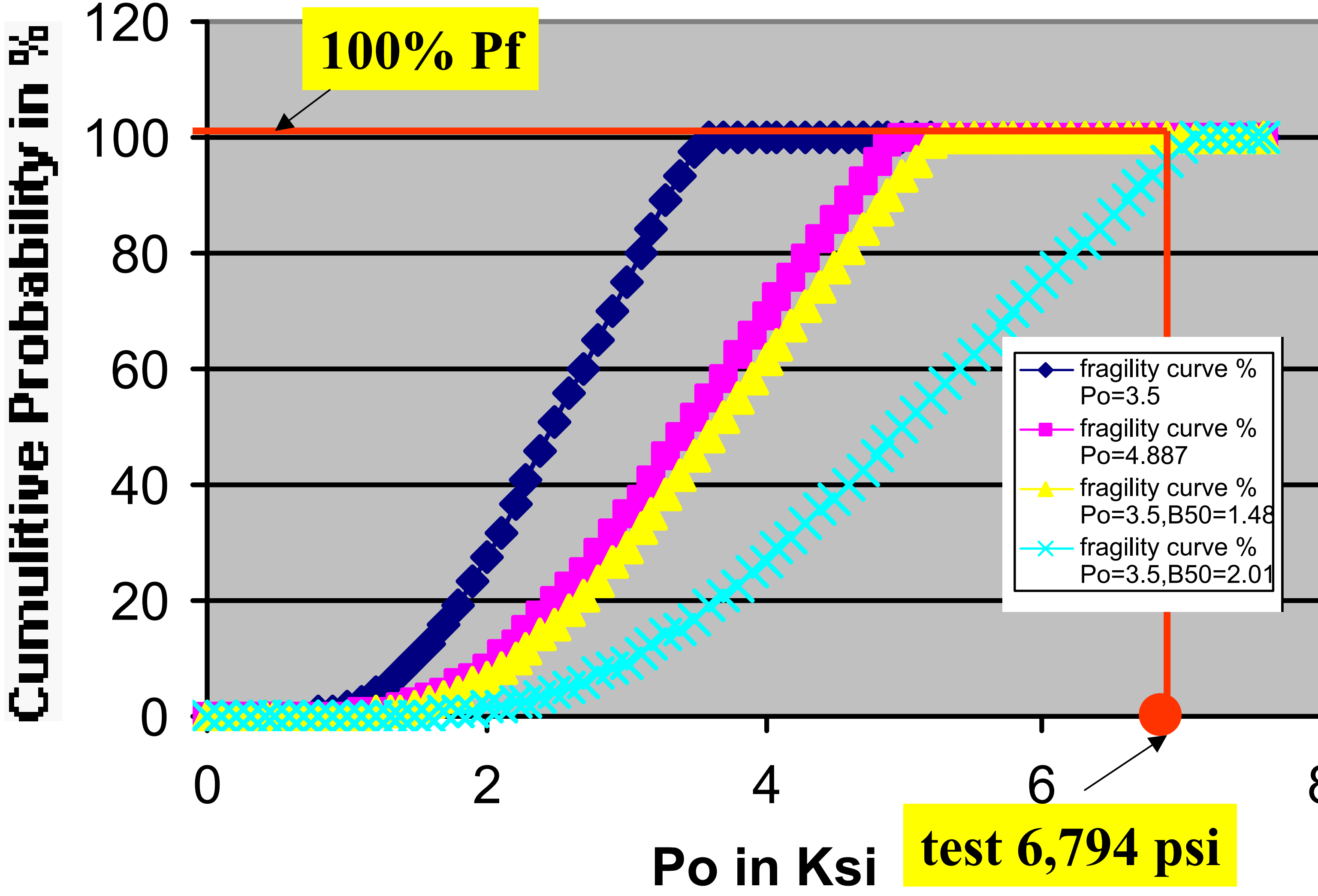
#2 After test analyses - DNV *Pb Probabilistic Analyses - ‘Fragility Curves’*



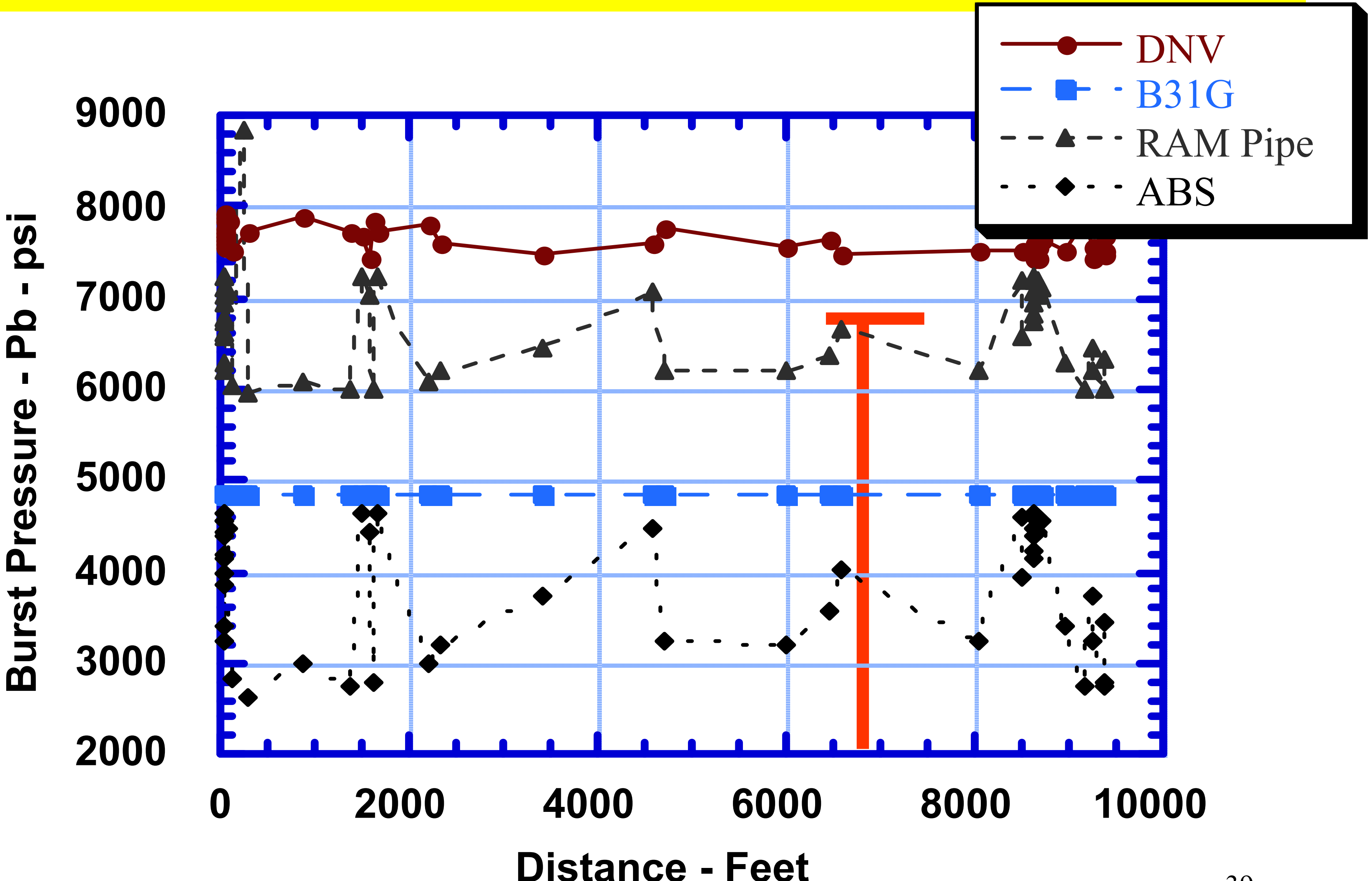
#2 After test analyses - *B31-G Pb*



#2 After test analyses - *B31G Pb Probabilistic Analyses*



#2 After test analyses - *All Methods Pb*

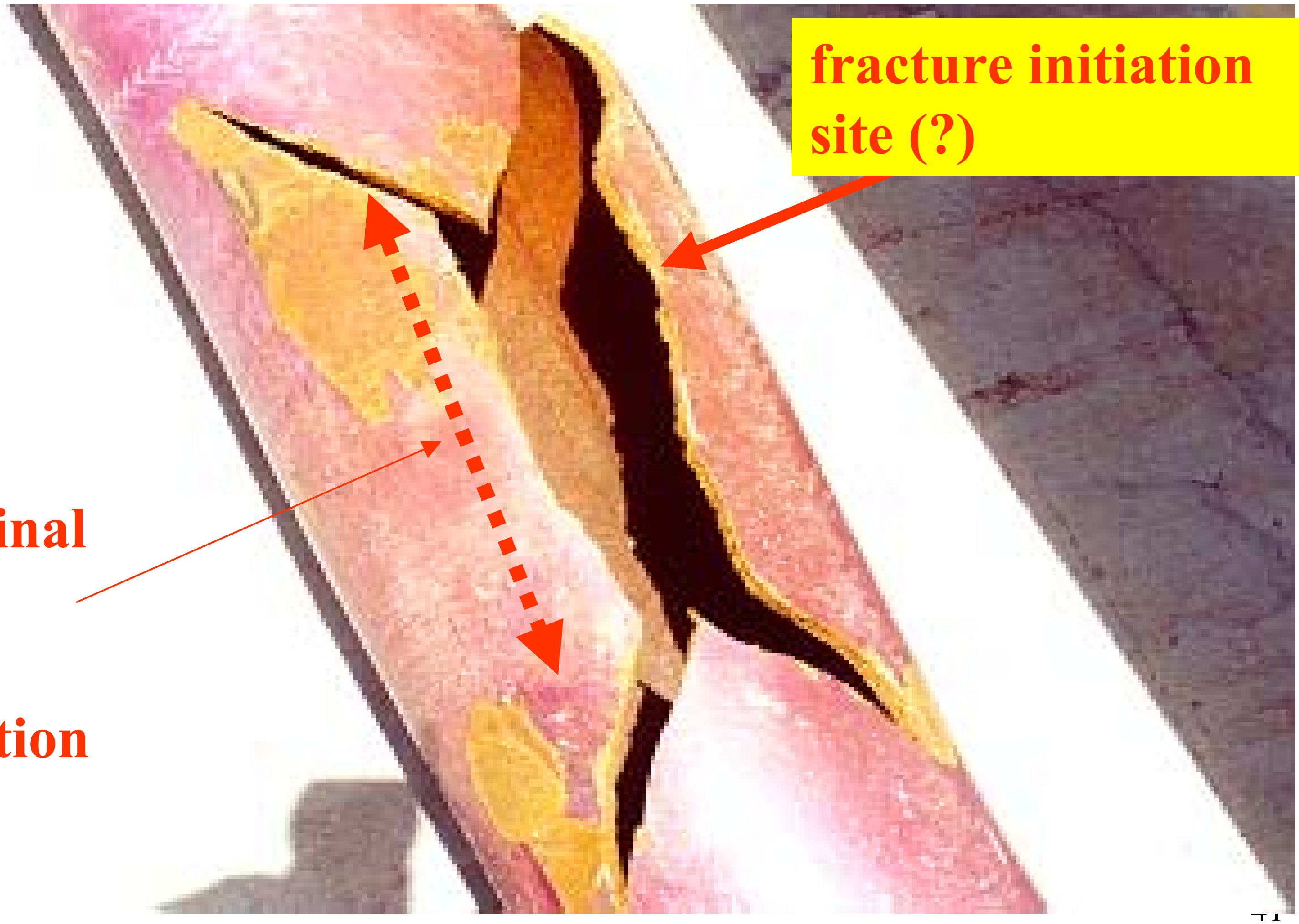


Stage #2 - Pb Biases

- **B31 G** $B_{Pb} = 1.39$
- **DNV** $B_{Pb} = 0.90$
- **ABS** $B_{Pb} = 1.84$
- **RAM** $B_{Pb} = 1.02$

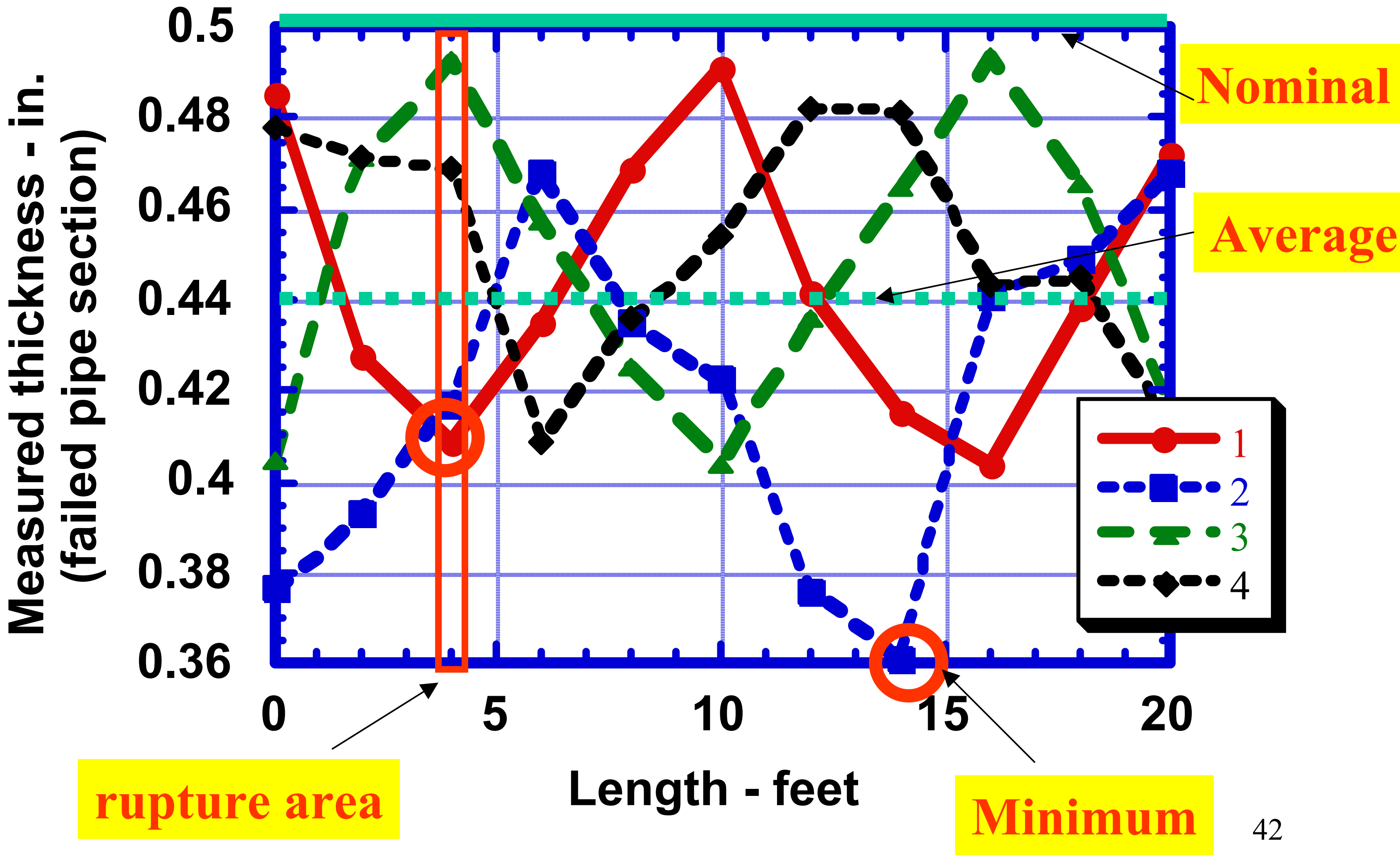
#3 Stress Engineering Tests

STRESS ENGINEERING SERVICES

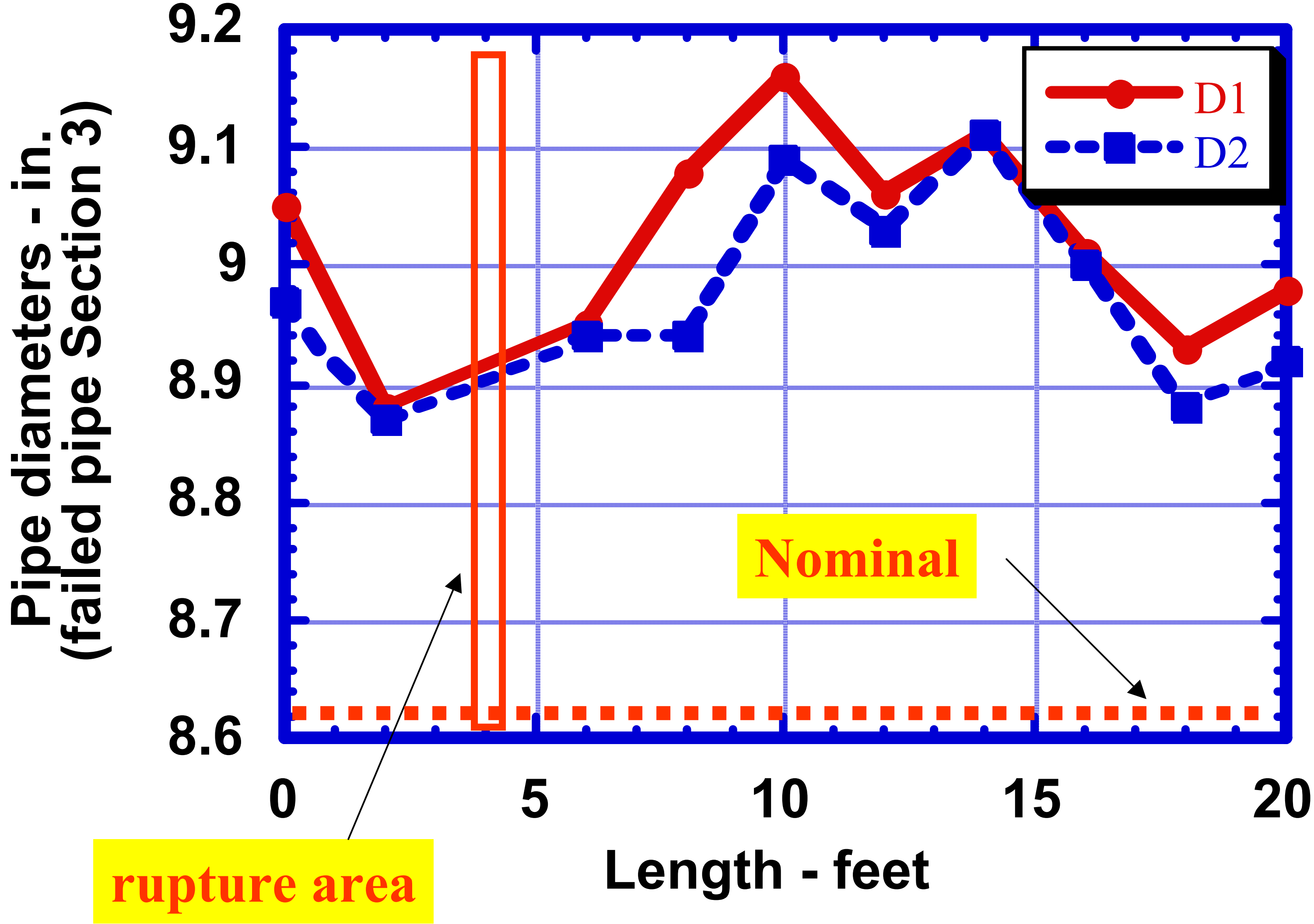


#3 Stress Engineering Tests

STRESS ENGINEERING SERVICES

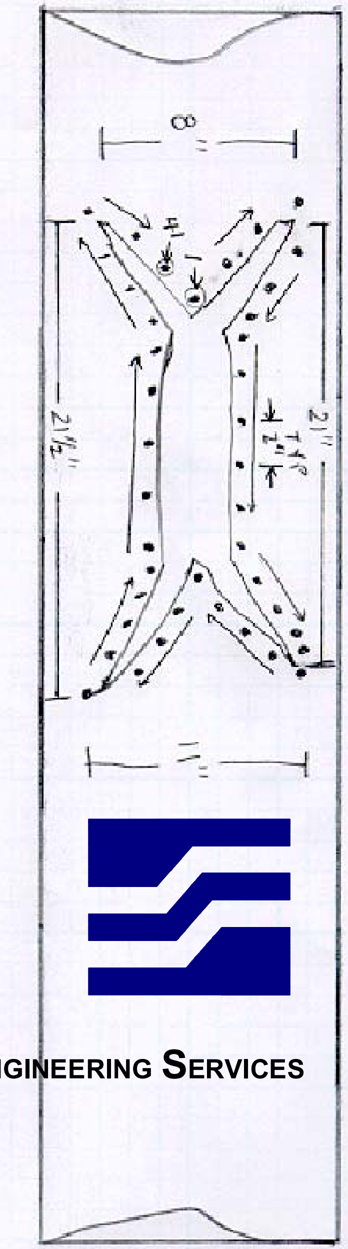


#3 Stress Engineering Tests



After Stress Engineering Data Analysis

1.	.417
2.	.430
3.	.430
4.	.446
5.	.436
6.	.426
7.	.416
8.	.408
9.	.375
10.	.355
11.	.349
12.	.352
13.	.393
14.	.420
15.	.447
16.	.484
17.	.490
18.	.493
19.	.459
20.	.422
21.	.379
22.	.348
23.	.406
24.	.417
25.	.425
26.	.389
27.	.374
28.	.344
29.	.369
30.	.363
31.	.360
32.	.359
33.	.362
34.	.370
35.	.393
36.	.428
37.	.461
38.	.470
39.	.481
40.	.471
41.	.447

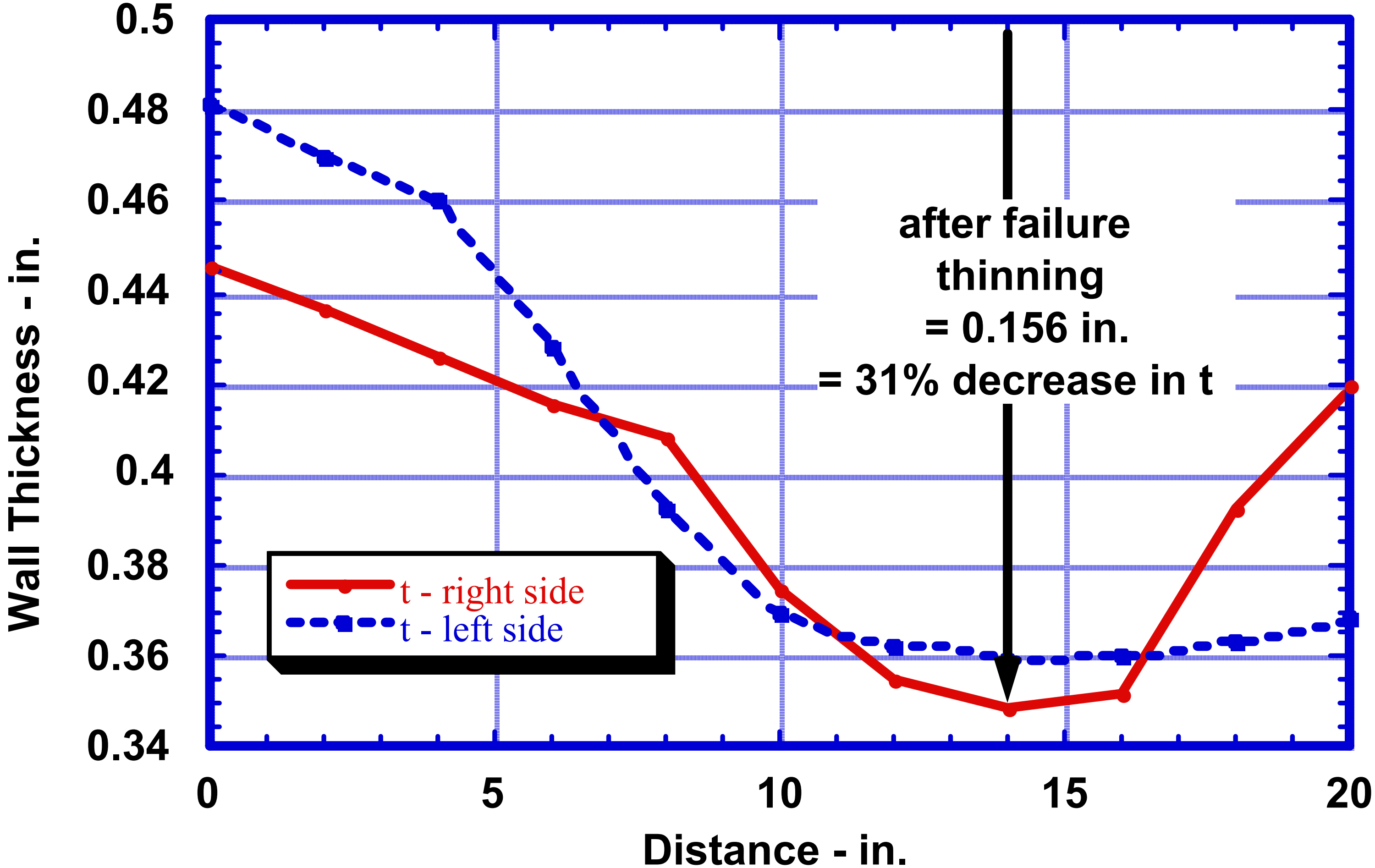


STRESS ENGINEERING SERVICES

#3 After Stress Engineering Data Analysis

STRESS ENGINEERING SERVICES

~~L = 30 to 40 inches~~



Dimensional tests results: t & D

STRESS ENGINEERING SERVICES

PRELIMINARY

Pipe 1	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
1	0.378	0.438	0.453	0.464	0.478	0.442	0.452	0.492	0.491	0.485	0.450	0.426	0.470						
2	0.461	0.486	0.489	0.429	0.525	0.465	0.508	0.489	0.804	0.487	0.520	0.502	0.505						
3	0.507	0.448	0.44	0.444	0.478	0.513	0.499	0.493	0.500	0.489	523.000	0.470	0.511						
4	0.461	0.427	0.43	0.485	0.454	0.524	0.493	0.506	0.485	0.500	0.473	0.485	0.497						
Hi/ Lo Dia.	9.08/8.96	8.99/8.96	8.95/8.95	8.82/8.81	8.71/8.62	8.72/8.63	8.72/8.63	8.71/8.63	8.64/8.63	8.63/8.61	8.63/8.63	8.66/8.66	8.72/8.71						
Pipe 2																			
1	0.497	0.51	0.493	0.462	0.491	0.487	0.481	0.497	0.500	0.492	0.479	0.509	0.478						
2	0.515	0.504	0.502	0.484	0.474	0.440	0.470	0.464	0.469	0.480	0.517	0.511	0.493						
3	0.448	0.447	0.493	0.533	0.481	0.493	0.491	0.475	0.476	0.480	0.494	0.466	0.501						
4	0.441	0.464	0.496	0.512	0.510	0.523	0.508	0.511	0.498	0.506	0.462	0.483	0.481						
Hi/ Lo Dia.	8.76/8.74	8.75/8.74	8.72/8.74	8.71/8.69	8.68/8.68	8.68/8.68	8.70/8.70	8.69/8.69	8.67/8.70	8.71/8.62	8.69/8.69	8.69/8.69	8.71/8.63						
Pipe 3																			
1	0.485	0.428	0.409	0.435	0.469	0.491	0.442	0.415	0.484	0.438	0.472								
2	0.377	0.393	0.417	0.468	0.435	0.423	0.376	0.361	0.441	0.449	0.468								
3	0.405	0.471	0.493	0.457	0.425	0.404	0.436	0.465	0.494	0.465	0.415								
4	0.478	0.471	0.469	0.409	0.436	0.454	0.482	0.481	0.443	0.445	0.411								
Hi/ Lo Dia.	9.05/8.97	8.88/8.87	see notes	8.95/8.94	9.08/8.94	9.16/9.09	9.06/9.04	9.11/9.11	9.01/9.00	8.93/8.88	8.98/8.92								
Pipe 4																			
1	0.496	0.496	0.51	0.490	0.459	0.489	0.483	0.460	0.471	0.479	0.334								
2	0.488	0.488	0.469	0.433	0.464	0.476	0.491	0.460	0.494	0.498	0.46								
3	0.47	0.47	0.454	0.476	0.485	0.462	0.477	0.450	0.489	0.462	0.417								
4	0.499	0.494	0.497	0.519	0.478	0.469	0.483	0.448	0.488	0.483	0.402								
Hi/ Lo Dia.	8.60/8.58	8.60/8.60	8.59/8.60	8.59/8.58	8.58/8.58	8.60/8.54	8.64/8.47	8.64/8.50	8.63/8.49	8.55/8.43	8.49/8.43								
Pipe 5																			
1	0.469	0.449	0.474	0.454	0.469	0.486	0.526	0.535	0.509	0.488	0.505	0.497	0.519	0.497	0.487	0.485	0.510		
2	0.485	0.49	0.496	0.476	0.496	0.489	0.475	0.528	0.502	0.522	0.508	0.518	0.496	0.491	0.500	0.498	0.503		
3	0.465	0.487	0.481	0.472	0.483	0.484	0.461	0.491	0.485	0.501	0.494	0.518	0.484	0.500	0.482	0.481	0.458		
4	0.488	0.487	0.487	0.509	0.488	0.504	0.491	0.476	0.502	0.496	0.493	0.489	0.483	0.493	0.476	0.487	0.465		
Hi/ Lo Dia.	8.64/8.63	8.63/8.63	8.64/8.63	8.63/8.62	8.64/8.63	8.66/8.61	N/A	8.70/8.58	8.62/8.62	8.70/8.57	8.61/8.60	8.61/8.61	8.69/8.59	8.70/8.69	8.67/8.62	8.68/8.58	8.66/8.57		
Pipe 6																			
1	Photo's taken and Sketch made.																		
2																			
3																			
4																			
Hi/ Lo Dia.																			
Cont...																			
Pipe 7	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
1	0.469	0.483	0.472	0.489	0.487	0.501	0.497	0.500	0.491	0.478	0.442	0.494	0.472	0.506	0.454	0.473	0.452	0.468	0.485
2	0.496	0.489	0.496	0.491	0.499	0.498	0.501	0.505	0.474	0.428	0.491	0.459	0.470	0.454	0.459	0.481	0.469	0.510	0.473
3	0.492	0.481	0.496	0.481	0.502	0.499	0.490	0.486	0.491	0.458	0.487	0.451	0.486	0.457	0.492	0.486	0.495	0.491	0.476
4	0.484	0.476	0.469	0.482	0.472	0.481	0.478	0.488	0.505	0.517	0.467	0.490	0.478	0.506	0.517	0.495	0.498	0.451	0.498
Hi/ Lo Dia.	8.65/8.64	8.66/8.65	8.65/8.60	8.62/8.61	8.62/8.61	8.62/8.61	8.62/8.60	8.61/8.59	8.60/8.58	8.60/8.60	8.59/8.59	8.61/8.61	8.60/8.60	8.60/8.60	8.61/8.60	8.61/8.60	8.60/8.59	8.62/8.60	8.61/8.60
Pipe 8																			

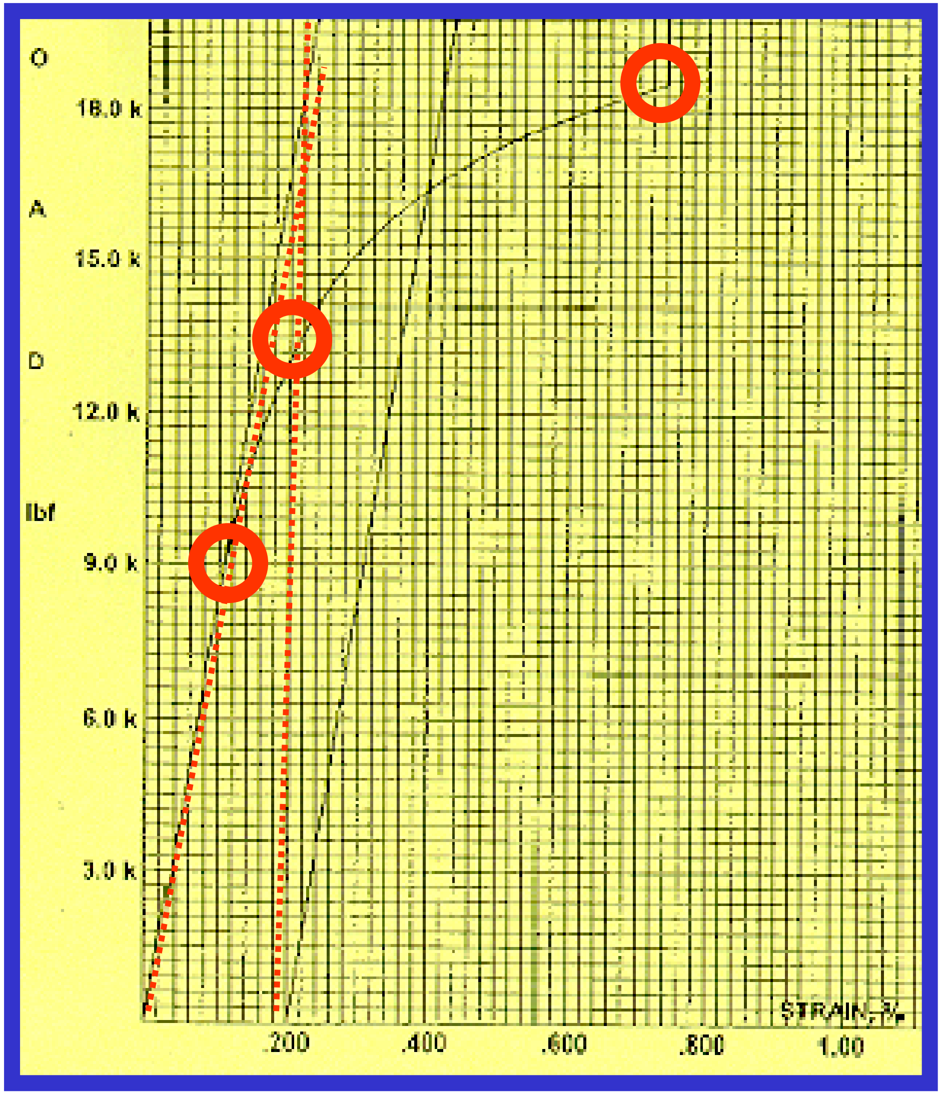
bulged section

failed section

minimum t section

Future bench test sections

Stress-strain data: *longitudinal & transverse*



	$\overline{\text{YS}}$ (ε=)2% psi	$\overline{\text{UTS}}$ psi
Long. away fracture	47,200 53,600	80,000 71,600
Trans. fracture	60,100	69,400

Other sections of Line 25 including riser - flange section

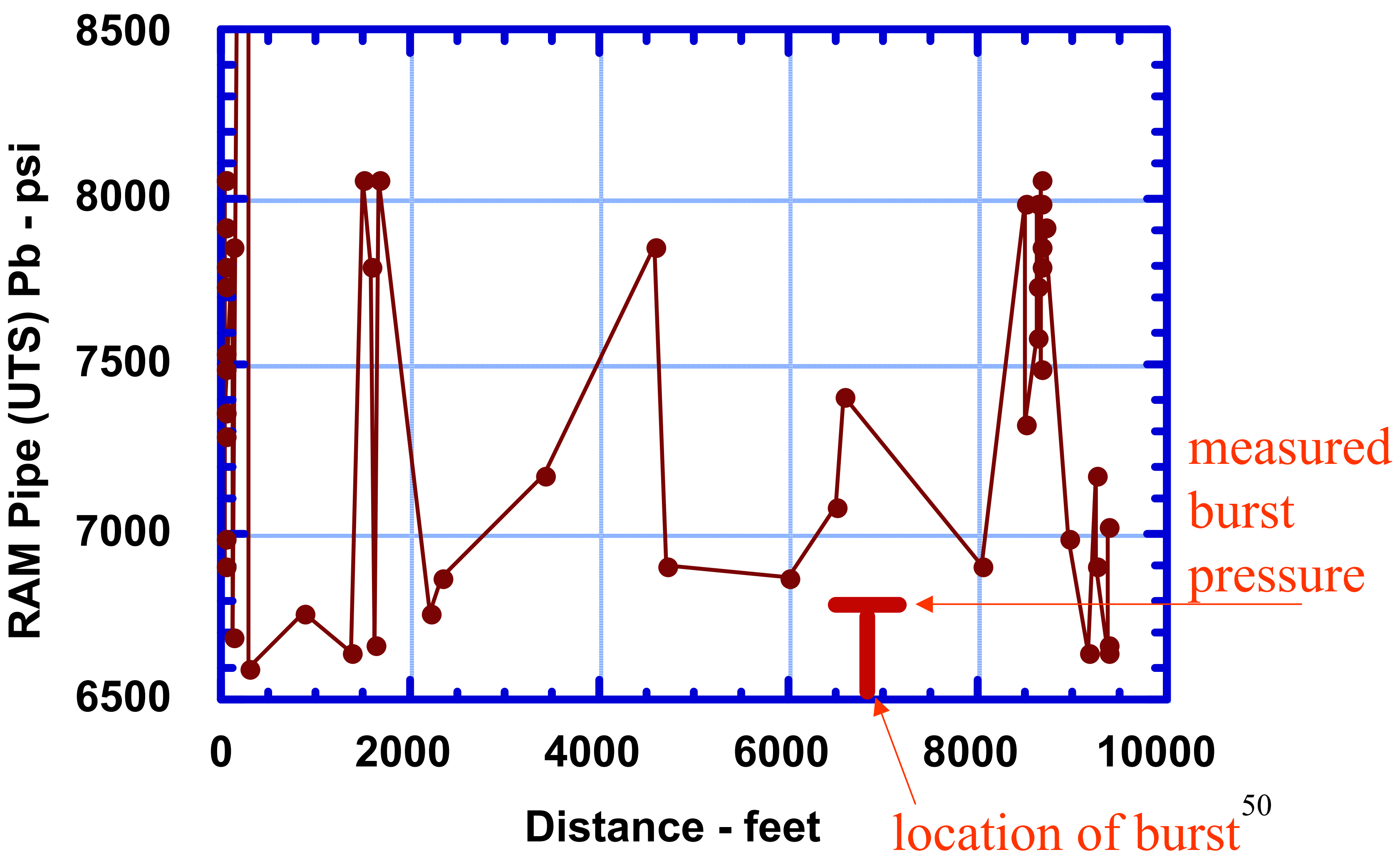
Stress Engineering Services

#3 After test analyses - Stress Eng. data *RAM Pipe*

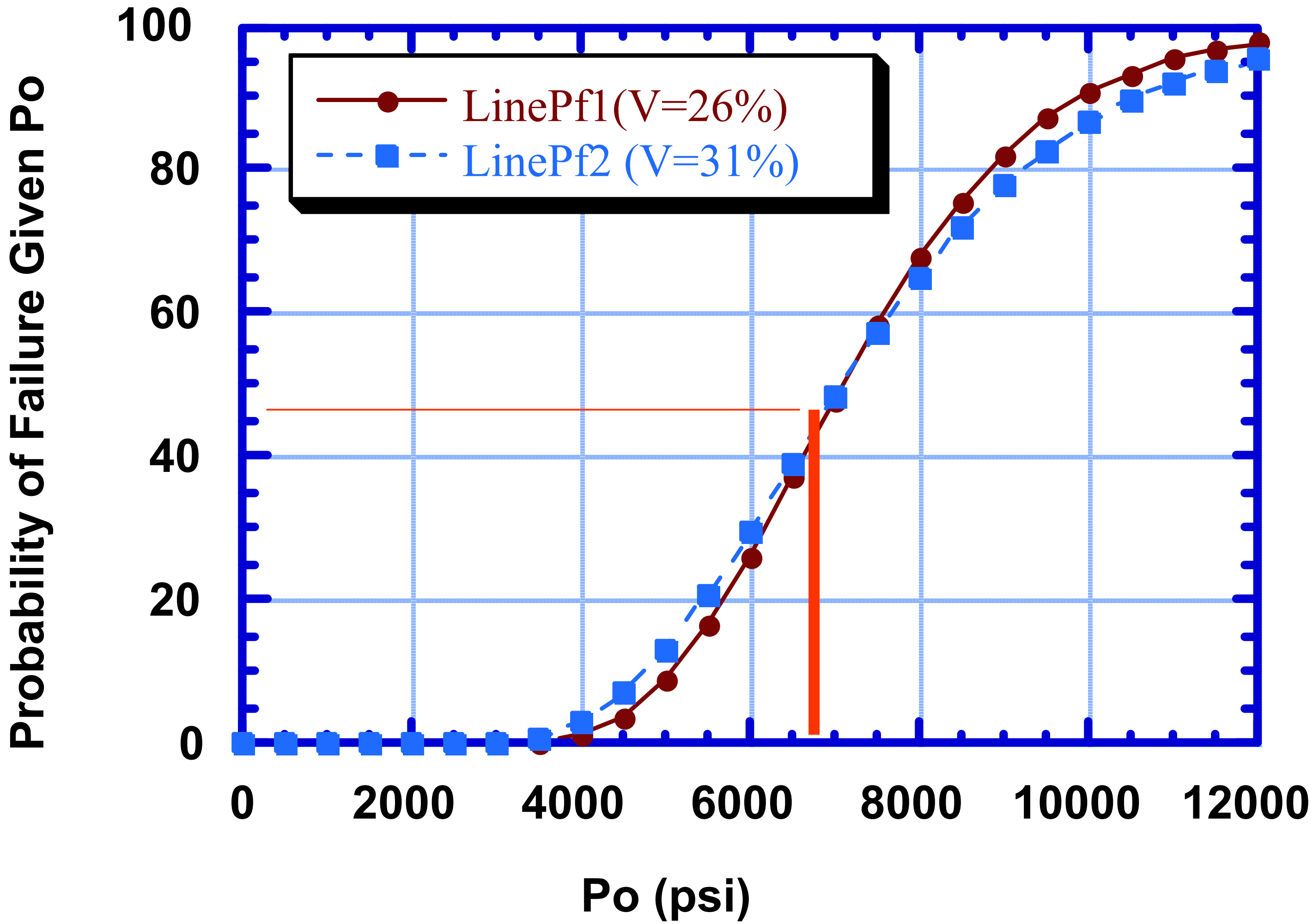
- t_{min} = 0.41 in
- t_{avg} = 0.44 in
- tc = 0 in ? (0 % loss?)
- D_{avg} = 8.87 in (8.625)
- Do = 8.43 in (8.125)
- Ro = 4.215 in (4.063)
- $\underline{UTS}_{long}$ = 71,600 psi
- $\underline{UTS}_{trans}$ = 69,400 psi

- Pb_{long} = 6,965 psi
- Pb_{tran} = 6,951 psi
- ***Pb_{test} = 6,794 psi***
- ***B_{Pb} = 0.98***

#3 After test analyses - Stress Data UTS - Rosen in-line tc - *RAM Pipe*



#3 After test analyses - Stress Eng. data *RAM Pipe Probabilistic Analyses*



#3 Analysis B 31-G & ABS Pb
YS = 47,200 - 53,600 psi

- **B31G: 4,683 - 5,318 psi**
  - **B = 1.28 - 1.45**
- **ABS: 4,927 - 5,595 psi**
  - **B_{Pb} = 1.21 - 1.38**

#3 Analysis - DNV RP F101 Pb

- **7,474 psi (71,600 ksi)**
  - **B = 0.91**
- **8,351 psi (80,000 ksi),**
  - **B = 0.81**

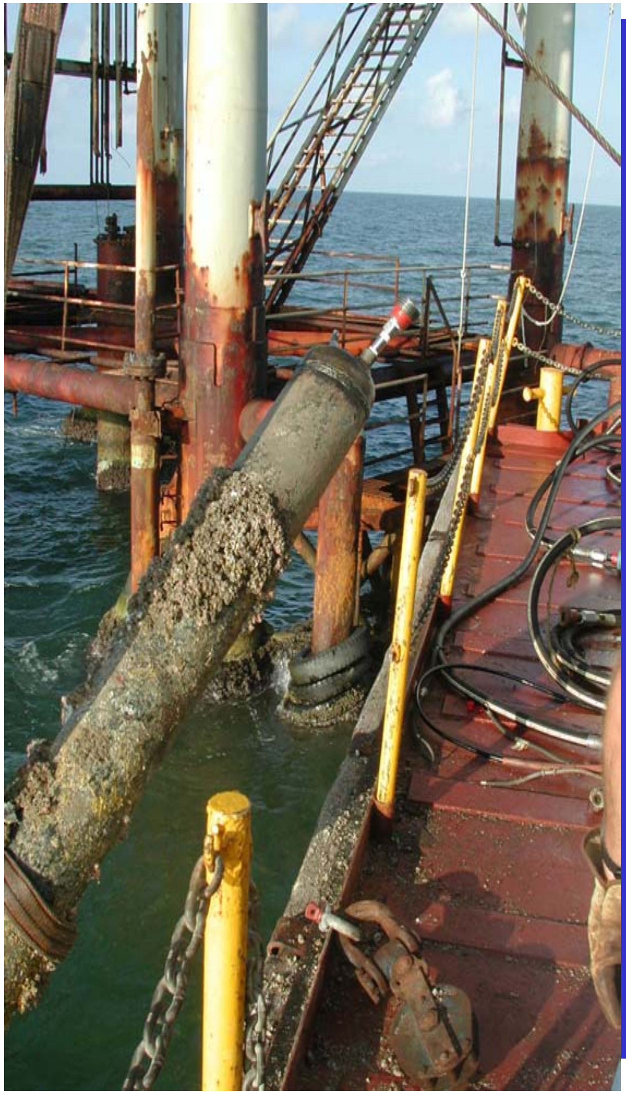
Stage #3 - Pb Biases

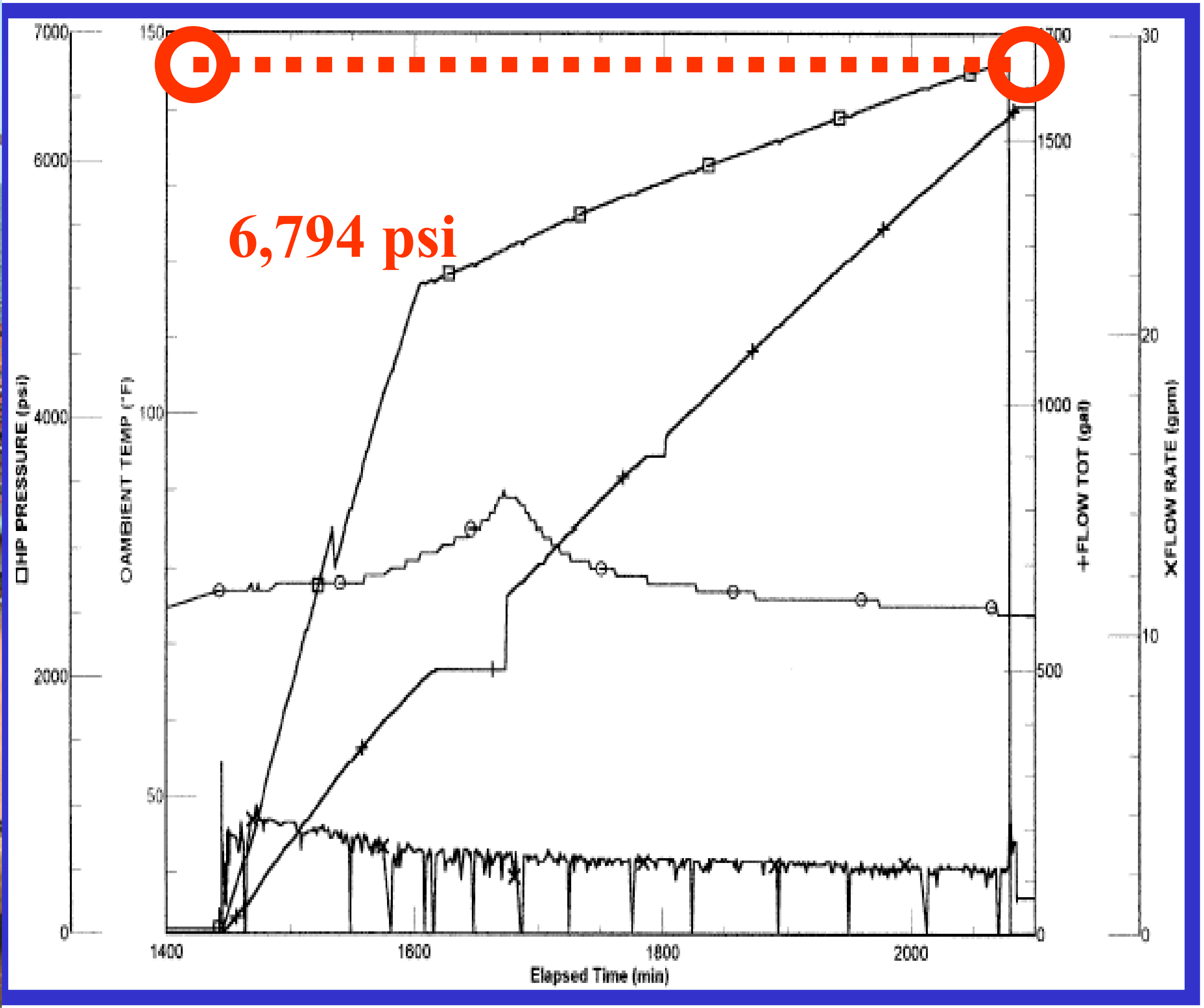
- B31 G $\quad B_{Pb} = 1.28 - 1.45$
- DNV $\quad B_{Pb} = 0.81 - 0.91$
- ABS $\quad B_{Pb} = 1.21 - 1.38$
- RAM $\quad B_{Pb} = 0.98 - 0.98$

#4 After Winmar Test Data Analysis

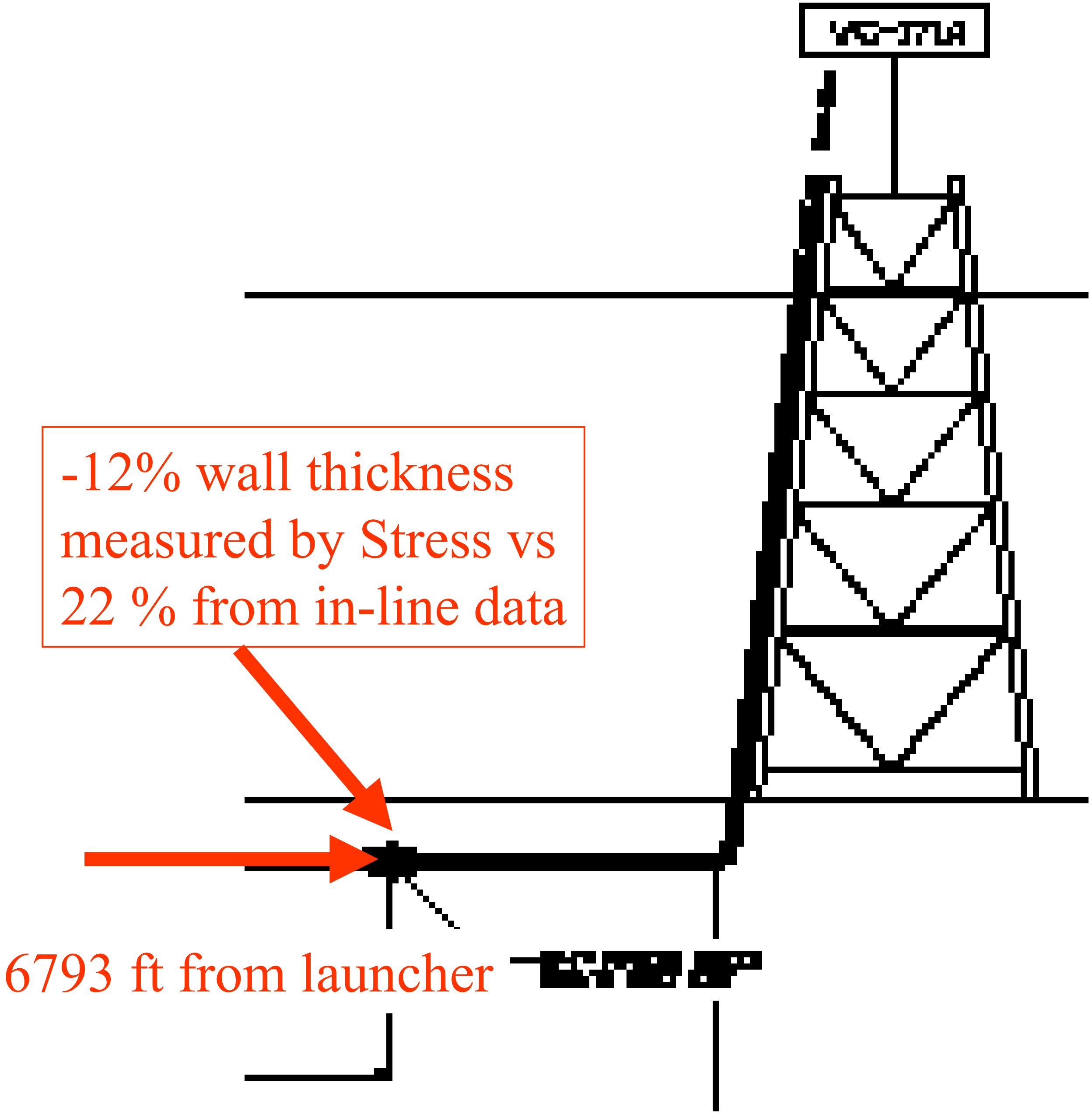
WINMAR
consulting services, inc.

#4 After Winmar Test Data Analysis

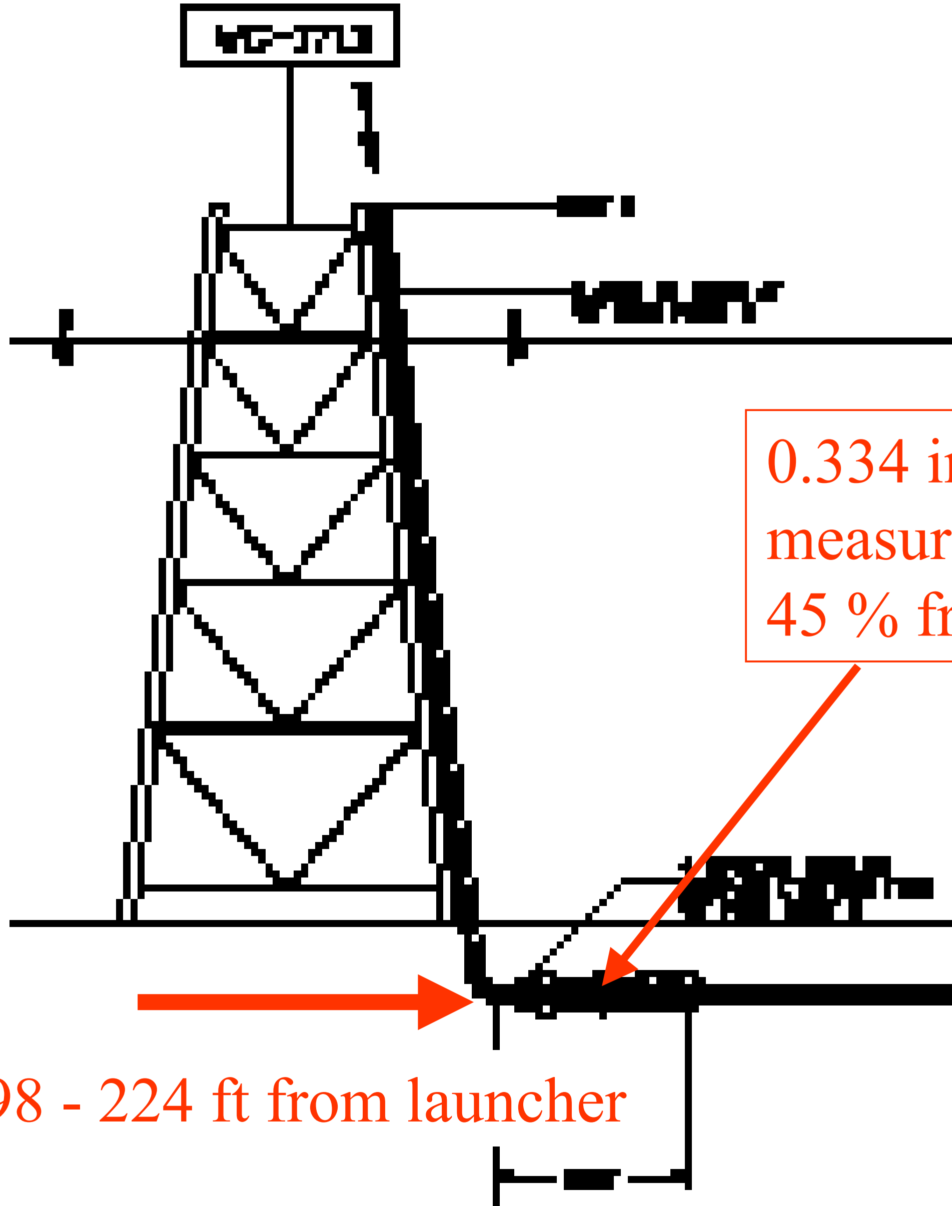




After Winmar Test Data Analysis



After Winmar Test Data Analysis



0.334 in = 33% wall loss measured by Stress vs 45 % from in-line data

98 - 224 ft from launcher

After test analyses - Winmar Field Data

- Location of failed section = 6,793 feet from B riser vs 500 to 9,500 feet from in-line data
- Wall loss from in-line = 22% vs 12% (?) from direct measurements
- Length of corrosion from in-line 0.59 in vs 0.0 in from direct measurements

- **Test pressure = 6,794 psi**

Summary of Pb Biases based on Line 25 field test results

Method/ Stage	#1 before test t/d=30%	#2 after Rosen	#3 after Stress
B31G	1.40	1.39	1.28 -1.45
DNV	0.97	0.90	0.81 - 0.91
ABS	1.79	1.84	1.21 – 1.38
RAM	1.19	1.02	0.98 – 0.98

Field Test Pb Analyses Observations

- **Potential reasons for differences between predictions and observations:**
  - **over-estimate of thickness loss**
    - **corrosion model**
    - **in-line data & interpretation**
  - **under-estimate of yield & ultimate tensile strengths**
    - **nominal vs average**
  - **Biases in analytical models**
    - **defect characteristics (tc, Lc)**
    - **burst pressures**

Next phase work (to end 2001)

- Resolution of differences between predictions and field test results
- Biases of B31G, DNV, ABS, RAM Pipe
  - database d/t and Lc ranges, different Biases
  - end and near end effects Biases
  - in-line instrumentation Biases
- Document results (9 - 12/2001)
- Assist with definition of future work - bench testing, results from other field tests