

A.6.3 Simulation Results

Electronic Appendix included in the annexed CD-Rom

Index

1	Simulations	4
1.1	BEAM-TO-COLUMN EXTENDED END-PLATE JOINT	5
1.1.1	Simulation details, statistical properties and studied cases	6
1.1.2	Case A – Variability of K_p critical component (Component [2])	11
1.1.3	Case B – Variability of K_p and F^Y of the components in shear and compression zone (Component [1], [2], [7])	26
1.1.4	Case C – Variability of K_p , F^Y and Δf	41
1.2	BEAM-TO-COLUMN FLUSH END-PLATE STEEL JOINT.....	61
1.2.1	Simulation details, statistical properties and studied cases	62
1.2.2	Case A – Variability of K_p of the components	66
1.2.3	Case B – Variability of K_p and F^Y of the components in tension zone...96	
1.2.4	Case C – Variability of K_p and F^Y and Δf	106
1.3	Lima FE1 connection modified	125
1.3.1	Simulation details, statistical properties and studied cases	126
1.3.2	Case B.....	128

Key

The simulation results for the described cases are displayed sequentially as follows:

Calculation summary presenting the percentage of simulations that DID NOT CONVERGE, DUCTILES, FAILURES

Figure– Calculation summary.

All simulated connections Moment-rotation curves

Figure – All curves.

Failure modes counter and respective percentage(of total simulations)

Figure – Failure modes counter

All simulated connections Moment-rotation curves and failure points marked in red.

Figure – All failures.

For each failing component, the distribution of Failure points(Red) and Yield points (yellow).

Figure – Failures by component

Cloud of Failures (M/rot)

Figure – Failure cloud

Histogram of rotations (mrad) at failure for all simulations and respective statistical parameters.

Figure – Histogram of rotation at failure.

Histogram of bending moments (kNm) at failure for all simulations and respective statistical parameters

Figure – Histogram of bending moment at failure.

Histograms for failures of component XX

Histogram of rotations (mrad) at failure of component XX and respective statistical parameters.

Histogram of bending moments (kNm) at failure of component XX and respective statistical parameters.

Figure – Histograms of rotations and bending moments at failure by responsible component.

Histogram of bending moments (kNm) when a rotation of 30_mrad is reached and respective statistical parameters

Figure – Histogram for rotation=30 mrad

1 SIMULATIONS

Probabilistic Evaluation of the Rotation Capacity of Steel Joints

1.1 BEAM-TO-COLUMN EXTENDED END-PLATE JOINT

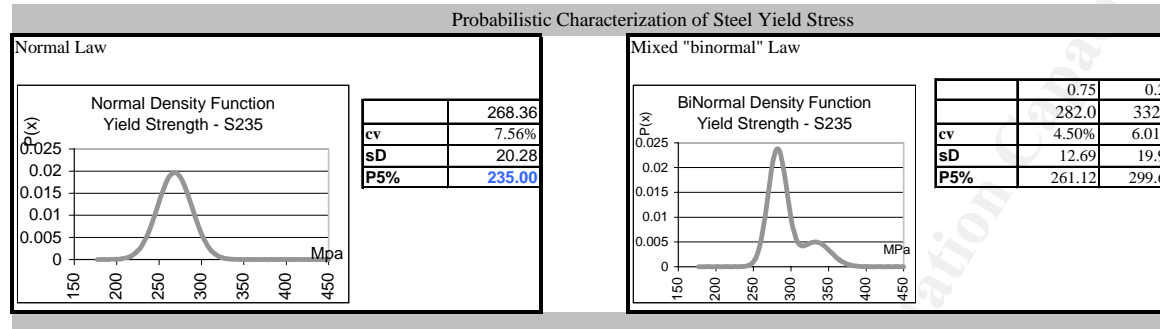
(Based in the SERICON 109.005 connection)

Probabilistic Evaluation of the Rotation Capacity of Steel Joints

1.1.1 Simulation details, statistical properties and studied cases

Extended Connection

Critical Component in Compression Zone



Real (measured) Steel properties

	Fynominal [N/mm2]	fyreal [N/mm2]	fu [N/mm2]
Column			
Flange	235	275.9	400.50
Web	235	306.60	445.00
Beam			
Flange	235	284.60	413.00
Web	235	315.60	298.00
Endplate	235	323.00	0.00
Bolts	M24 10.9	900.00	1000.00

Components		Fy [kN]										ke [kN/m]	kp [kN/m]			Df		
		FYk nominal		real		Normal distribution			Binormal distribution				real	calibrated (109.005)	cv	= Df/DY	cv	
									a=0.75		a=0.25							
		x	(P X>x)*	x	(P X>x)*	a	=a Fvk	cv= 7.5%		cv		cv						
[3.1]	Column Web in Transverse Tension	417.04	98.69%	544.11	12.24%	1.20	500.45	7.50%	500.45	4.50%	590.12	6.01%	1.50E+06	1.70E+04	1.50E+04	50.00%	20.00	
[4.1]	Column Flange in Bending	392.23	98.69%	460.50	61.35%	1.20	470.68	7.50%	470.68	4.50%	555.01	6.01%	3.75E+06	3.37E+05			200.00	
[5.1]	End-Plate in Bending	462.29	98.69%	635.40	2.63%	1.20	554.75	7.50%	554.75	4.50%	654.14	6.01%	2.41E+07	1.44E+05			200.00	
[10.1]	Bolts in Tension	635.00	98.69%	635.00	98.69%	1.20	762.00	7.50%	762.00	4.50%	898.53	6.01%	1.31E+06	1.31E+04			3.00	
[3.2]	Column Web in Transverse Tension	175.04	98.69%	228.37	12.24%	1.20	210.05	7.50%	210.05	4.50%	247.68	6.01%	1.50E+06	1.05E+03	1.05E+03	50.00%	10.00	
[4.2]	Column Flange in Bending	350.37	98.69%	411.35	61.35%	1.20	420.44	7.50%	420.44	4.50%	495.77	6.01%	3.75E+06	4.92E+04			200.00	
[5.2]	End-Plate in Bending	462.29	98.69%	635.40	2.63%	1.20	554.75	7.50%	554.75	4.50%	654.14	6.01%	2.45E+07	2.45E+05			200.00	
[8.2]	Beam Web in Tension	677.52	98.69%	909.90	5.61%	1.20	813.03	7.50%	813.03	4.50%	958.70	6.01%	1.00E+12	1.00E+10			200.00	
[10.2]	Bolts in Tension	635.00	98.69%	635.00	98.69%	1.20	762.00	7.50%	762.00	4.50%	898.53	6.01%	1.31E+06	5.91E+03			3.00	
[1]	Column Web Panel in Shear	-416.83	98.69%	-543.83	12.24%	1.20	-500.20	7.50%	-500.20	4.50%	-589.81	6.01%	6.11E+05	1.83E+04	3.06E+04	50.00%	200.00	
[2]	Column Web in Transverse Compression	-461.65	98.69%	-602.31	12.24%	1.20	-553.98	7.50%	-553.98	4.50%	-653.24	6.01%	2.46E+06	1.23E+05	7.38E+04	100.00%	12.00	15.00
[7]	Beam Flange in Compression	-993.52	98.69%	-1203.22	45.11%	1.20	-1192.23	7.50%	-1192.23	4.50%	-1405.84	6.01%	1.00E+12	1.00E+10			10.00	
[19]	Welds																	

*Cumulative distribution function for the normal distribution

Case A.1																	
Kp																	
Components	FYk nominal	real	Fy [kN]								ke [kN/m]	kp [kN/m]			Df		
			Normal distribution			Binormal distribution					real	calibrated (109.005)	μ	cv	φ= Δf/ΔY	μ	cv
			x	μ=x FYk	cv= 7.5%	α=0.76		α=0.26									
						μ	cv	μ	cv								
[3.1]	Column Web in Transverse Tension	417.04	544.11	1.20	500.45	7.50%	500.45	4.50%	590.12	6.01%	1.50E+06	1.70E+04	1.50E+04	50.00%	20.00		
[4.1]	Column Flange in Bending	392.23	460.50	1.20	470.68	7.50%	470.68	4.50%	555.01	6.01%	3.75E+06	3.37E+05			200.00		
[5.1]	End-Plate in Bending	462.29	635.40	1.20	554.75	7.50%	554.75	4.50%	654.14	6.01%	2.41E+07	1.44E+05			200.00		
[10.1]	Bolts in Tension	635.00	635.00	1.20	762.00	7.50%	762.00	4.50%	898.53	6.01%	1.31E+06	1.31E+04			3.00		
[3.2]	Column Web in Transverse Tension	175.04	228.37	1.20	210.05	7.50%	210.05	4.50%	247.68	6.01%	1.50E+06	1.05E+03	1.05E+03	50.00%	10.00		
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[2]	Column Web in Transverse Compression	-461.65	-602.31	1.20	-553.98	7.50%	-553.98	4.50%	-653.24	6.01%	2.46E+06	1.23E+05	7.38E+04	100.00%	12.00	15.00	50.00%
[7]	Beam Flange in Compression	-993.52	-1203.22	1.20	-1192.23	7.50%	-1192.23	4.50%	-1405.84	6.01%	1.00E+12	1.00E+10			10.00		
[19]	Welds																

Case A.2																	
Kp																	
Components	FYk nominal	real	Fy [kN]								ke [kN/m]	kp [kN/m]			Df		
			Normal distribution			Binormal distribution					real	calibrated (109.005)	μ	cv	φ= Δf/ΔY	μ	cv
			x	μ=x FYk	cv= 7.5%	α=0.77		α=0.27									
						μ	cv	μ	cv								
[3.1]	Column Web in Transverse Tension	417.04	544.11	1.20	500.45	7.50%	500.45	4.50%	590.12	6.01%	1.50E+06	1.70E+04	1.50E+04	50.00%	20.00		
[4.1]	Column Flange in Bending	392.23	460.50	1.20	470.68	7.50%	470.68	4.50%	555.01	6.01%	3.75E+06	3.37E+05			200.00		
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[10.1]	Bolts in Tension	635.00	635.00	1.20	762.00	7.50%	762.00	4.50%	898.53	6.01%	1.31E+06	1.31E+04			3.00		
[3.2]	Column Web in Transverse Tension	175.04	228.37	1.20	210.05	7.50%	210.05	4.50%	247.68	6.01%	1.50E+06	1.05E+03	1.05E+03	50.00%	10.00		
[4.2]	Column Flange in Bending	350.37	411.35	1.20	420.44	7.50%	420.44	4.50%	495.77	6.01%	3.75E+06	4.92E+04			200.00		
[5.2]	End-Plate in Bending	462.29	635.40	1.20	554.75	7.50%	554.75	4.50%	654.14	6.01%	2.45E+07	2.45E+05			200.00		
[8.2]	Beam Web in Tension	677.52	909.90	1.20	813.03	7.50%	813.03	4.50%	958.70	6.01%	1.00E+12	1.00E+10			200.00		
[10.2]	Bolts in Tension	635.00	635.00	1.20	762.00	7.50%	762.00	4.50%	898.53	6.01%	1.31E+06	5.91E+03			3.00		
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[2]	Column Web in Transverse Compression	-461.65	-602.31	1.20	-553.98	7.50%	-553.98	4.50%	-653.24	6.01%	2.46E+06	1.23E+05	7.38E+04	100.00%	12.00	15.00	50.00%
[7]	Beam Flange in Compression	-993.52	-1203.22	1.20	-1192.23	7.50%	-1192.23	4.50%	-1405.84	6.01%	1.00E+12	1.00E+10			10.00		
[19]	Welds																

Case B1																		
		Kp+Fy		Fy [kN]								ke [kN/m]		kp [kN/m]		Df		
Components		FYk nominal	real	Normal distribution			Binormal distribution				real	calibrated (109.005)	μ	cv	φ= Δf/ΔY	μ	cv	
				x	μ=x FYk	cv= 7.5%	α=0.78		α=0.28									
							μ	cv	μ	cv								
[3.1]	Column Web in Transverse Tension	417.04	544.11	1.20	500.45	7.50%	500.45	4.50%	590.12	6.01%	1.50E+06	1.70E+04	1.50E+04	50.00%	20.00			
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[3.2]	Column Web in Transverse Tension	175.04	228.37	1.20	210.05	7.50%	210.05	4.50%	247.68	6.01%	1.50E+06	1.05E+03	1.05E+03	50.00%	10.00			
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[7]	Beam Flange in Compression	-993.52	-1203.22	1.20	-1192.23	7.50%	-1192.23	4.50%	-1405.84	6.01%	1.00E+12	1.00E+10			10.00			
[19]	Welds																	

Case B2																		
		Kp+Fy		Fy [kN]								ke [kN/m]		kp [kN/m]		Df		
Components		FYk nominal	real	Normal distribution			Binormal distribution				real	calibrated (109.005)	μ	cv	φ= Δf/ΔY	μ	cv	
				x	μ=x FYk	cv= 7.5%	α=0.76		α=0.26									
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[7]	Beam Flange in Compression	-993.52	-1203.22	1.20	-1192.23	7.50%	-1192.23	4.50%	-1405.84	6.01%	1.00E+12	1.00E+10			10.00			
[19]	Welds																	

Case B.3																		
		Kp+Fy																
Components		Fy [kN]								ke [kN/m]		kp [kN/m]				Df		
		FYk nominal	real	Normal distribution			Binormal distribution				real	calibrated (109.005)	μ	cv	$\phi= \Delta f/\Delta Y$	μ	cv	
				x	$\mu=x \cdot Fy_k$	cv= 7.5%	$\alpha=0.77$		$\alpha=0.27$									
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[19]	Welds																	

Case C.1																		
		Kp+Fy+Df																
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				x	$\mu=x \cdot Fy_k$	cv= 7.5%	$\alpha=0.78$		$\alpha=0.28$									
							μ	cv	μ	cv								
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[5.1]	End-Plate in Bending	462.29	635.40	1.20	554.75	7.50%	554.75	4.50%	654.14	6.01%	2.41E+07	1.44E+05			200.00			
[10.1]	Bolts in Tension	635.00	635.00	1.20	762.00	7.50%	762.00	4.50%	898.53	6.01%	1.31E+06	1.31E+04			3.00			
[3.2]	Column Web in Transverse Tension	175.04	228.37	1.20	210.05	7.50%	210.05	4.50%	247.68	6.01%	1.50E+06	1.05E+03	1.05E+03	50.00%	10.00			
[4.2]	Column Flange in Bending	350.37	411.35	1.20	420.44	7.50%	420.44	4.50%	495.77	6.01%	3.75E+06	4.92E+04			200.00			
[5.2]	End-Plate in Bending	462.29	635.40	1.20	554.75	7.50%	554.75	4.50%	654.14	6.01%	2.45E+07	2.45E+05			200.00			
[8.2]	Beam Web in Tension	677.52	909.90	1.20	813.03	7.50%	813.03	4.50%	958.70	6.01%	1.00E+12	1.00E+10			200.00			
[10.2]	Bolts in Tension	635.00	635.00	1.20	762.00	7.50%	762.00	4.50%	898.53	6.01%	1.31E+06	5.91E+03			3.00			
[1]	Column Web Panel in Shear	-416.83	-543.83	1.20	-500.20	7.50%	-500.20	4.50%	-589.81	6.01%	6.11E+05	1.83E+04	3.06E+04	50.00%	200.00			
[2]	Column Web in Transverse Compression	-461.65	-602.31	1.20	-553.98	7.50%	-553.98	4.50%	-653.24	6.01%	2.46E+06	1.23E+05	7.38E+04	100.00%	12.00	15.00	50.00%	
[7]	Beam Flange in Compression	-993.52	-1203.22	1.20	-1192.23	7.50%	-1192.23	4.50%	-1405.84	6.01%	1.00E+12	1.00E+10			10.00			
[19]	Welds																	

Case C.2

Kp+Fy+Df

Components		Fy [kN]								ke [kN/m]	kp [kN/m]			Df			
		FYk nominal	real	Normal distribution			Binormal distribution				real	calibrated (109.005)	μ	cv	φ= Δf/ΔY	μ	cv
							α=0.79		α=0.29								
				x	μ=x Fy _k	cv= 7.5%	μ	cv	μ	cv							
[3.1]	Column Web in Transverse Tension	417.04	544.11	1.20	500.45	7.50%	500.45	4.50%	590.12	6.01%	1.50E+06	1.70E+04	1.50E+04	50.00%	20.00		
[4.1]	Column Flange in Bending	392.23	460.50	1.20	470.68	7.50%	470.68	4.50%	555.01	6.01%	3.75E+06	3.37E+05			200.00		
[5.1]	End-Plate in Bending	462.29	635.40	1.20	554.75	7.50%	554.75	4.50%	654.14	6.01%	2.41E+07	1.44E+05			200.00		
[10.1]	Bolts in Tension	635.00	635.00	1.20	762.00	7.50%	762.00	4.50%	898.53	6.01%	1.31E+06	1.31E+04			3.00		
[3.2]	Column Web in Transverse Tension	175.04	228.37	1.20	210.05	7.50%	210.05	4.50%	247.68	6.01%	1.50E+06	1.05E+03	1.05E+03	50.00%	10.00		
[4.2]	Column Flange in Bending	350.37	411.35	1.20	420.44	7.50%	420.44	4.50%	495.77	6.01%	3.75E+06	4.92E+04			200.00		
[5.2]	End-Plate in Bending	462.29	635.40	1.20	554.75	7.50%	554.75	4.50%	654.14	6.01%	2.45E+07	2.45E+05			200.00		
[8.2]	Beam Web in Tension	677.52	909.90	1.20	813.03	7.50%	813.03	4.50%	958.70	6.01%	1.00E+12	1.00E+10			200.00		
[10.2]	Bolts in Tension	635.00	635.00	1.20	762.00	7.50%	762.00	4.50%	898.53	6.01%	1.31E+06	5.91E+03			3.00		
[1]	Column Web Panel in Shear	-416.83	-543.83	1.20	-500.20	7.50%	-500.20	4.50%	-589.81	6.01%	6.11E+05	1.83E+04	3.06E+04	50.00%	200.00		
[2]	Column Web in Transverse Compression	-461.65	-602.31	1.20	-553.98	7.50%	-553.98	4.50%	-653.24	6.01%	2.46E+06	1.23E+05	7.38E+04	100.00%	12.00	15.00	50.00%
[7]	Beam Flange in Compression	-993.52	-1203.22	1.20	-1192.23	7.50%	-1192.23	4.50%	-1405.84	6.01%	1.00E+12	1.00E+10			10.00		
[19]	Welds																

Case C.3

Kp+Fy+Df

Components		Fy [kN]								ke [kN/m]	kp [kN/m]				Df		
		FYk nominal	real	Normal distribution			Binormal distribution				real	calibrated (109.005)	μ	cv	φ= Δf/ΔY	μ	cv
							α=0.79		α=0.29								
				x	μ=x Fy _k	cv= 7.5%	μ	cv	μ	cv							
[3.1]	Column Web in Transverse Tension	417.04	544.11	1.20	500.45	7.50%	500.45	4.50%	590.12	6.01%	1.50E+06	1.70E+04	1.50E+04	50.00%	20.00		
[4.1]	Column Flange in Bending	392.23	460.50	1.20	470.68	7.50%	470.68	4.50%	555.01	6.01%	3.75E+06	3.37E+05			200.00		
[5.1]	End-Plate in Bending	462.29	635.40	1.20	554.75	7.50%	554.75	4.50%	654.14	6.01%	2.41E+07	1.44E+05			200.00		
[10.1]	Bolts in Tension	635.00	635.00	1.20	762.00	7.50%	762.00	4.50%	898.53	6.01%	1.31E+06	1.31E+04			3.00		
[3.2]	Column Web in Transverse Tension	175.04	228.37	1.20	210.05	7.50%	210.05	4.50%	247.68	6.01%	1.50E+06	1.05E+03	1.05E+03	50.00%	10.00		
[4.2]	Column Flange in Bending	350.37	411.35	1.20	420.44	7.50%	420.44	4.50%	495.77	6.01%	3.75E+06	4.92E+04			200.00		
[5.2]	End-Plate in Bending	462.29	635.40	1.20	554.75	7.50%	554.75	4.50%	654.14	6.01%	2.45E+07	2.45E+05			200.00		
[8.2]	Beam Web in Tension	677.52	909.90	1.20	813.03	7.50%	813.03	4.50%	958.70	6.01%	1.00E+12	1.00E+10			200.00		
[10.2]	Bolts in Tension	635.00	635.00	1.20	762.00	7.50%	762.00	4.50%	898.53	6.01%	1.31E+06	5.91E+03			3.00		
[1]	Column Web Panel in Shear	-416.83	-543.83	1.20	-500.20	7.50%	-500.20	4.50%	-589.81	6.01%	6.11E+05	1.83E+04	3.06E+04	50.00%	200.00		
[2]	Column Web in Transverse Compression	-461.65	-602.31	1.20	-553.98	7.50%	-553.98	4.50%	-653.24	6.01%	2.46E+06	1.23E+05	7.38E+04	100.00%	12.00	15.00	50.00%
[7]	Beam Flange in Compression	-993.52	-1203.22	1.20	-1192.23	7.50%	-1192.23	4.50%	-1405.84	6.01%	1.00E+12	1.00E+10			10.00		
[19]	Welds																

1.1.2 Case A – Variability of Kp critical component (Component [2])

1.1.2.1 A.1) nominal F^Y (10.000 Combinations)

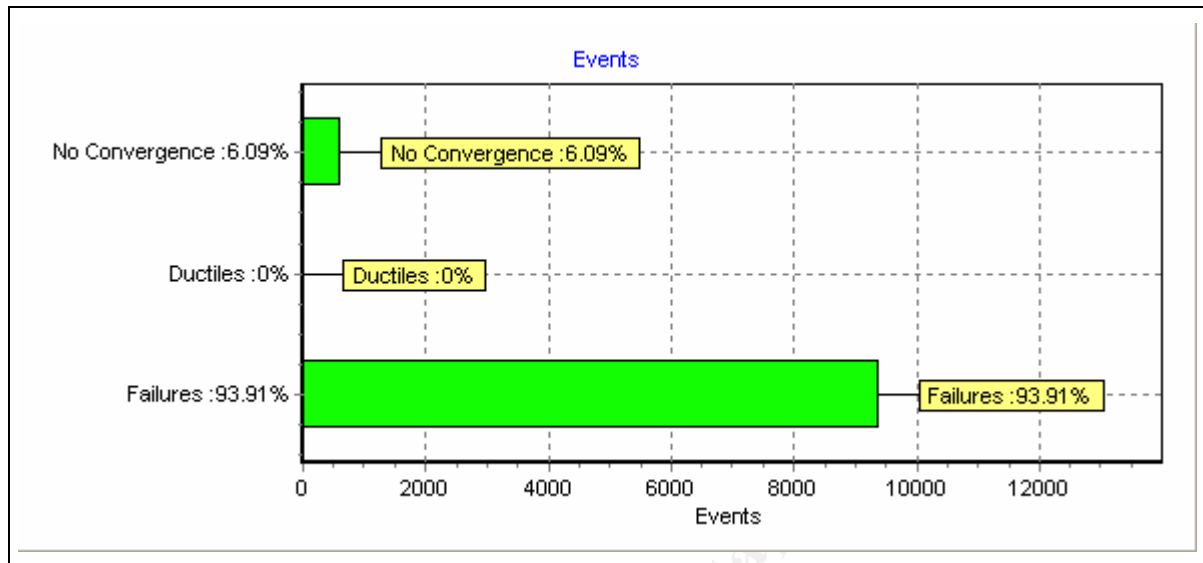


Figure 1 – Calculation summary.

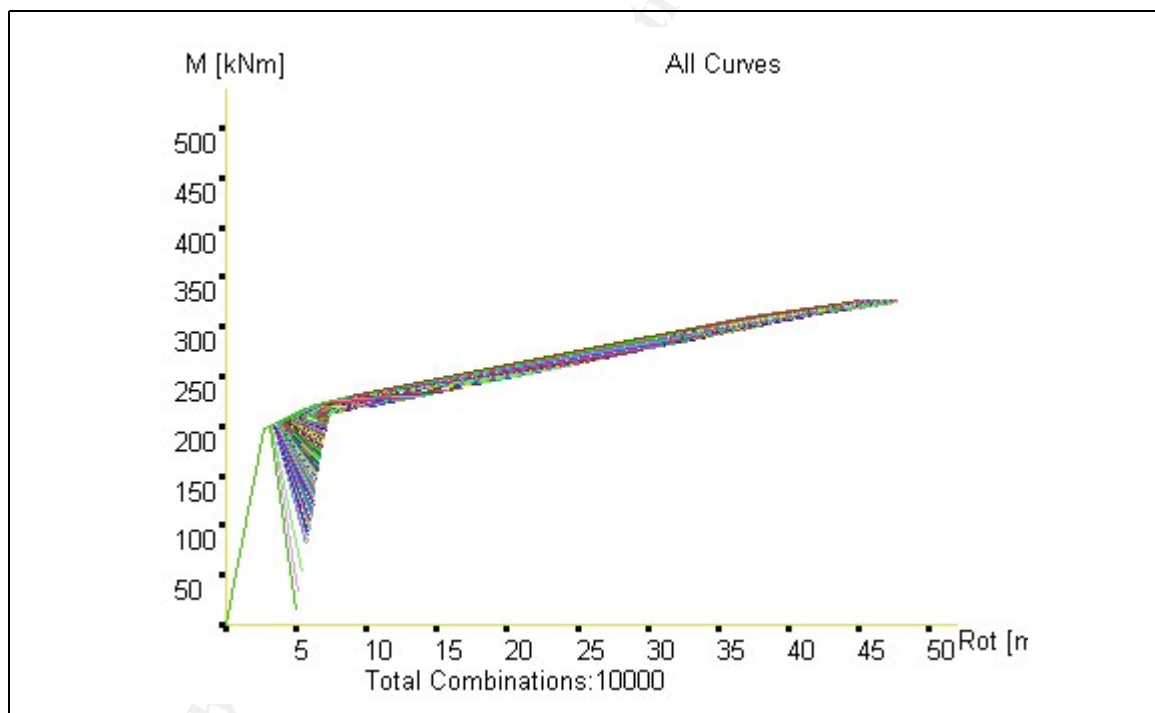


Figure 2 – All curves.

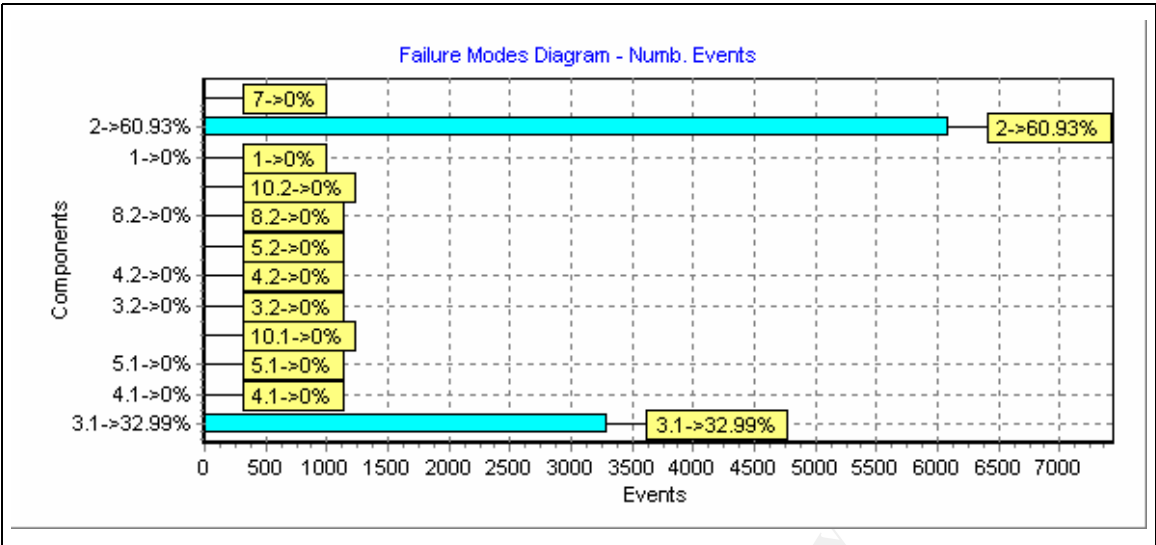


Figure 3 – Failure modes counter.

3.1 : 3299
2 : 6093

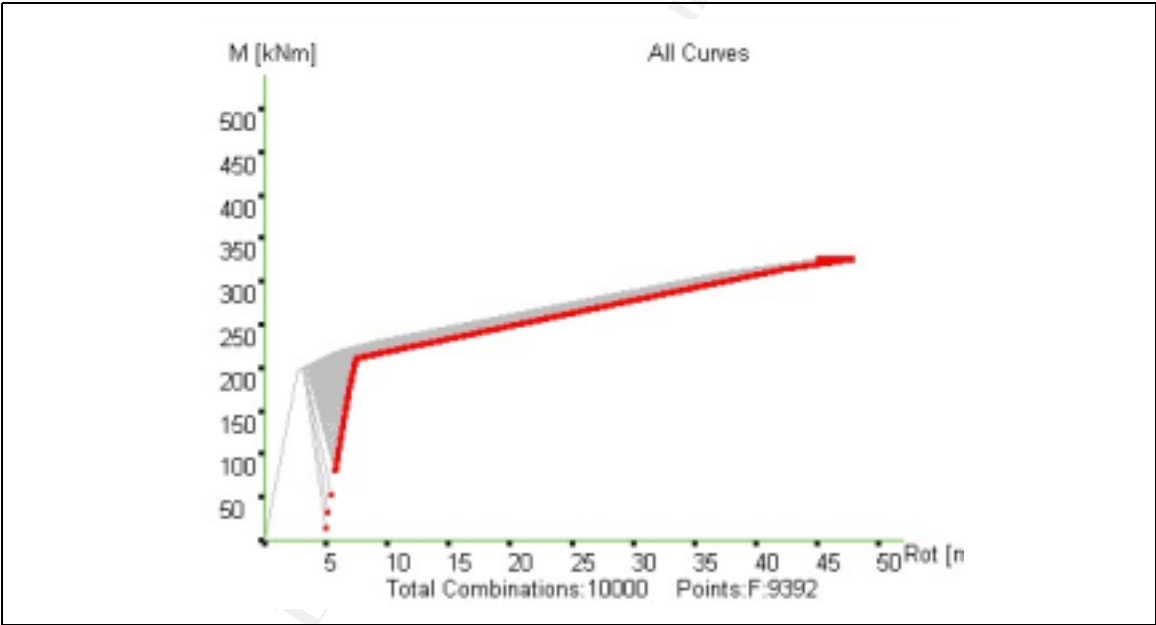


Figure 4 – All failures.

3.1 Column Web in Tension

2 Column Web in Compression

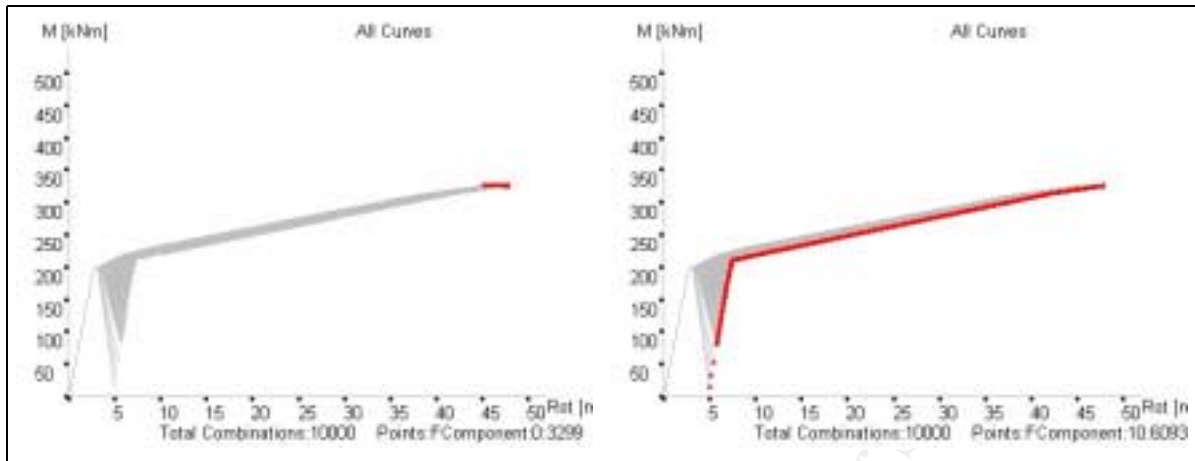


Figure 5 – Failures by component

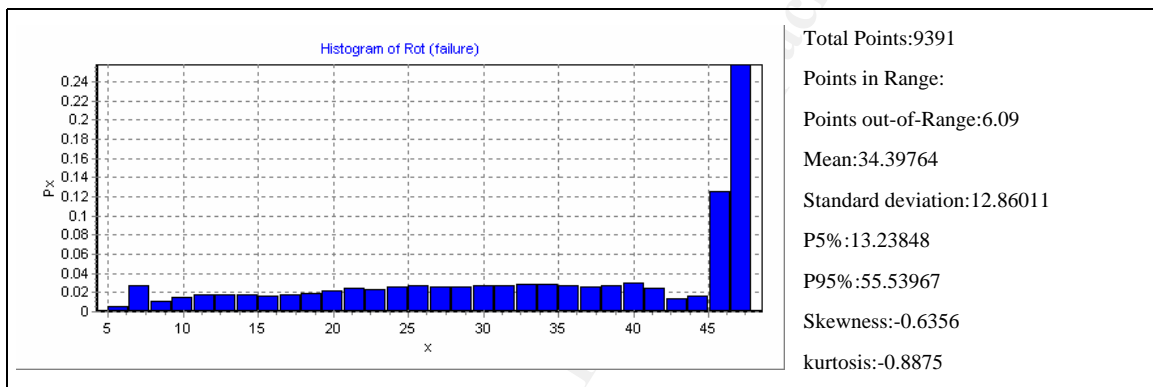


Figure 6 – Histogram for rotation at failure.

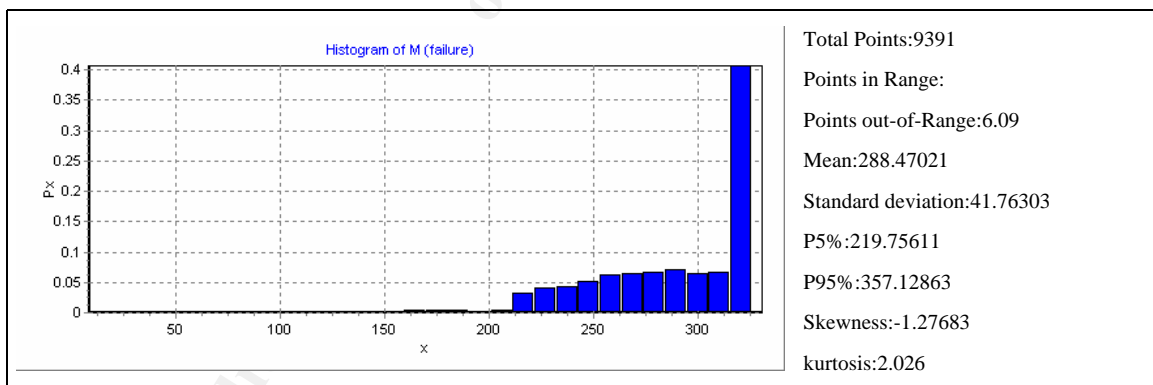
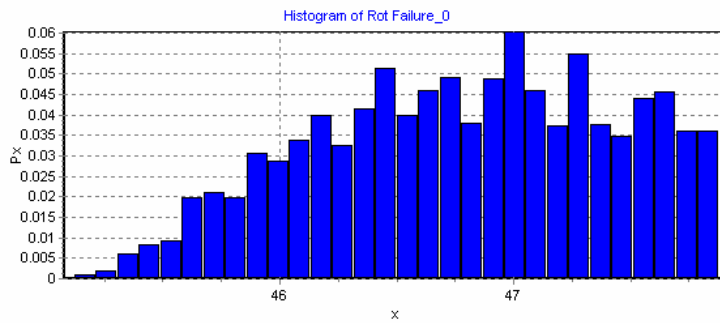
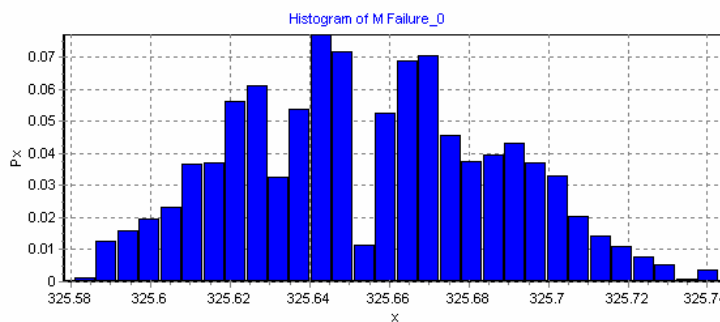


Figure 7 – Histogram for moment at failure.

Histograms for failures of component 3.1

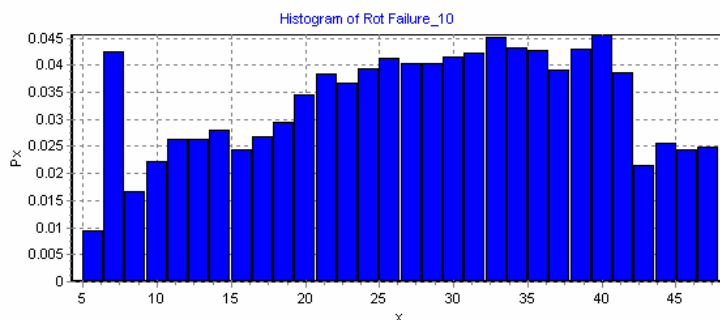


Total Points:3299
 Points in Range:32.99
 Points out-of-Range:67.01
 Mean:46.78647
 Standard deviation:0.63742
 P5%:45.7377
 P95%:47.83438
 Skewness:-0.21042
 kurtosis:-0.86915

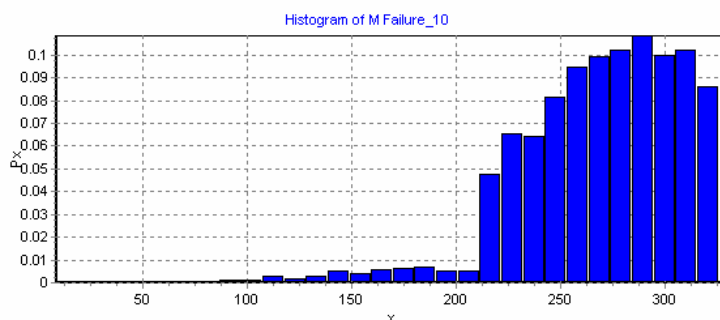


Total Points:3299
 Points in Range:32.99
 Points out-of-Range:67.01
 Mean:325.65476
 Standard deviation:0.03271
 P5%:325.60094
 P95%:325.70854
 Skewness:0.11775
 kurtosis:-0.6858

Histograms for failures of component 2



Total Points:6093
 Points in Range:60.93
 Points out-of-Range:39.07
 Mean:27.69204
 Standard deviation:11.25329
 P5%:9.17662
 P95%:46.19246
 Skewness:-0.19099
 kurtosis:-0.96582



Total Points:6093
 Points in Range:60.93
 Points out-of-Range:39.07
 Mean:268.34306
 Standard deviation:39.17477
 P5%:203.8875
 P95%:332.74639
 Skewness:-1.17055
 kurtosis:2.50742

Figure 8 – Histograms of rotations and bending moments at failure by responsible component.

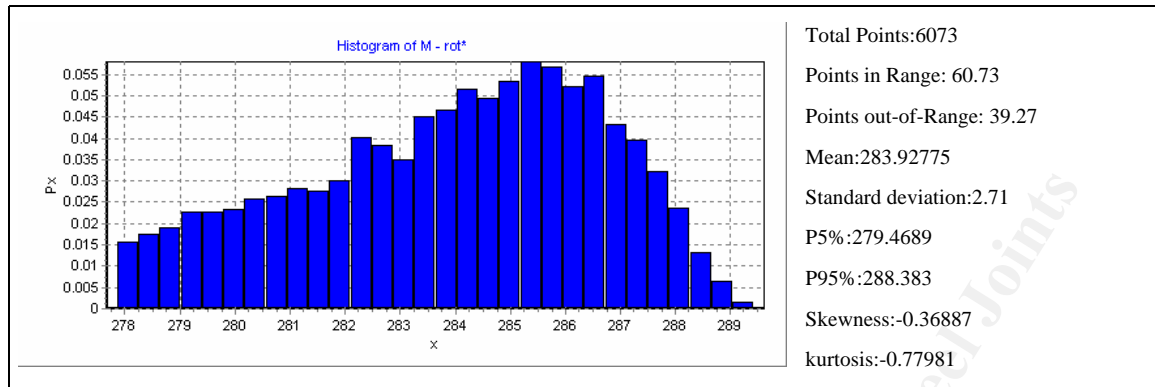


Figure 9 – Histogram for rotation=30 mrad

1.1.2.2 A.2) real F^Y (10.000 Combinations)

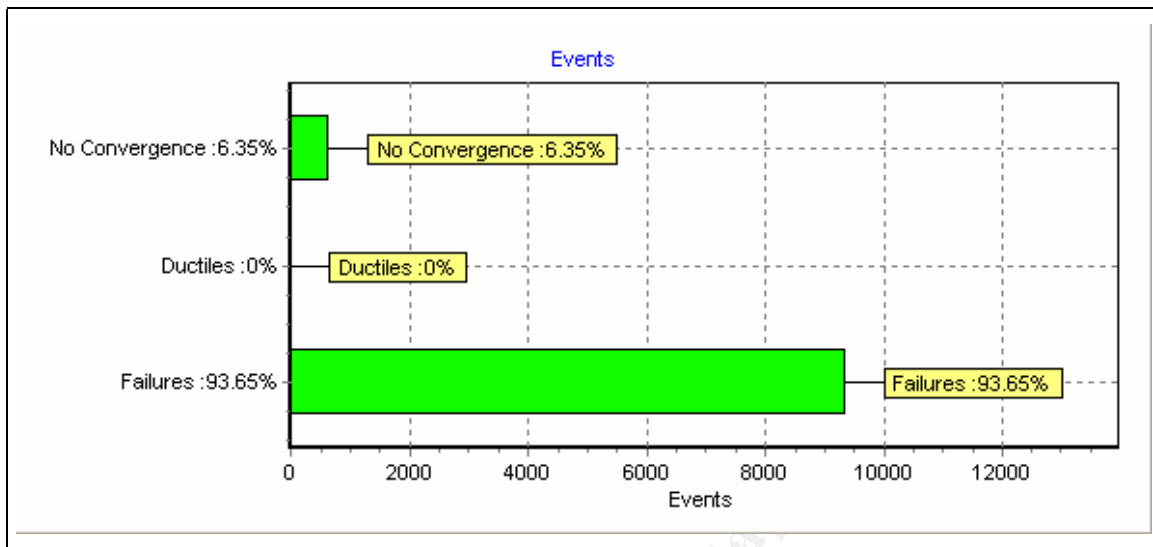


Figure 10 – Calculation summary.

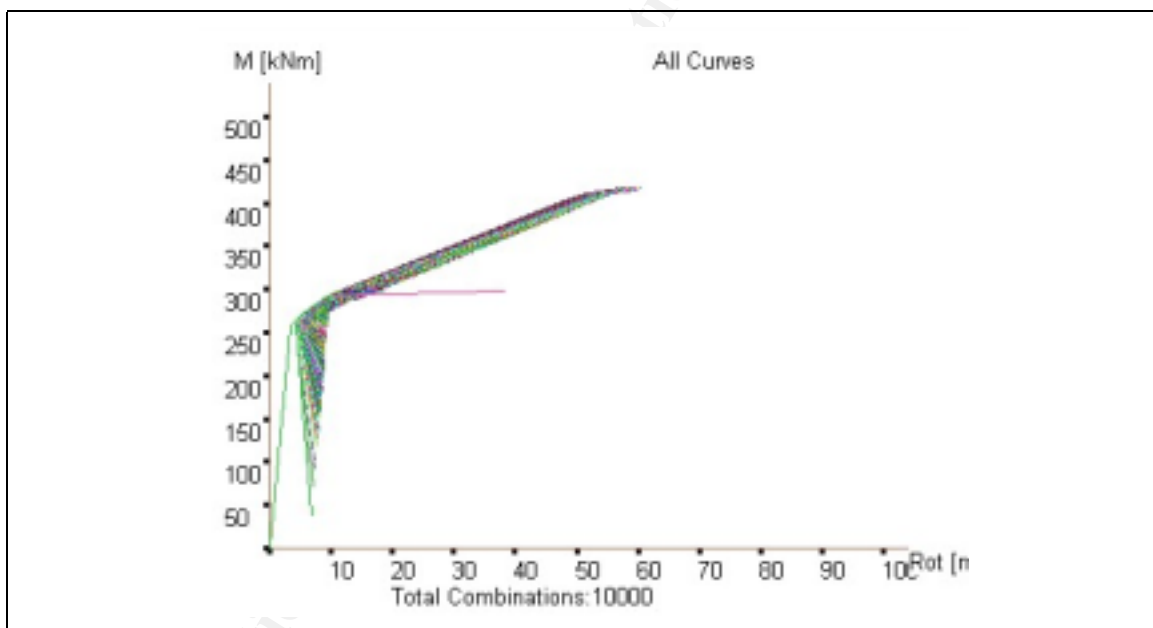


Figure 11 – All curves.

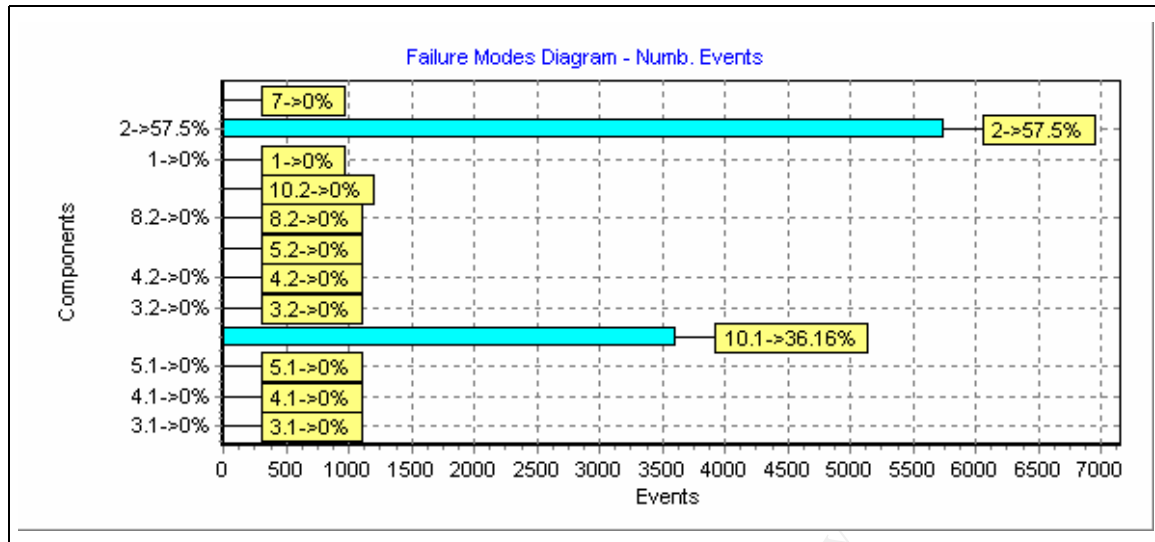


Figure 12 – Failure modes counter

10.1 : 3616

2 : 5750

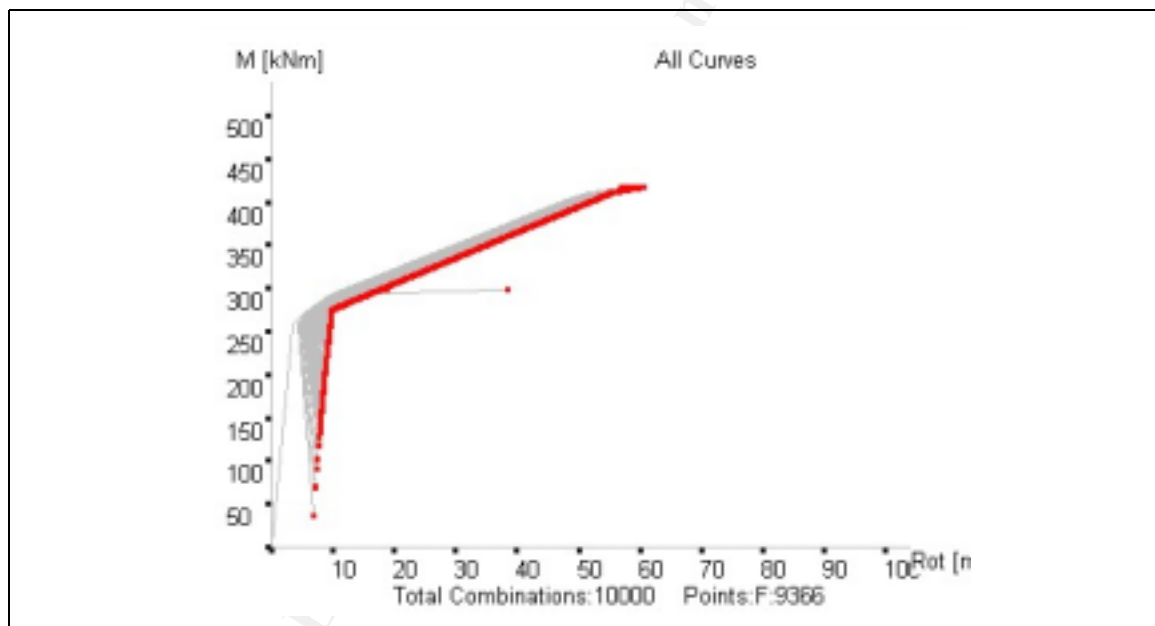


Figure 13 – All failures.

10.1 Bolts in tension	2 Column Web in Compression
-----------------------	-----------------------------

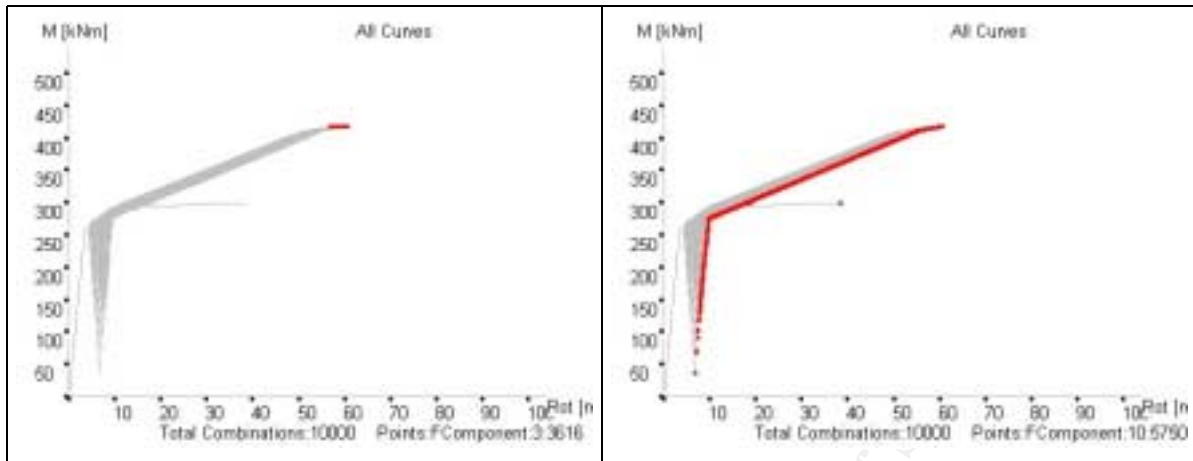


Figure 14 – Failures by component

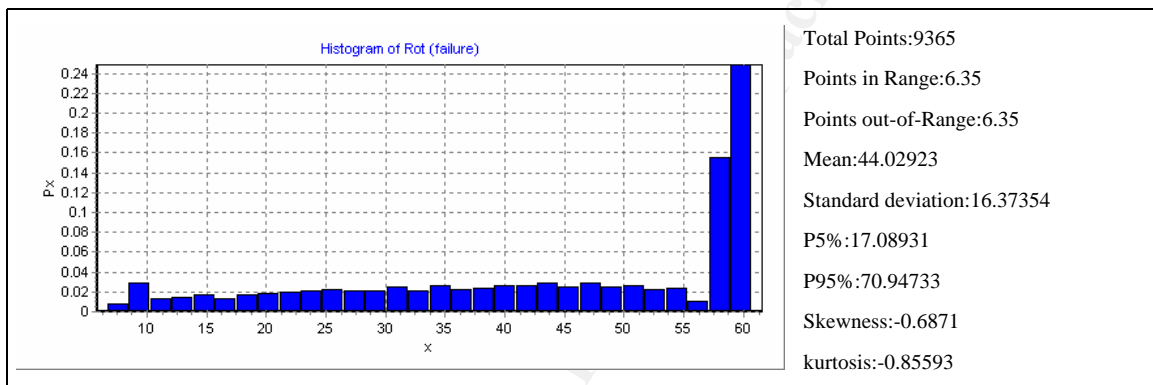


Figure 15 – Histograms of rotations at failure.

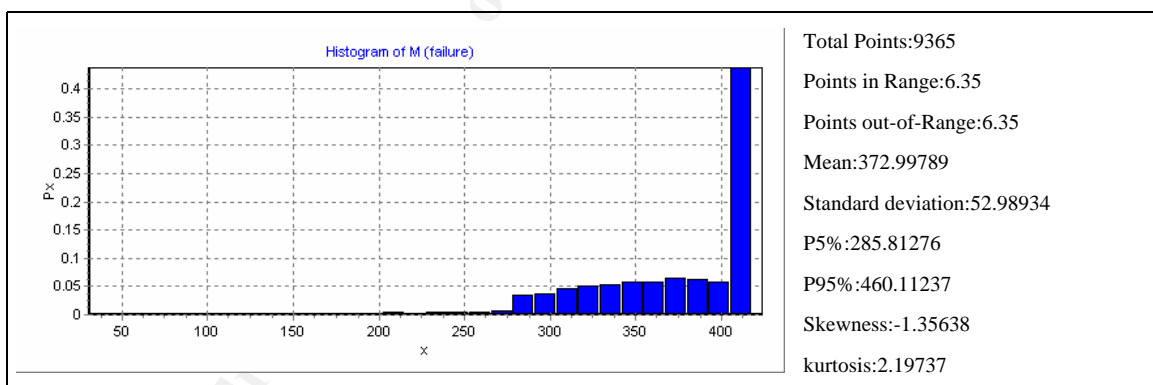


Figure 16 – Histograms of bending moments at failure.

Histograms for failures of component 10.1

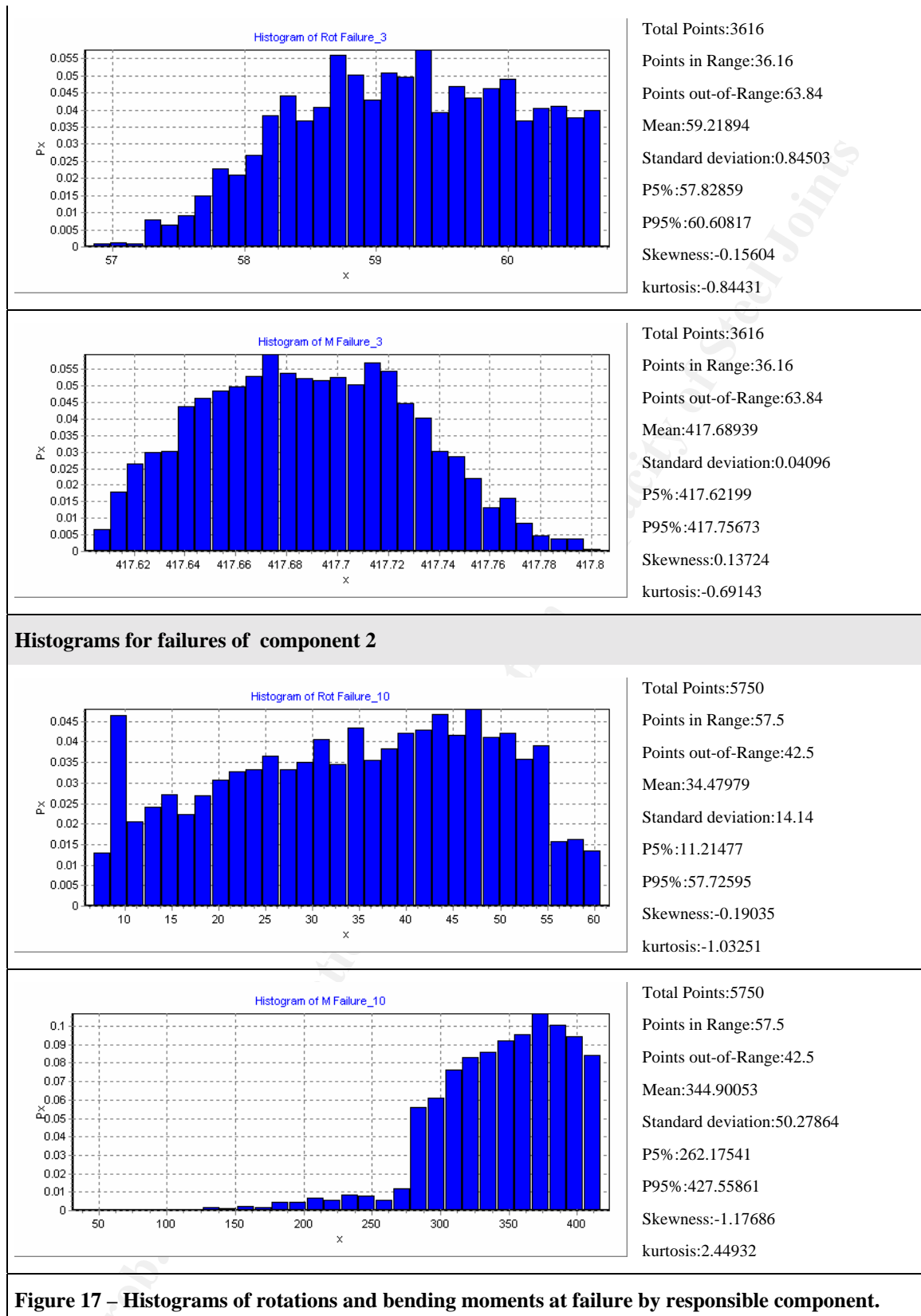


Figure 17 – Histograms of rotations and bending moments at failure by responsible component.

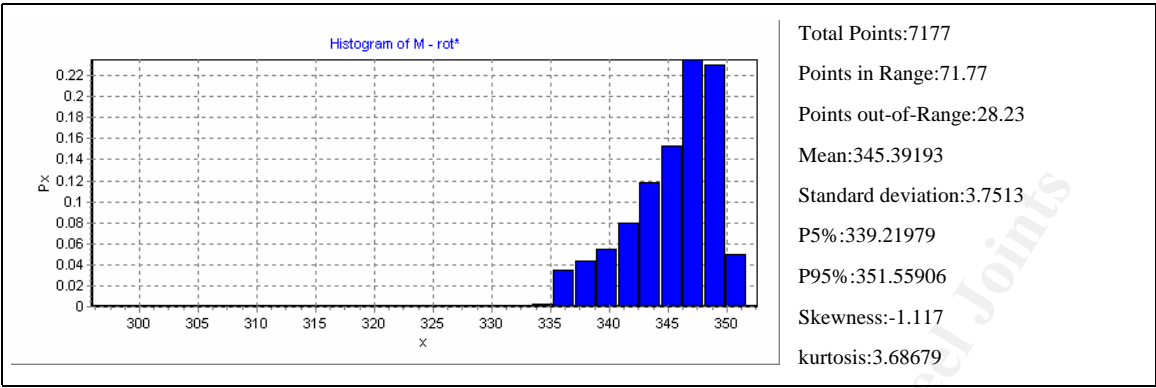


Figure 18 – Histogram for rotation=30 mrad

1.1.2.3 A.3) real F^Y (10.000 Combinations)

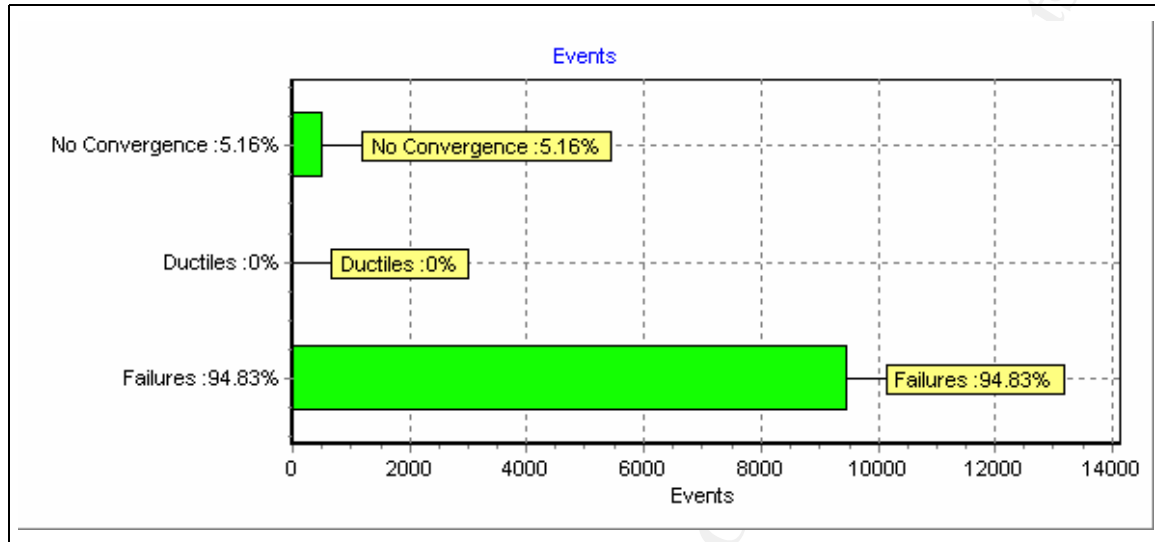


Figure 19 – Calculation summary.

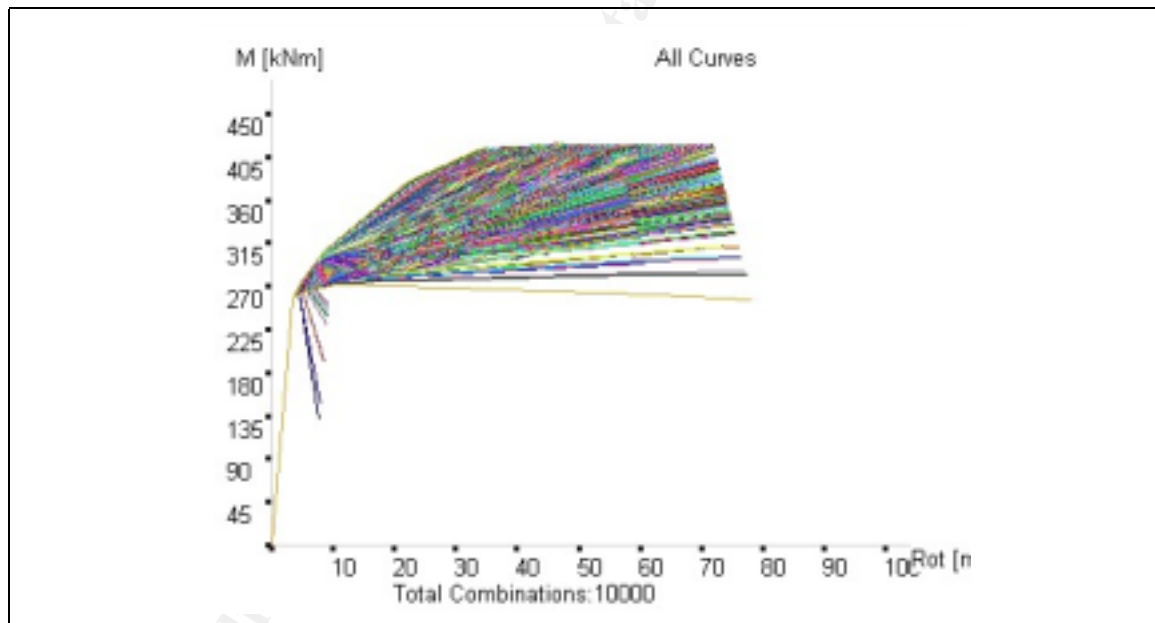


Figure 20 – All curves.

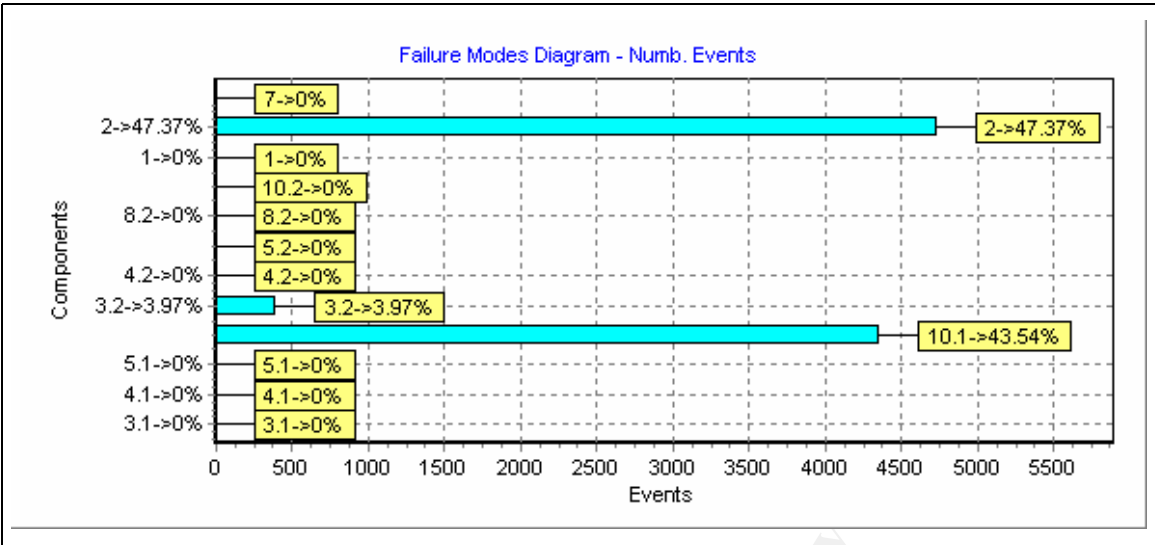


Figure 21 – Failure modes counter

10.1 : 4354
3.2 : 397
2 : 4737

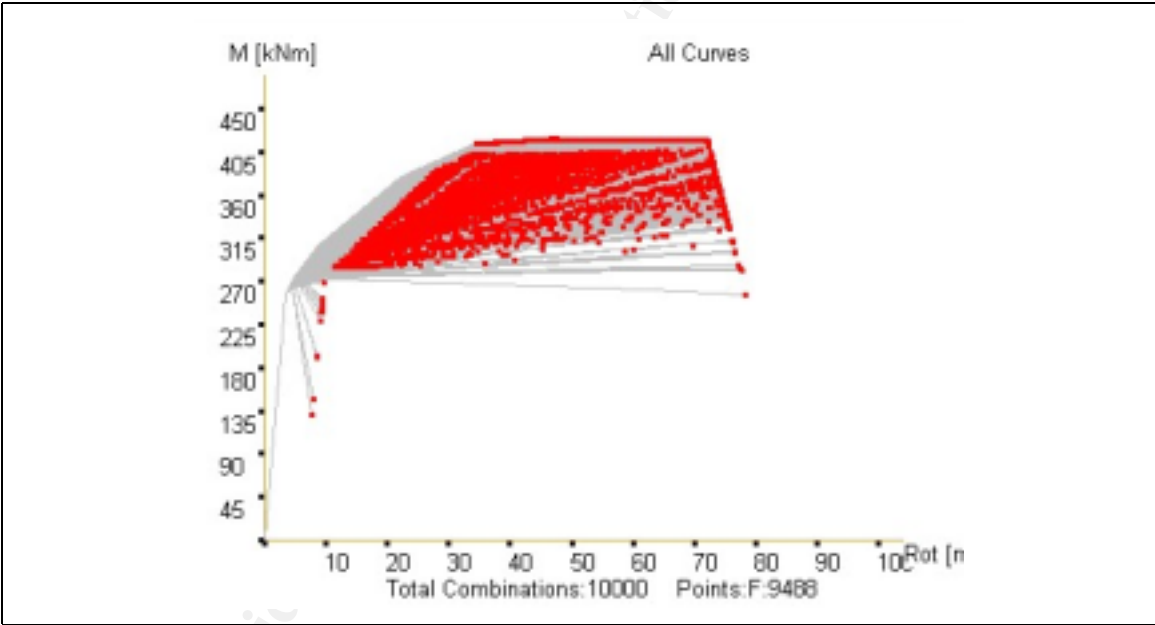


Figure 22 – All failures.

10.1 Bolts in tension	3.2 Column Web in Tension
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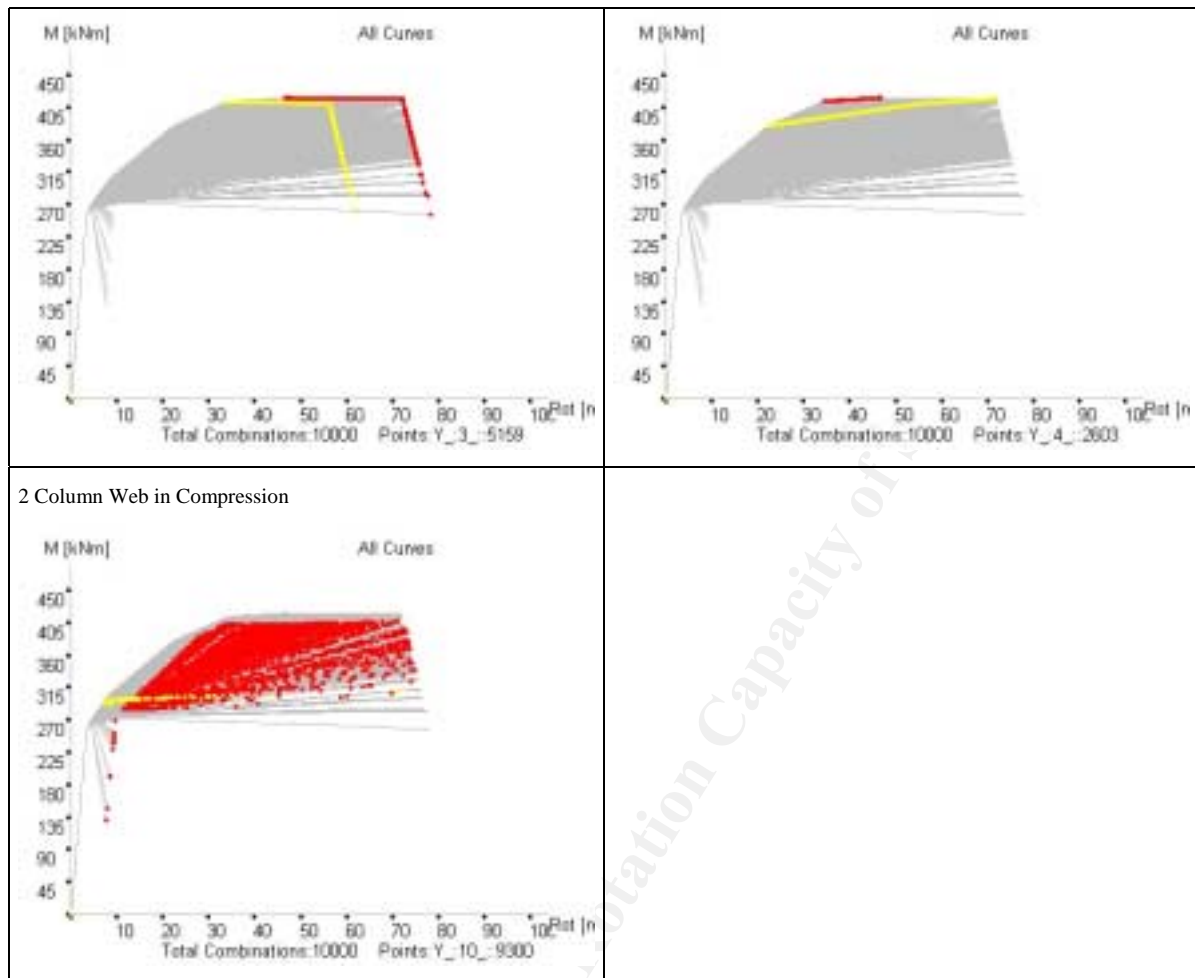
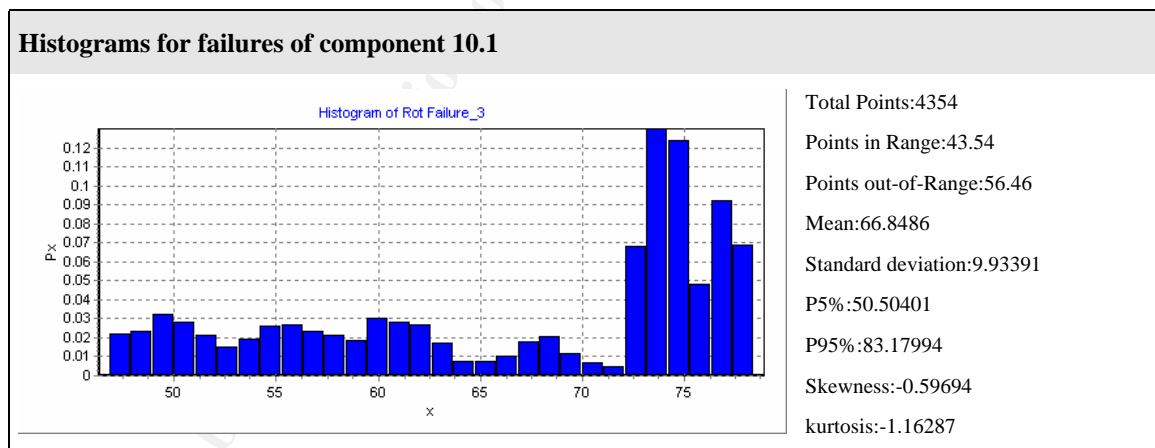
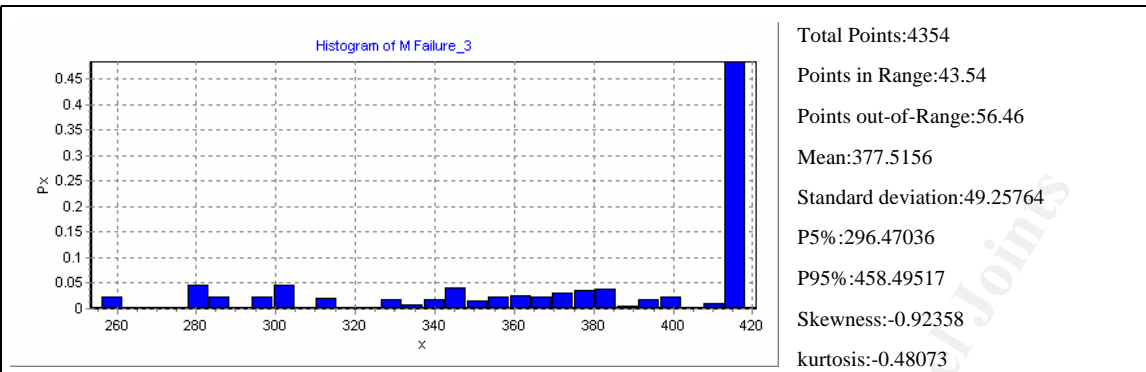
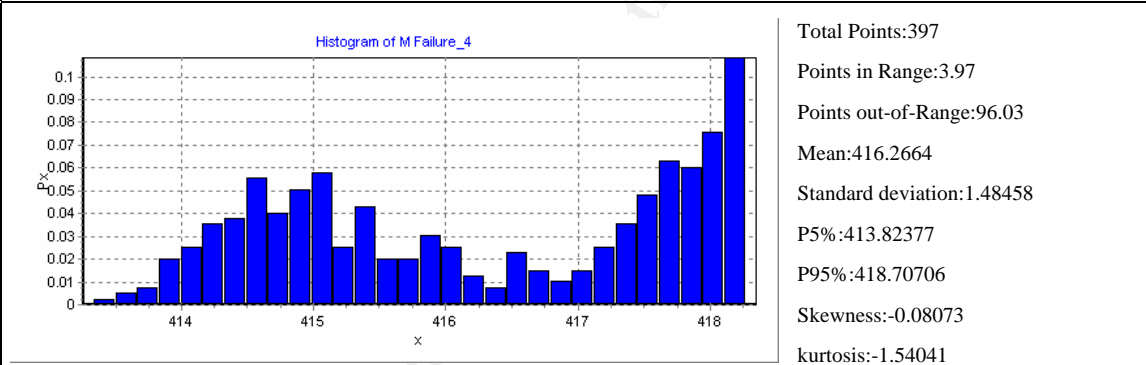
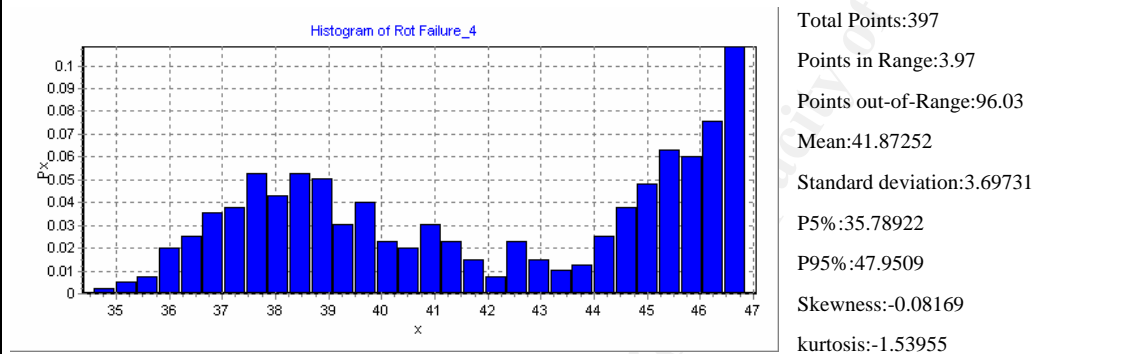


Figure 23 – Failures by component

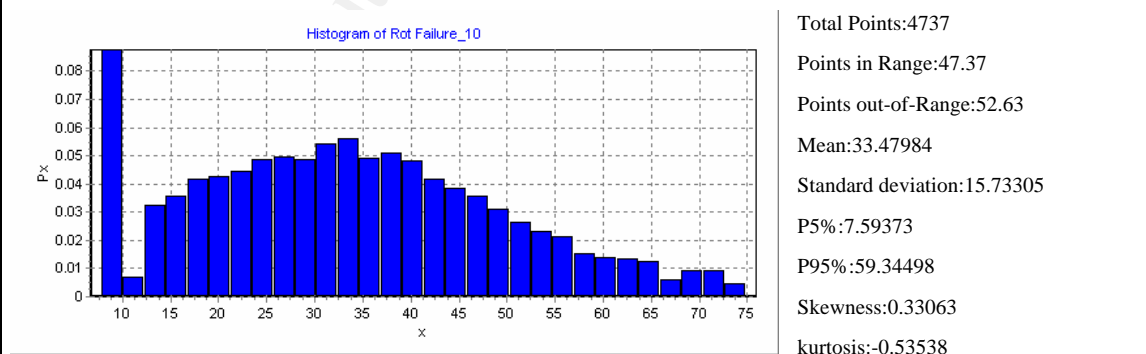


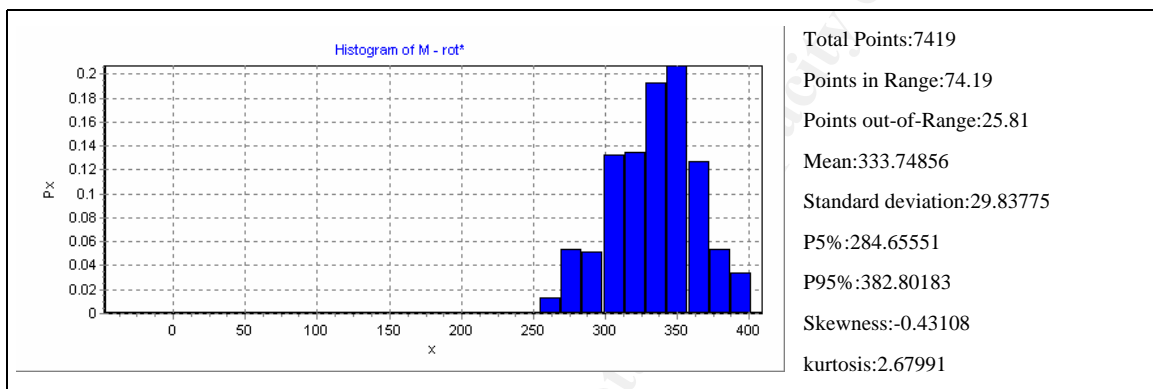
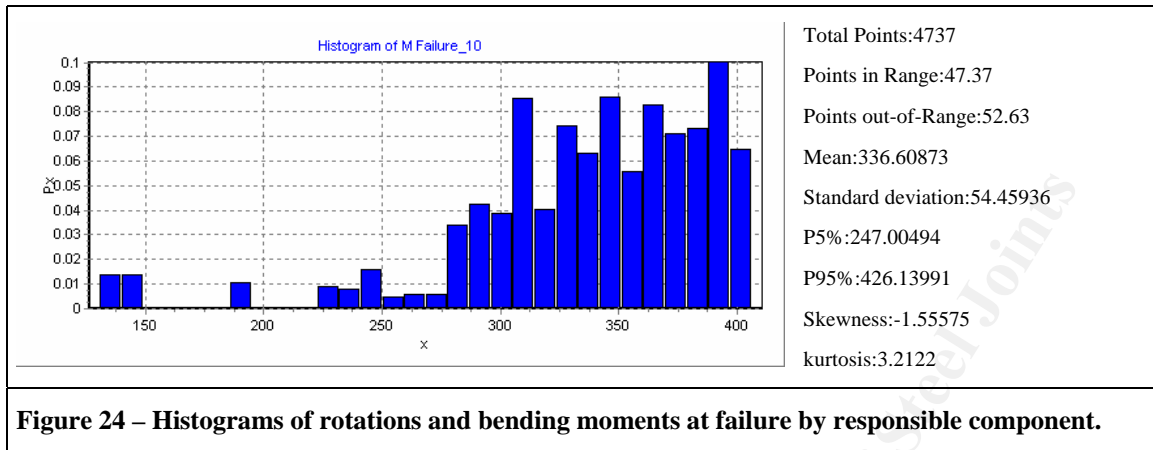


Histograms for failures of component 3.2



Histograms for failures of component 2





1.1.3 Case B – Variability of K_p and F^Y of the components in shear and compression zone (Component [1], [2], [7])

1.1.3.1 B.1) F^Y normal([1], [2], [7]) + K_p ([1], [2])

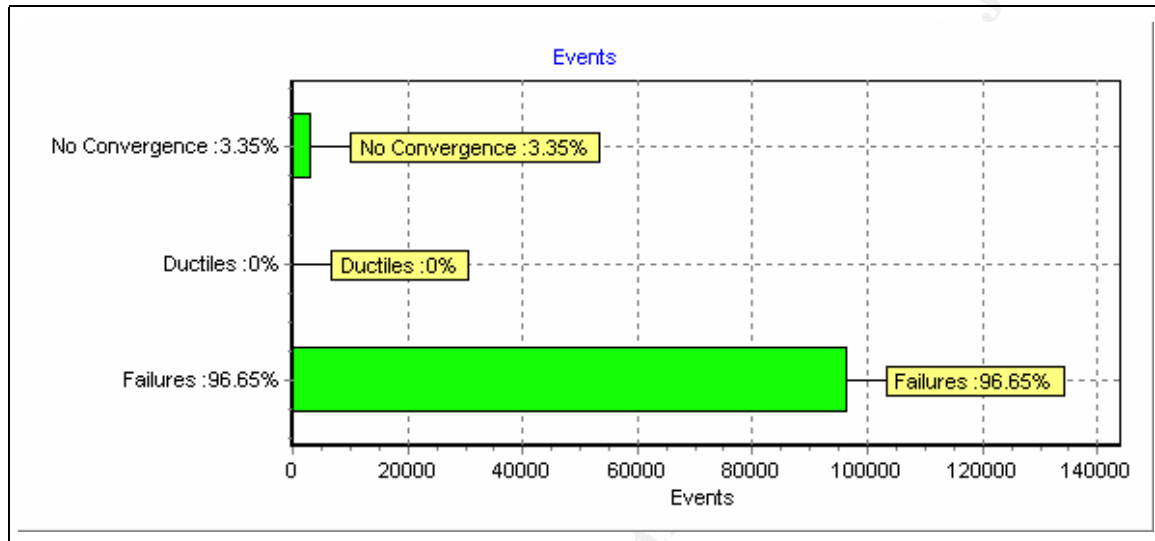


Figure 26 – Calculation summary.

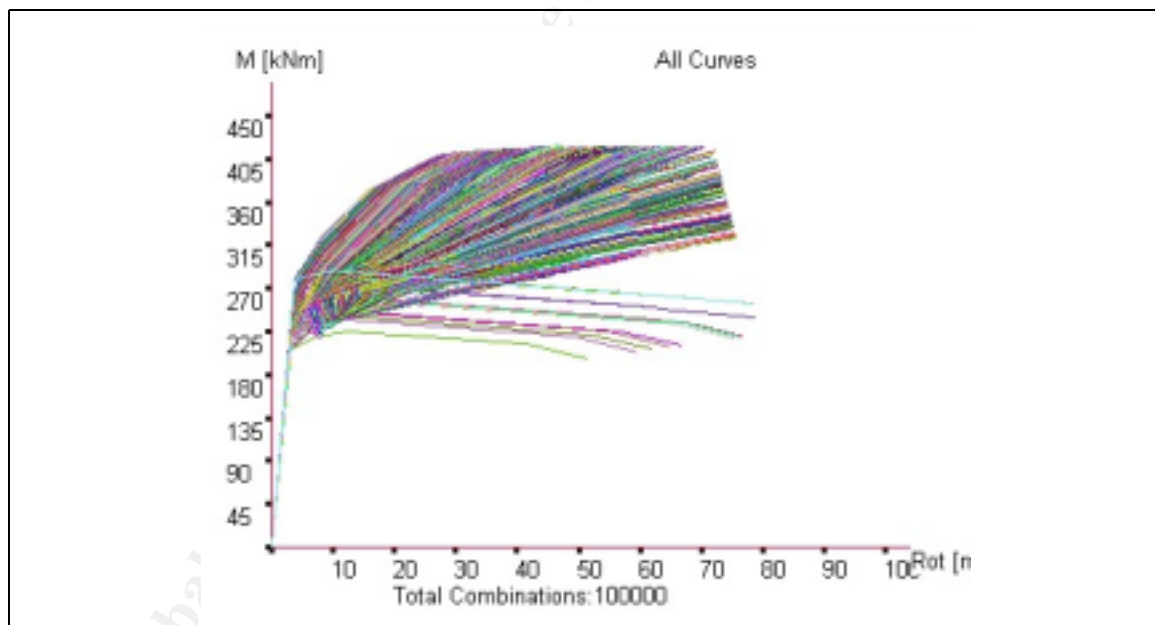


Figure 27 – All curves.

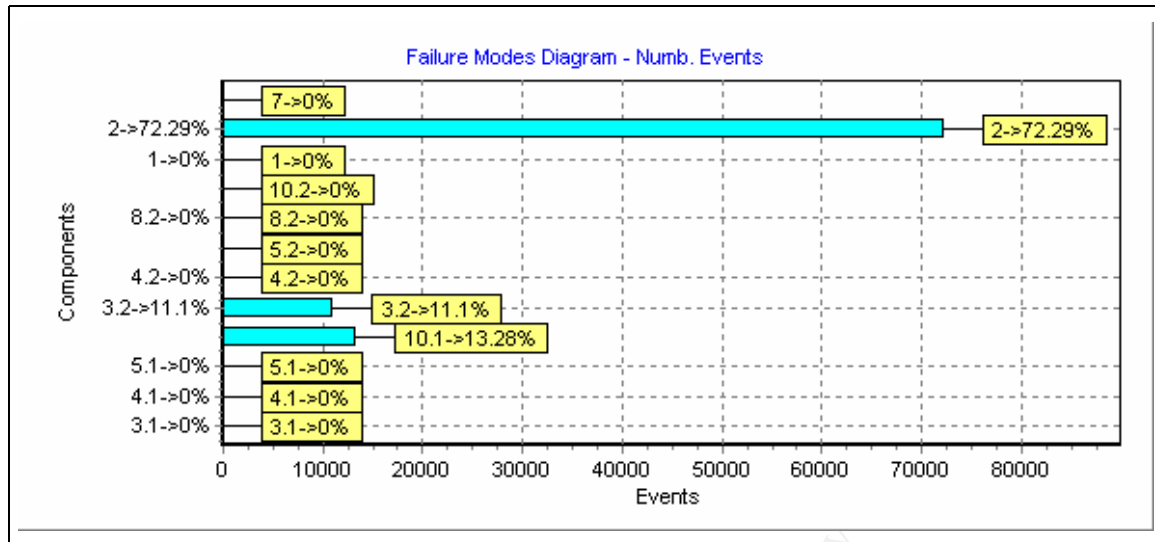


Figure 28 – Failure modes counter

Component Failure

3.1 : 6240
 4.1 : 10000
 10.1 : 55700

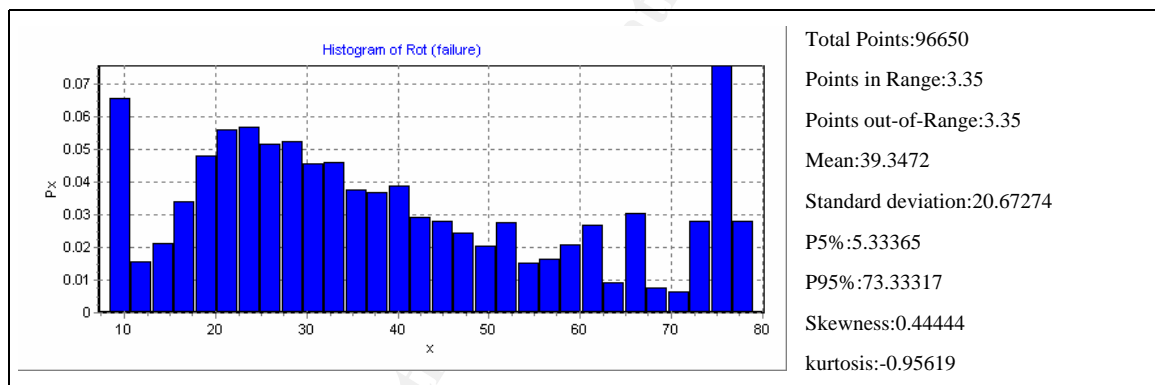


Figure 29 – Histogram of rotation at failure.

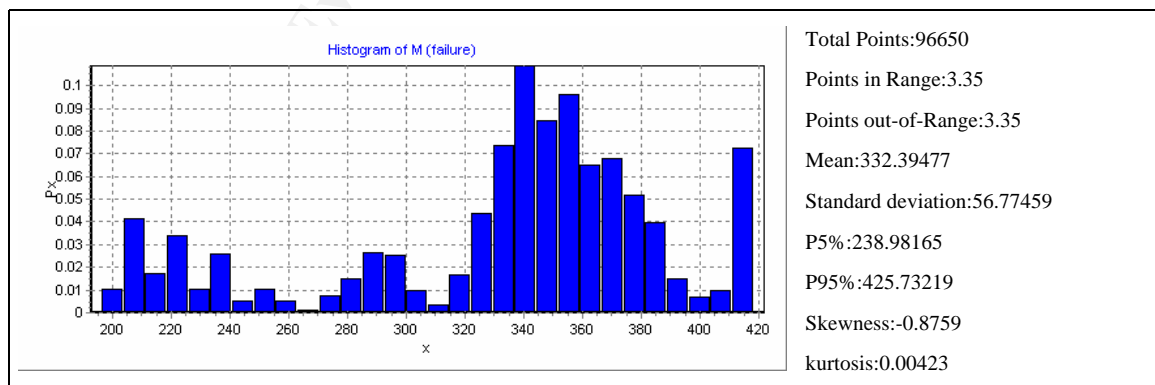
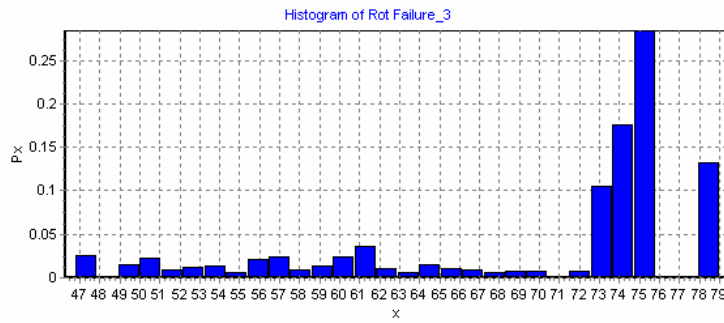
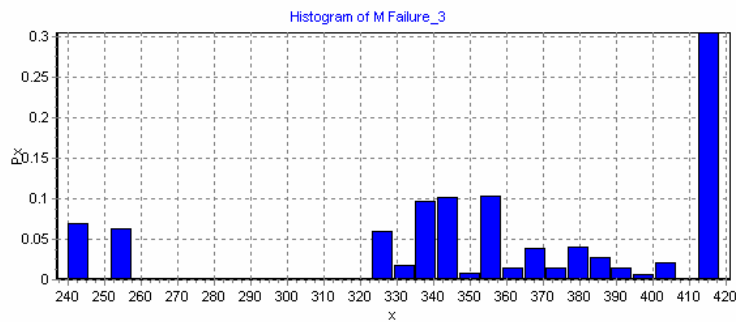


Figure 30 – Histogram of moment at failure.

Histograms for failures of component 10.1

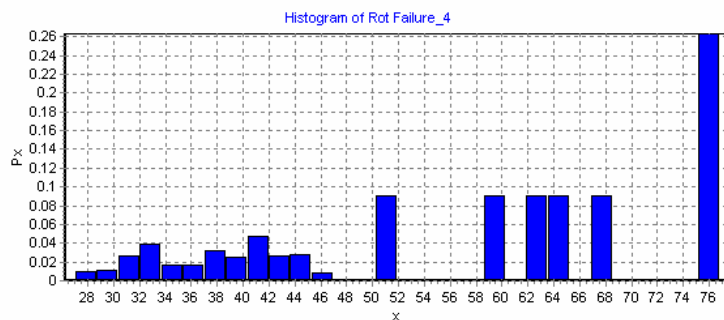


Total Points:13280
 Points in Range:13.28
 Points out-of-Range:86.72
 Mean:70.1055
 Standard deviation:8.85903
 P5%:55.52944
 P95%:84.66974
 Skewness:-1.22097
 kurtosis:0.15726

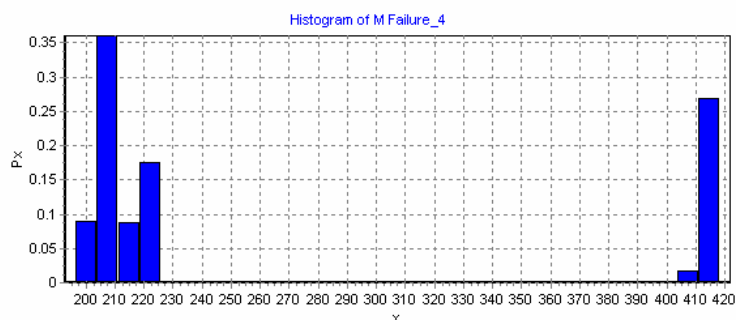


Total Points:13280
 Points in Range:13.28
 Points out-of-Range:86.72
 Mean:359.40472
 Standard deviation:54.54421
 P5%:269.66131
 P95%:449.0754
 Skewness:-0.8162
 kurtosis:-0.09985

Histograms for failures of component 3.2



Total Points:11100
 Points in Range:11.1
 Points out-of-Range:88.9
 Mean:58.30091
 Standard deviation:15.21142
 P5%:33.27306
 P95%:83.30848
 Skewness:-0.40754
 kurtosis:-1.1171



Total Points:11100
 Points in Range:11.1
 Points out-of-Range:88.9
 Mean:268.95298
 Standard deviation:92.44774
 P5%:116.84562
 P95%:420.93707
 Skewness:0.92758
 kurtosis:-1.11328

Histograms for failures of component 2

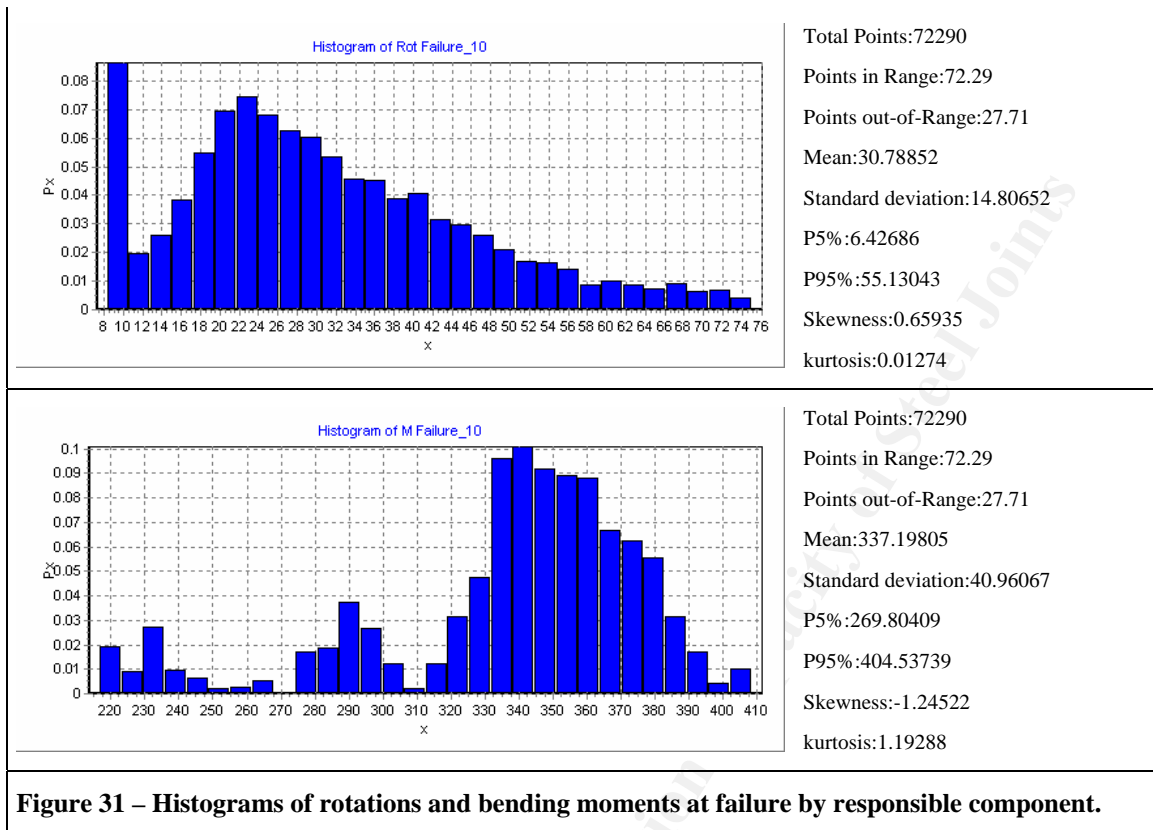


Figure 31 – Histograms of rotations and bending moments at failure by responsible component.

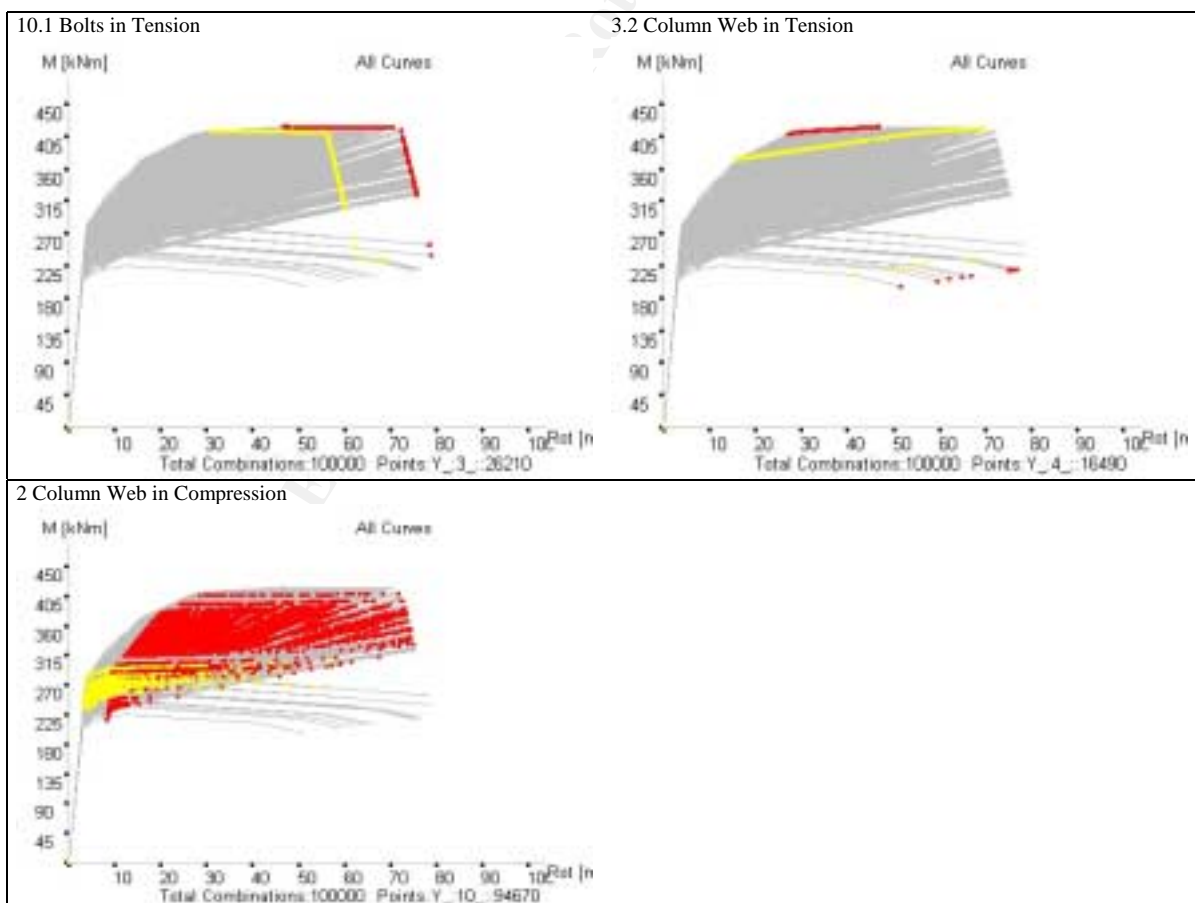


Figure 32 – Failures by component

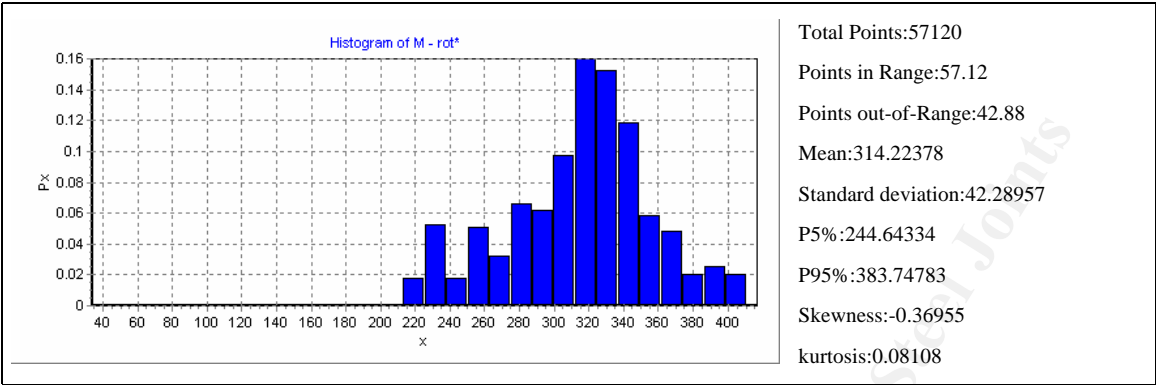


Figure 33 – Histogram for rotation=30 mrad

1.1.3.2 B.2) F^Y binormal + K_p [1], [2], [7]*

* k_p not simulated

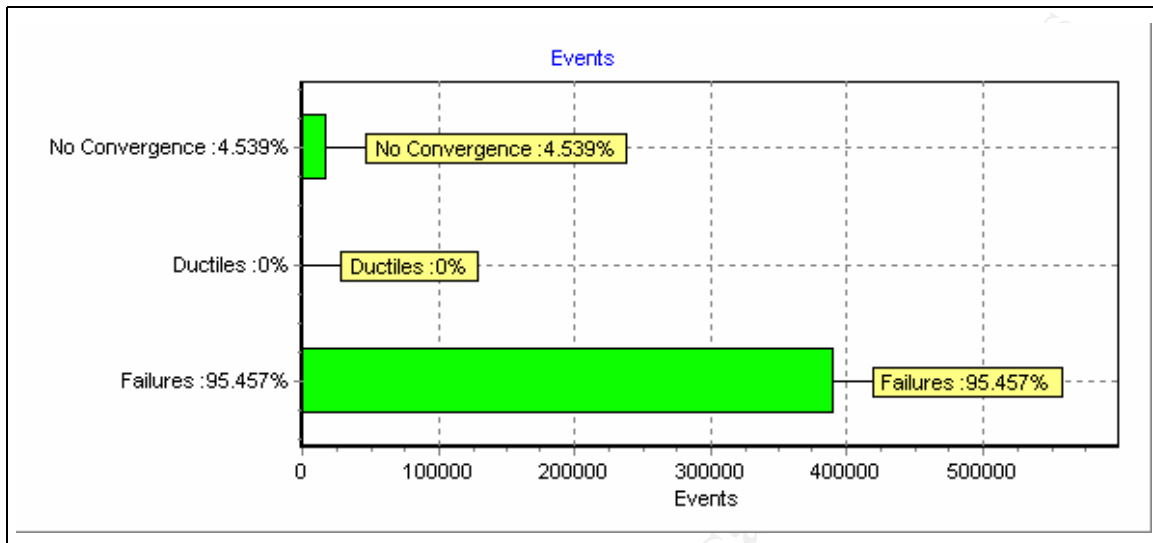


Figure 34 – Calculation summary.

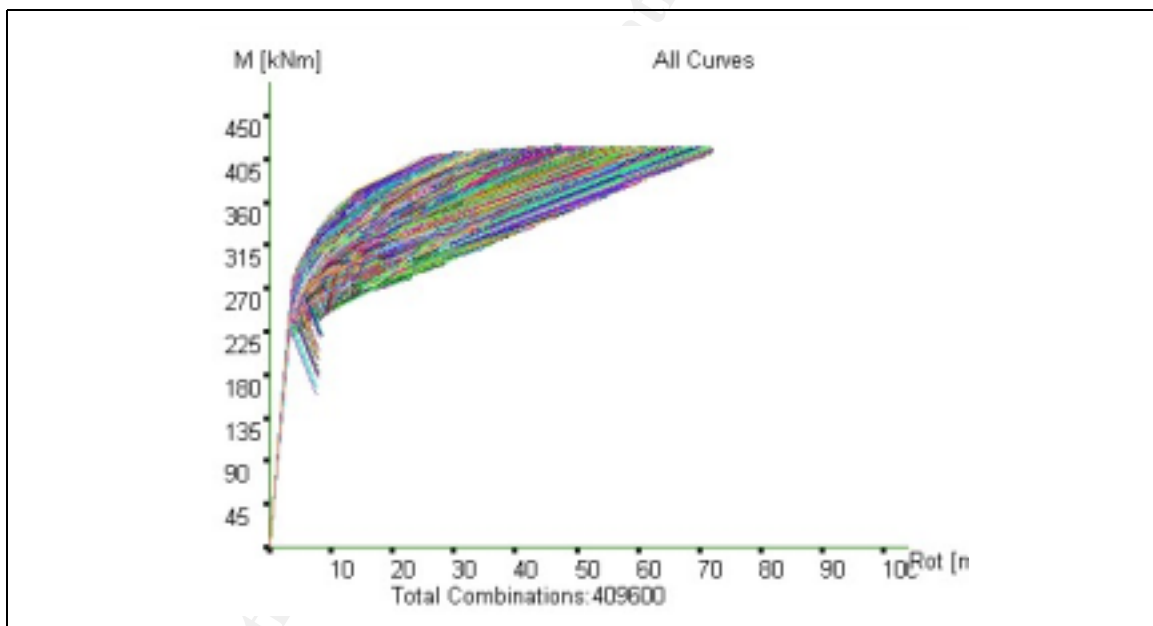


Figure 35 – All curves.

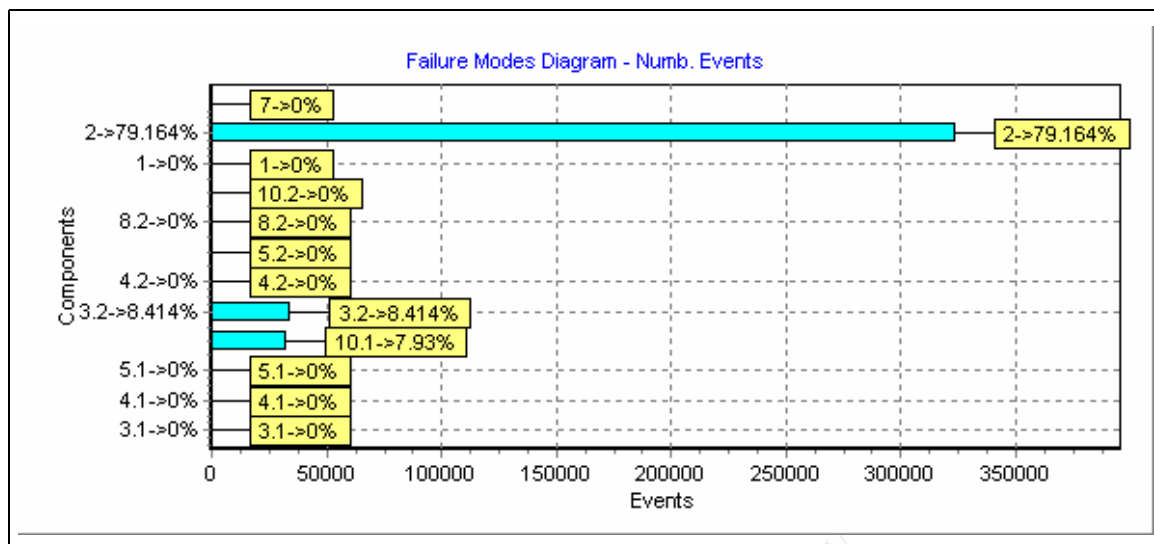


Figure 36 – All failure modes.

10.1 : 32480
 3.2 : 34464
 2 : 324256

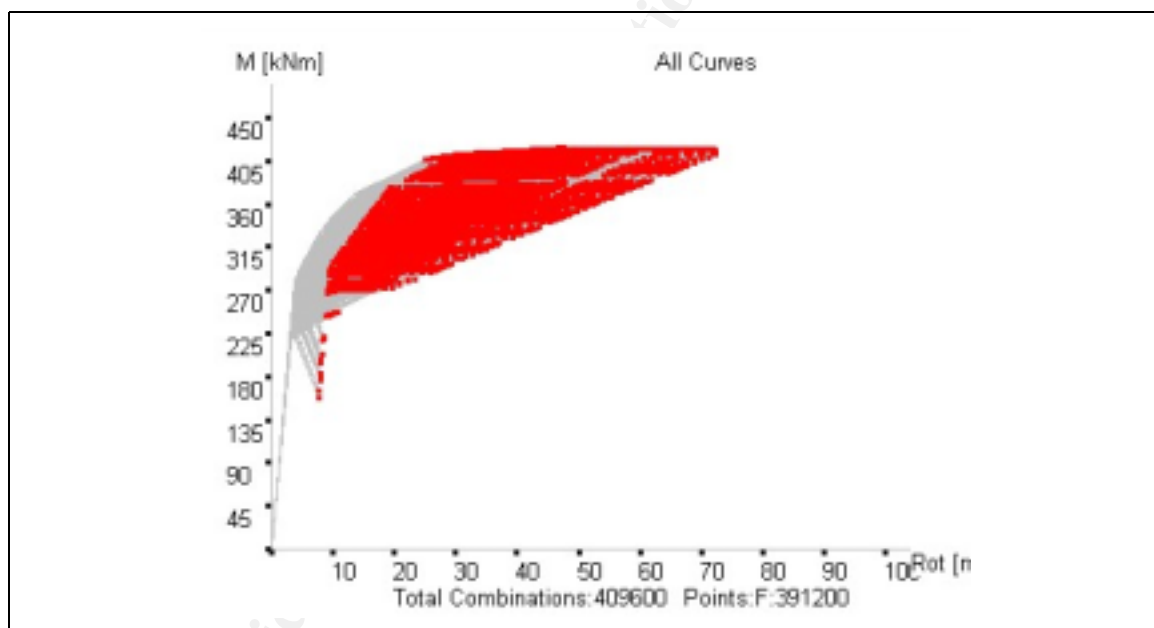


Figure 37 – All failures.

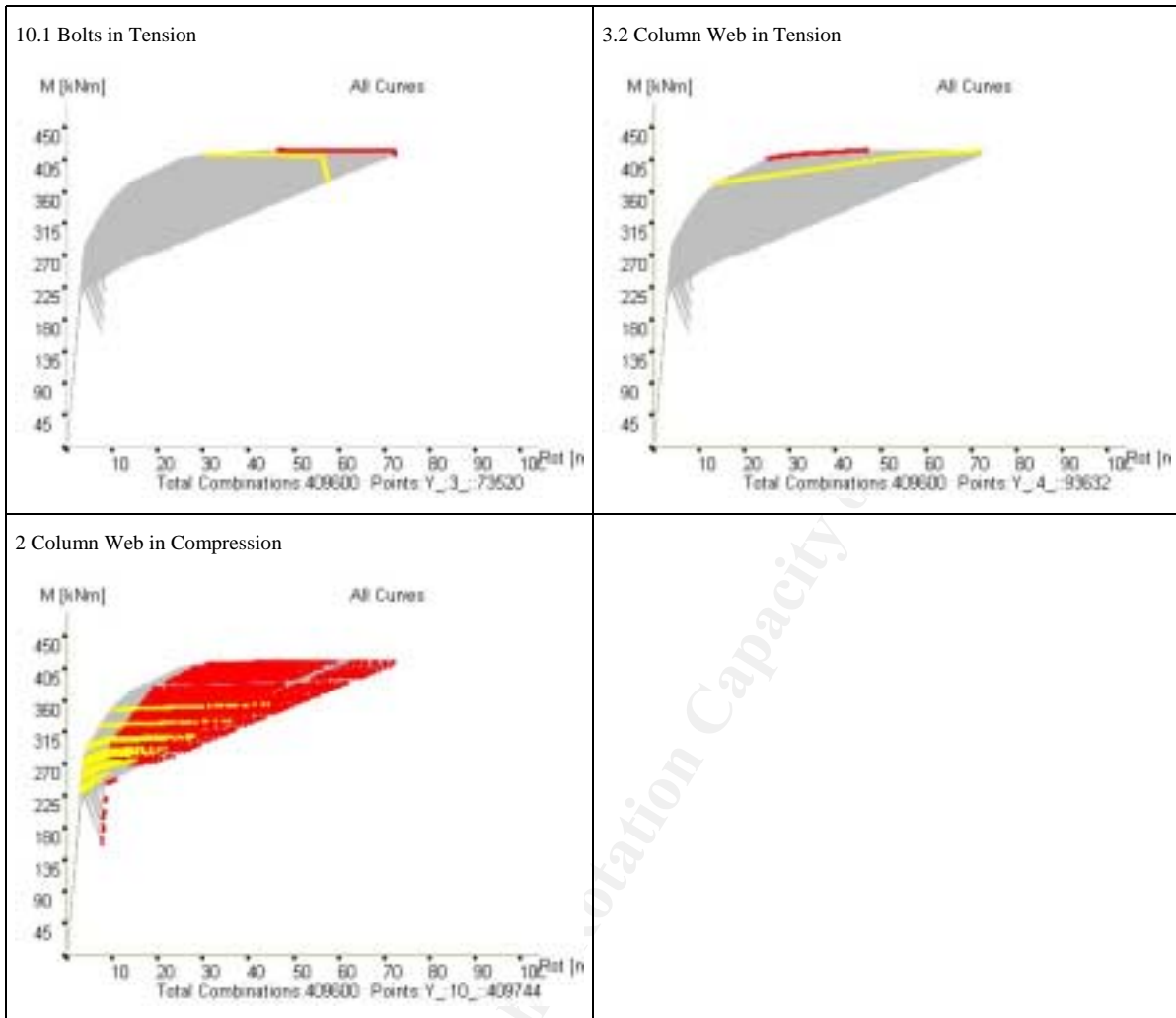


Figure 38 – Failures by component

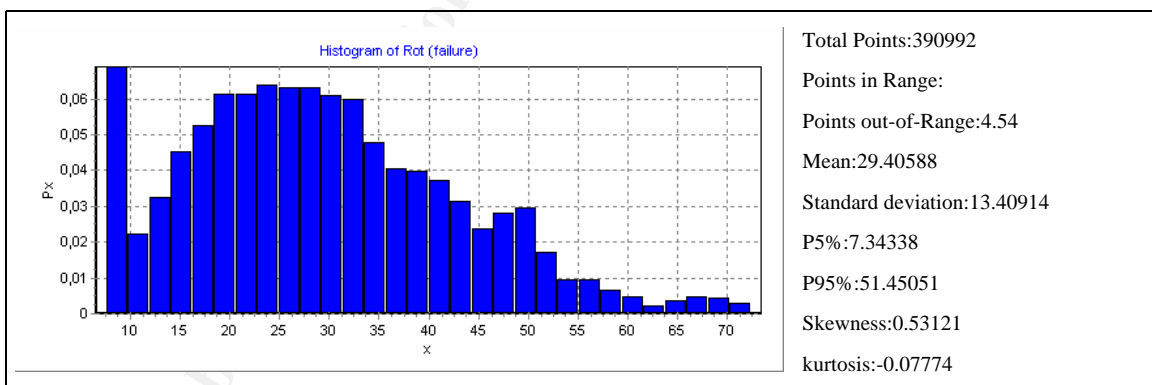


Figure 39 – Histogram of rotation at failure.

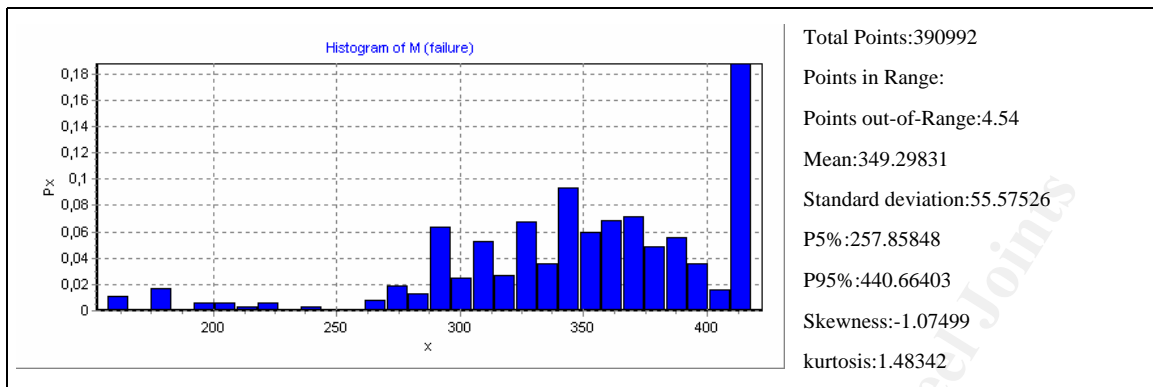
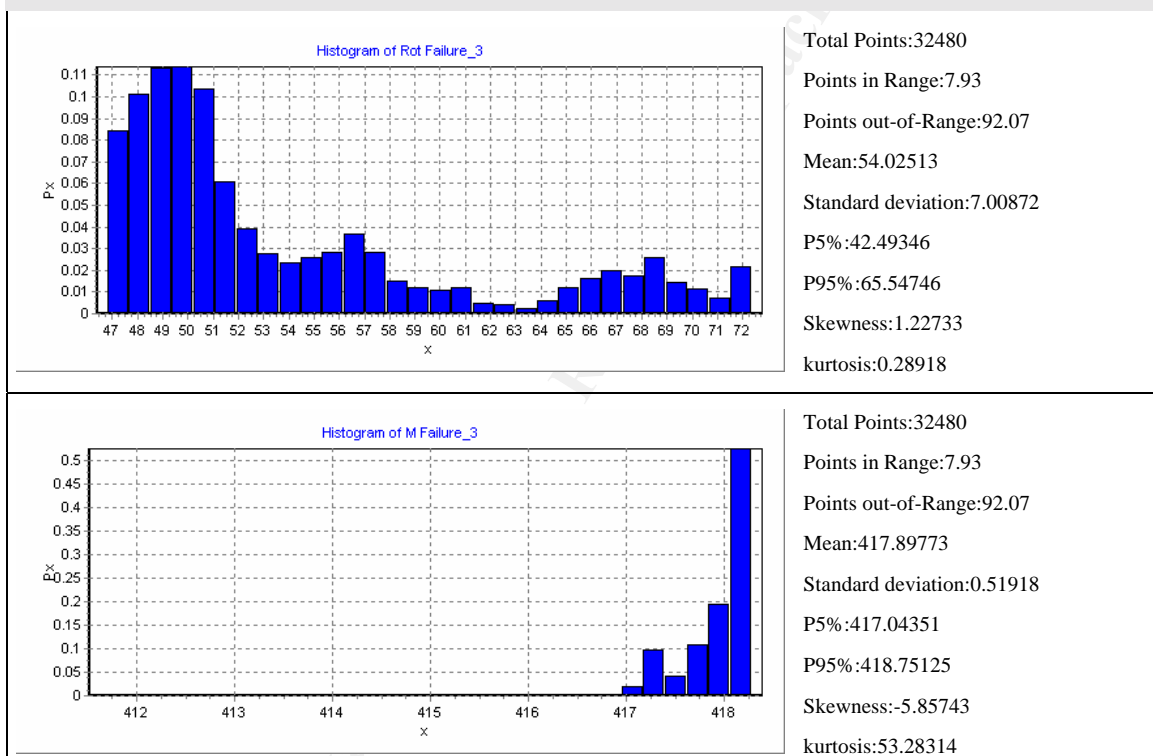
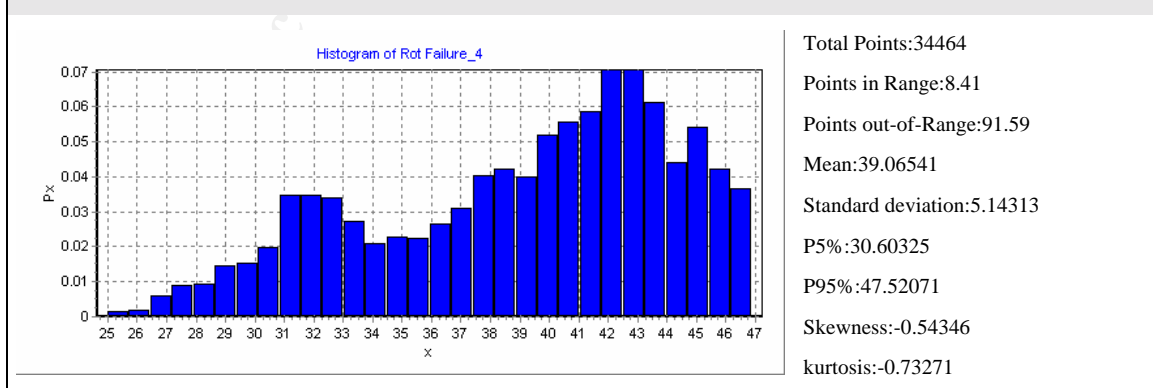


Figure 40 – Histogram of bending moment at failure.

Histograms for failures of component 10.1



Histograms for failures of component 3.2



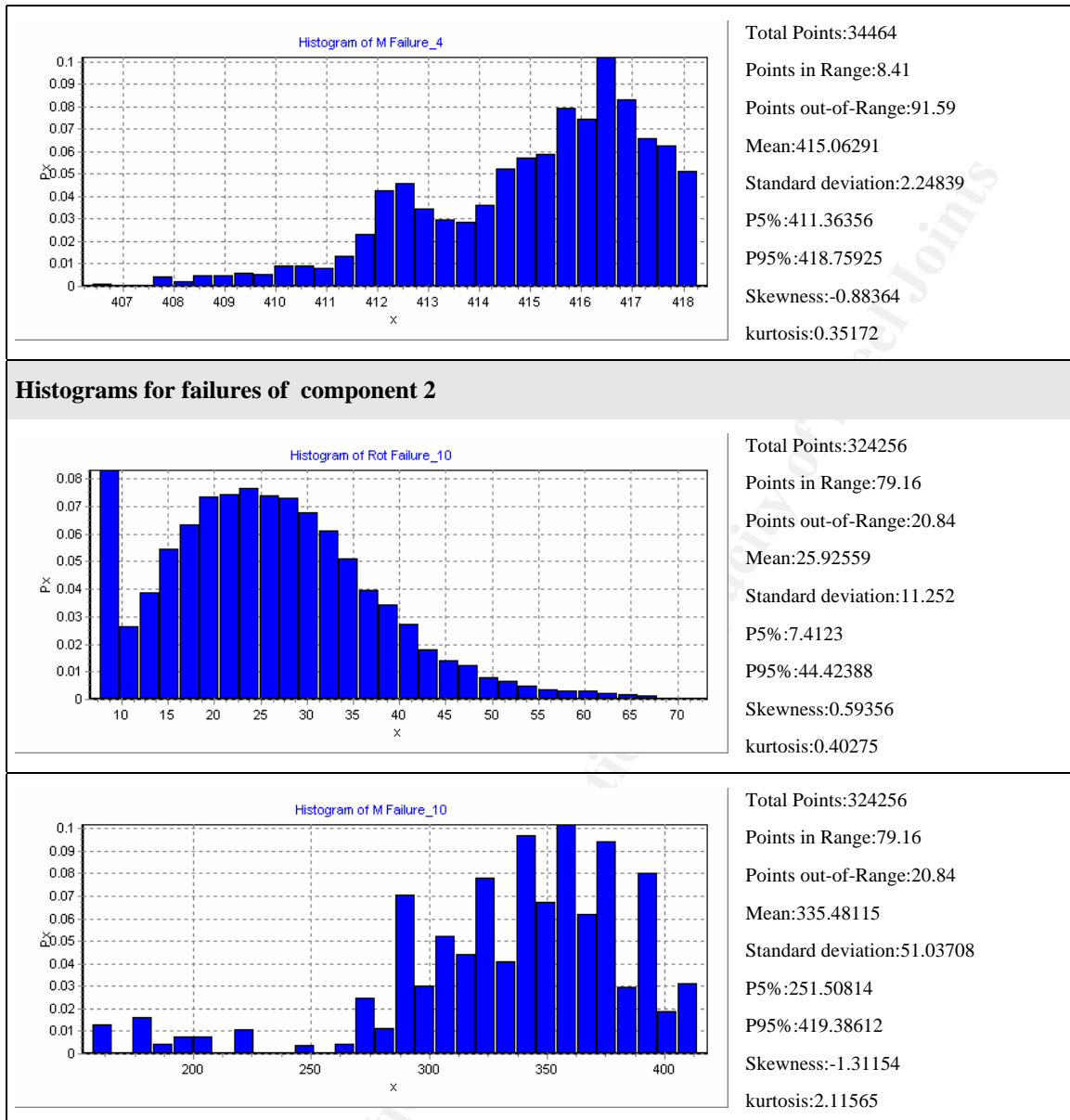


Figure 41 – Histograms of rotations and bending moments at failure by responsible component.

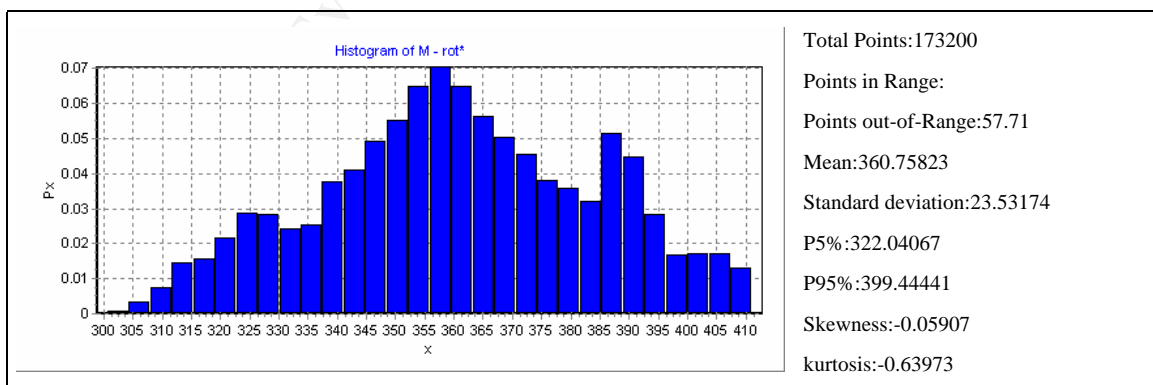


Figure 42 – Histogram for rotation=30 mrad

1.1.3.3 B.3) F^Y normal + K_p [1], [2], [3.2]

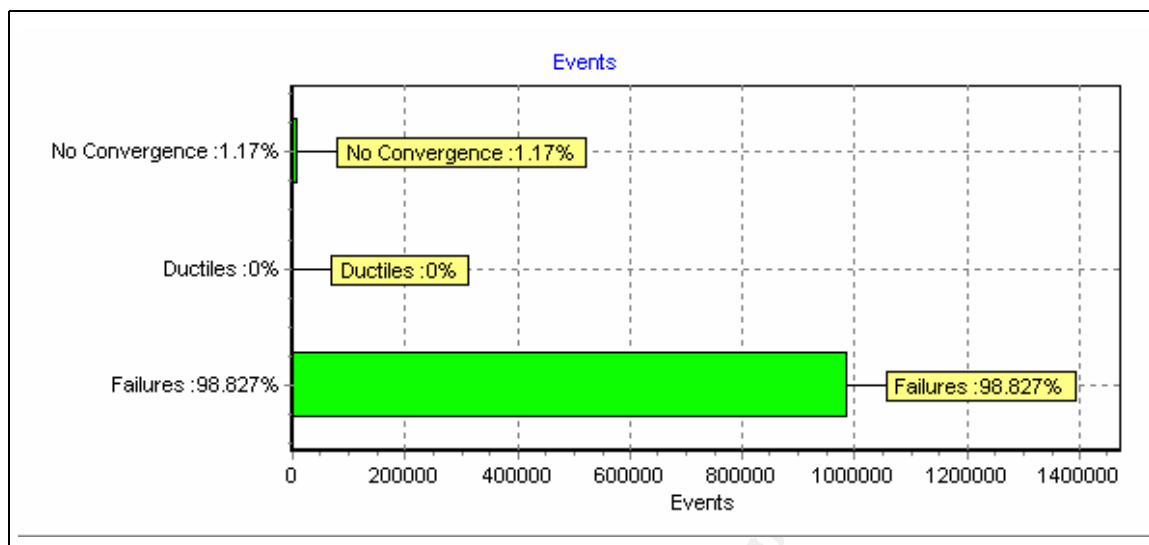


Figure 43 – Calculation summary.

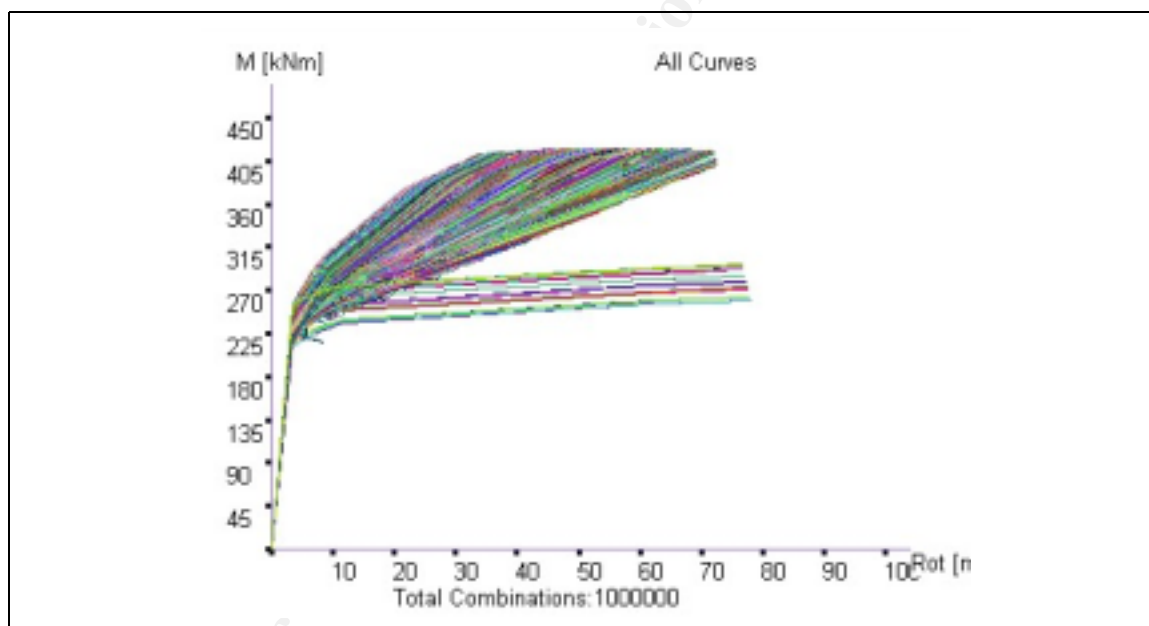


Figure 44 – All curves.

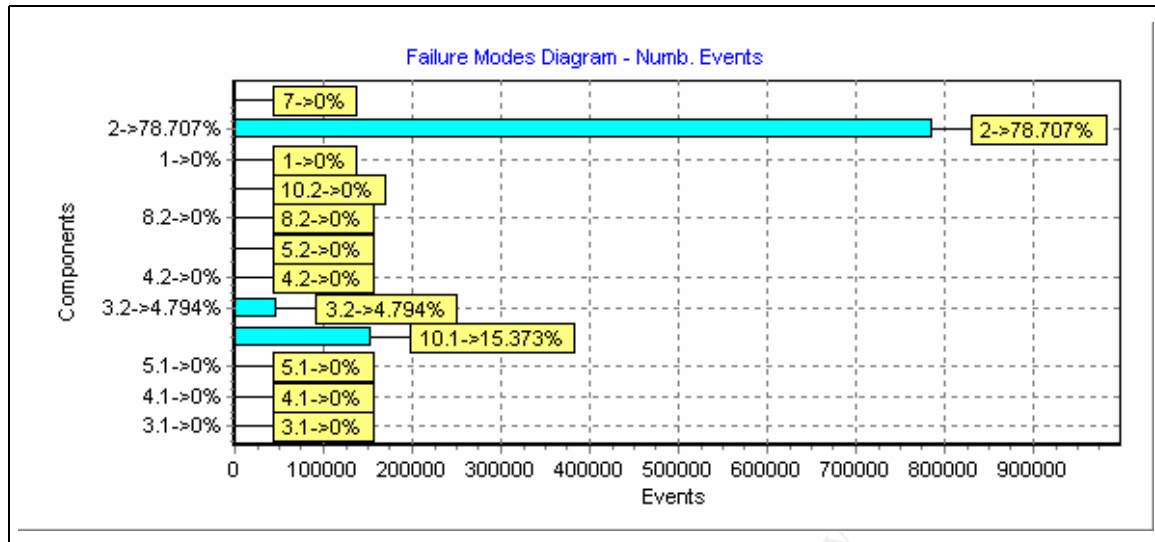


Figure 45 – Failure modes counter

10.1 : 153727
 3.2 : 47943
 2 : 787069

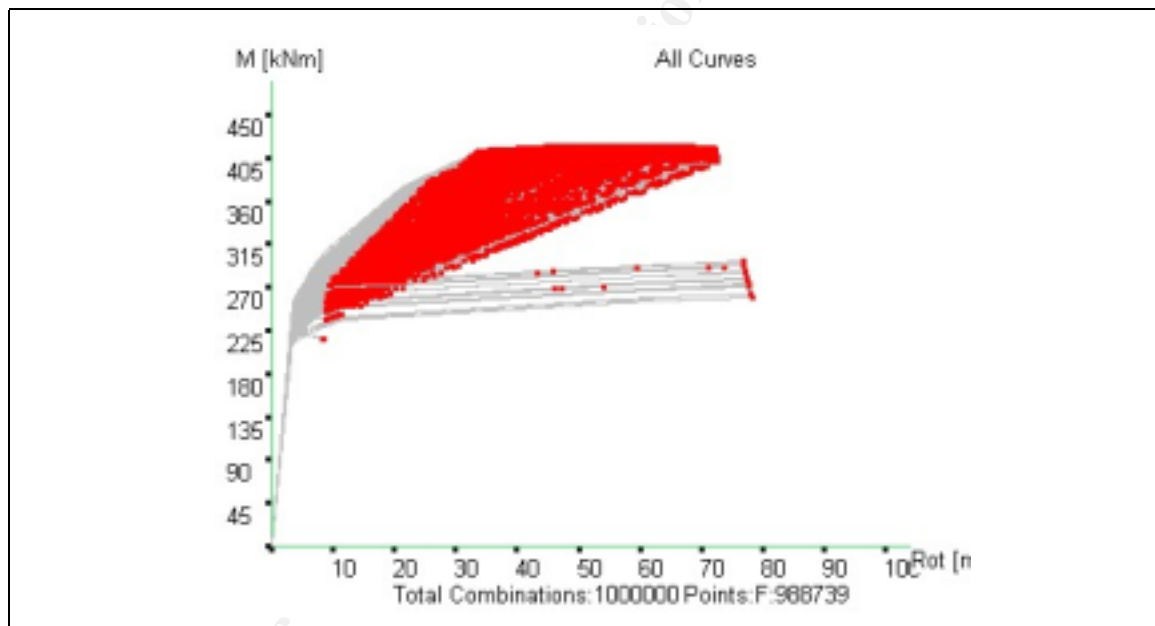


Figure 46 – All failures.

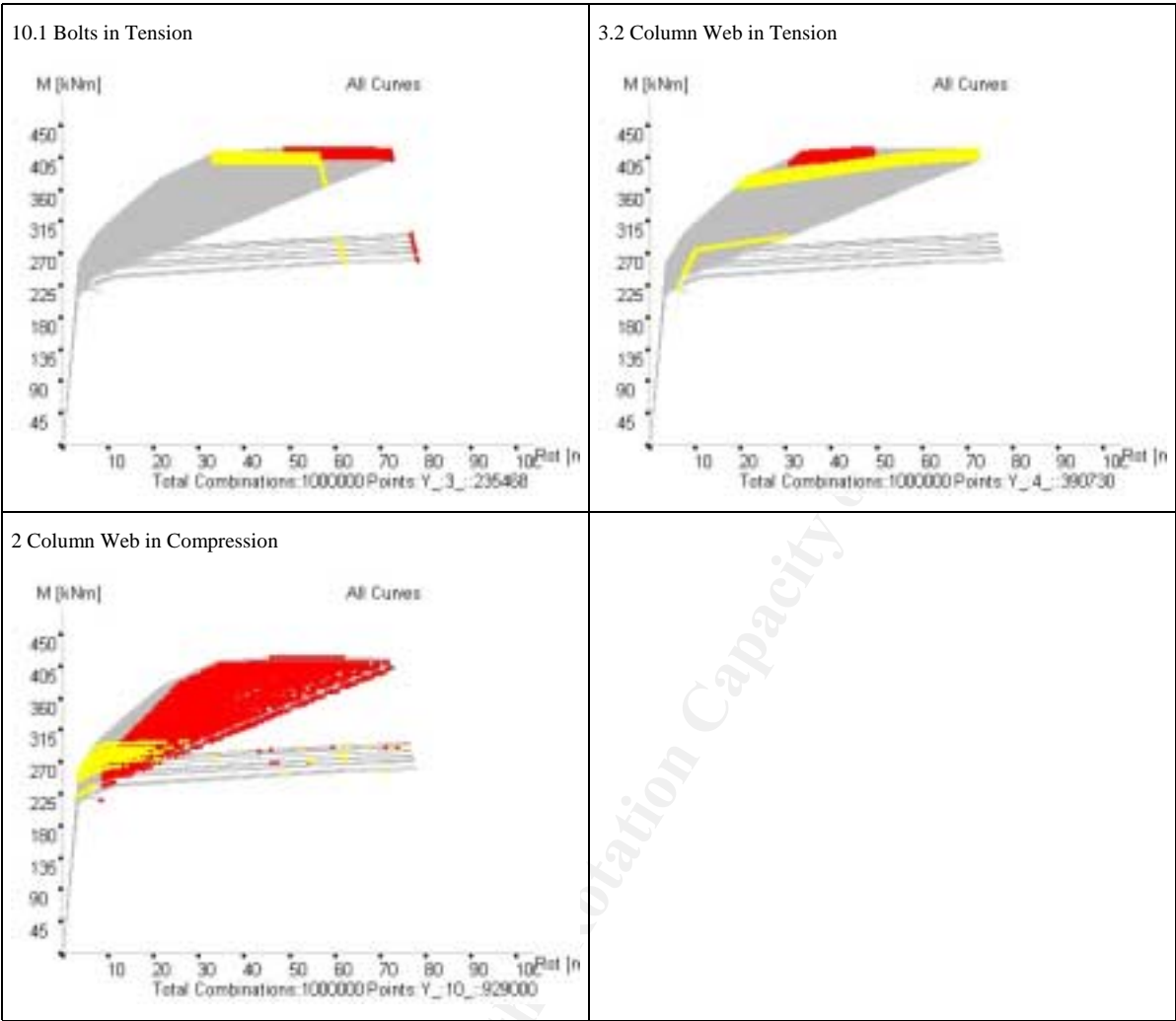


Figure 47 – Failures by component.

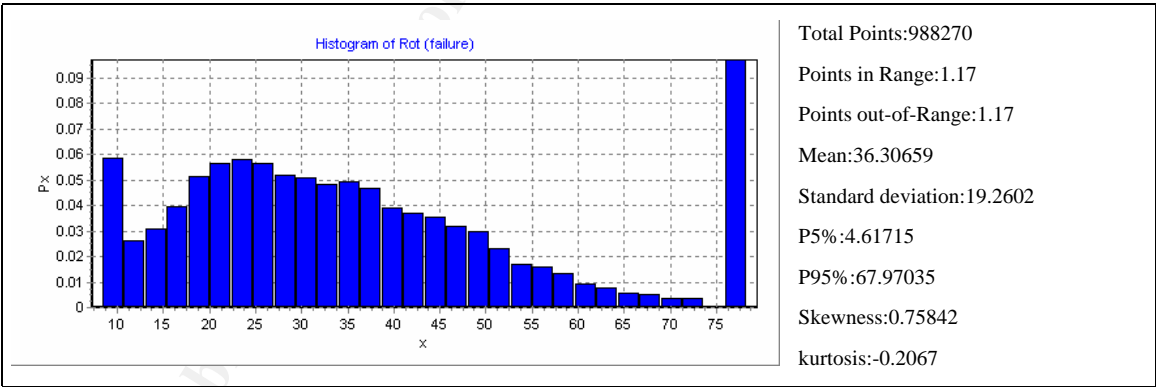


Figure 48 – Histogram of rotation at failure.

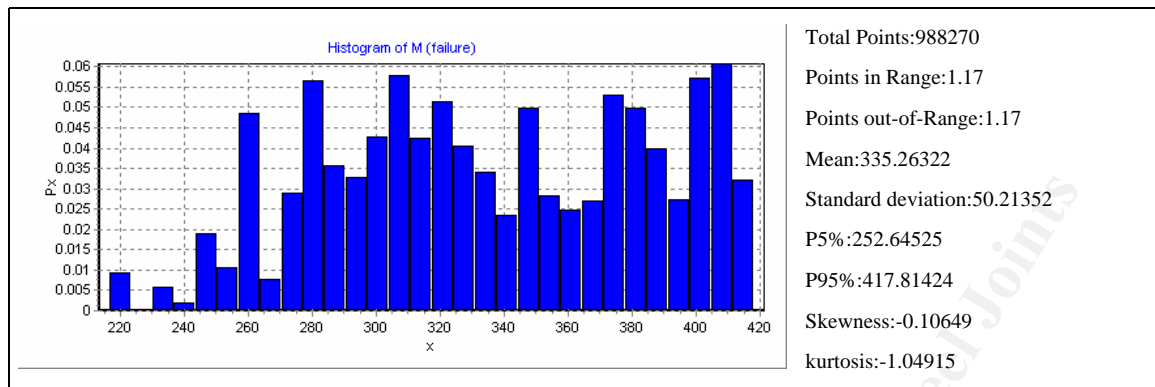
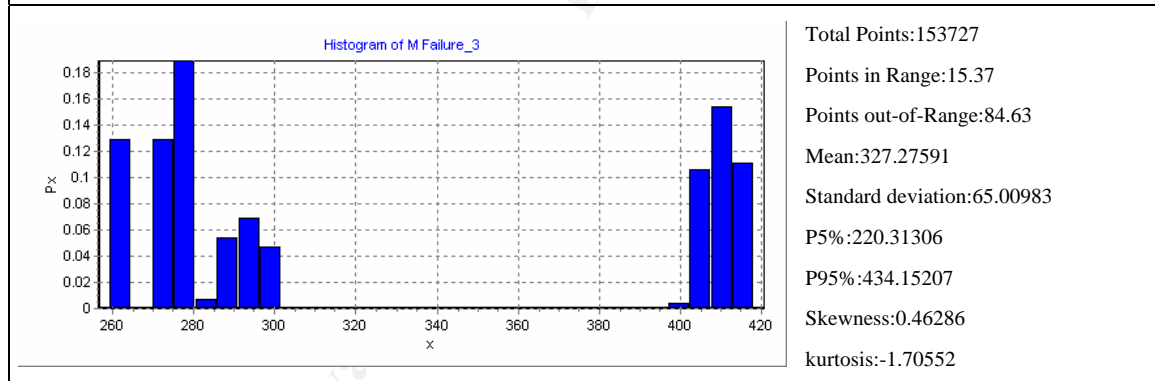
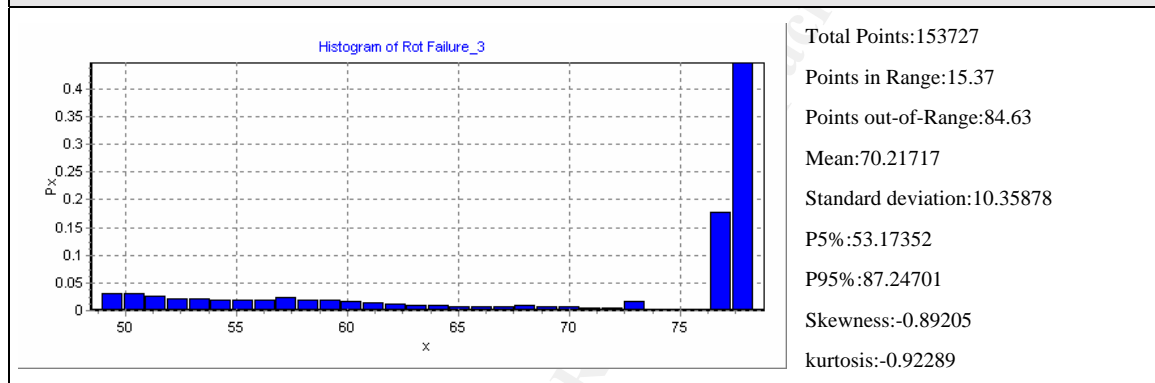
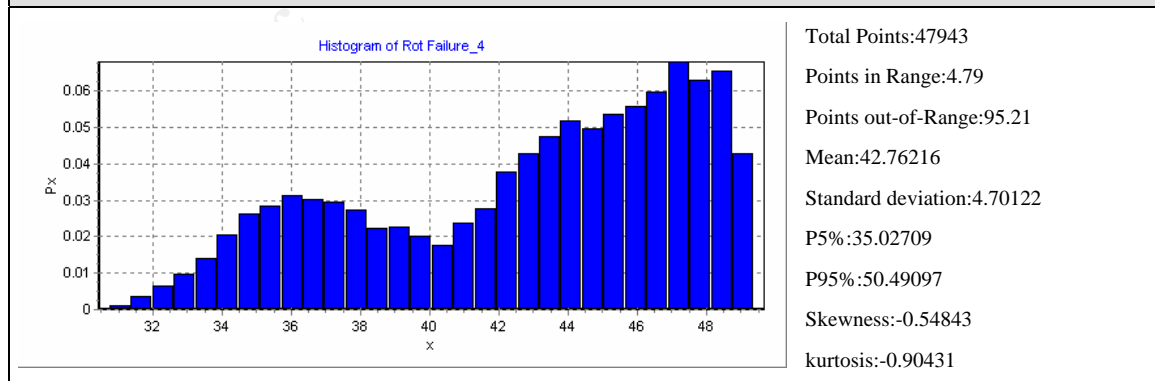


Figure 49 – Histogram of bending moment at failure.

Histograms for failures of component 10.1



Histograms for failures of component 3.2



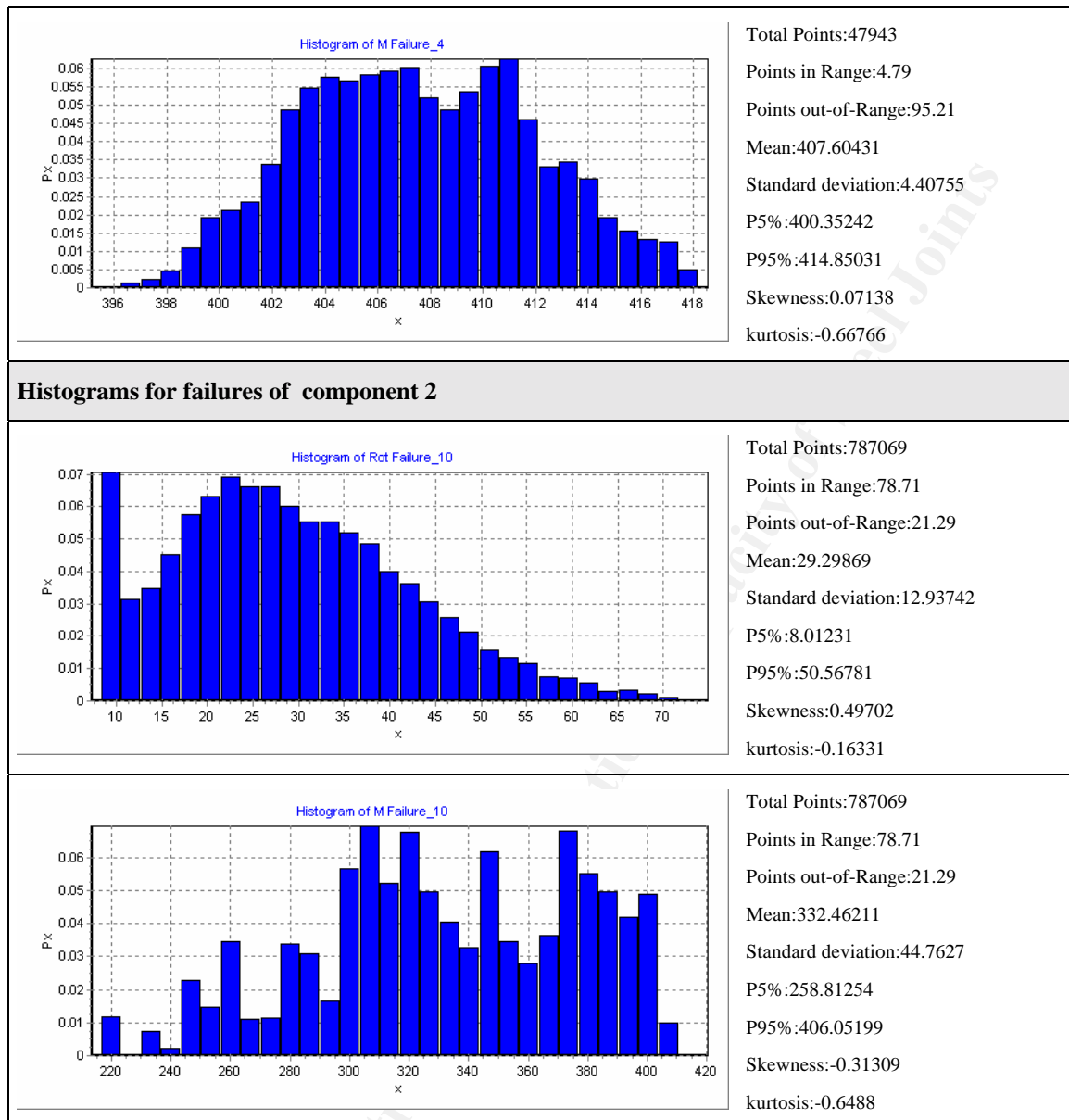


Figure 50 – Histograms of rotations and bending moments at failure by responsible component.

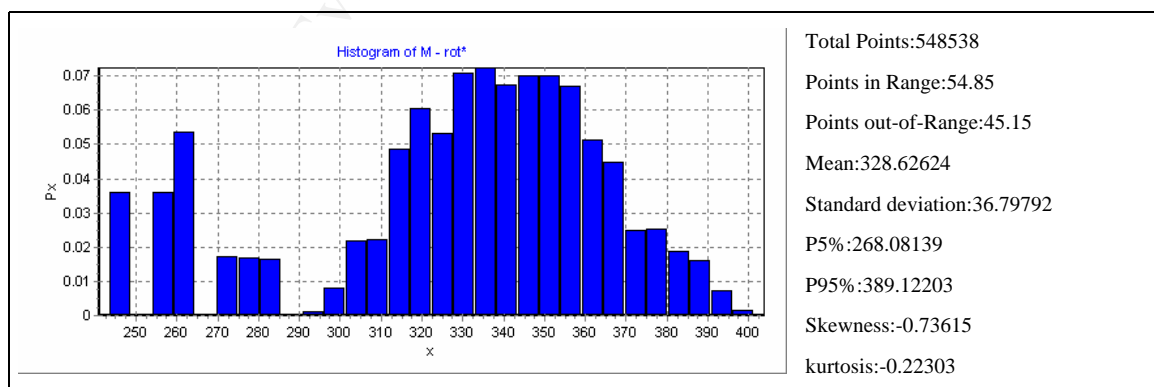


Figure 51 – Histogram for rotation=30 mrad

1.1.4 Case C – Variability of K_p , F^Y and Δf .

1.1.4.1 C.1) K_p [2], [1] and F^Y [1], [2], [3.2] and Δf [2]

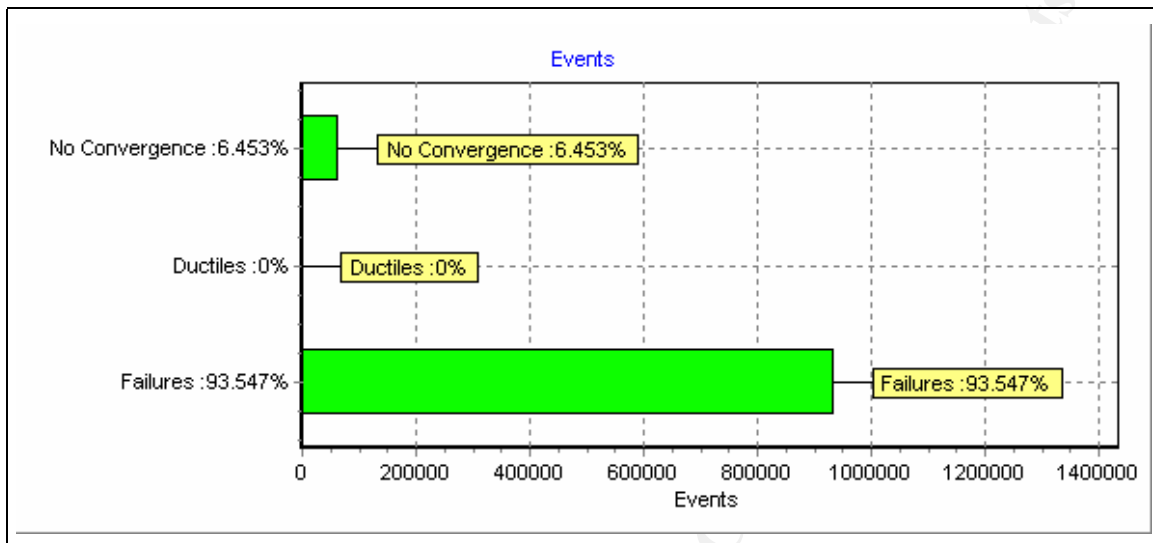


Figure 52 – Calculation summary.

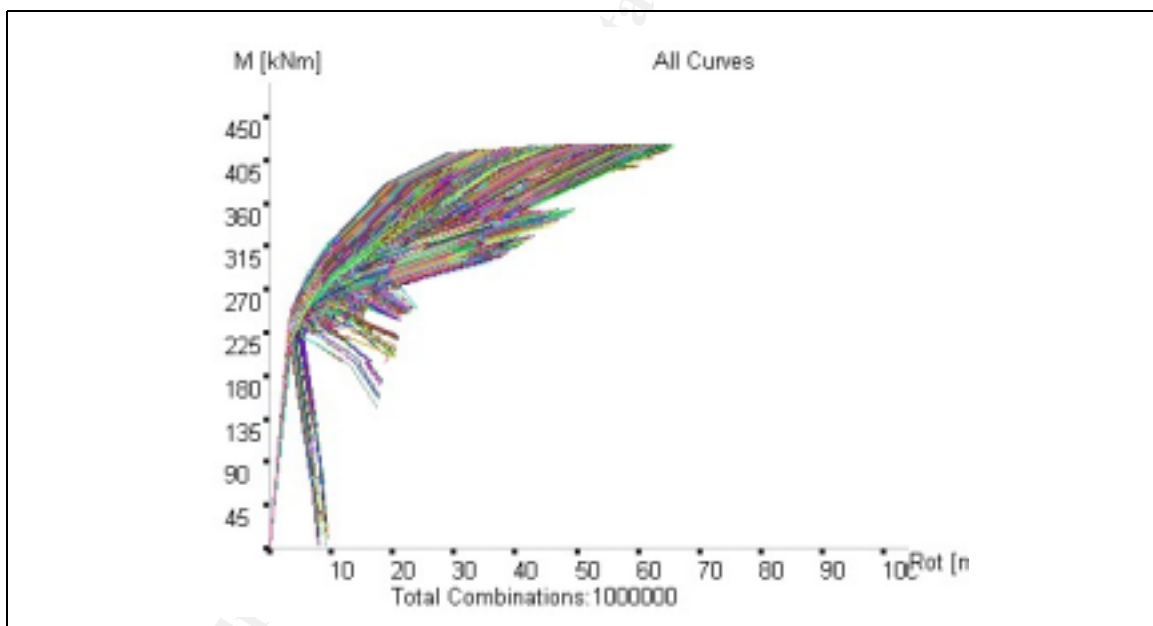


Figure 53 – All curves.

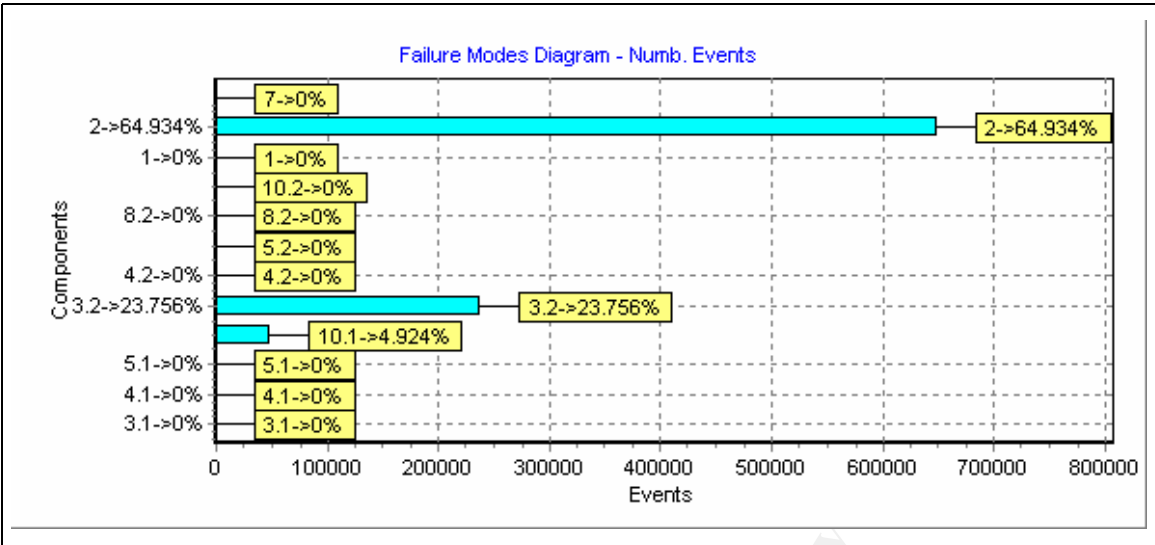


Figure 54 – Failure modes counter

10.1 : 49239
3.2 : 237560
2 : 649337

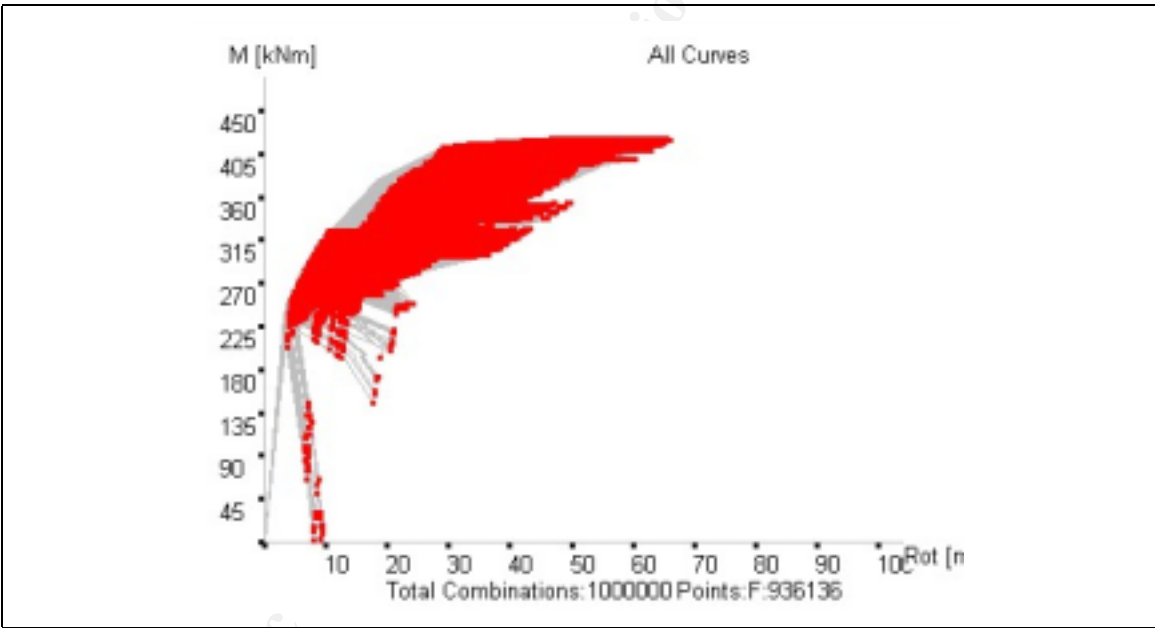


Figure 55 – All failures.

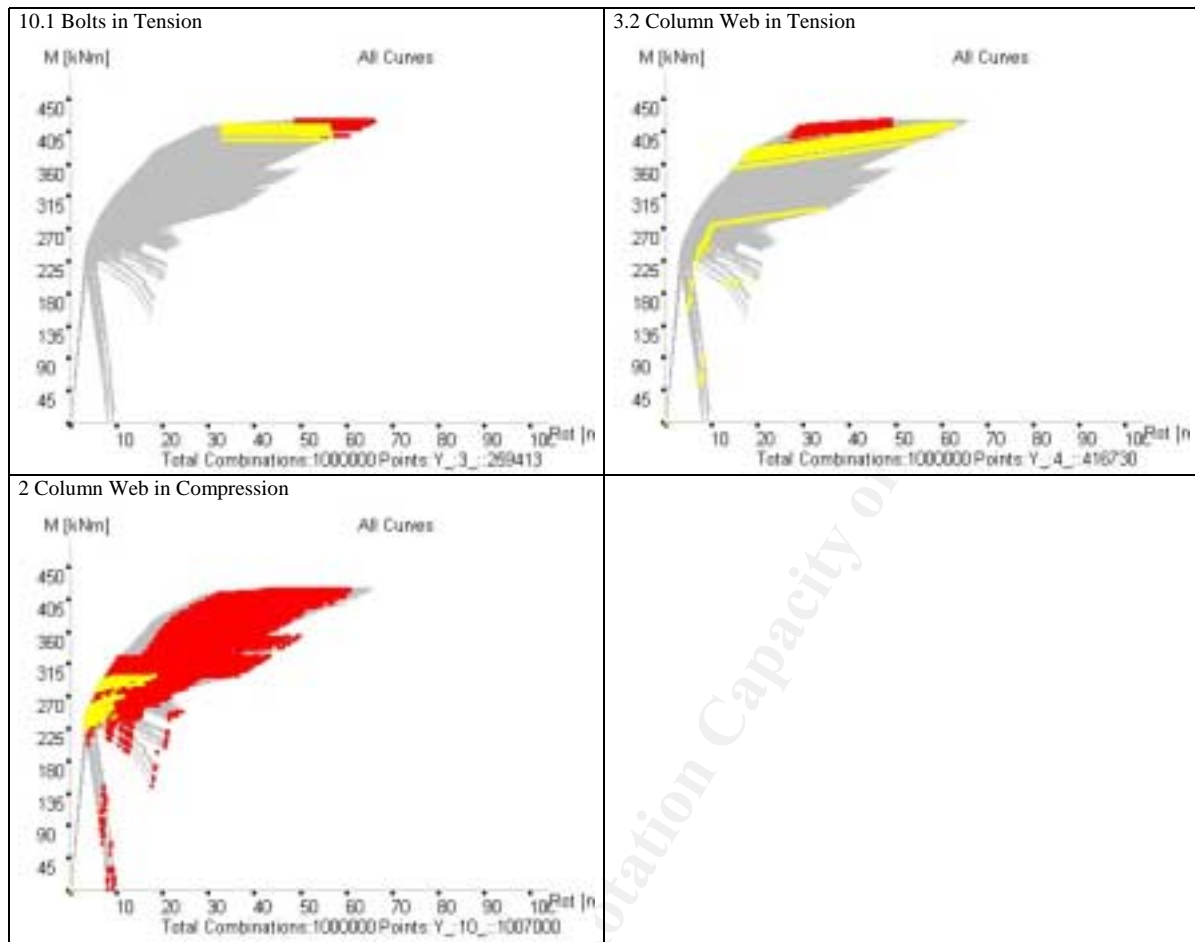


Figure 56 – Failures by component

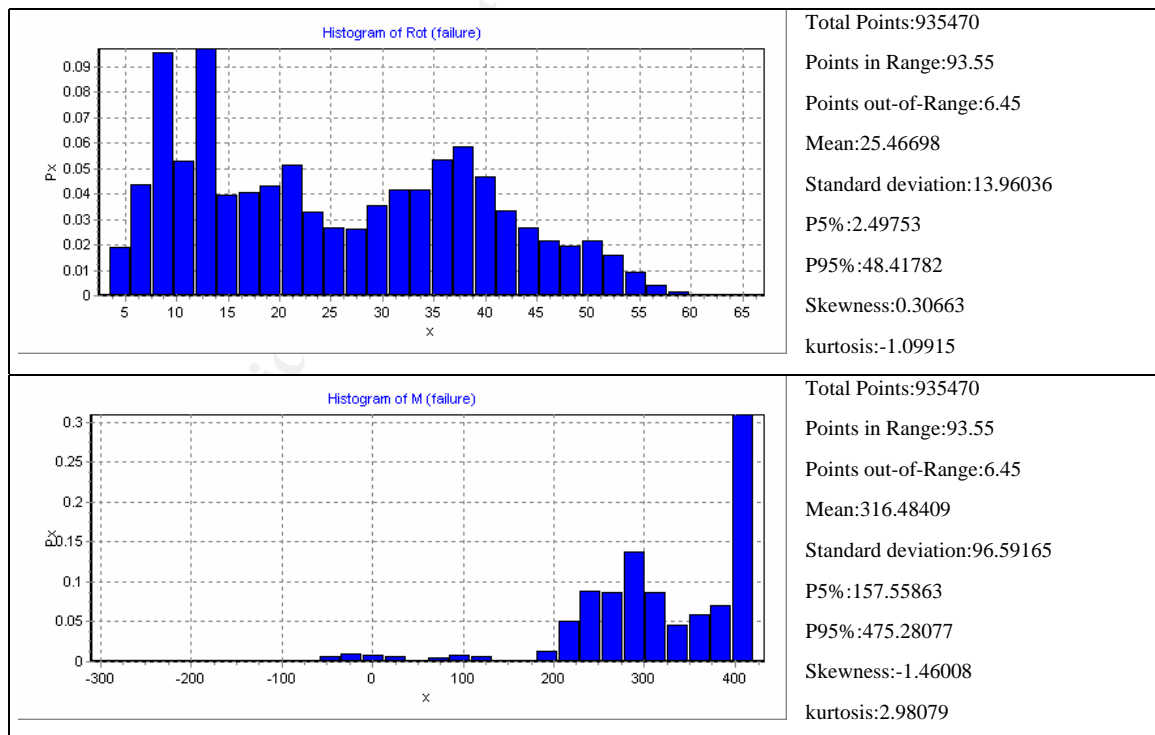
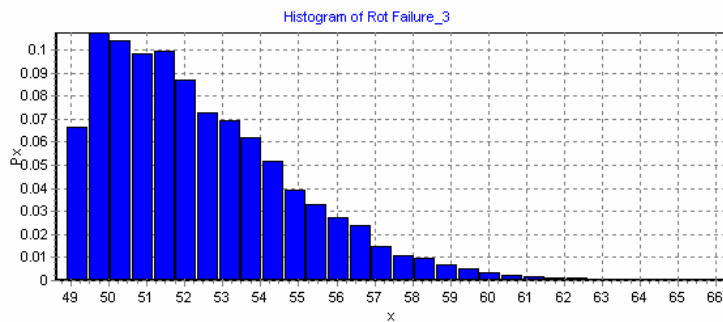
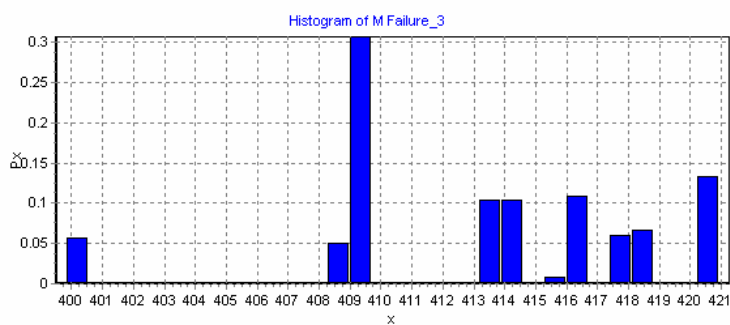


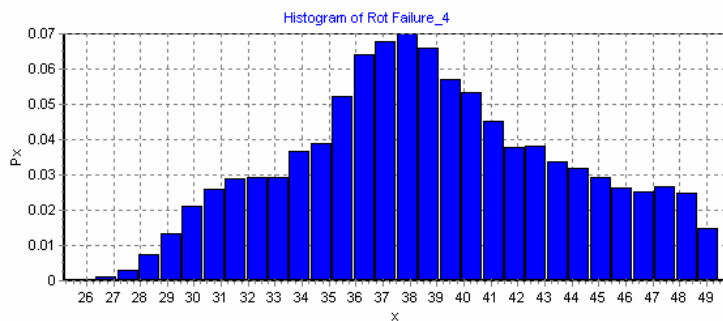
Figure 57 – Histograms of Rotation and bending moment at failure

Histograms for failures of component 10.1

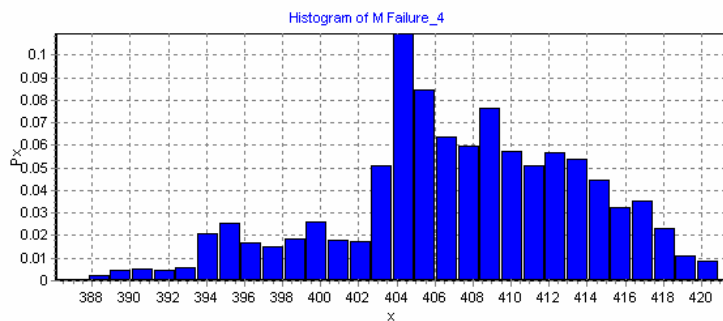
Total Points:49239
 Points in Range:4.92
 Points out-of-Range:95.08
 Mean:52.42899
 Standard deviation:2.52551
 P5%:48.27368
 P95%:56.58094
 Skewness:1.03831
 kurtosis:1.07831



Total Points:49239
 Points in Range:4.92
 Points out-of-Range:95.08
 Mean:413.1538
 Standard deviation:5.19458
 P5%:404.60698
 P95%:421.69369
 Skewness:-0.4779
 kurtosis:-0.01428

Histograms for failures of component 3.2

Total Points:237560
 Points in Range:23.76
 Points out-of-Range:76.24
 Mean:38.74177
 Standard deviation:5.01639
 P5%:30.48814
 P95%:46.98872
 Skewness:0.08537
 kurtosis:-0.63847



Total Points:237560
 Points in Range:23.76
 Points out-of-Range:76.24
 Mean:407.28862
 Standard deviation:6.47476
 P5%:396.63548
 P95%:417.93311
 Skewness:-0.40738
 kurtosis:-0.09385

Histograms for failures of component 2

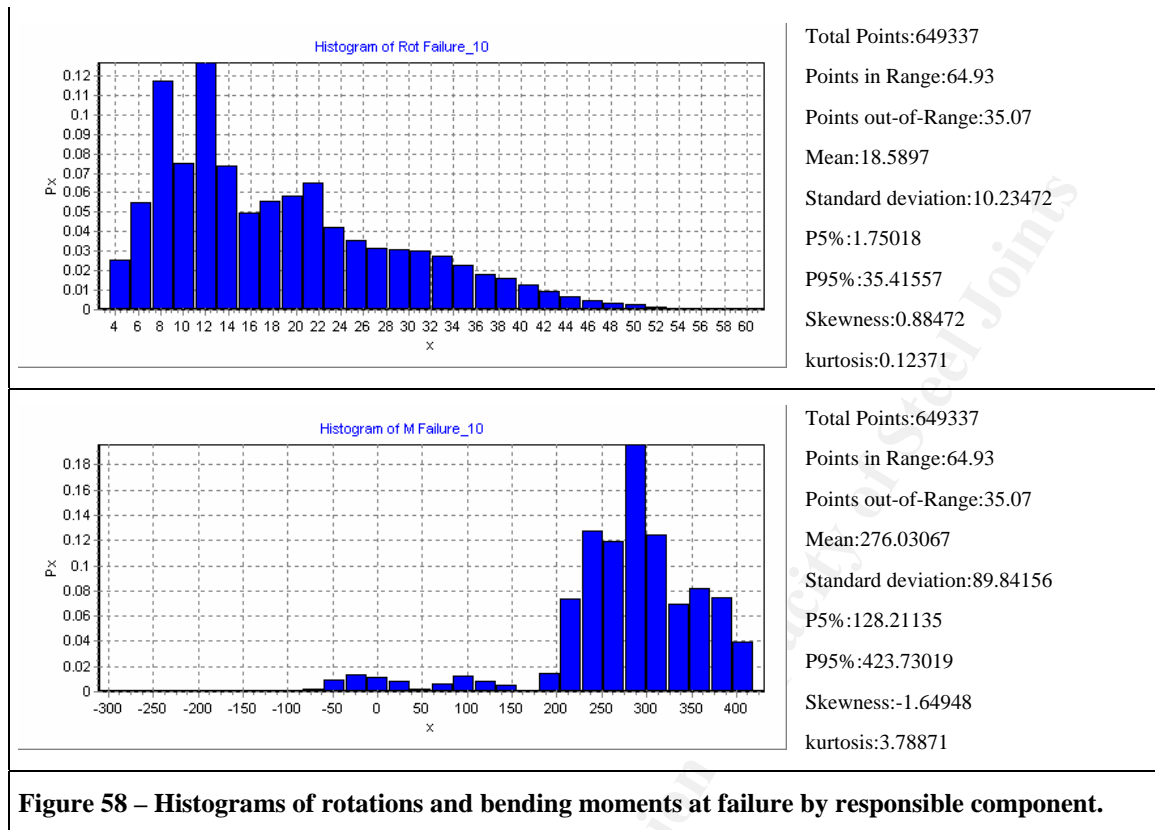


Figure 58 – Histograms of rotations and bending moments at failure by responsible component.

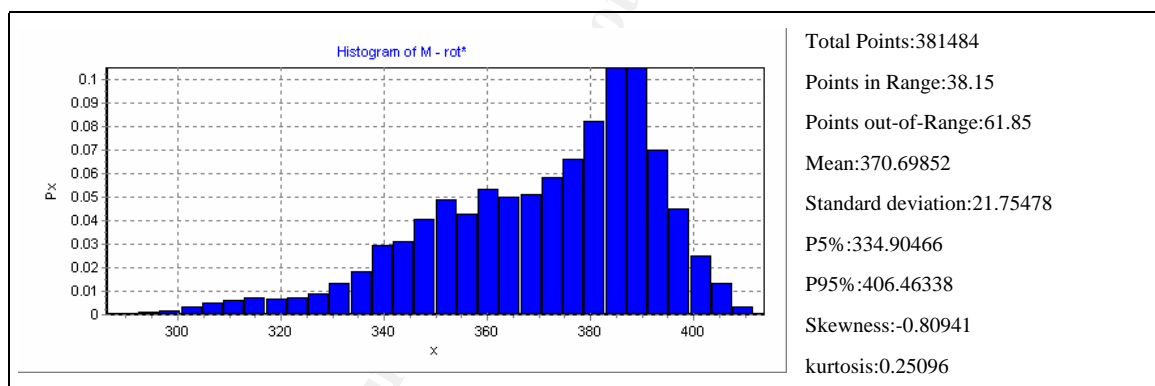


Figure 59 – Histogram for rotation=30 mrad

1.1.4.2 C.2) K_p [2], [1] and F^Y [1], [2], [3.2] (real) and Δf [2]

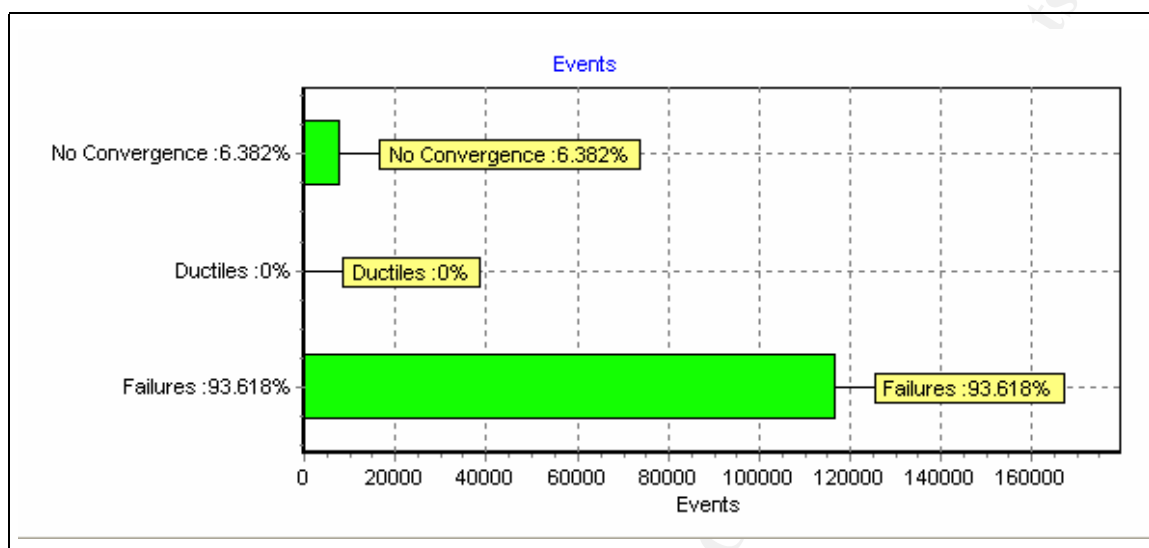


Figure 60 – Calculation summary.

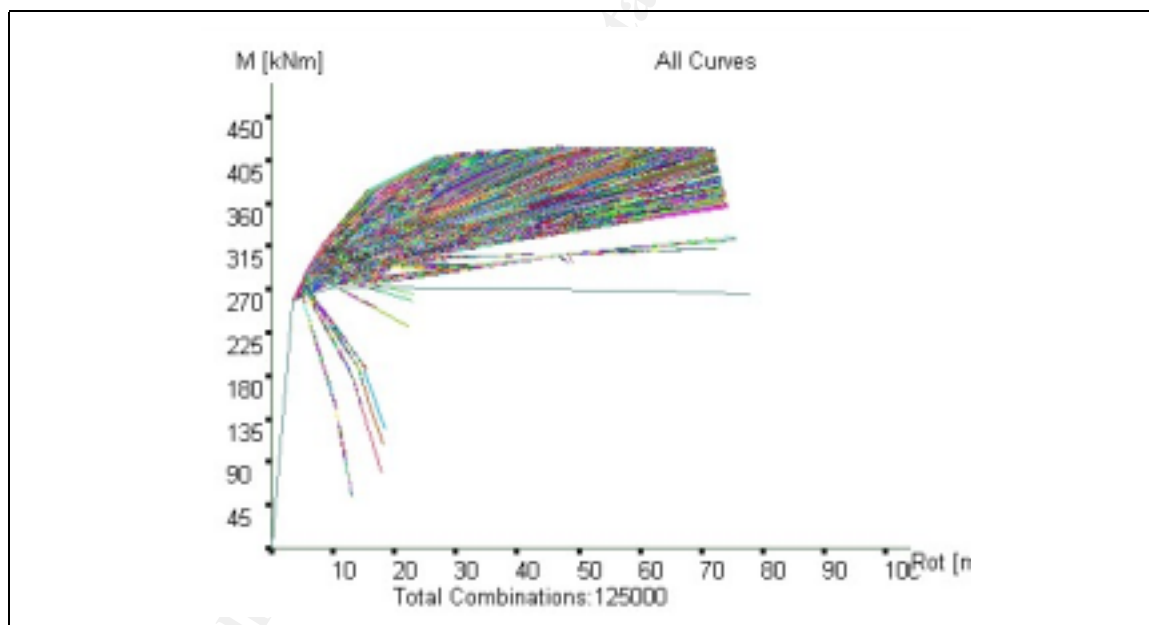


Figure 61 – All curves.

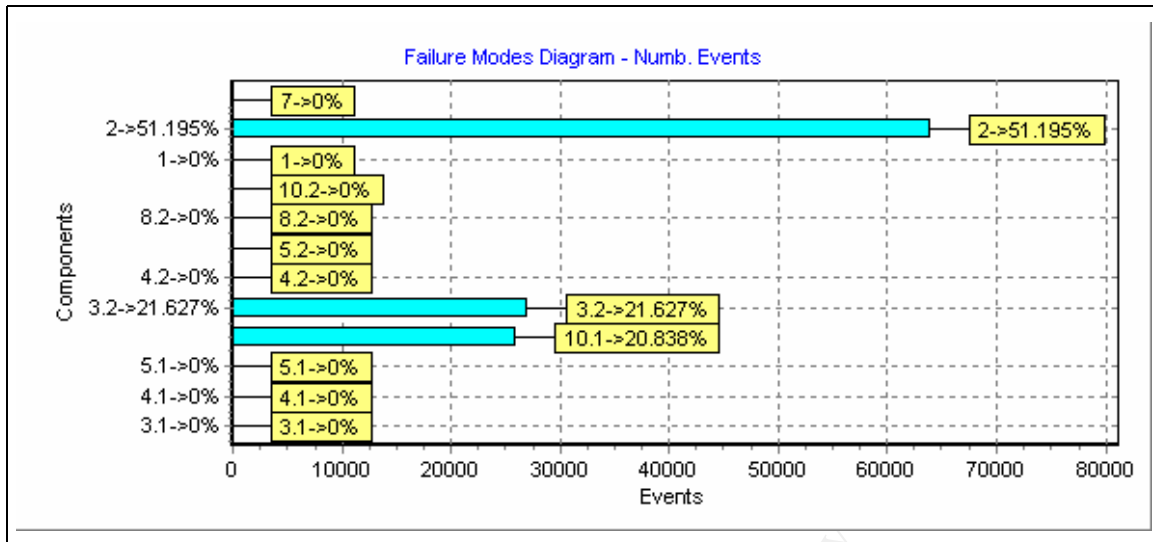


Figure 62 – Failure modes counter

10.1 : 26048
 3.2 : 27034
 2 : 63994

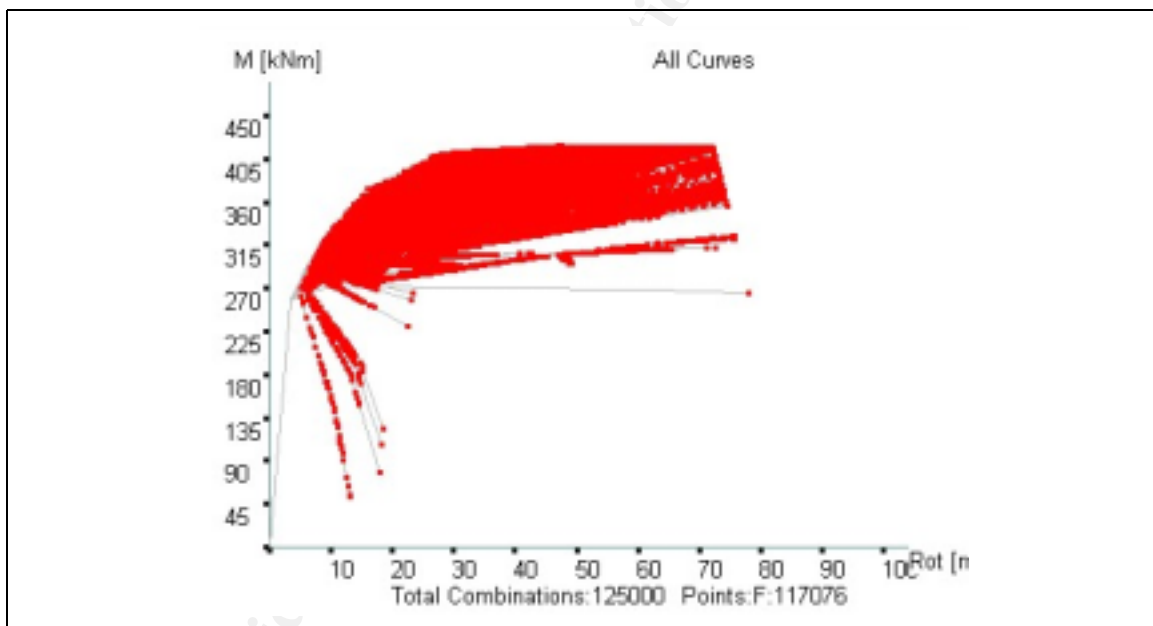


Figure 63 – All failures.

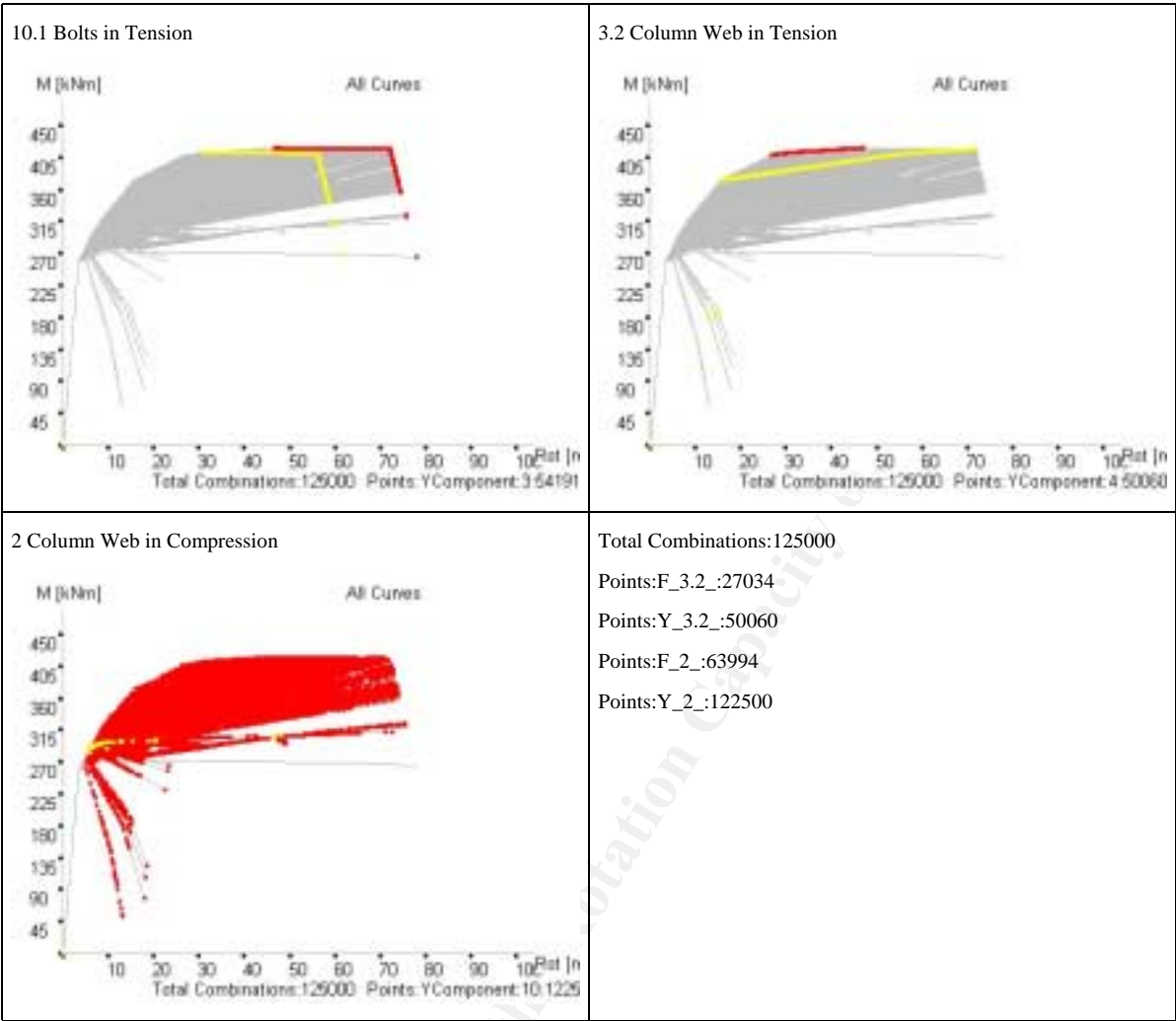


Figure 64 – Failures by component

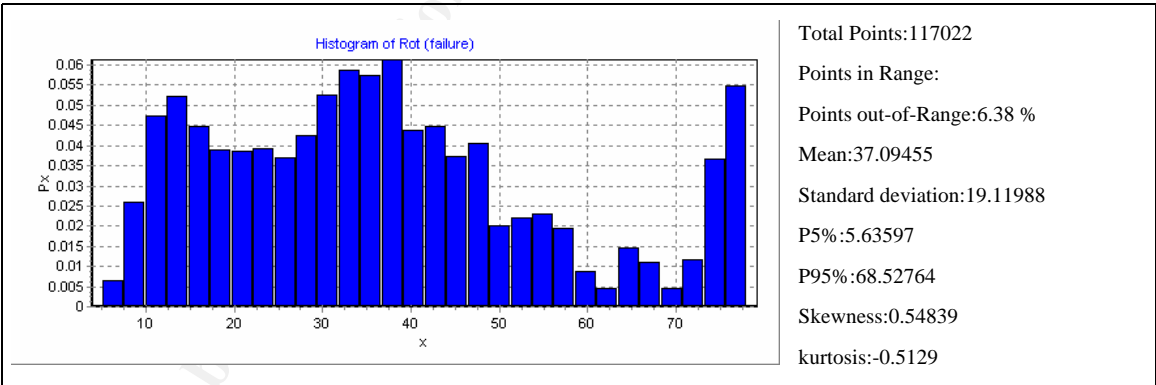


Figure 65 – Histogram for rotation at failure

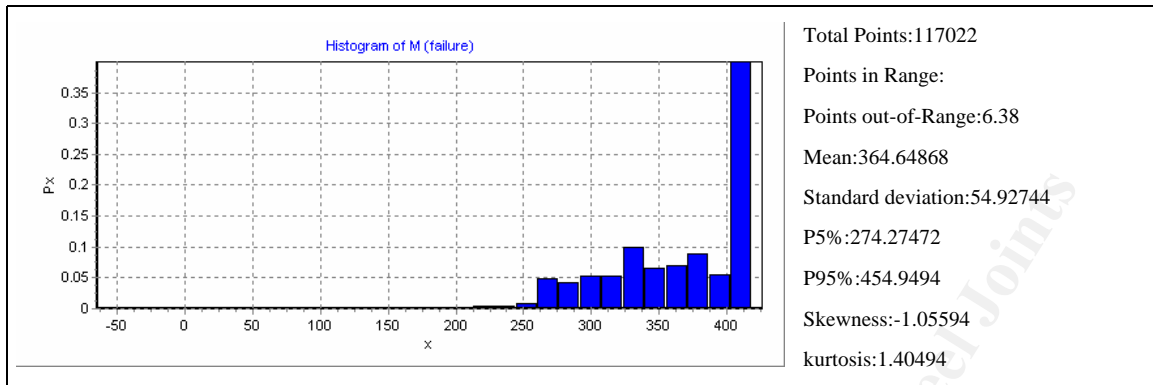
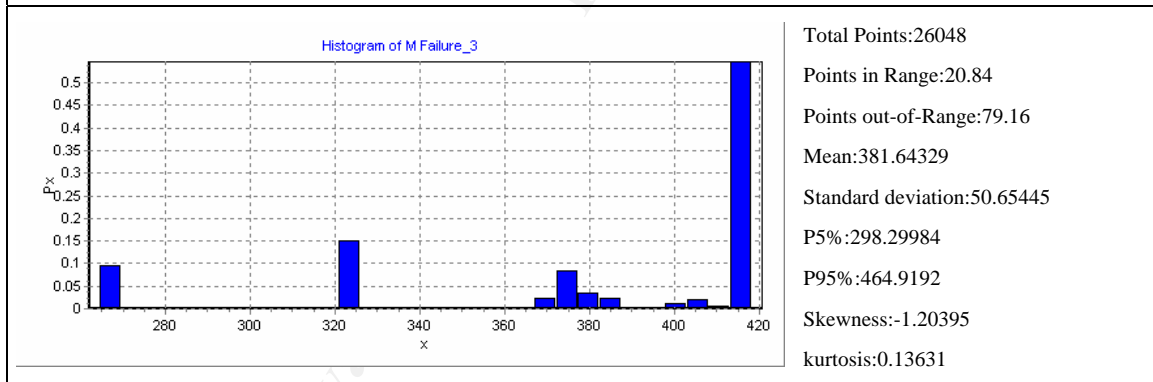
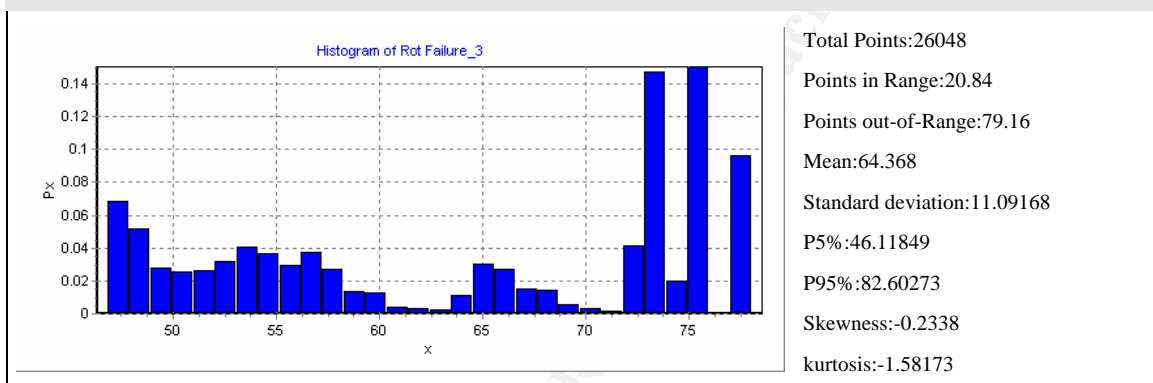
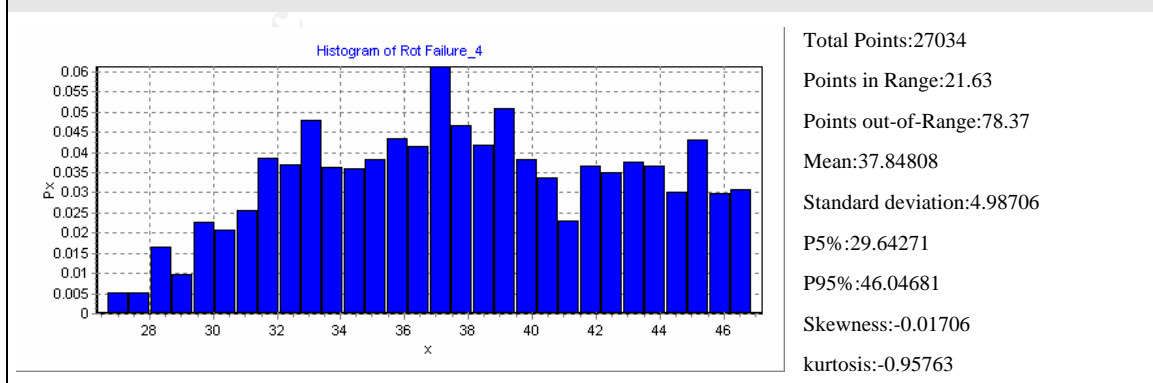


Figure 66 – Histogram for bending moment at failure

Histograms for failures of component 10.1



Histograms for failures of component 3.2



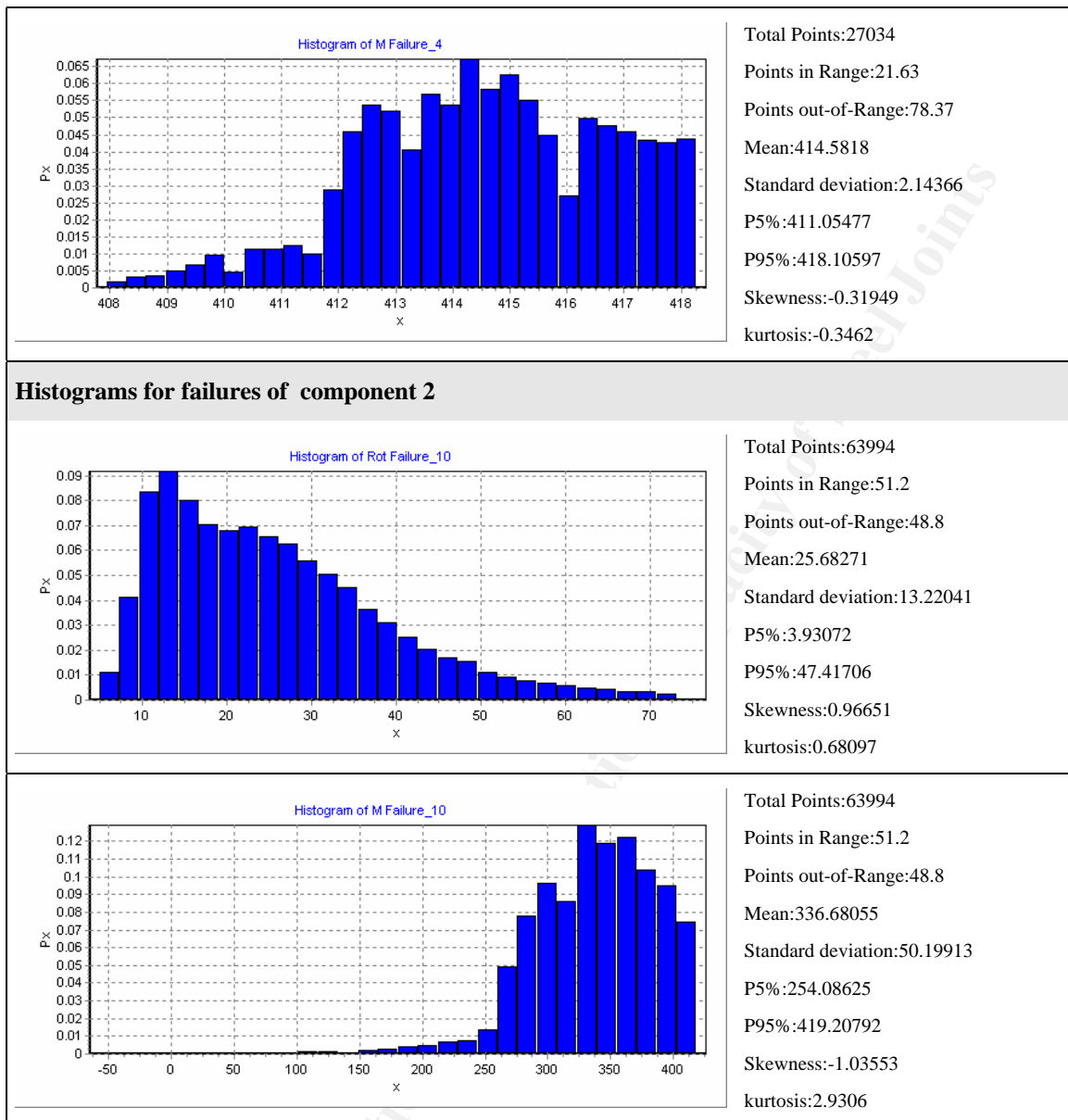


Figure 67 – Histograms of rotations and bending moments at failure by responsible component.

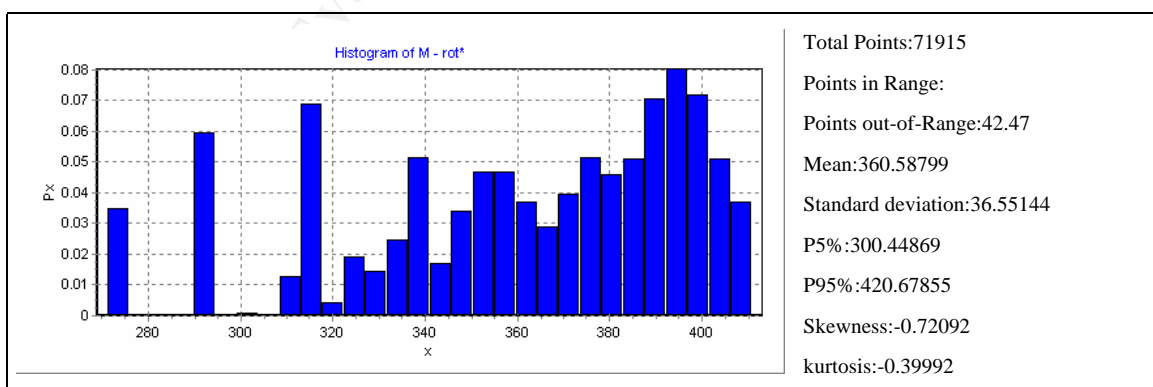


Figure 68 – Histogram for rotation=30 mrad

1.1.4.3 C.2b) K_p [2], [1] and F^Y [1], [2], [3.2] (real) and Δf [2]

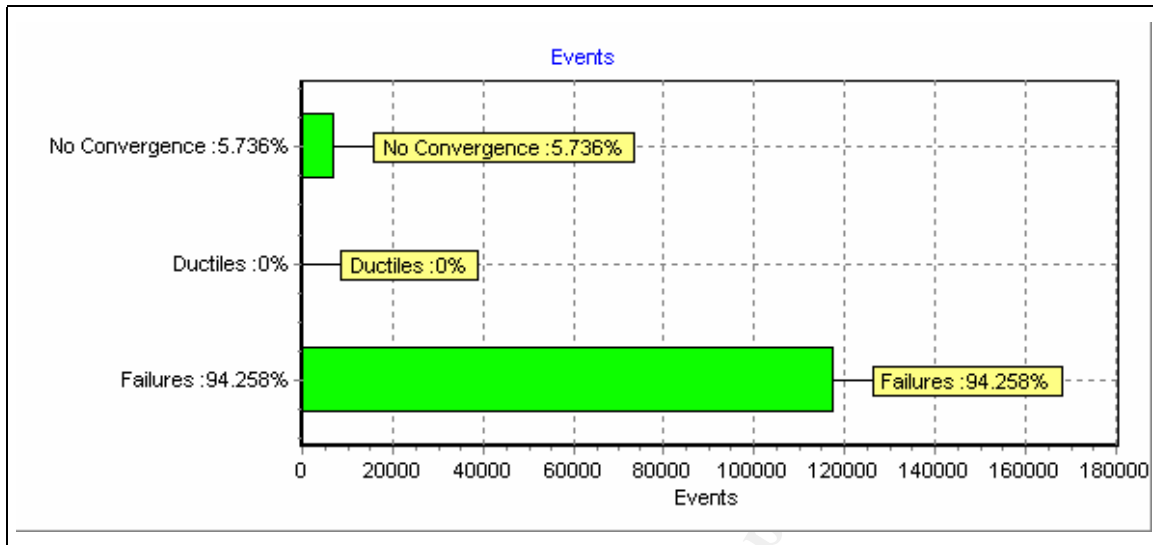


Figure 69 – Calculation summary.

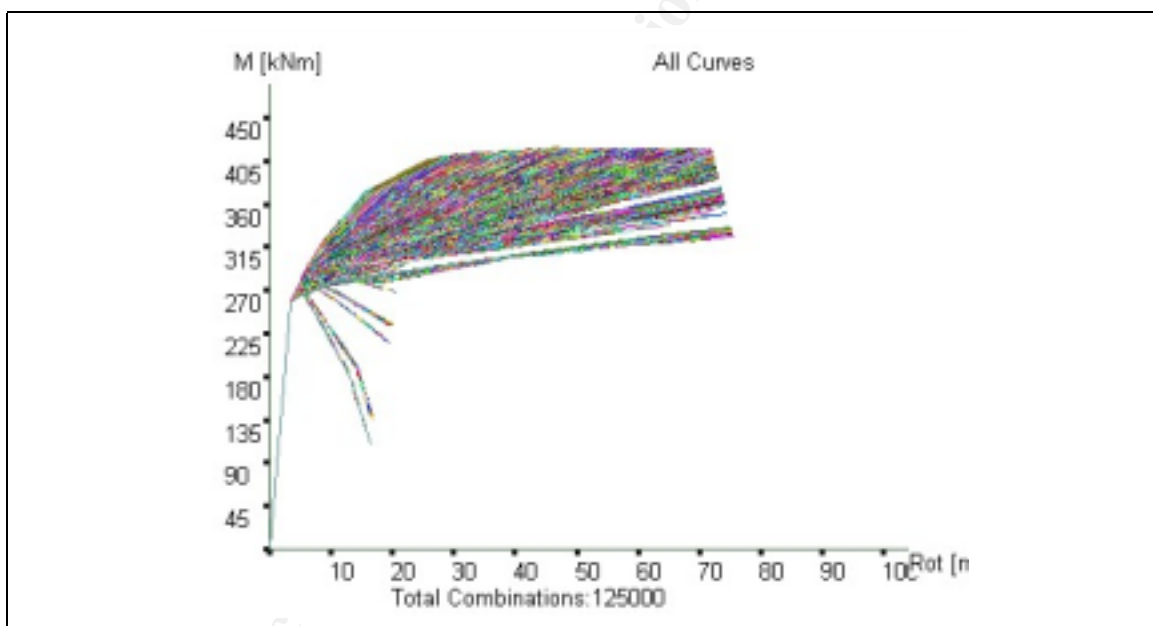


Figure 70 – All curves.

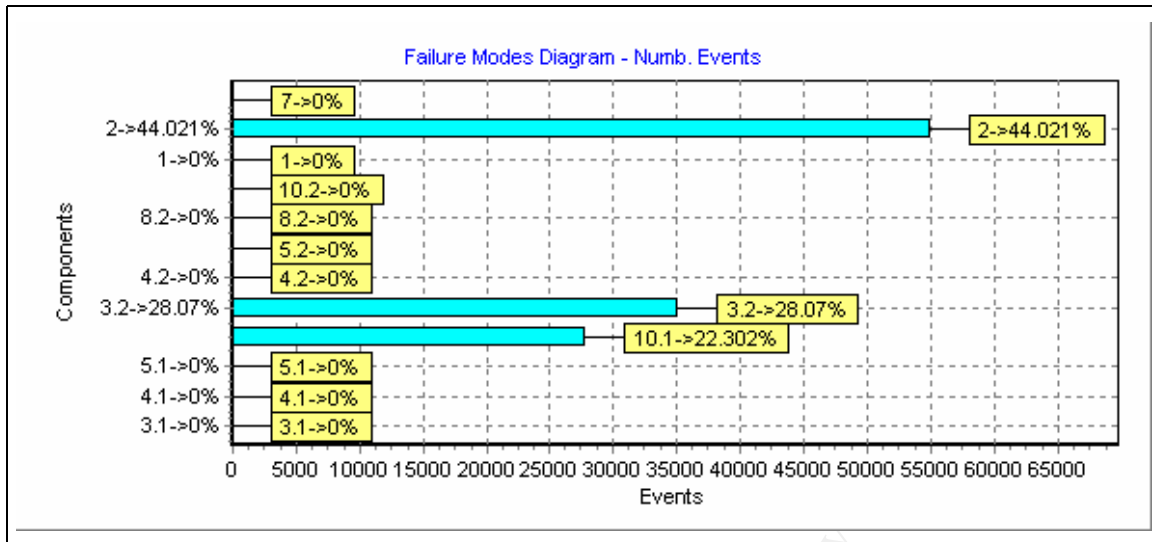


Figure 71 – Failure modes counter

10.1 : 27878
 3.2 : 35087
 2 : 55026

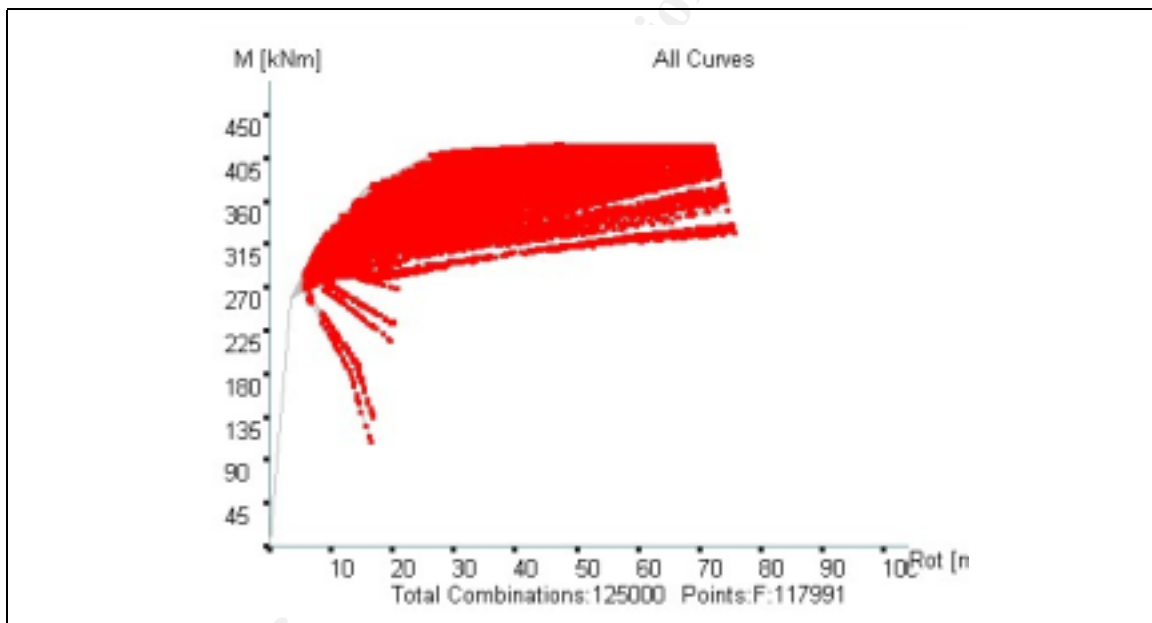


Figure 72 – All failures.

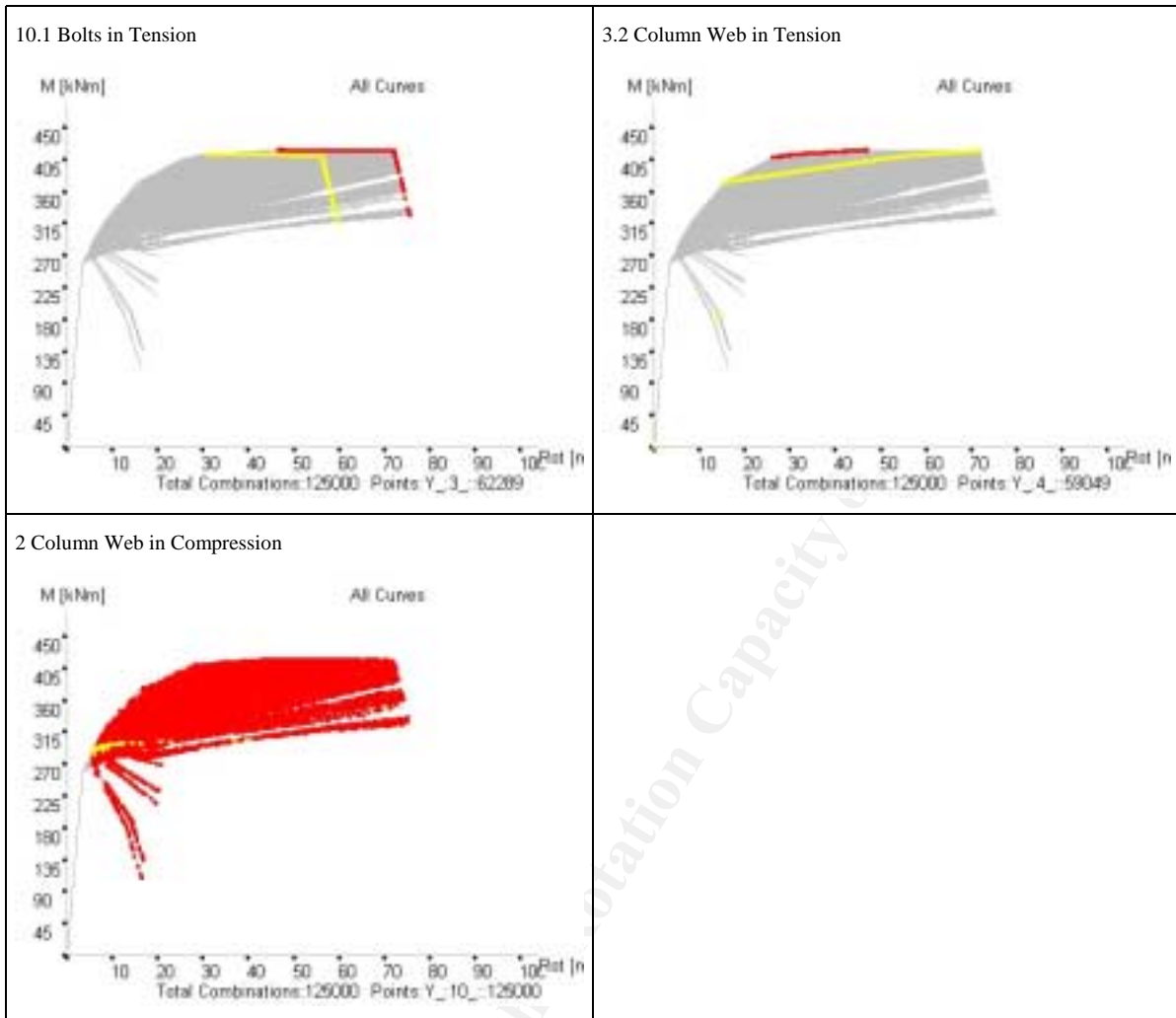


Figure 73 – Failures by component

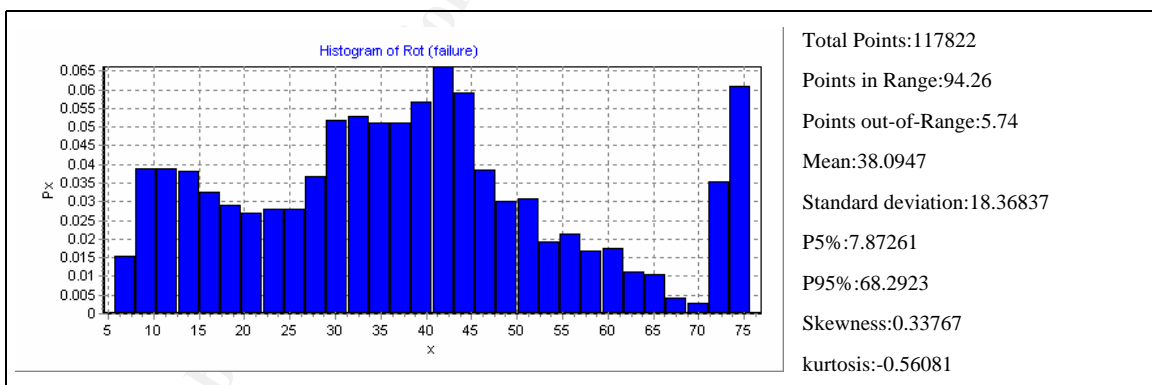


Figure 74 – Histogram for rotation at failure

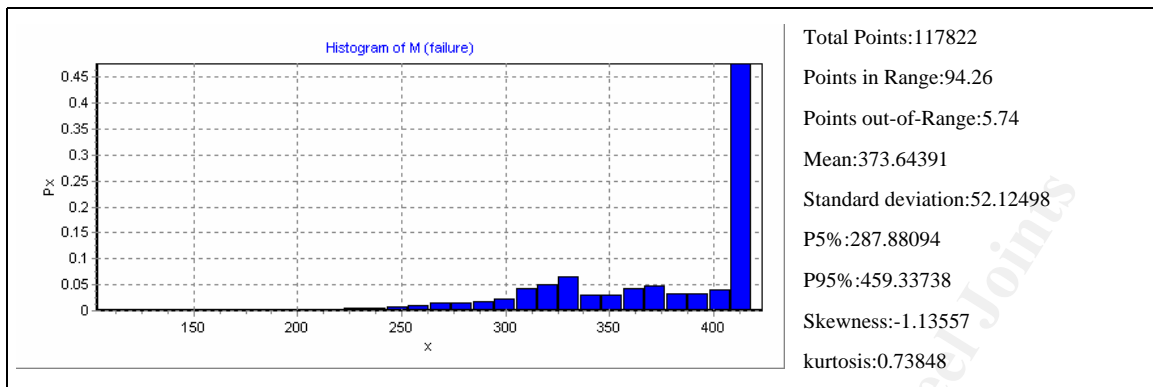
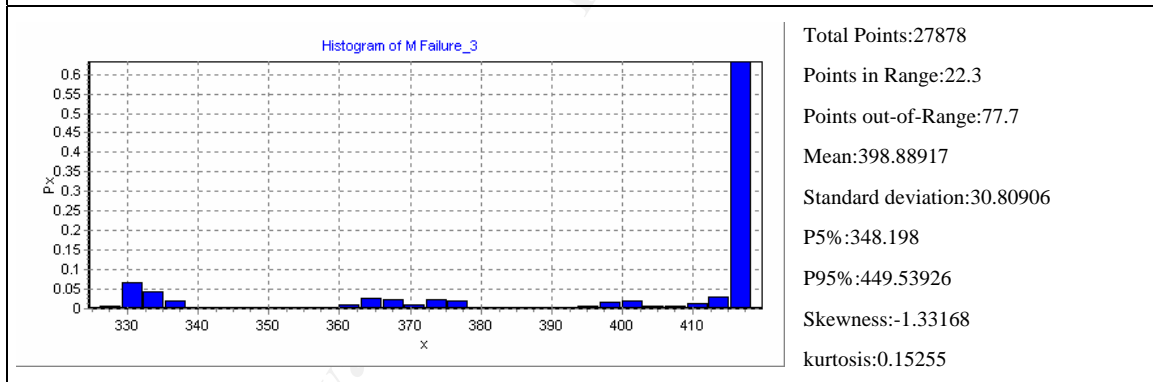
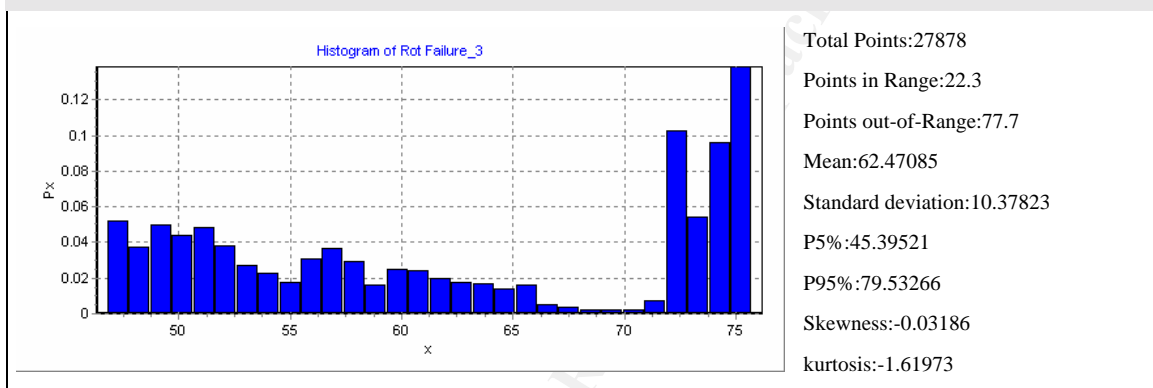
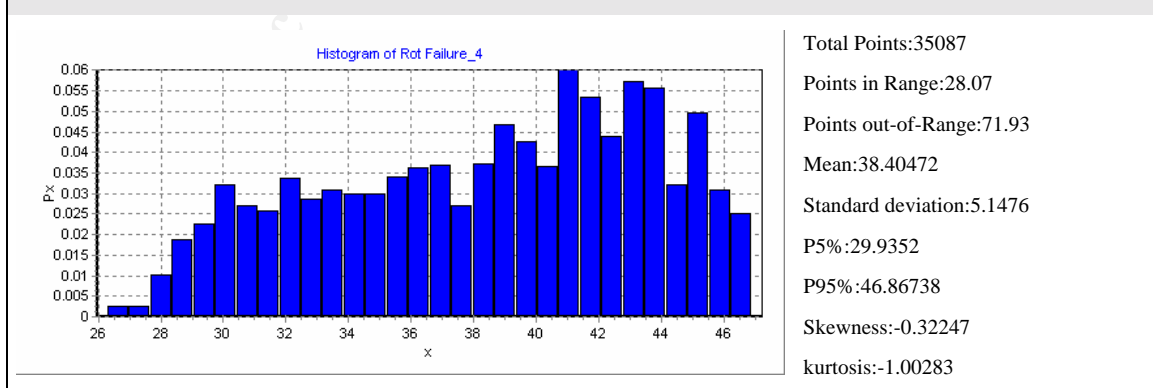


Figure 75 – Histogram for bending moment at failure

Histograms for failures of component 10.1



Histograms for failures of component 3.2



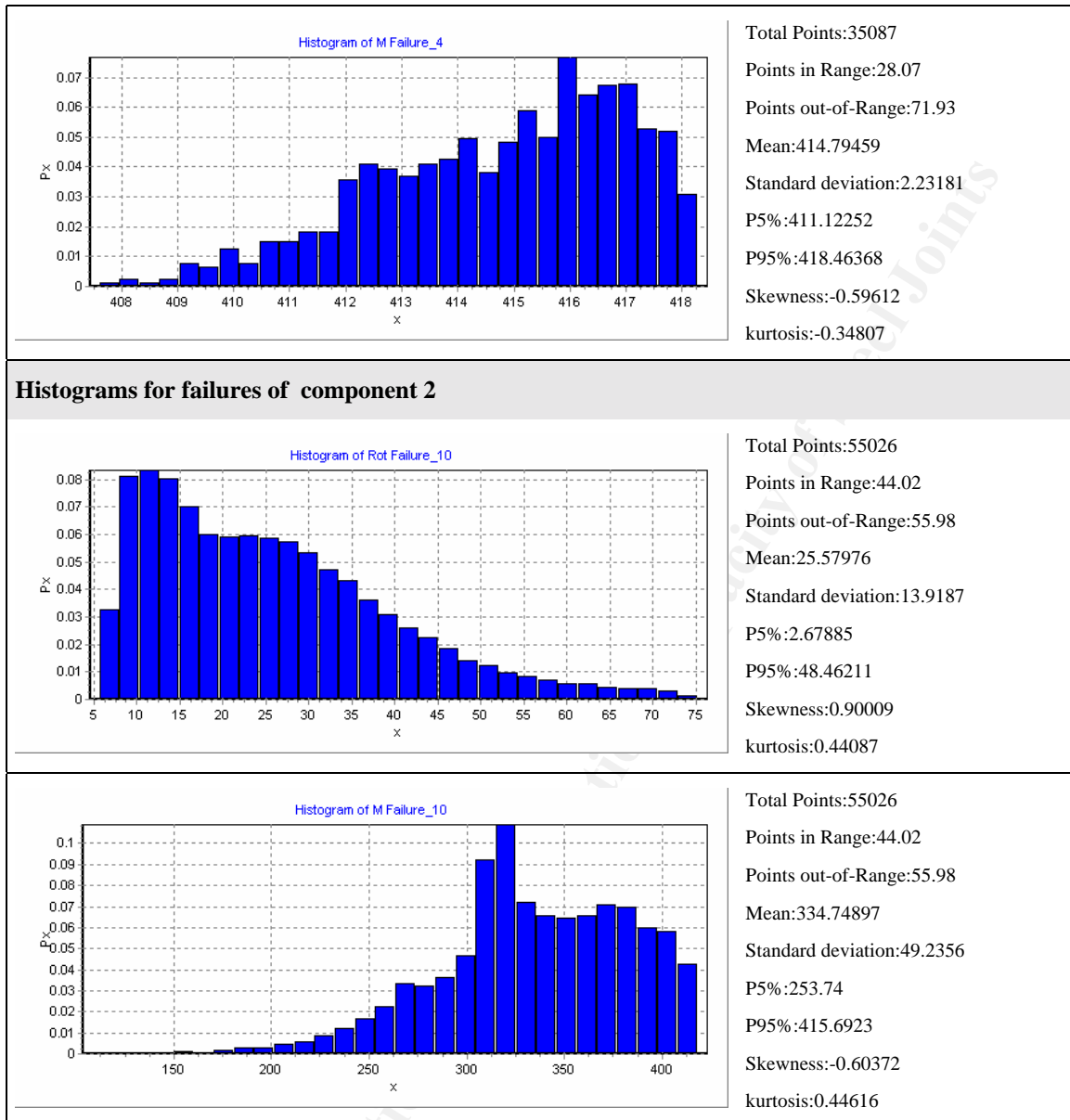


Figure 76 – Histograms of rotations and bending moments at failure by responsible component.

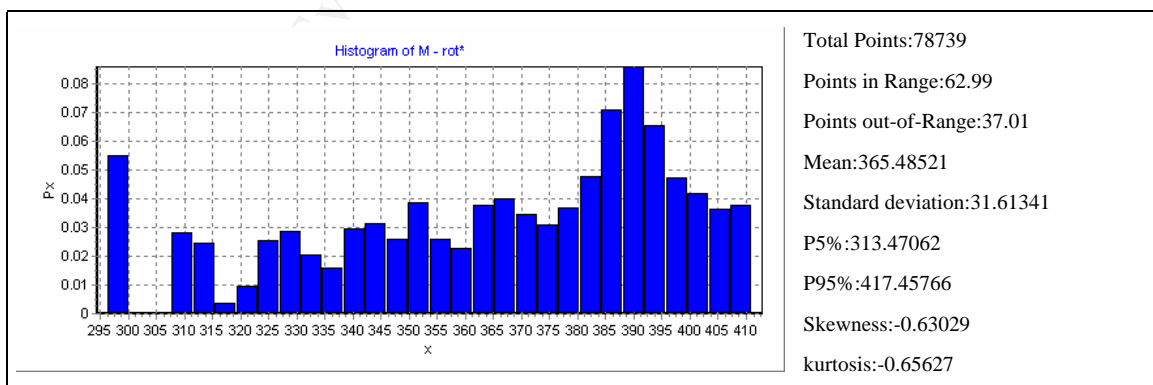


Figure 77 – Histogram for rotation=30 mrad

1.1.4.4 C.3) K_p [2], [1] and F^Y [1], [2], [3.2] (nominal) and Δf [2]

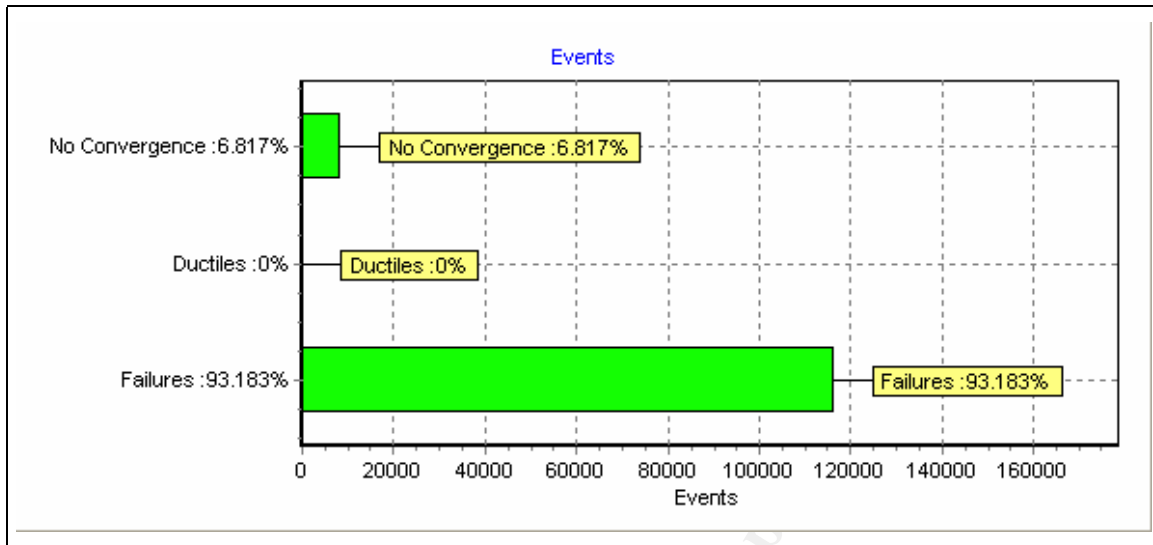


Figure 78 – Calculation summary.

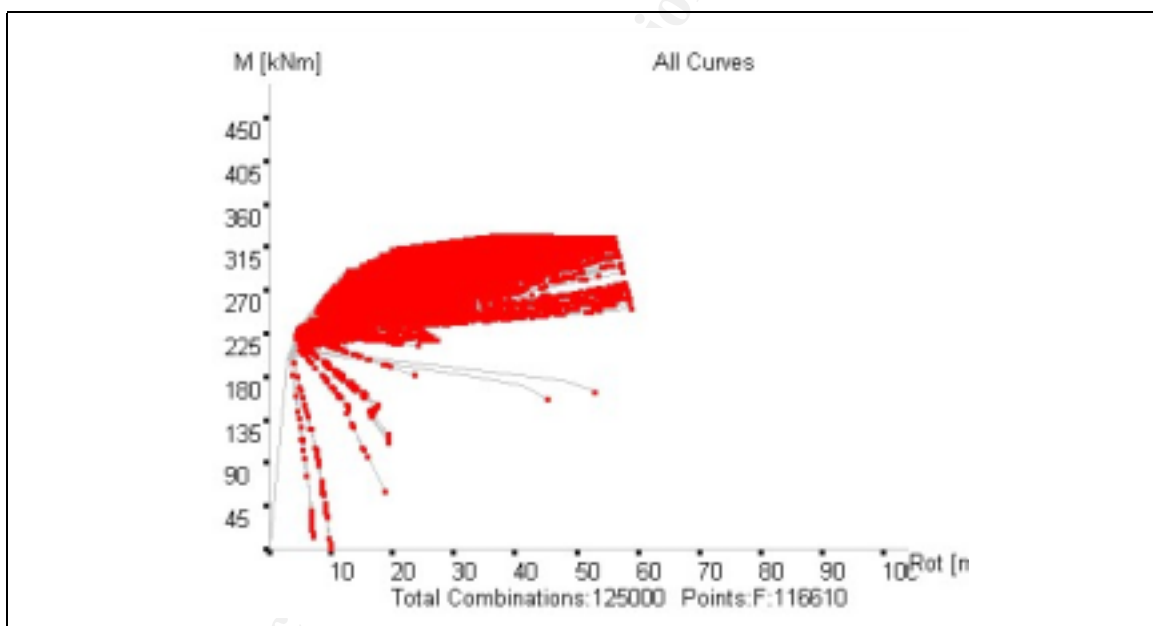


Figure 79 – All curves and failures.

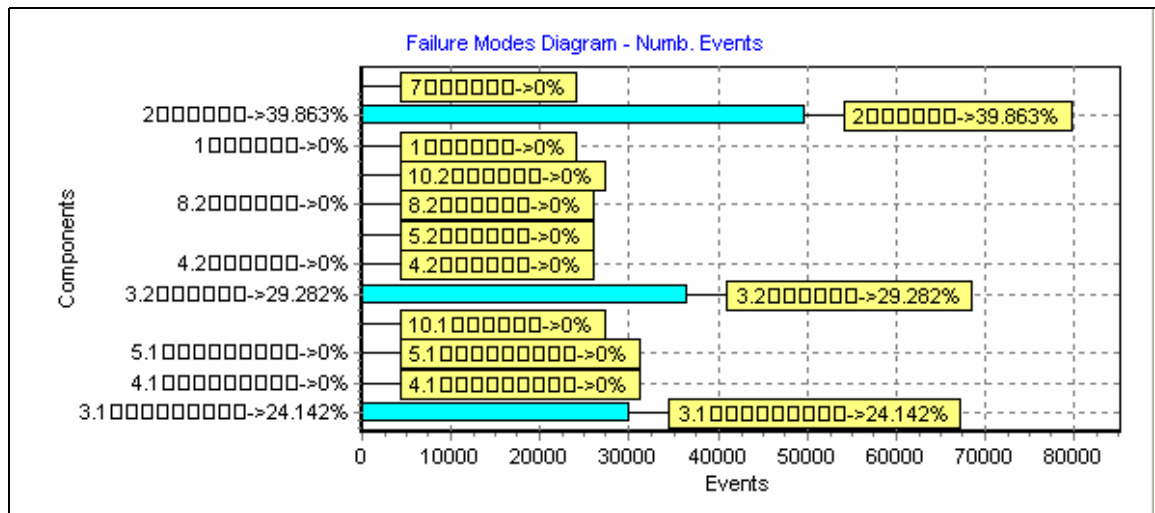


Figure 80 – Failure modes counter

3.1 : 30178

3.2 : 36603

2 : 49829

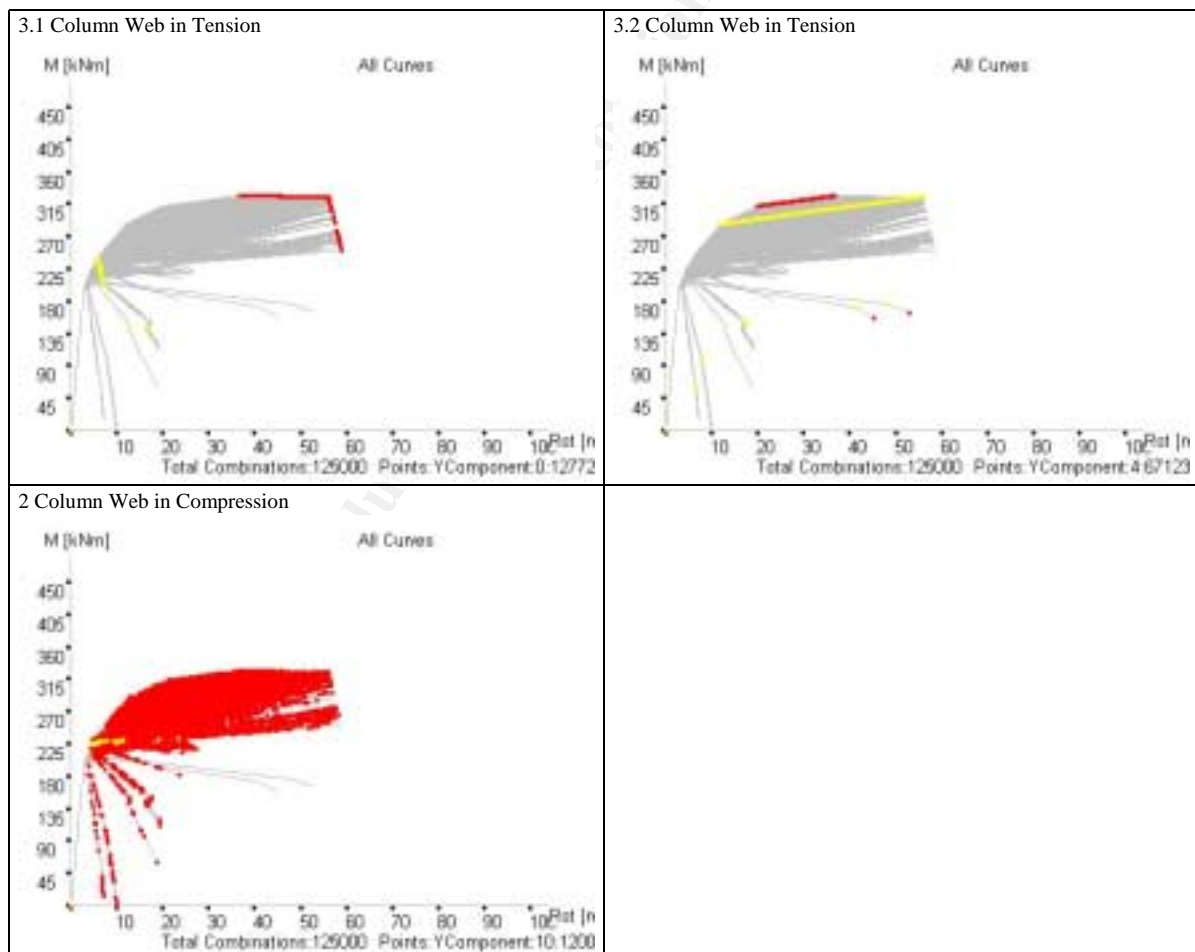


Figure 81 – Failures and yields by component 3.1; 3.2 ; 2

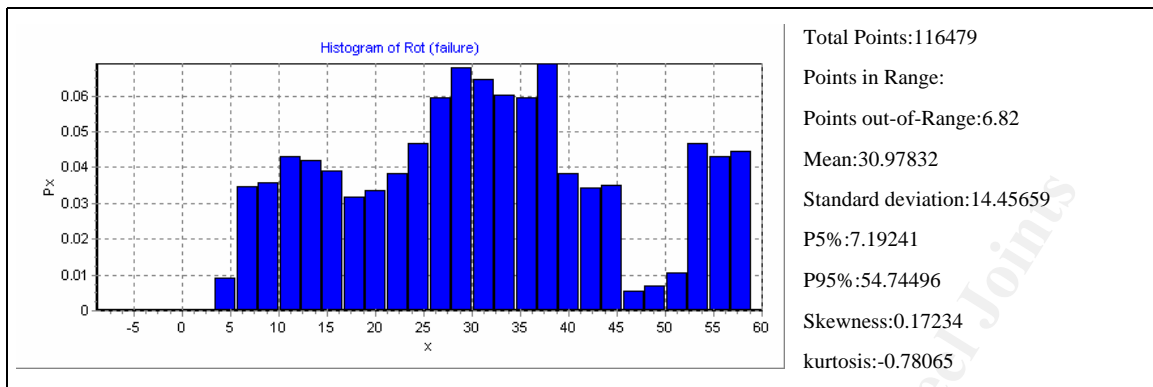


Figure 82 - Histogram for rotation at failure

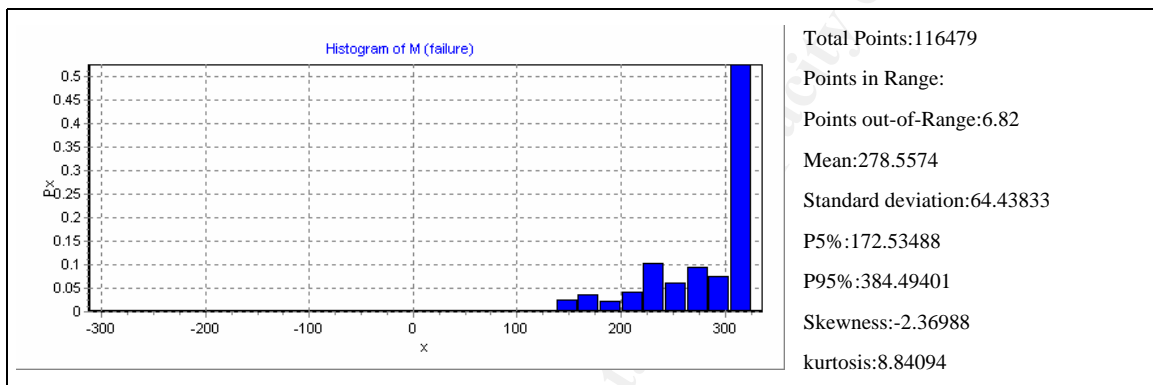
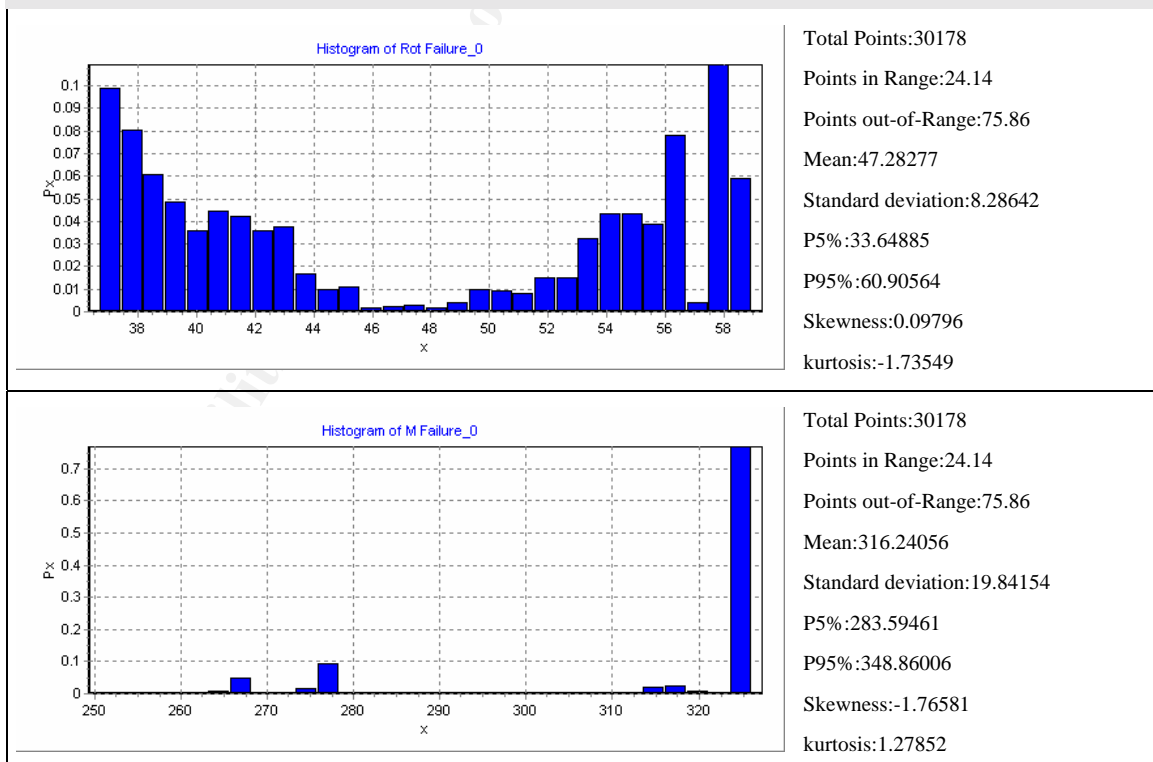
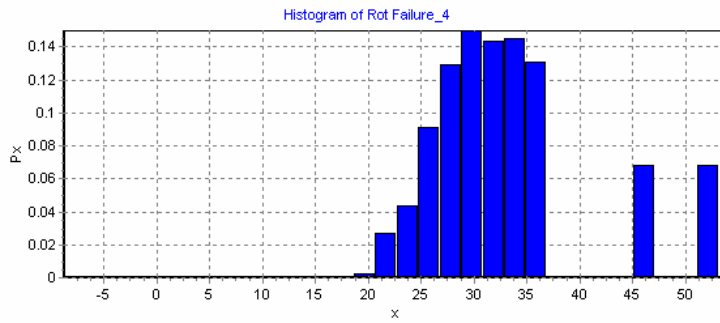


Figure 83 - Histogram for moment at failure.

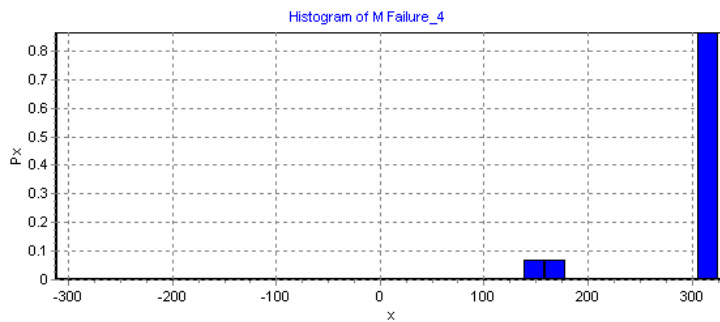
Histograms for failures of component 3.1



Histograms for failures of component 3.2

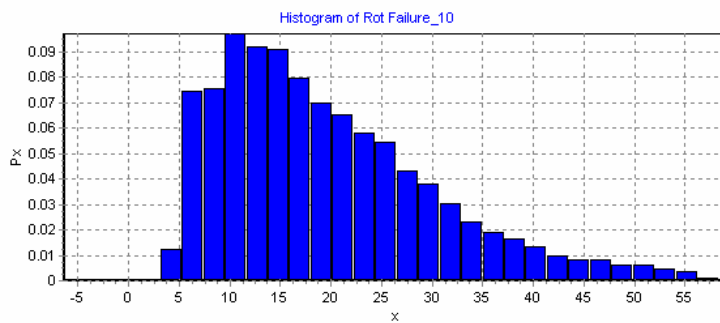


Total Points:36603
 Points in Range:29.28
 Points out-of-Range:70.72
 Mean:32.96764
 Standard deviation:7.55598
 P5%:20.53553
 P95%:45.38967
 Skewness:1.28115
 kurtosis:1.35686

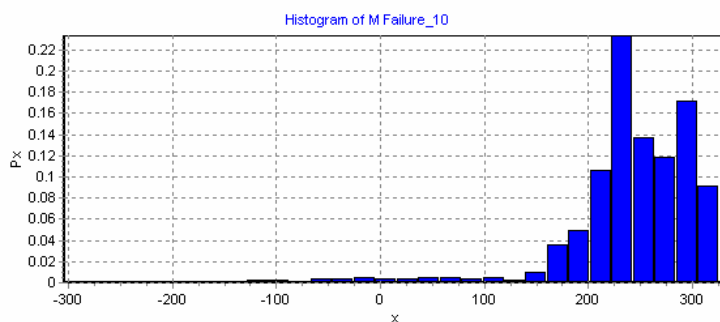


Total Points:36603
 Points in Range:29.28
 Points out-of-Range:70.72
 Mean:298.93778
 Standard deviation:55.3554
 P5%:207.85971
 P95%:389.94205
 Skewness:-2.15344
 kurtosis:3.14674

Histograms for failures of component 2



Total Points:49829
 Points in Range:39.86
 Points out-of-Range:60.14
 Mean:19.66044
 Standard deviation:10.63905
 P5%:2.15566
 P95%:37.15104
 Skewness:0.96157
 kurtosis:0.5957



Total Points:49829
 Points in Range:39.86
 Points out-of-Range:60.14
 Mean:240.88851
 Standard deviation:68.1092
 P5%:128.82618
 P95%:352.86004
 Skewness:-2.6297
 kurtosis:10.09983

Figure 84 – Histograms of rotations and bending moments at failure by responsible component.

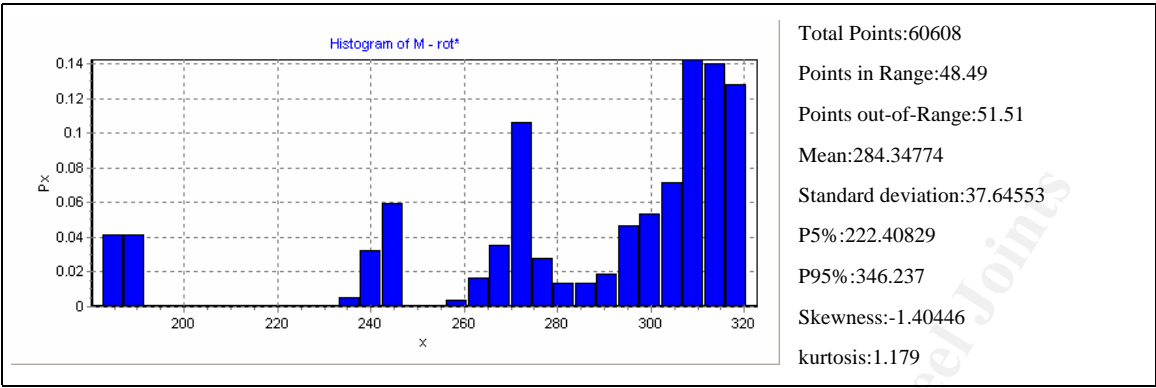


Figure 85 – Histogram for rotation=30 mrad

1.2 BEAM-TO-COLUMN FLUSH END-PLATE STEEL JOINT

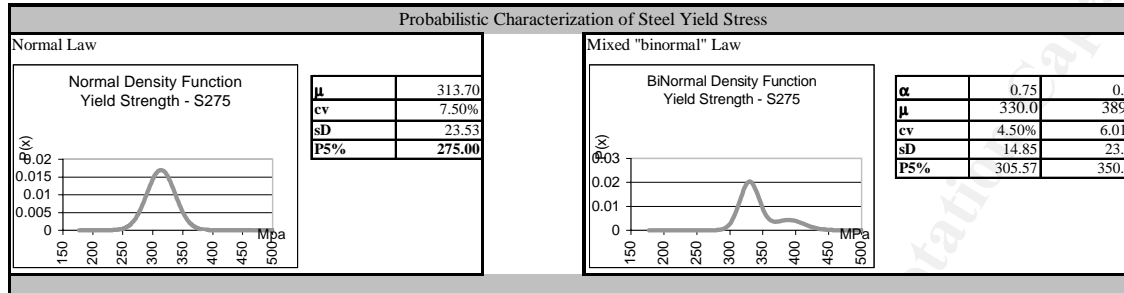
(Lima Connection FE1 as base)

Probabilistic Evaluation of the Rotation Capacity of Steel Joints

1.2.1 Simulation details, statistical properties and studied cases

Flush Connection (Luciano Lima test)

Critical Component in Tension Zone



Real (measured) Steel properties			
	Fy Nominal	f _{yreal}	f _u
	[N/mm ²]	[N/mm ²]	[N/mm ²]
Column			
Flange	275	342.9	477.3
Web	275	372.0	448.8
Beam			
Flange	275	340.1	448.2
Web	275	363.4	454.3
Endplate	275	369.4	503.5
Bolts	M20 10.9	900.0	1000.0

Components		Fy [kN]										ke [kN/m]	kp [kN/m]				Df		
		FYk nominal		real		Normal distribution			Binormal distribution				real	calibrated (109.005)	μ	cv	Φ= Df/DY	μ	cv
									a=0.75		a=0.25								
		x	(P X>x)*	x	(P X>x)*	a	μ=a Fyk	cv= 7.5%	μ	cv	μ	cv							
[3.1]	Column Web in Transverse Tension	445.36	98.69%	602.45	4.49%	1.20	534.43	7.50%	534.43	4.50%	630.18	6.01%	1.48E+06	1.48E+04	1.48E+04	50.00%	10.00	10.00	50.00%
[4.1]	Column Flange in Bending	375.48	98.69%	408.32	89.44%	1.20	450.58	7.50%	450.58	4.50%	531.30	6.01%	8.03E+06	8.03E+03	8.03E+03	50.00%	200.00	200.00	50.00%
[5.1]	End-Plate in Bending	305.79	98.69%	339.36	84.19%	1.20	366.95	7.50%	366.95	4.50%	432.69	6.01%	2.63E+06	1.05E+04	1.05E+04	50.00%	200.00	200.00	50.00%
[8.1]	Beam Web in Tension	365.68	98.69%	483.23	8.86%	1.20	438.82	7.50%	438.82	4.50%	517.44	6.01%	1.00E+12	1.00E+10	1.00E+10	50.00%	200.00	200.00	50.00%
[10.1]	Bolts in Tension	441.00	98.69%	441.00	98.69%	1.20	529.20	7.50%	529.20	4.50%	624.02	6.01%	1.63E+06	3.26E+04	3.26E+04	50.00%	3.00	3.00	83.33%
[1]	Column Web Panel in Shear	-474.77	98.69%	-642.24	4.48%	1.20	-569.72	7.50%	-569.72	4.50%	-671.80	6.01%	1.58E+06	1.83E+04	7.90E+04	50.00%	200.00	200.00	50.00%
[2]	Column Web in Transverse Compression	-507.06	98.69%	-634.55	28.38%	1.20	-608.47	7.50%	-608.47	4.50%	-717.49	6.01%	2.13E+06	1.23E+05	6.40E+04	50.00%	12.00	15.00	50.00%
[7]	Beam Flange in Compression	-438.00	98.69%	-555.57	22.35%	1.20	-525.60	7.50%	-525.60	4.50%	-619.77	6.01%	1.00E+12	1.00E+10	1.00E+10	50.00%	10.00	10.00	50.00%
[19]	Welds																		

*Cumulative distribution function for the normal distribution

Case A1

	Components	Fy [kN]								ke [kN/m]	kp [kN/m]			Df			
		FYk nominal	real	Normal distribution			Binormal distribution			real	calibrated (109.005)	m	cv	j= Df/DY	m	cv	
							a=0.75		a=0.25								
				x	m=x Fyk	v= 7.5%	m	cv	m								cv
[3.1]	Column Web in Transverse Tension	445.36	602.45	1.20	534.43	7.50%	534.43	4.50%	630.18	6.01%	1.48E+06	1.48E+04	1.48E+04	50.00%	10.00	10.00	
[4.1]	Column Flange in Bending	375.48	408.32	1.20	450.58	7.50%	450.58	4.50%	531.30	6.01%	8.03E+06	8.03E+03	8.03E+03	50.00%	200.00	200.00	
[5.1]	End-Plate in Bending	305.79	339.36	1.20	366.95	7.50%	366.95	4.50%	432.69	6.01%	2.63E+06	1.05E+04	1.05E+04	50.00%	200.00	200.00	
[8.1]	Beam Web in Tension	365.68	483.23	1.20	438.82	7.50%	438.82	4.50%	517.44	6.01%	1.00E+12	1.00E+10	1.00E+10	50.00%	200.00	200.00	
[10.1]	Bolts in Tension	441.00	441.00	1.20	529.20	7.50%	529.20	4.50%	624.02	6.01%	1.63E+06	3.26E+04	3.26E+04	50.00%	3.00	3.00	
[1]	Column Web Panel in Shear	-474.77	-642.24	1.20	-569.72	7.50%	-569.72	4.50%	-671.80	6.01%	1.58E+06	2.28E+05	7.90E+04	50.00%	200.00	200.00	
[2]	Column Web in Transverse Compression	-507.06	-634.55	1.20	-608.47	7.50%	-608.47	4.50%	-717.49	6.01%	2.13E+06	3.32E+05	6.40E+04	50.00%	12.00	15.00	40%
[7]	Beam Flange in Compression	-438.00	-555.57	1.20	-525.60	7.50%	-525.60	4.50%	-619.77	6.01%	1.00E+12	1.00E+10	1.00E+10	50.00%	10.00	10.00	
[19]	Welds																

Case A2

	Components	Fy [kN]								ke [kN/m]	kp [kN/m]			Df			
		FYk nominal	real	Normal distribution			Binormal distribution				real	calibrated (109.005)	m	cv	j= Df/DY	m	cv
				x	m=x Fyk	v= 7.5%	a=0.75		a=0.25								
							m	cv	m	cv							
[3.1]	Column Web in Transverse Tension	445.36	602.45	1.20	534.43	7.50%	534.43	4.50%	630.18	6.01%	1.48E+06	1.48E+04	1.48E+04	50.00%	10.00	10.00	
[4.1]	Column Flange in Bending	375.48	408.32	1.20	450.58	7.50%	450.58	4.50%	531.30	6.01%	8.03E+06	8.03E+03	8.03E+03	50.00%	200.00	200.00	
[5.1]	End-Plate in Bending	305.79	339.36	1.20	366.95	7.50%	366.95	4.50%	432.69	6.01%	2.63E+06	1.05E+04	1.05E+04	50.00%	200.00	200.00	
[8.1]	Beam Web in Tension	365.68	483.23	1.20	438.82	7.50%	438.82	4.50%	517.44	6.01%	1.00E+12	1.00E+10	1.00E+10	50.00%	200.00	200.00	
[10.1]	Bolts in Tension	441.00	441.00	1.20	529.20	7.50%	529.20	4.50%	624.02	6.01%	1.63E+06	3.26E+04	3.26E+04	50.00%	3.00	3.00	
[1]	Column Web Panel in Shear	-474.77	-642.24	1.20	-569.72	7.50%	-569.72	4.50%	-671.80	6.01%	1.58E+06	4.37E+05	7.90E+04	50.00%	200.00	200.00	
[2]	Column Web in Transverse Compression	-507.06	-634.55	1.20	-608.47	7.50%	-608.47	4.50%	-717.49	6.01%	2.13E+06	5.41E+05	6.40E+04	50.00%	12.00	15.00	40%
[7]	Beam Flange in Compression	-438.00	-555.57	1.20	-525.60	7.50%	-525.60	4.50%	-619.77	6.01%	1.00E+12	1.00E+10	1.00E+10	50.00%	10.00	10.00	
[19]	Welds																

Case A3

Components	Fy [kN]									ke [kN/m]	kp [kN/m]			Df		
	FYk nominal	real	Normal distribution			Binormal distribution				real	calibrated (109.005)	m	cv	j= Df/DY	m	cv
			x	m=x Fyk	v= 7.5%	a=0.75		a=0.25								
						m	cv	m	cv							
[3.1] Column Web in Transverse Tension	445.36	602.45	1.20	534.43	7.50%	534.43	4.50%	630.18	6.01%	1.48E+06	1.48E+04	1.48E+04	50.00%	10.00	10.00	
[4.1] Column Flange in Bending	375.48	408.32	1.20	450.58	7.50%	450.58	4.50%	531.30	6.01%	8.03E+06	8.03E+03	8.03E+03	50.00%	200.00	200.00	
[5.1] End-Plate in Bending	305.79	339.36	1.20	366.95	7.50%	366.95	4.50%	432.69	6.01%	2.63E+06	1.05E+04	1.05E+04	50.00%	200.00	200.00	
[8.1] Beam Web in Tension	365.68	483.23	1.20	438.82	7.50%	438.82	4.50%	517.44	6.01%	1.00E+12	1.00E+10	1.00E+10	50.00%	200.00	200.00	
[10.1] Bolts in Tension	441.00	441.00	1.20	529.20	7.50%	529.20	4.50%	624.02	6.01%	1.63E+06	3.26E+04	3.26E+04	50.00%	3.00	3.00	
[1] Column Web Panel in Shear	-474.77	-642.24	1.20	-569.72	7.50%	-569.72	4.50%	-671.80	6.01%	1.58E+06	4.37E+05	7.90E+04	50.00%	200.00	200.00	
[2] Column Web in Transverse Compression	-507.06	-634.55	1.20	-608.47	7.50%	-608.47	4.50%	-717.49	6.01%	2.13E+06	5.41E+05	6.40E+04	50.00%	12.00	15.00	40%
[7] Beam Flange in Compression	-438.00	-555.57	1.20	-525.60	7.50%	-525.60	4.50%	-619.77	6.01%	1.00E+12	1.00E+10	1.00E+10	50.00%	10.00	10.00	
[19] Welds																

Case B1

	Components	Fy [kN]								ke [kN/m]	kp [kN/m]			Df			
		FYk nominal	real	Normal distribution			Binormal distribution				real	calibrated (109.005)	m	cv	j= Df/DY	m	cv
							a=0.75		a=0.25								
				x	m=x Fy _k	v= 7.5%	m	cv	m	cv							
[3.1]	Column Web in Transverse Tension	445.36	602.45	1.20	534.43	7.50%	534.43	4.50%	630.18	6.01%	1.48E+06	1.48E+04	1.48E+04	50.00%	10.00	10.00	
[4.1]	Column Flange in Bending	375.48	408.32	1.20	450.58	7.50%	450.58	4.50%	531.30	6.01%	8.03E+06	8.03E+03	8.03E+03	50.00%	200.00	200.00	
[5.1]	End-Plate in Bending	305.79	339.36	1.20	366.95	7.50%	366.95	4.50%	432.69	6.01%	2.63E+06	1.05E+04	1.05E+04	50.00%	200.00	200.00	
[8.1]	Beam Web in Tension	365.68	483.23	1.20	438.82	7.50%	438.82	4.50%	517.44	6.01%	1.00E+12	1.00E+10	1.00E+10	50.00%	200.00	200.00	
[10.1]	Bolts in Tension	441.00	441.00	1.20	529.20	7.50%	529.20	4.50%	624.02	6.01%	1.63E+06	3.26E+04	3.26E+04	50.00%	3.00	3.00	
[1]	Column Web Panel in Shear	-474.77	-642.24	1.20	-569.72	7.50%	-569.72	4.50%	-671.80	6.01%	1.58E+06	6.46E+05	7.90E+04	50.00%	200.00	200.00	
[2]	Column Web in Transverse Compression	-507.06	-634.55	1.20	-608.47	7.50%	-608.47	4.50%	-717.49	6.01%	2.13E+06	7.51E+05	6.40E+04	50.00%	12.00	15.00	40%
[7]	Beam Flange in Compression	-438.00	-555.57	1.20	-525.60	7.50%	-525.60	4.50%	-619.77	6.01%	1.00E+12	1.00E+10	1.00E+10	50.00%	10.00	10.00	
[19]	Welds																

Case B2

	Components	Fy [kN]								ke [kN/m]	kp [kN/m]			Df			
		FYk nominal	real	Normal distribution			Binormal distribution				real	calibrated (109.005)	m	cv	j= Df/DY	m	cv
							a=0.75		a=0.25								
				x	m=x Fyk	v= 7.5%	m	cv	m	cv							
[3.1]	Column Web in Transverse Tension	445.36	602.45	1.20	534.43	7.50%	534.43	4.50%	630.18	6.01%	1.48E+06	1.48E+04	1.48E+04	50.00%	10.00	10.00	
[4.1]	Column Flange in Bending	375.48	408.32	1.20	450.58	7.50%	450.58	4.50%	531.30	6.01%	8.03E+06	8.03E+03	8.03E+03	50.00%	200.00	200.00	
[5.1]	End-Plate in Bending	305.79	339.36	1.20	366.95	7.50%	366.95	4.50%	432.69	6.01%	2.63E+06	1.05E+04	1.05E+04	50.00%	200.00	200.00	
[8.1]	Beam Web in Tension	365.68	483.23	1.20	438.82	7.50%	438.82	4.50%	517.44	6.01%	1.00E+12	1.00E+10	1.00E+10	50.00%	200.00	200.00	
[10.1]	Bolts in Tension	441.00	441.00	1.20	529.20	7.50%	529.20	4.50%	624.02	6.01%	1.63E+06	3.26E+04	3.26E+04	50.00%	3.00	3.00	
[1]	Column Web Panel in Shear	-474.77	-642.24	1.20	-569.72	7.50%	-569.72	4.50%	-671.80	6.01%	1.58E+06	2.28E+05	7.90E+04	50.00%	200.00	200.00	
[2]	Column Web in Transverse Compression	-507.06	-634.55	1.20	-608.47	7.50%	-608.47	4.50%	-717.49	6.01%	2.13E+06	3.32E+05	6.40E+04	50.00%	12.00	15.00	40%
[7]	Beam Flange in Compression	-438.00	-555.57	1.20	-525.60	7.50%	-525.60	4.50%	-619.77	6.01%	1.00E+12	1.00E+10	1.00E+10	50.00%	10.00	10.00	
[19]	Welds																

Case C1

	Components	Fy [kN]									ke [kN/m]	kp [kN/m]			Df		
		FYk nominal	real	Normal distribution			Binormal distribution				real	calibrated (109.005)	m	cv	j= Df/DY	m	cv
							a=0.75		a=0.25								
				x	m=x Fyk	v= 7.5%	m	cv	m	cv							
[3.1]	Column Web in Transverse Tension	445.36	602.45	1.20	534.43	7.50%	534.43	4.50%	630.18	6.01%	1.48E+06	1.48E+04	1.48E+04	50.00%	10.00	10.00	50%
[4.1]	Column Flange in Bending	375.48	408.32	1.20	450.58	7.50%	450.58	4.50%	531.30	6.01%	8.03E+06	8.03E+03	8.03E+03	50.00%	200.00	200.00	
[5.1]	End-Plate in Bending	305.79	339.36	1.20	366.95	7.50%	366.95	4.50%	432.69	6.01%	2.63E+06	1.05E+04	1.05E+04	50.00%	200.00	200.00	
[8.1]	Beam Web in Tension	365.68	483.23	1.20	438.82	7.50%	438.82	4.50%	517.44	6.01%	1.00E+12	1.00E+10	1.00E+10	50.00%	200.00	200.00	
[10.1]	Bolts in Tension	441.00	441.00	1.20	529.20	7.50%	529.20	4.50%	624.02	6.01%	1.63E+06	3.26E+04	3.26E+04	50.00%	3.00	3.00	
[1]	Column Web Panel in Shear	-474.77	-642.24	1.20	-569.72	7.50%	-569.72	4.50%	-671.80	6.01%	1.58E+06	4.37E+05	7.90E+04	50.00%	200.00	200.00	
[2]	Column Web in Transverse Compression	-507.06	-634.55	1.20	-608.47	7.50%	-608.47	4.50%	-717.49	6.01%	2.13E+06	5.41E+05	6.40E+04	50.00%	12.00	15.00	40%
[7]	Beam Flange in Compression	-438.00	-555.57	1.20	-525.60	7.50%	-525.60	4.50%	-619.77	6.01%	1.00E+12	1.00E+10	1.00E+10	50.00%	10.00	10.00	
[19]	Welds																

Case C2

	Components	Fy [kN]								ke [kN/m]	kp [kN/m]			Df			
		FYk nominal	real	Normal distribution			Binormal distribution				real	calibrated (109.005)	m	cv	j= Df/DY	m	cv
							a=0.75		a=0.25								
				x	m=x Fyk	v= 7.5%	m	cv	m	cv							
[3.1]	Column Web in Transverse Tension	445.36	602.45	1.20	534.43	7.50%	534.43	4.50%	630.18	6.01%	1.48E+06	1.48E+04	1.48E+04	50.00%	10.00	10.00	50%
[4.1]	Column Flange in Bending	375.48	408.32	1.20	450.58	7.50%	450.58	4.50%	531.30	6.01%	8.03E+06	8.03E+03	8.03E+03	50.00%	200.00	200.00	
[5.1]	End-Plate in Bending	305.79	339.36	1.20	366.95	7.50%	366.95	4.50%	432.69	6.01%	2.63E+06	1.05E+04	1.05E+04	50.00%	200.00	200.00	
[8.1]	Beam Web in Tension	365.68	483.23	1.20	438.82	7.50%	438.82	4.50%	517.44	6.01%	1.00E+12	1.00E+10	1.00E+10	50.00%	200.00	200.00	
[10.1]	Bolts in Tension	441.00	441.00	1.20	529.20	7.50%	529.20	4.50%	624.02	6.01%	1.63E+06	3.26E+04	3.26E+04	50.00%	3.00	3.00	
[1]	Column Web Panel in Shear	-474.77	-642.24	1.20	-569.72	7.50%	-569.72	4.50%	-671.80	6.01%	1.58E+06	6.46E+05	7.90E+04	50.00%	200.00	200.00	
[2]	Column Web in Transverse Compression	-507.06	-634.55	1.20	-608.47	7.50%	-608.47	4.50%	-717.49	6.01%	2.13E+06	7.51E+05	6.40E+04	50.00%	12.00	15.00	
[7]	Beam Flange in Compression	-438.00	-555.57	1.20	-525.60	7.50%	-525.60	4.50%	-619.77	6.01%	1.00E+12	1.00E+10	1.00E+10	50.00%	10.00	10.00	
[19]	Welds																

Case C3

	Components	Fy [kN]								ke [kN/m]	kp [kN/m]			Df			
		FYk nominal	real	Normal distribution			Binormal distribution				real	calibrated (109.005)	m	cv	j= Df/DY	m	cv
				x	m=x Fyk	v= 7.5%	a=0.75		a=0.25								
							m	cv	m	cv							
[3.1]	Column Web in Transverse Tension	445.36	602.45	1.20	534.43	7.50%	534.43	4.50%	630.18	6.01%	1.48E+06	1.48E+04	1.48E+04	50.00%	10.00	10.00	50%
[4.1]	Column Flange in Bending	375.48	408.32	1.20	450.58	7.50%	450.58	4.50%	531.30	6.01%	8.03E+06	8.03E+03	8.03E+03	50.00%	200.00	200.00	50%
[5.1]	End-Plate in Bending	305.79	339.36	1.20	366.95	7.50%	366.95	4.50%	432.69	6.01%	2.63E+06	1.05E+04	1.05E+04	50.00%	200.00	200.00	
[8.1]	Beam Web in Tension	365.68	483.23	1.20	438.82	7.50%	438.82	4.50%	517.44	6.01%	1.00E+12	1.00E+10	1.00E+10	50.00%	200.00	200.00	
[10.1]	Bolts in Tension	441.00	441.00	1.20	529.20	7.50%	529.20	4.50%	624.02	6.01%	1.63E+06	3.26E+04	3.26E+04	50.00%	3.00	3.00	
[1]	Column Web Panel in Shear	-474.77	-642.24	1.20	-569.72	7.50%	-569.72	4.50%	-671.80	6.01%	1.58E+06	6.46E+05	7.90E+04	50.00%	200.00	200.00	
[2]	Column Web in Transverse Compression	-507.06	-634.55	1.20	-608.47	7.50%	-608.47	4.50%	-717.49	6.01%	2.13E+06	7.51E+05	6.40E+04	50.00%	12.00	15.00	
[7]	Beam Flange in Compression	-438.00	-555.57	1.20	-525.60	7.50%	-525.60	4.50%	-619.77	6.01%	1.00E+12	1.00E+10	1.00E+10	50.00%	10.00	10.00	
[19]	Welds																

1.2.2 Case A – Variability of Kp of the components

1.2.2.1 A.1) real F^Y (125.000 Combinations) (Component [3], [4], [5])

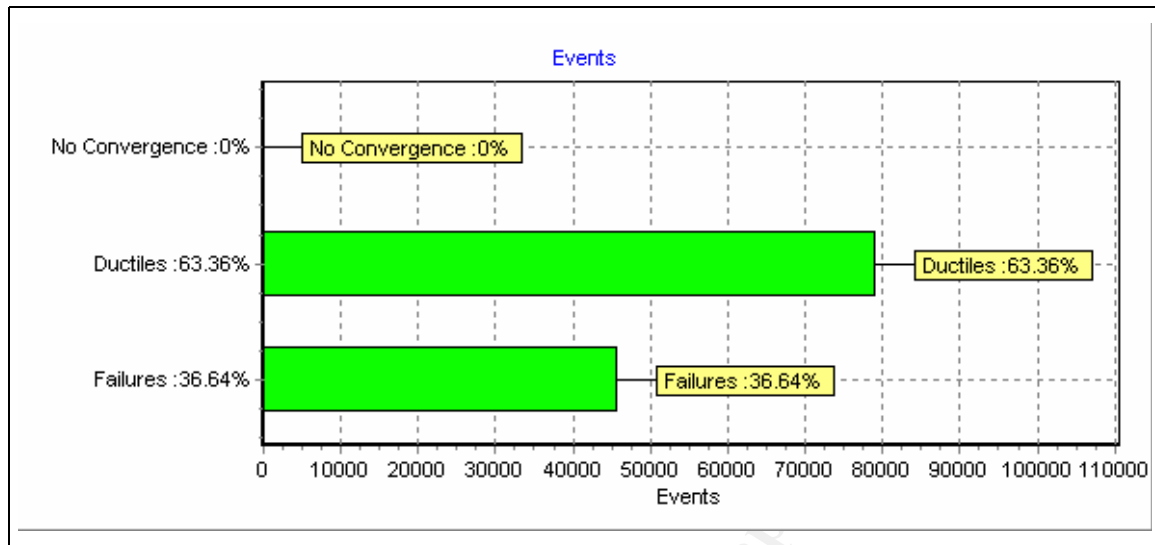


Figure 86 – Calculation summary – Case A.1

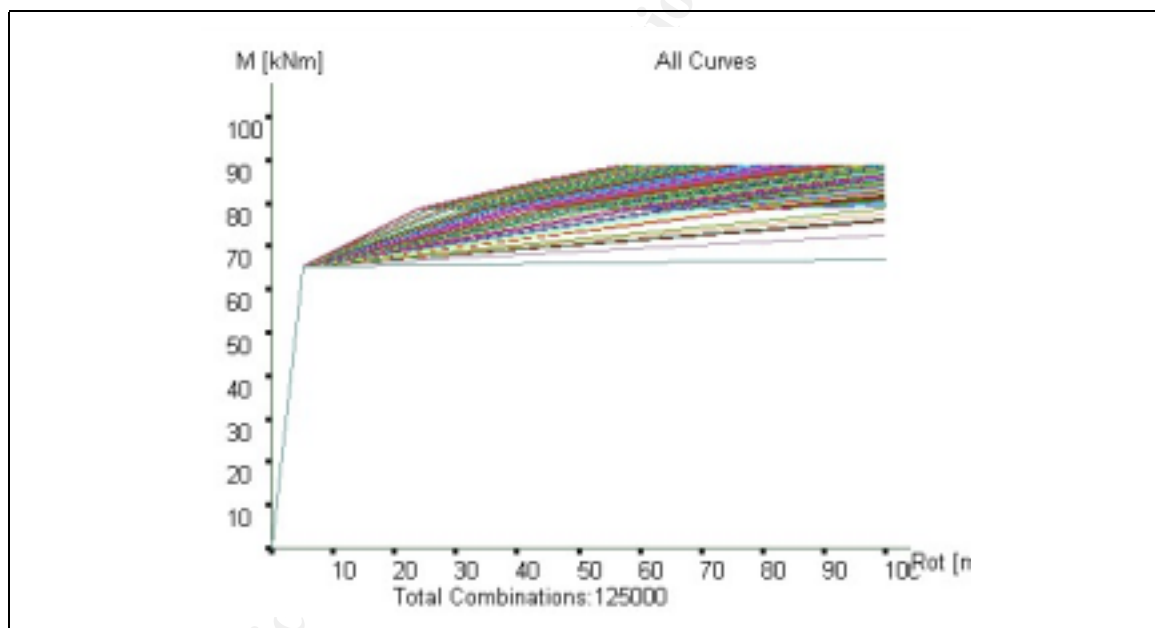


Figure 87 – All curves.

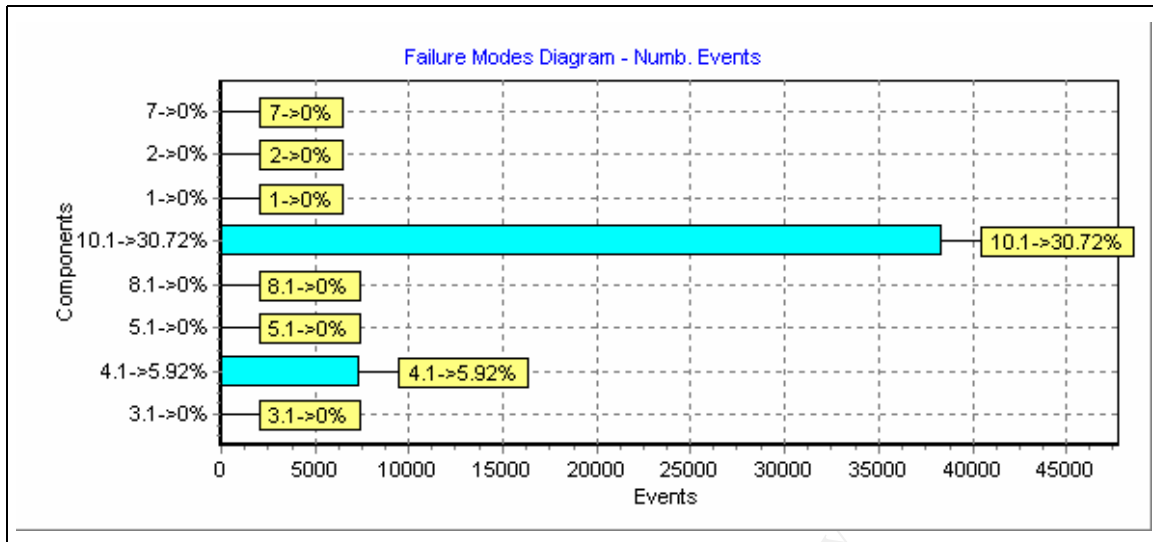


Figure 88 – Failure modes counter

4.1 : 7400
10.1 : 38400

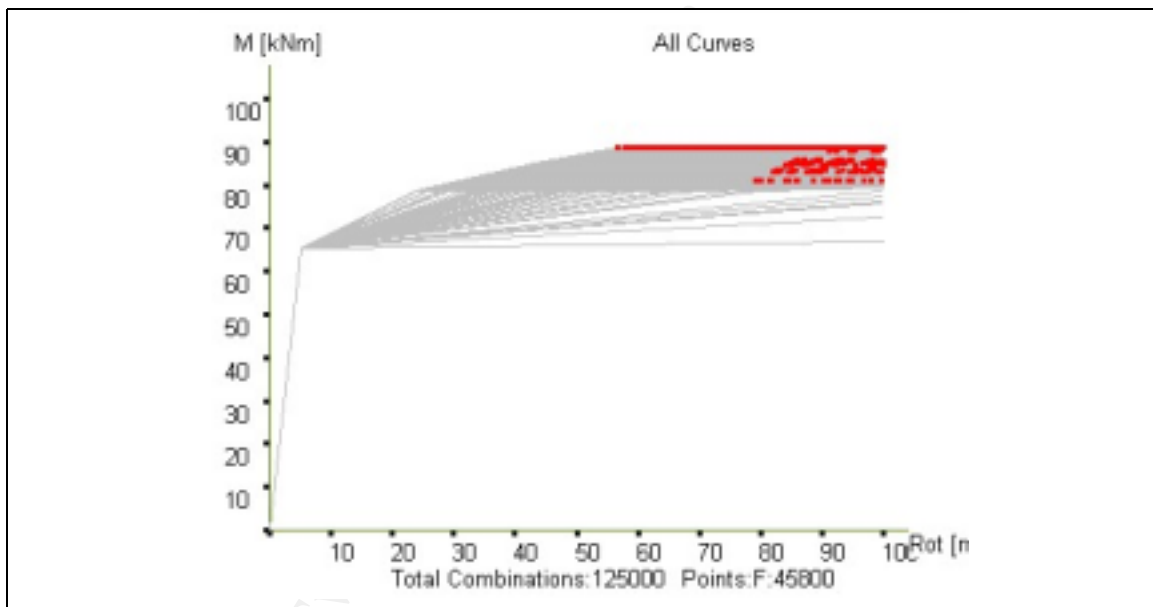


Figure 89 – All failures.

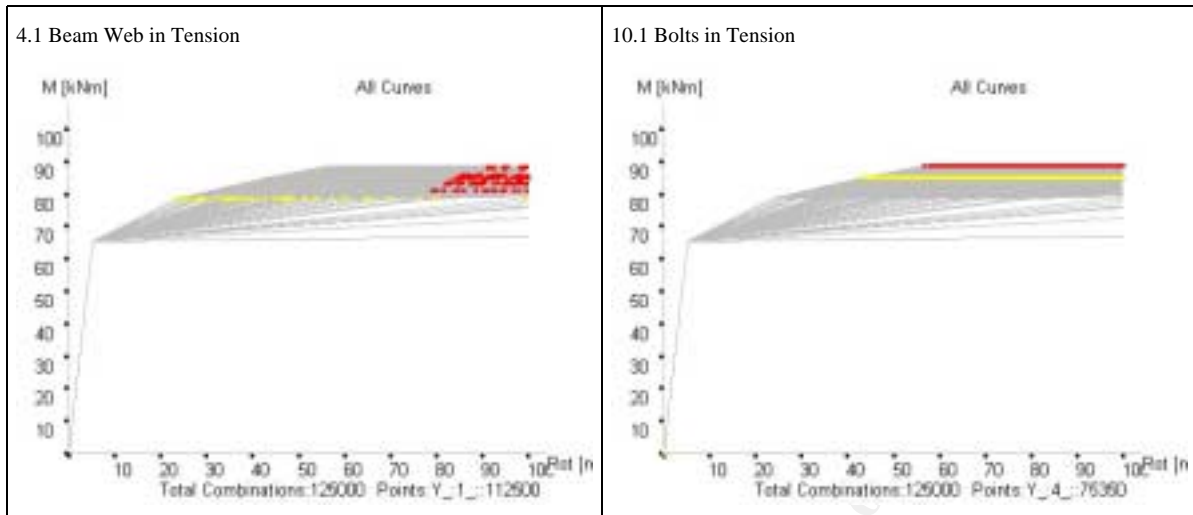


Figure 90 – Failures by component

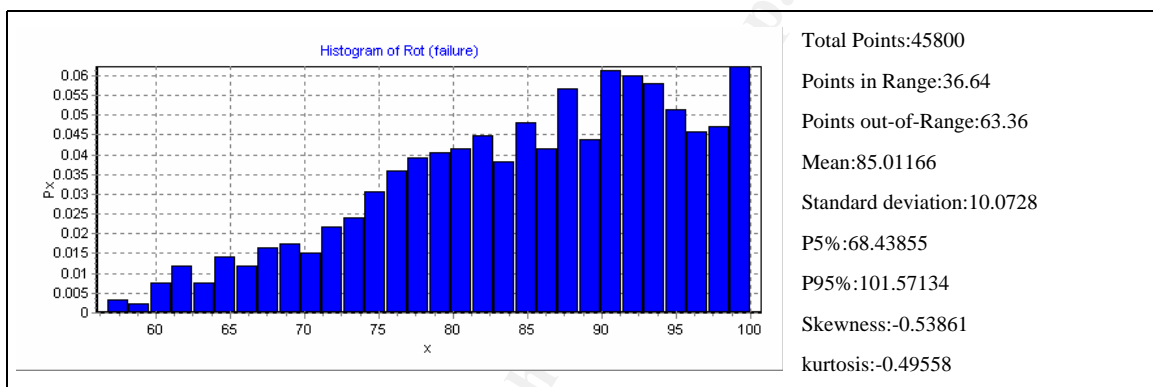


Figure 91 – Histogram of rotation at failure.

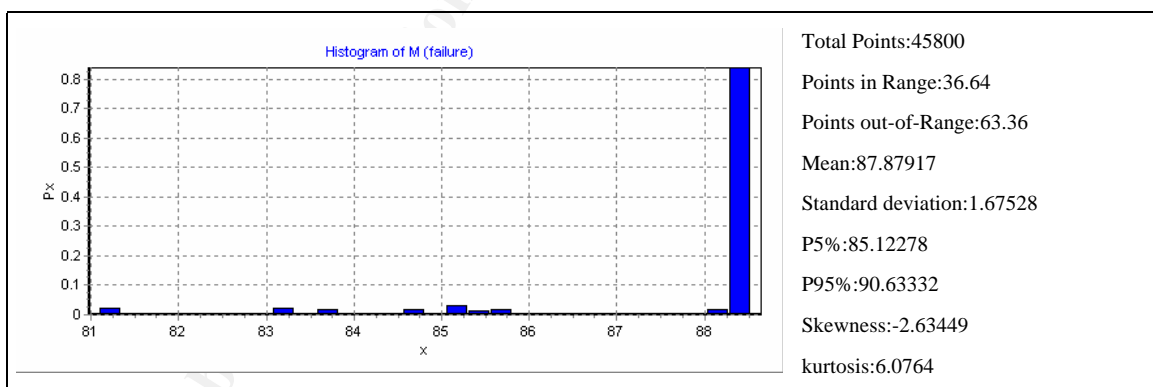
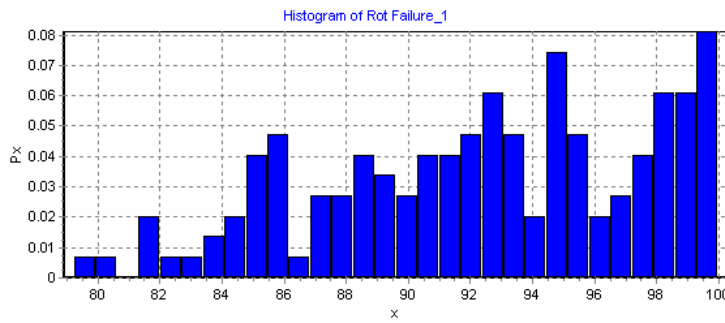
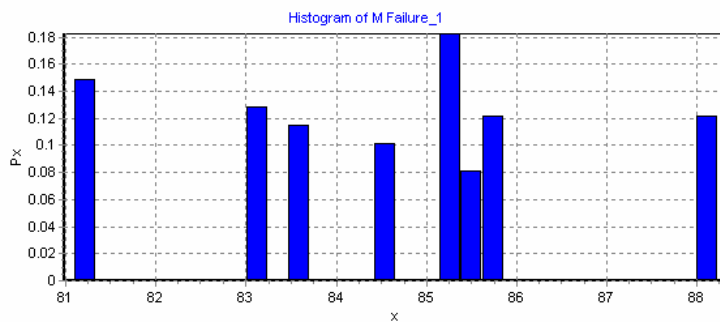


Figure 92 – Histogram of bending moment at failure.

Histograms for failures of component 4.1

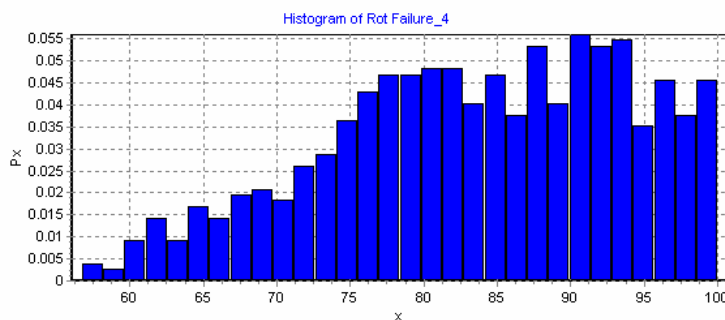


Total Points:7400
 Points in Range:5.92
 Points out-of-Range:94.08
 Mean:92.39702
 Standard deviation:5.19165
 P5%:83.85503
 P95%:100.93209
 Skewness:-0.36542
 kurtosis:-0.78865

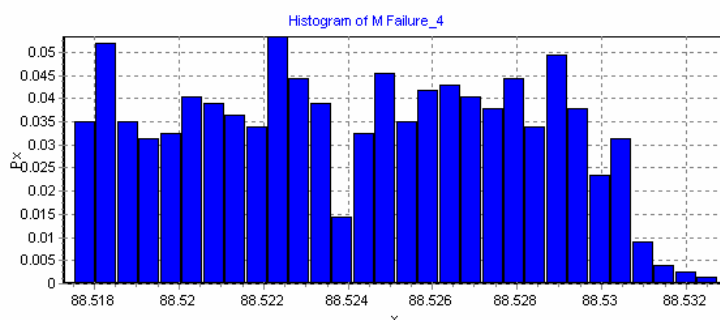


Total Points:7400
 Points in Range:5.92
 Points out-of-Range:94.08
 Mean:84.53207
 Standard deviation:2.00208
 P5%:81.23798
 P95%:87.8235
 Skewness:-0.03924
 kurtosis:-0.35741

Histograms for failures of component 10.1



Total Points:38400
 Points in Range:30.72
 Points out-of-Range:69.28
 Mean:83.58844
 Standard deviation:10.16286
 P5%:66.86714
 P95%:100.29618
 Skewness:-0.3768
 kurtosis:-0.66137



Total Points:38400
 Points in Range:30.72
 Points out-of-Range:69.28
 Mean:88.52419
 Standard deviation:0.00385
 P5%:88.51784
 P95%:88.53052
 Skewness:0.00021
 kurtosis:-1.16797

Figure 93 – Histograms of rotations and bending moments at failure by responsible component.

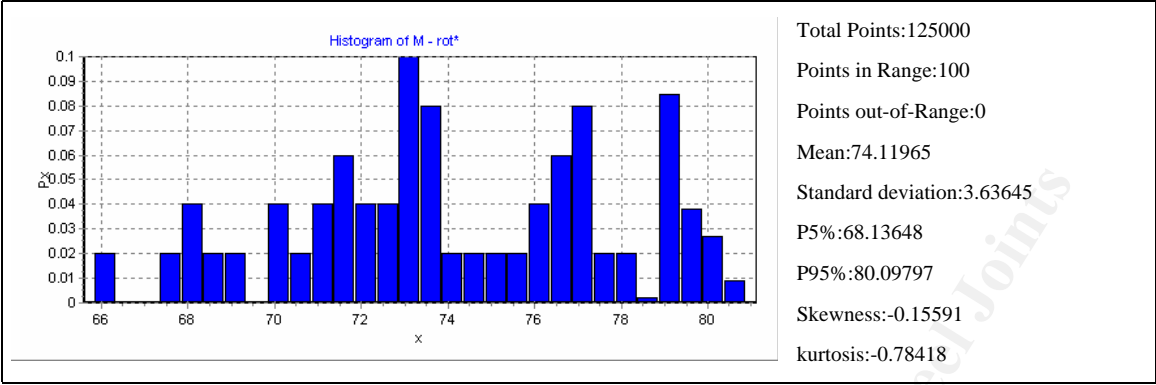


Figure 94 – Histogram for rotation=30 mrad

1.2.2.2 A.2) real F^Y (160.000 Combinations) (Component [3], [4], [5], [1])

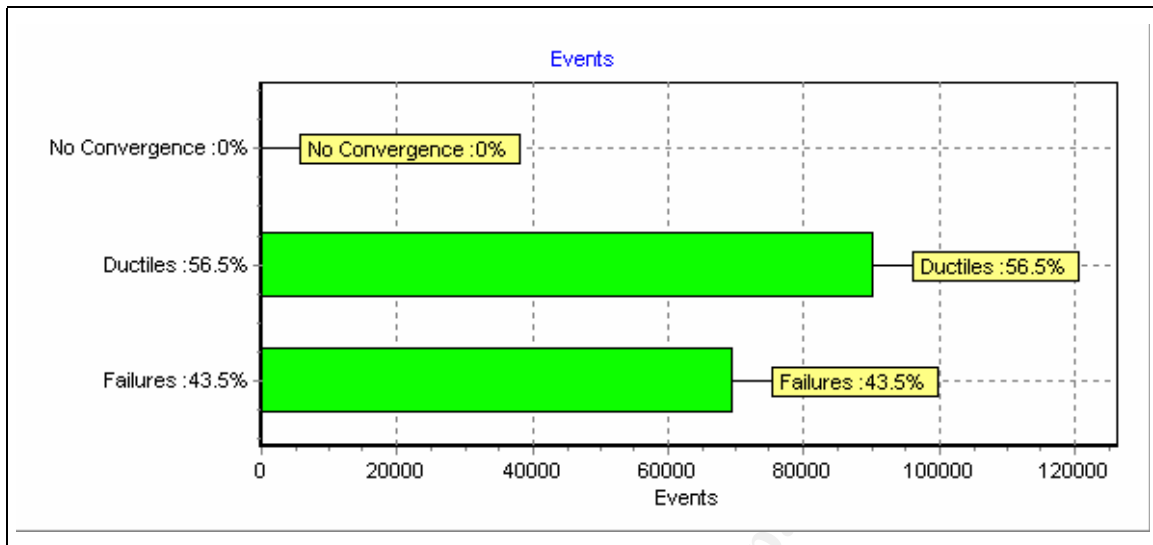


Figure 95 – Calculation summary.

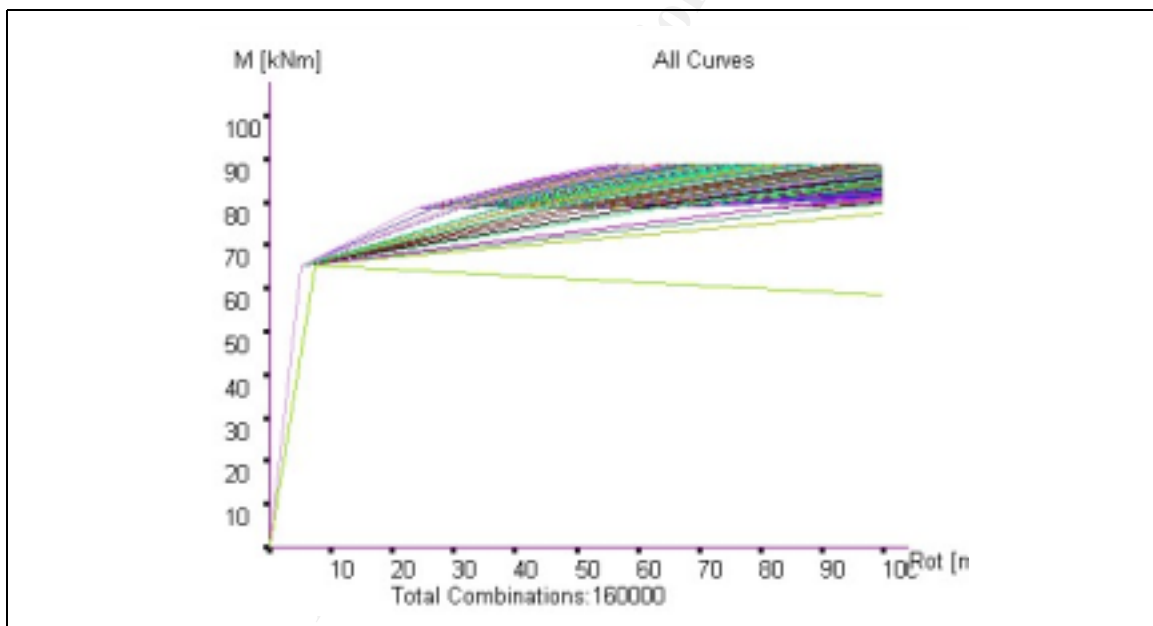


Figure 96 – All curves.

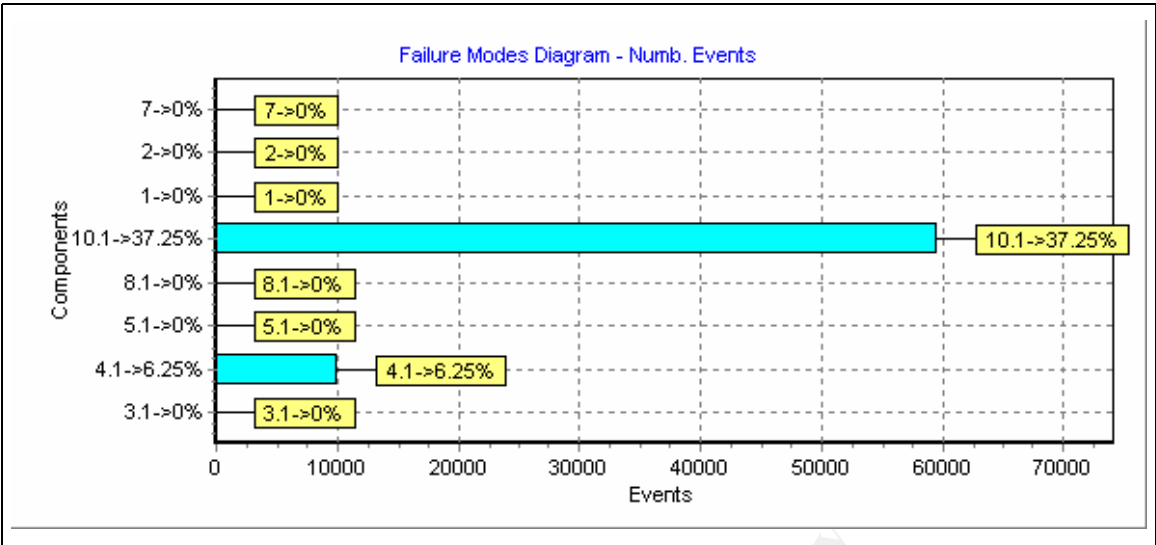


Figure 97 – Failure modes counter

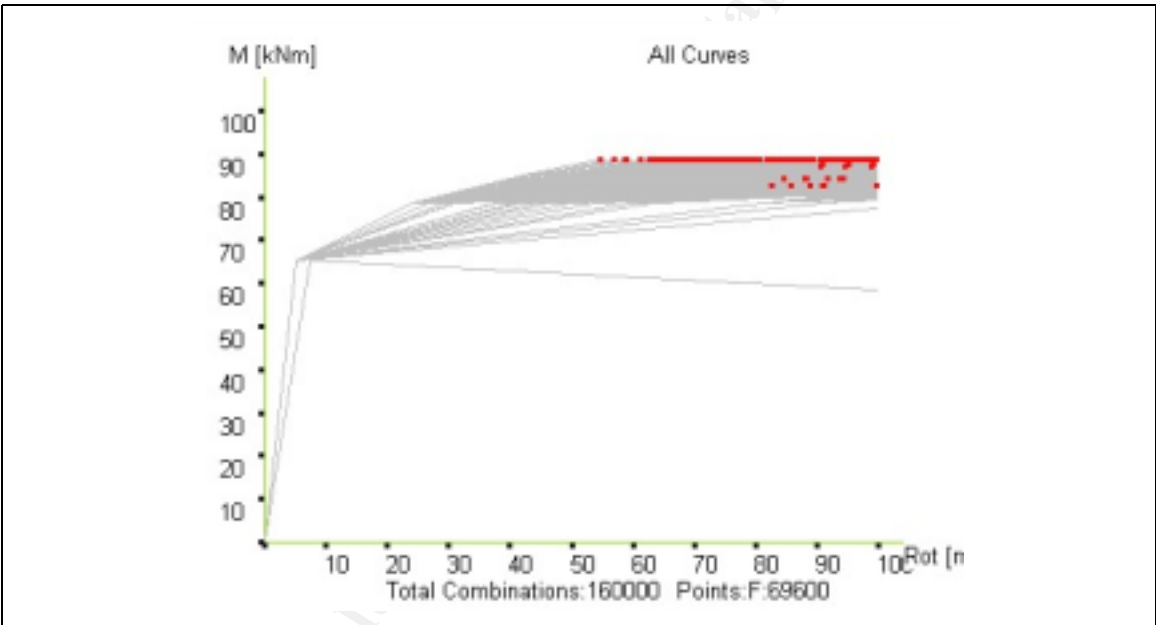


Figure 98 – All failures.

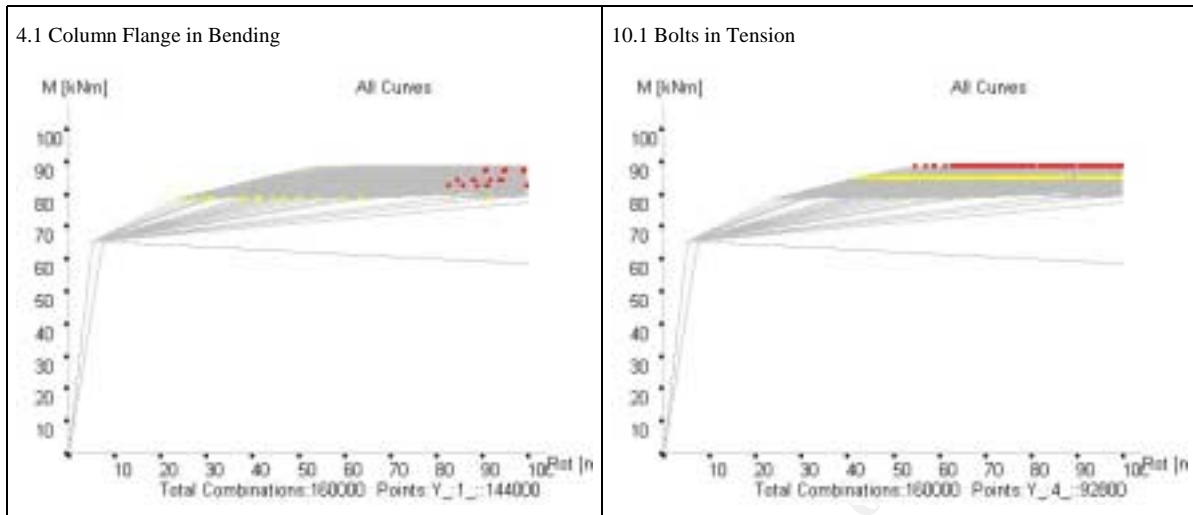


Figure 99 – Failures by component

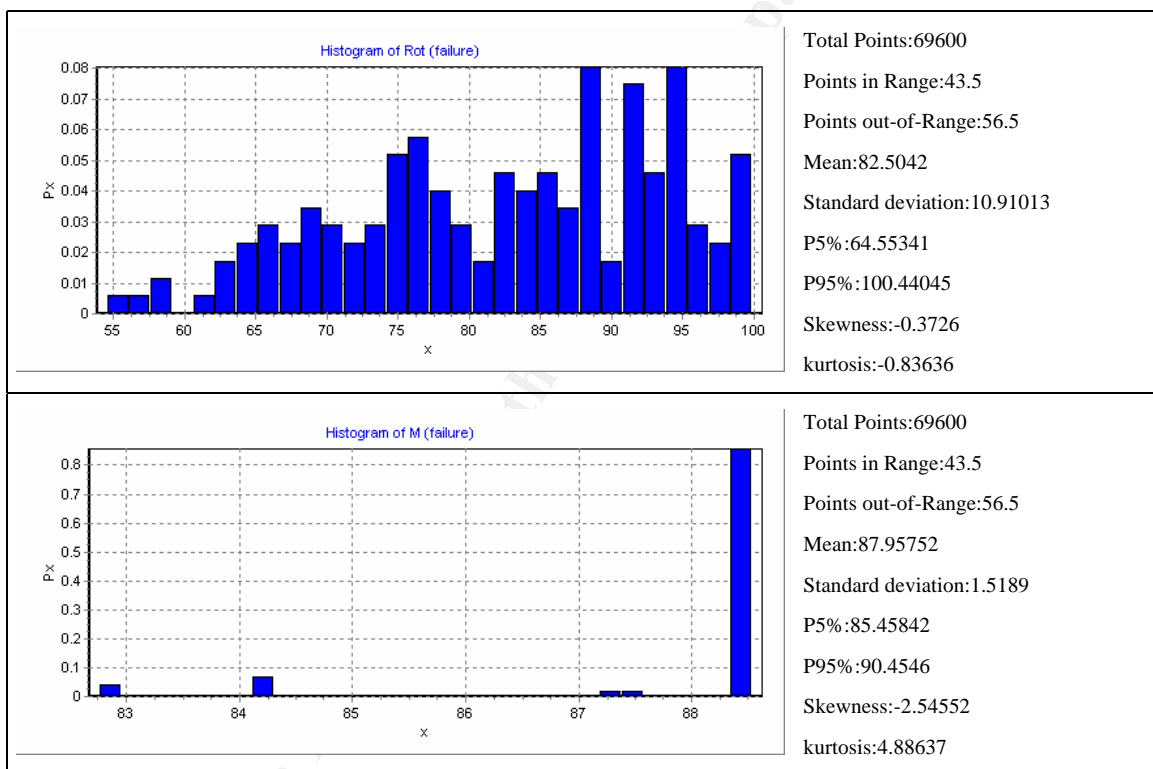


Figure 100 - Histograms of rotations and bending moments at failure.

Histograms for failures of component 4.1

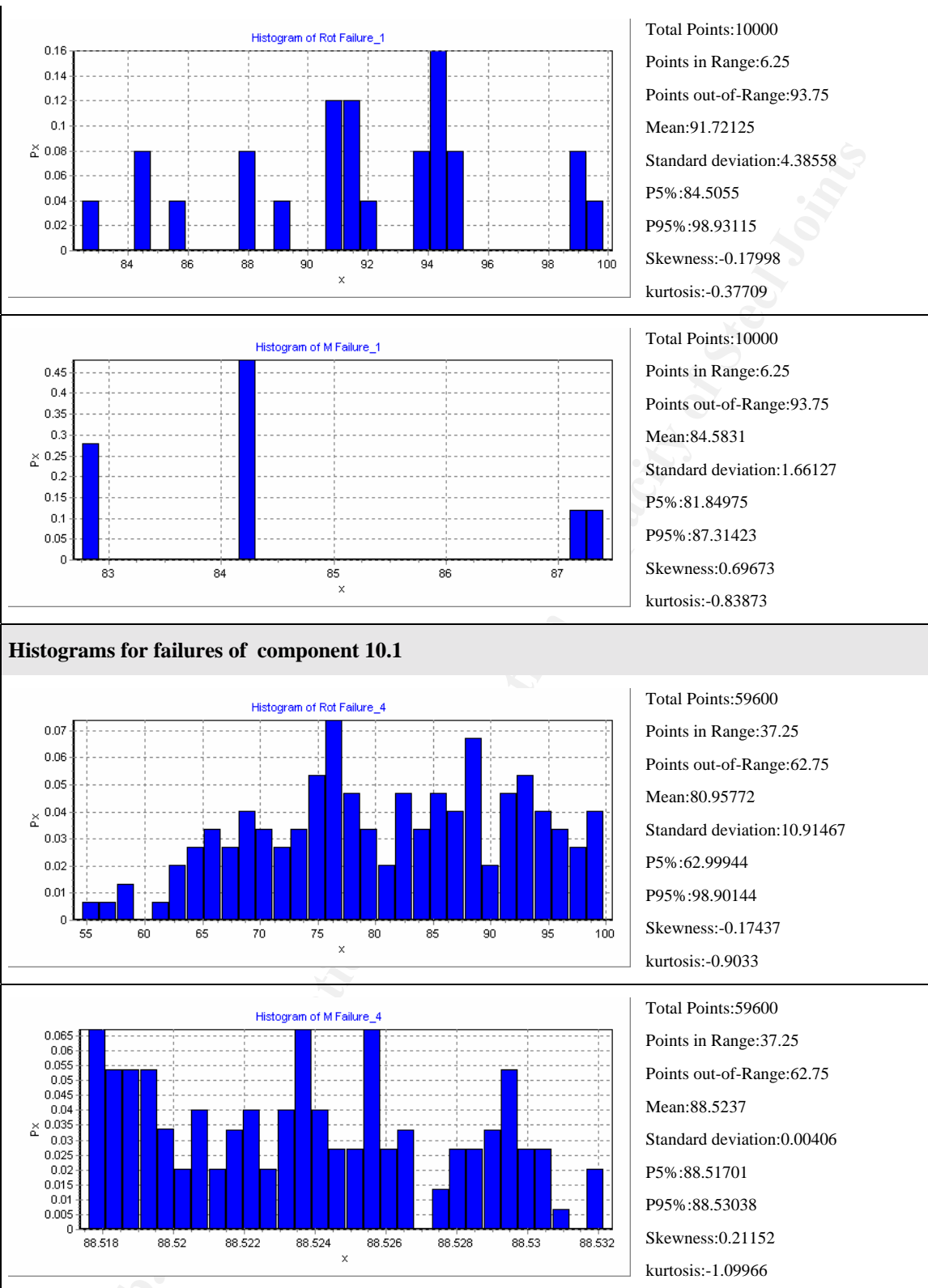


Figure 101 – Histograms of rotations and bending moments at failure by responsible component.

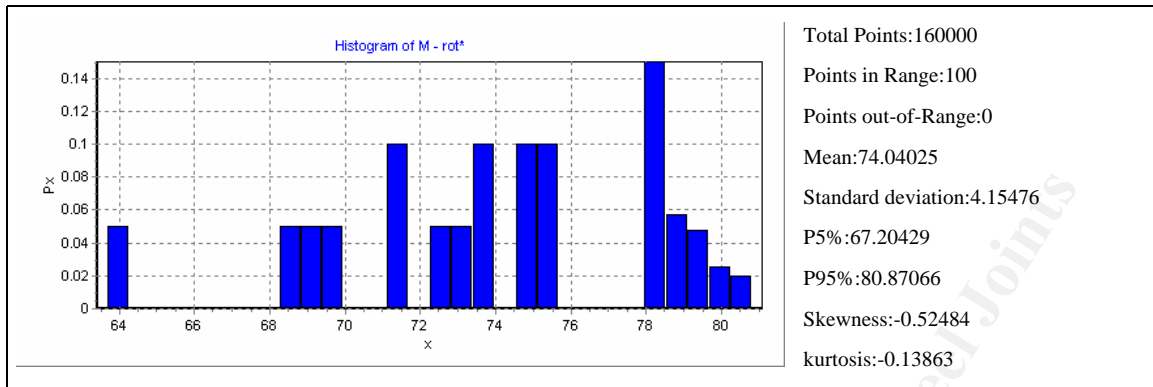


Figure 102 – Histogram for rotation=30 mrad

1.2.2.3 A.3) nominal F^Y (8.000 Combinations) (Component [3], [4], [5])

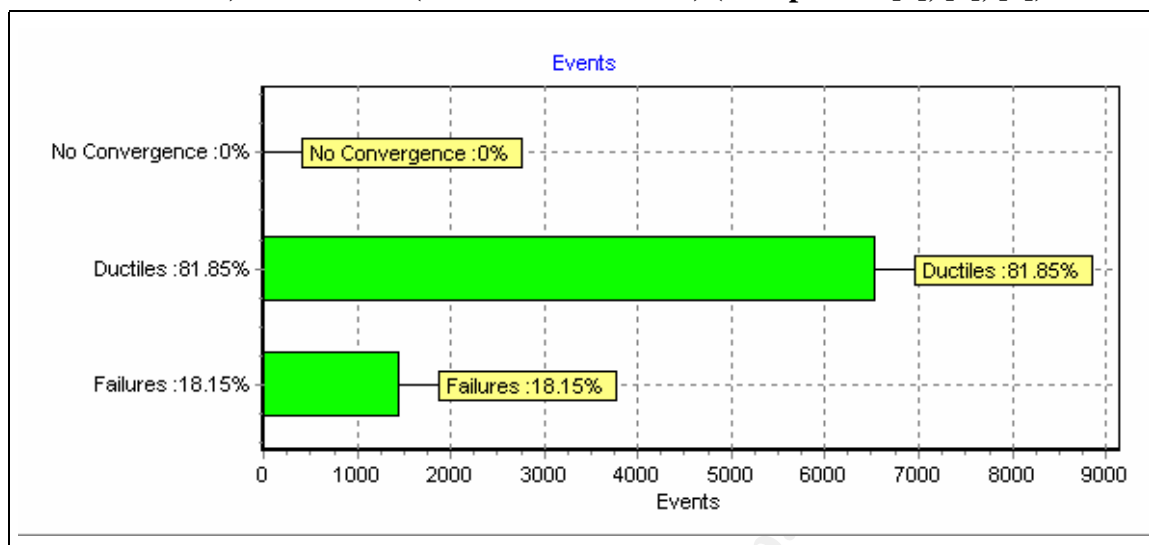


Figure 103 – Calculation summary.

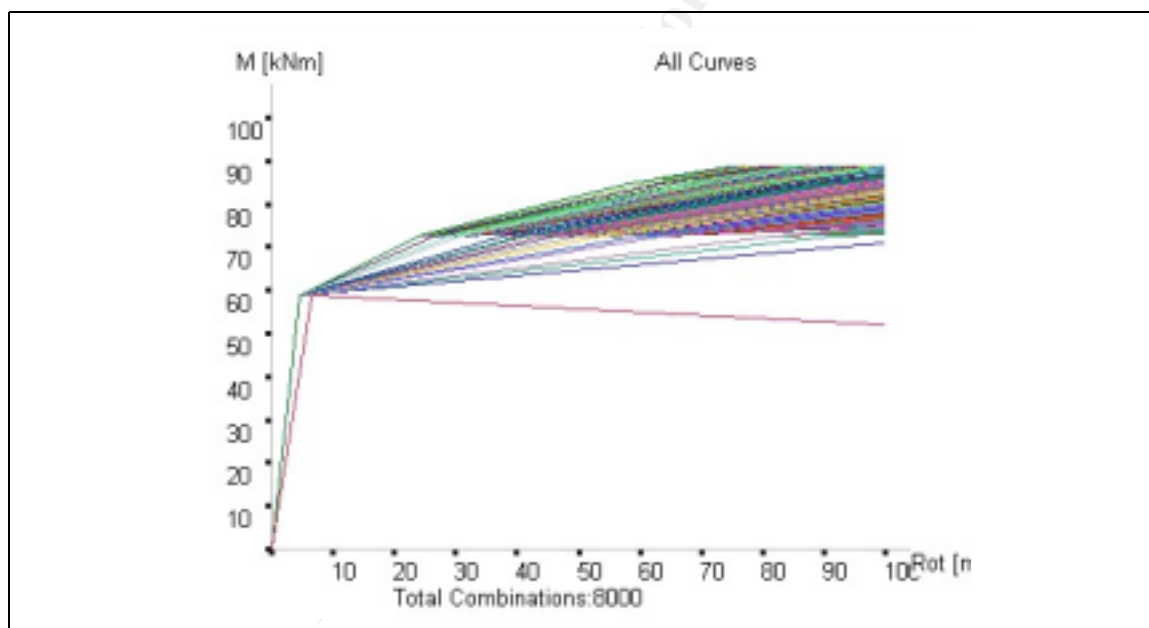


Figure 104 – All curves.

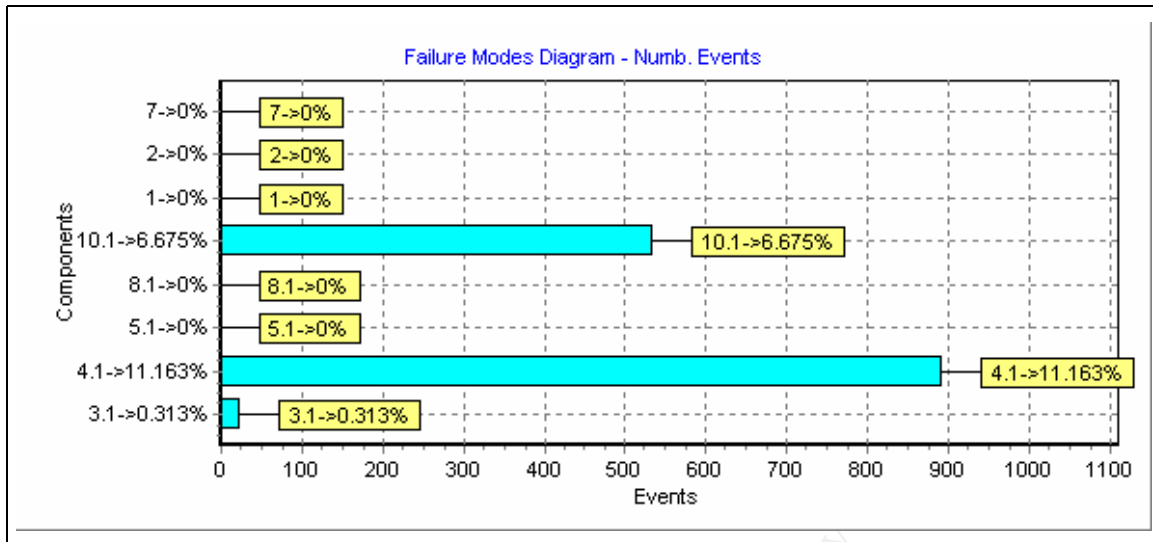


Figure 105 – Failure modes counter

3.1 : 25
4.1 : 893
10.1 : 534

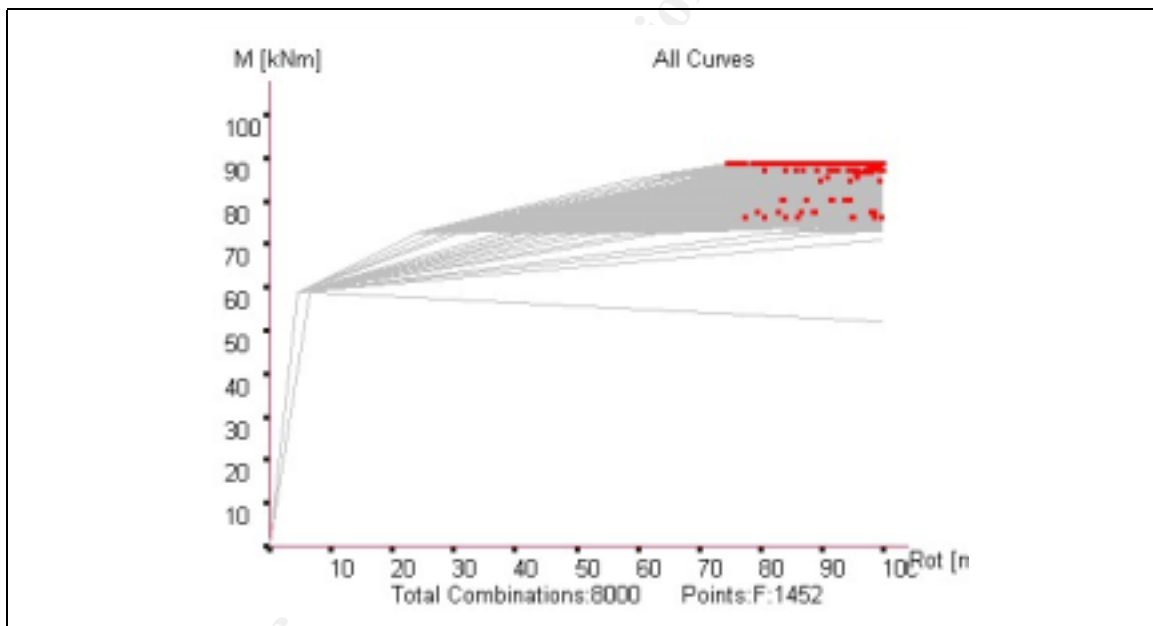


Figure 106 – All failures.

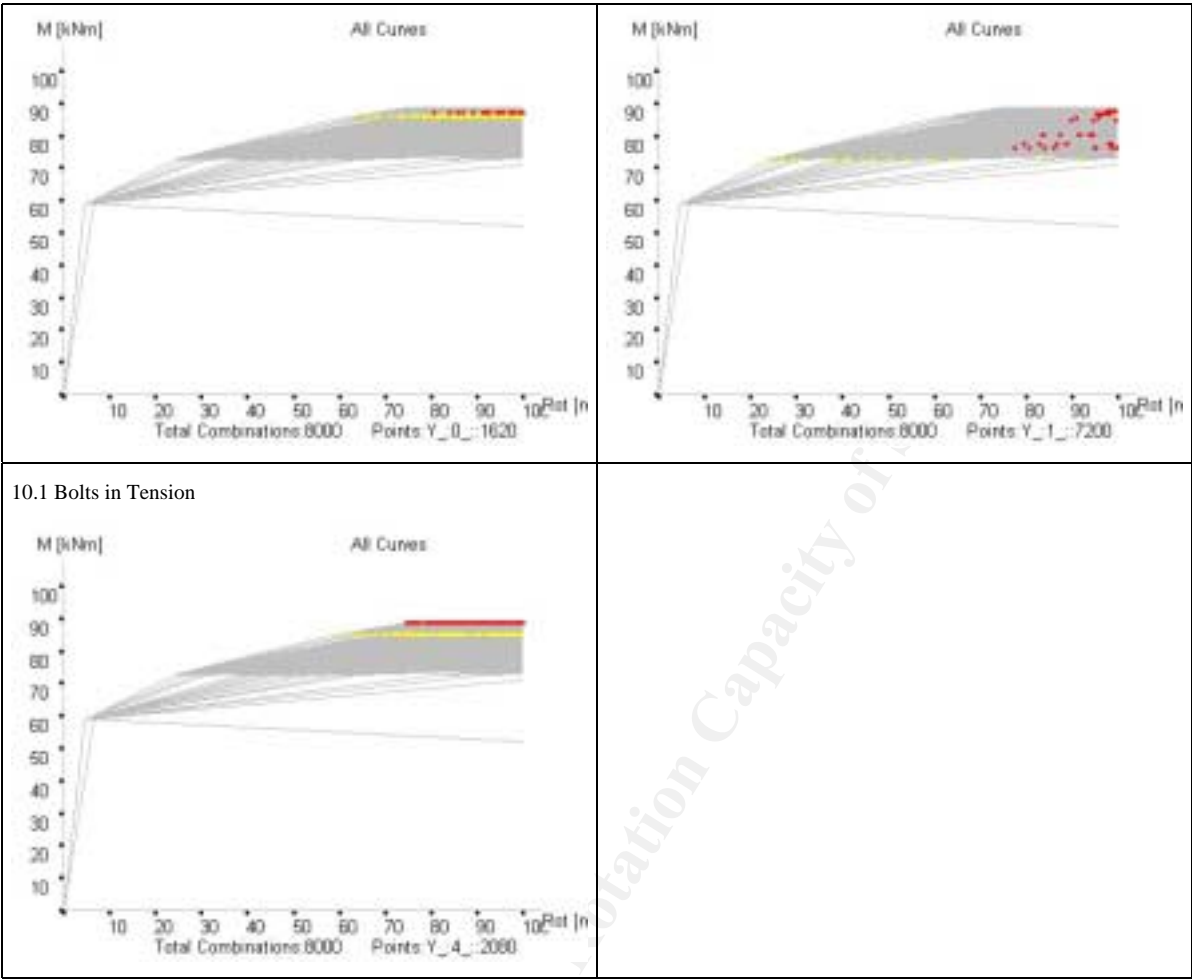


Figure 107 – Failures by component

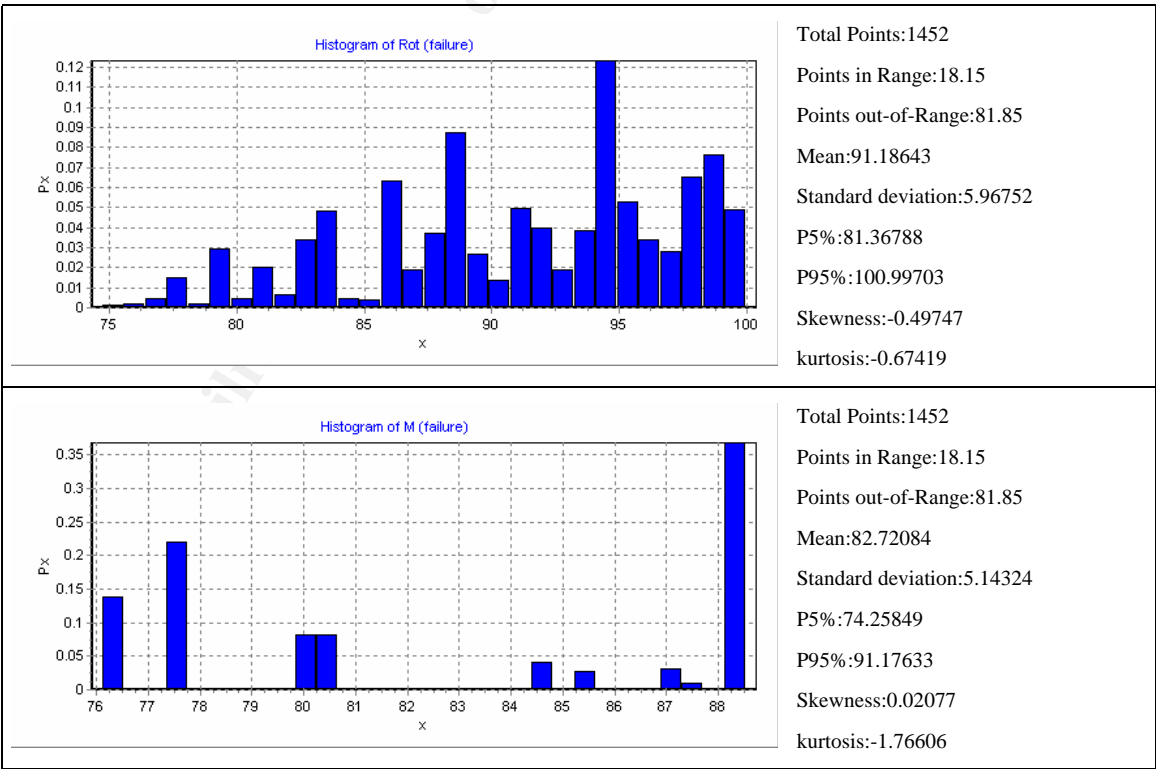
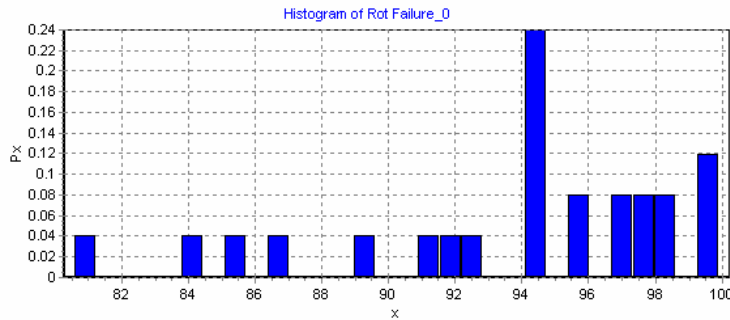
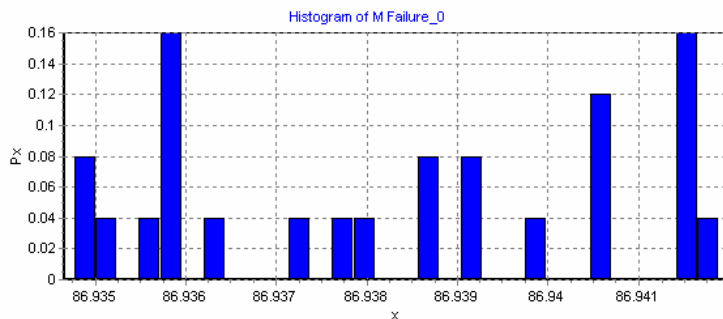


Figure 108 - Histograms of rotations and bending moments at failure.

Histograms for failures of component 3.1

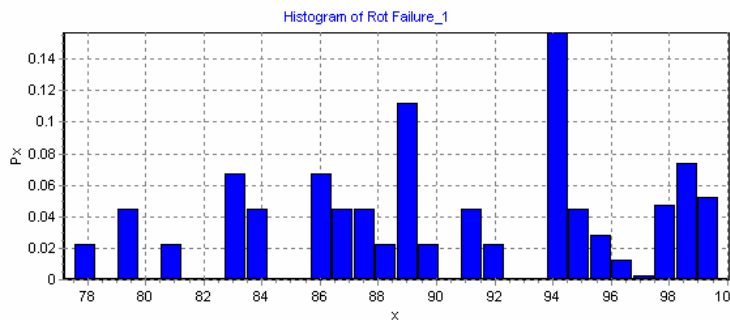


Total Points:25
 Points in Range:0.31
 Points out-of-Range:99.69
 Mean:93.8277
 Standard deviation:5.10224
 P5%:85.43281
 P95%:102.21578
 Skewness:-0.99288
 kurtosis:0.09035

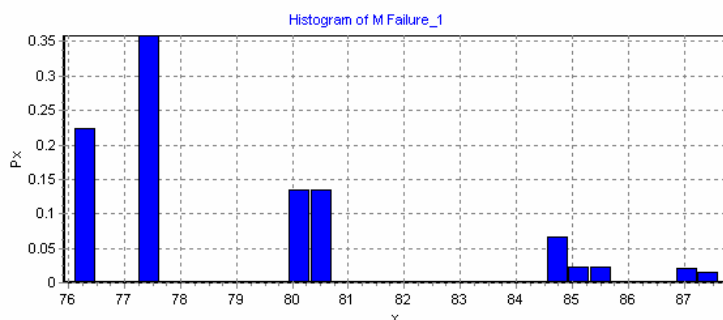


Total Points:25
 Points in Range:0.31
 Points out-of-Range:99.69
 Mean:86.93835
 Standard deviation:0.00246
 P5%:86.9343
 P95%:86.94239
 Skewness:0.00464
 kurtosis:-1.58576

Histograms for failures of component 4.1



Total Points:893
 Points in Range:11.16
 Points out-of-Range:88.84
 Mean:90.34977
 Standard deviation:5.99641
 P5%:80.48369
 P95%:100.20786
 Skewness:-0.21401
 kurtosis:-0.93042



Total Points:893
 Points in Range:11.16
 Points out-of-Range:88.84
 Mean:79.13263
 Standard deviation:3.07933
 P5%:74.0661
 P95%:84.19504
 Skewness:1.15737
 kurtosis:0.38706

Histograms for failures of component 10.1

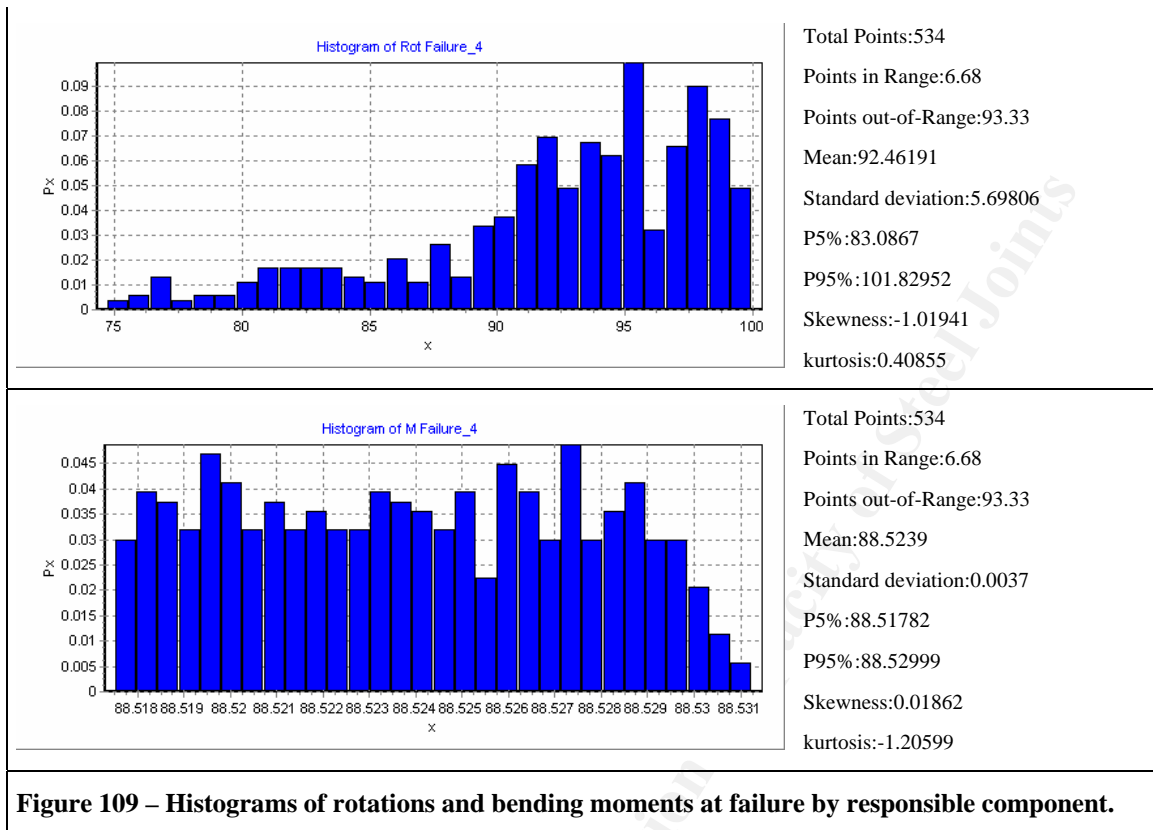


Figure 109 – Histograms of rotations and bending moments at failure by responsible component.

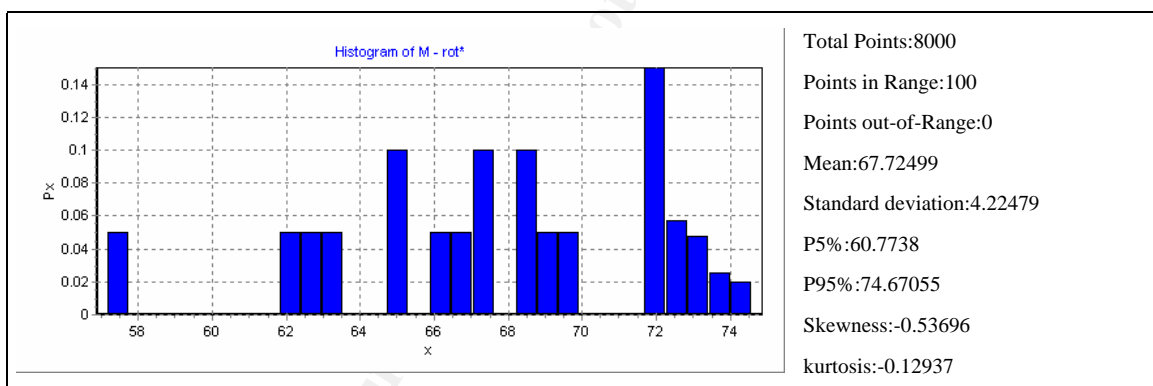


Figure 110 – Histogram for rotation=30 mrad

1.2.2.4 A.3b) nominal F^Y (125.000 Combinations) (Component [3], [4], [5])

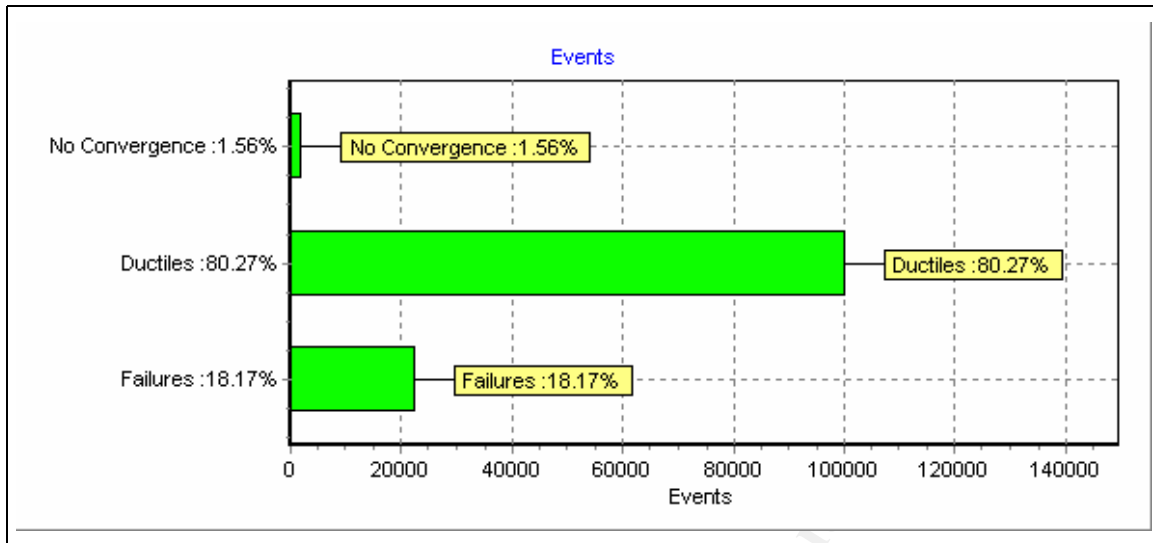


Figure 111 – Calculation summary.

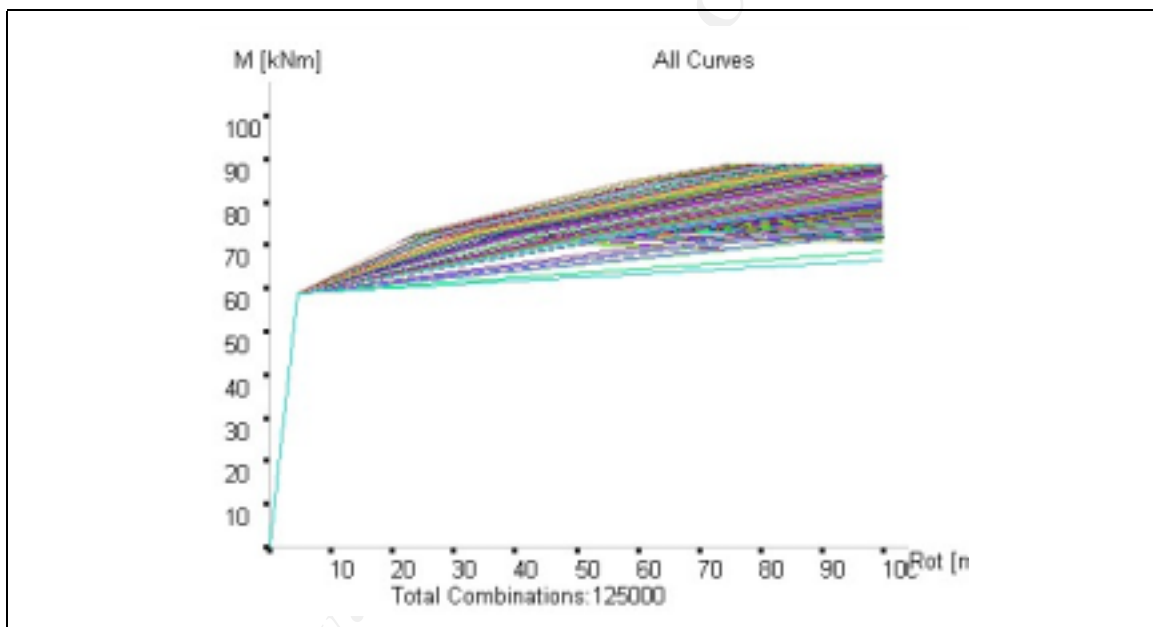


Figure 112 – All curves.

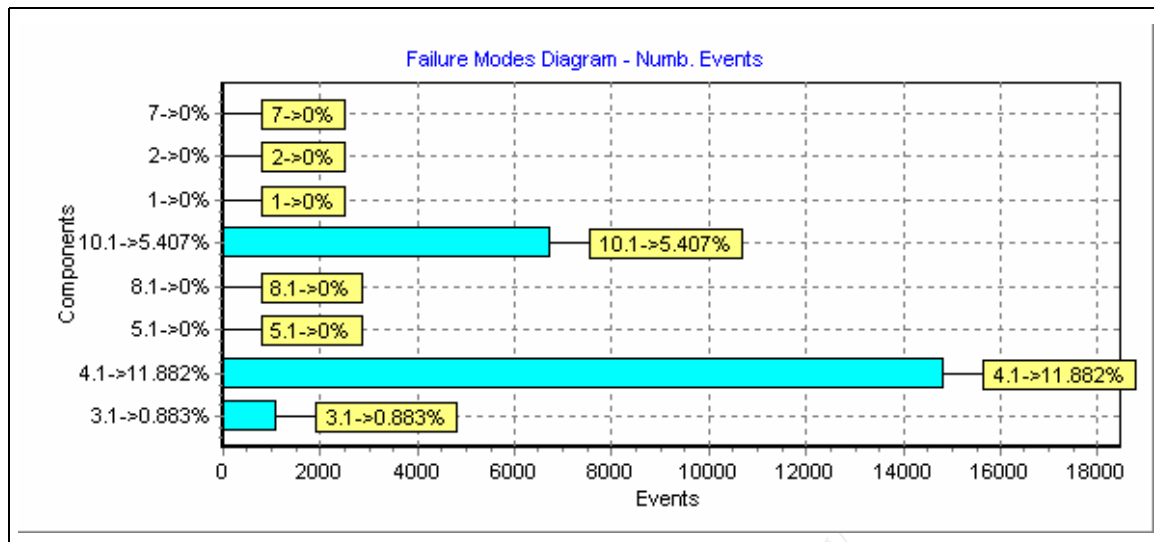


Figure 113 – Failure modes counter

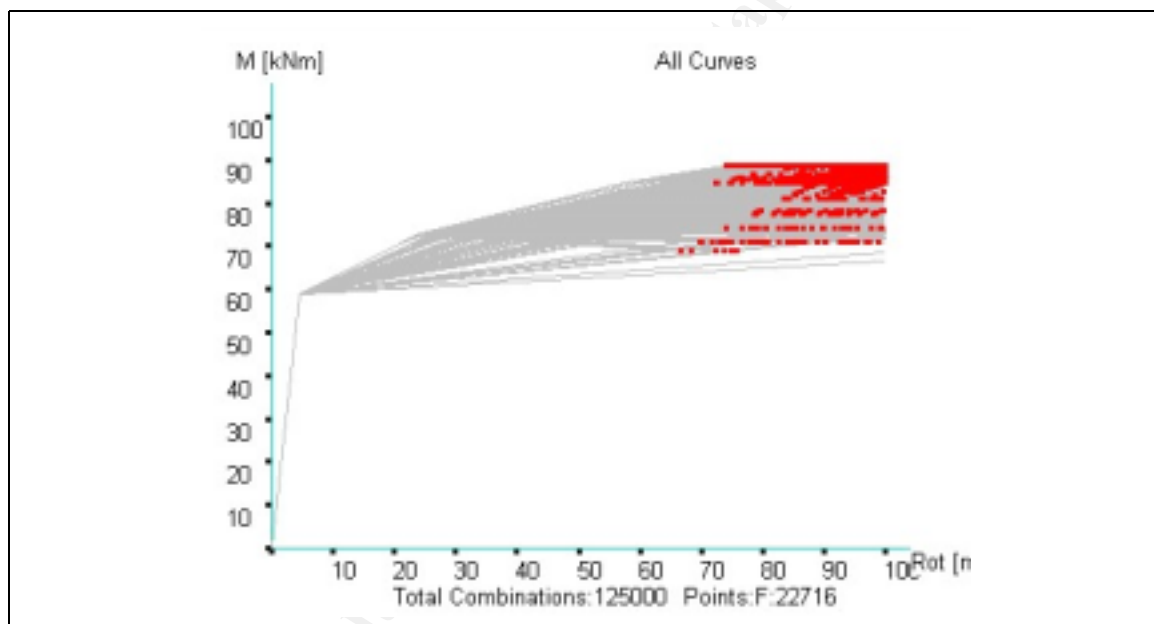


Figure 114 – All failures.

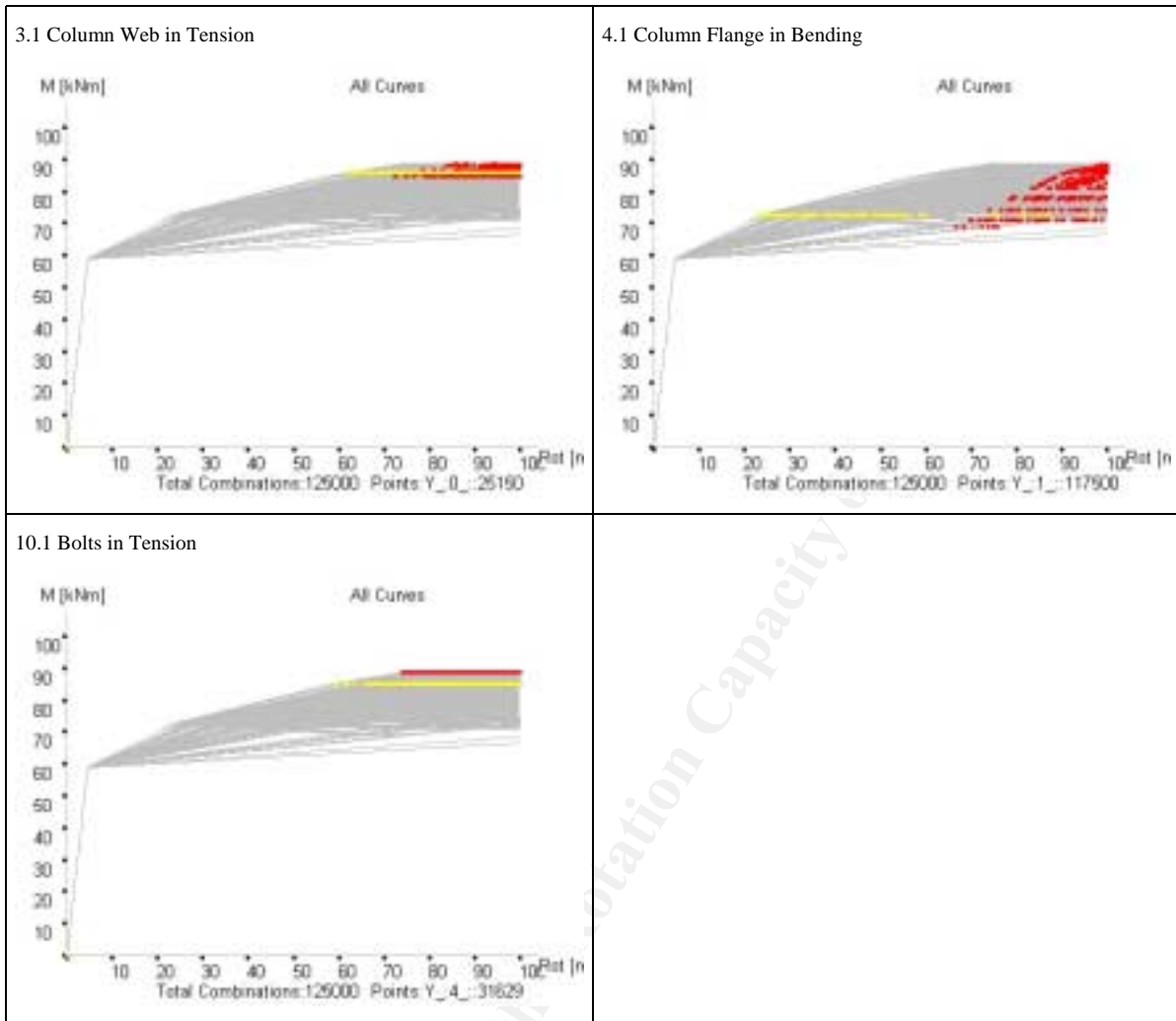
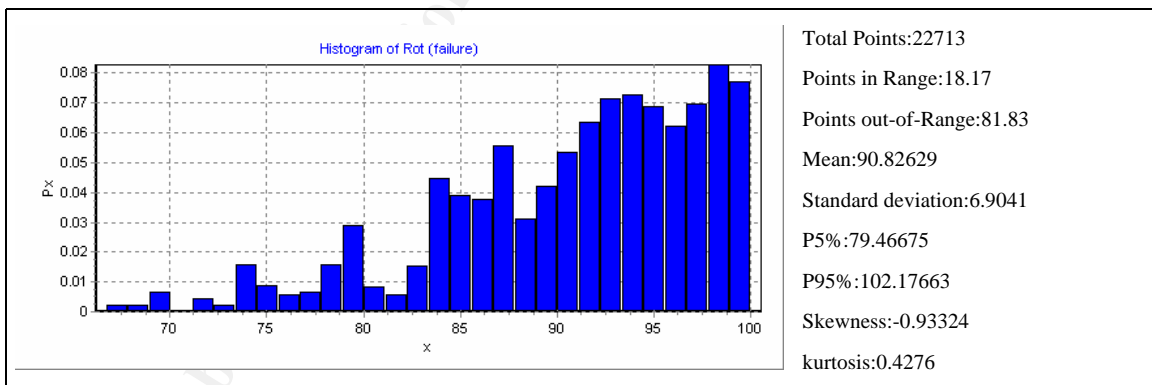


Figure 115 – Failures by component



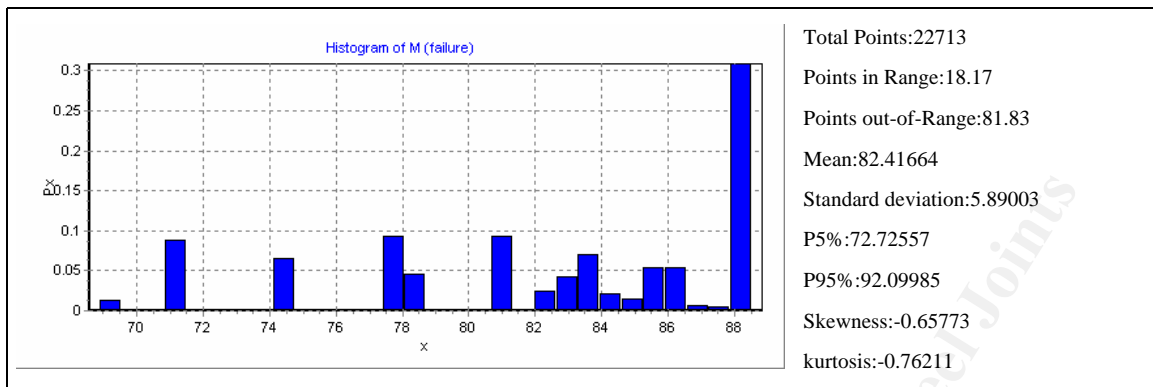
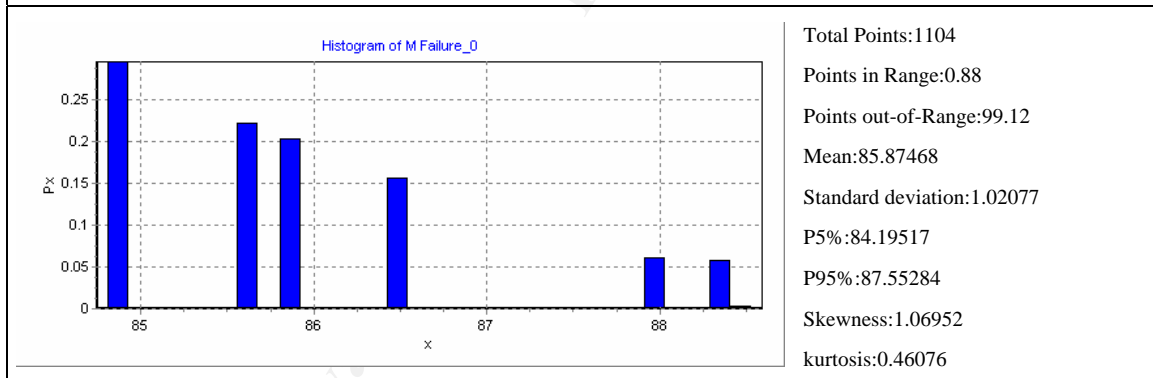
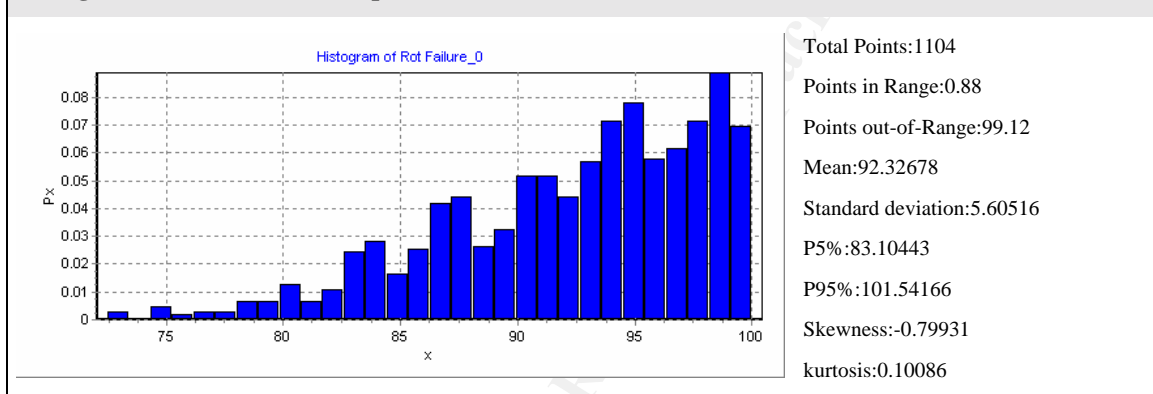
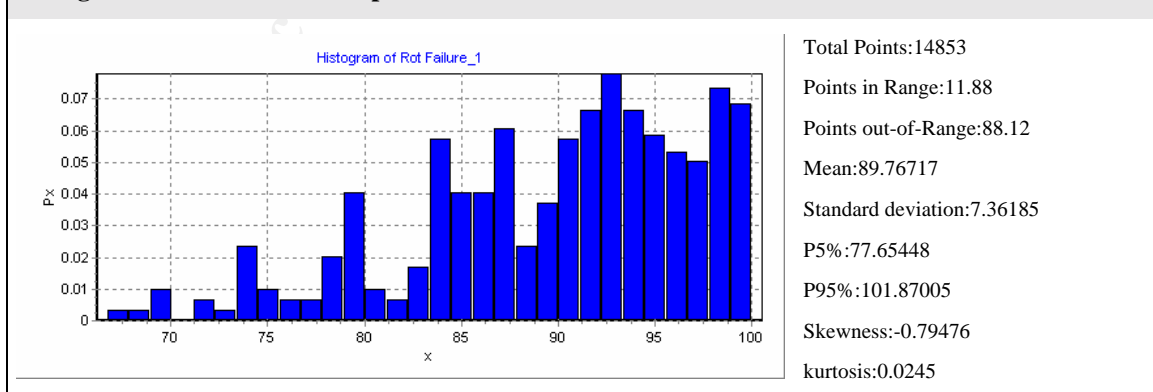


Figure 116 - Histograms of rotations and bending moments at failure.

Histograms for failures of component 3.1



Histograms for failures of component 4.1



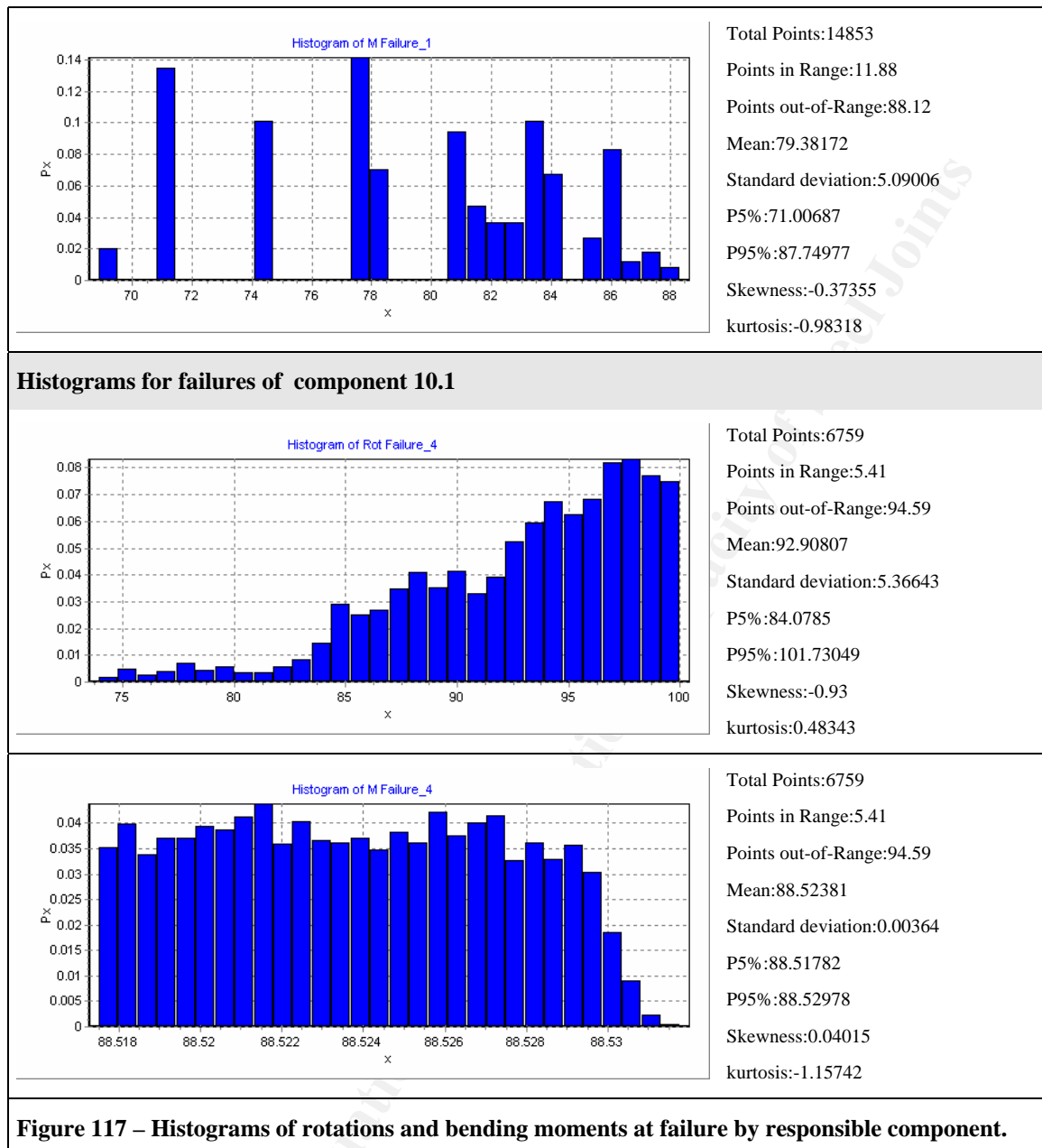


Figure 117 – Histograms of rotations and bending moments at failure by responsible component.

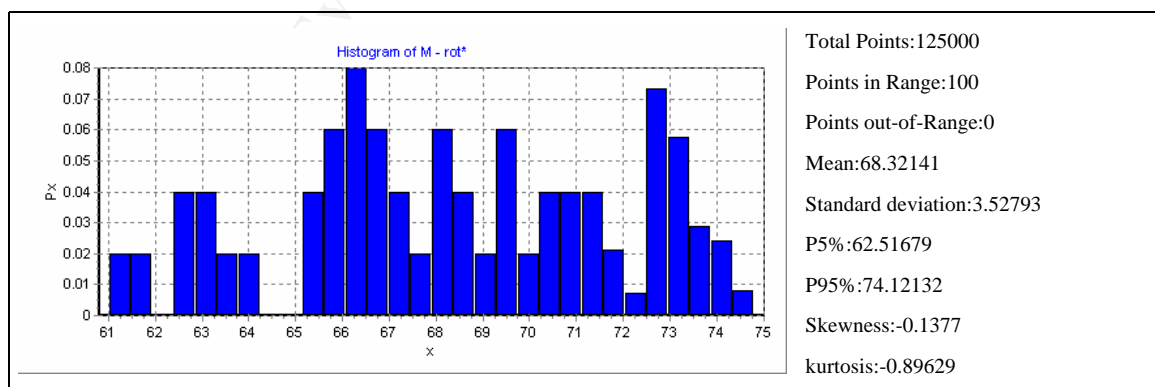


Figure 118 – Histogram for rotation=30 mrad

1.2.2.5 A.3c) nominal F^Y (8.000 Combinations) (Component [3], [4], [5])

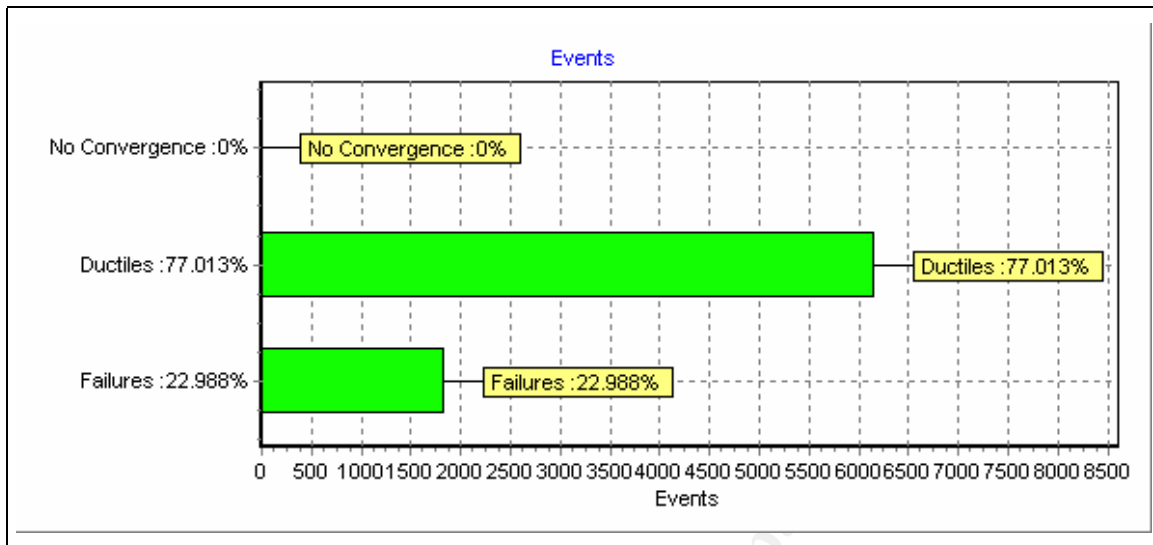


Figure 119 – Calculation summary.

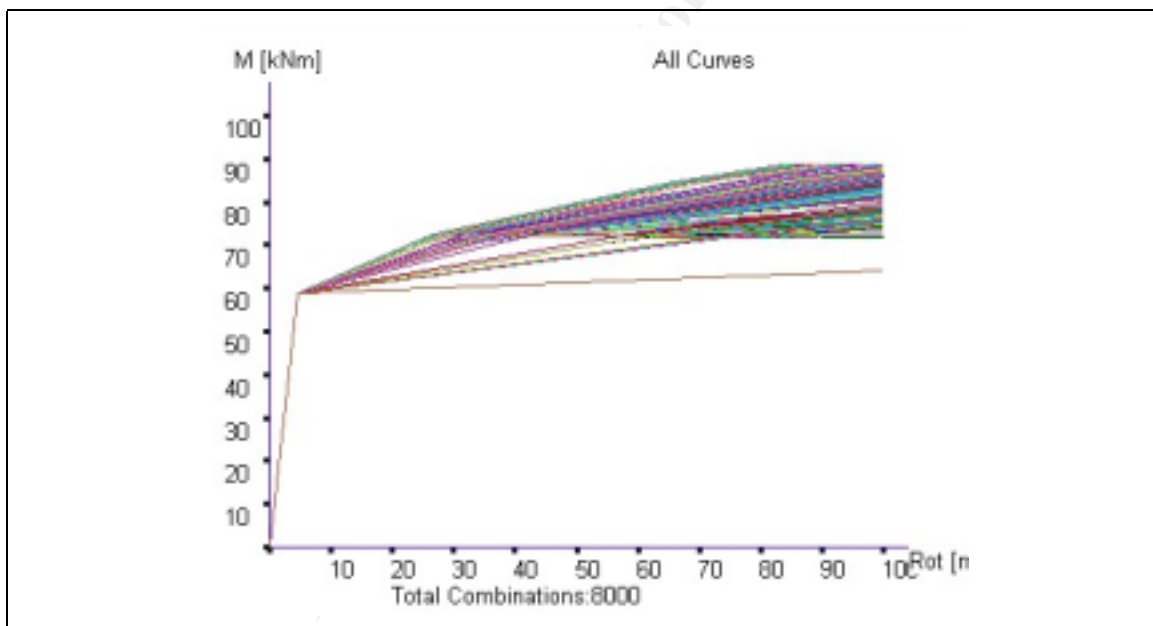


Figure 120 – All curves.

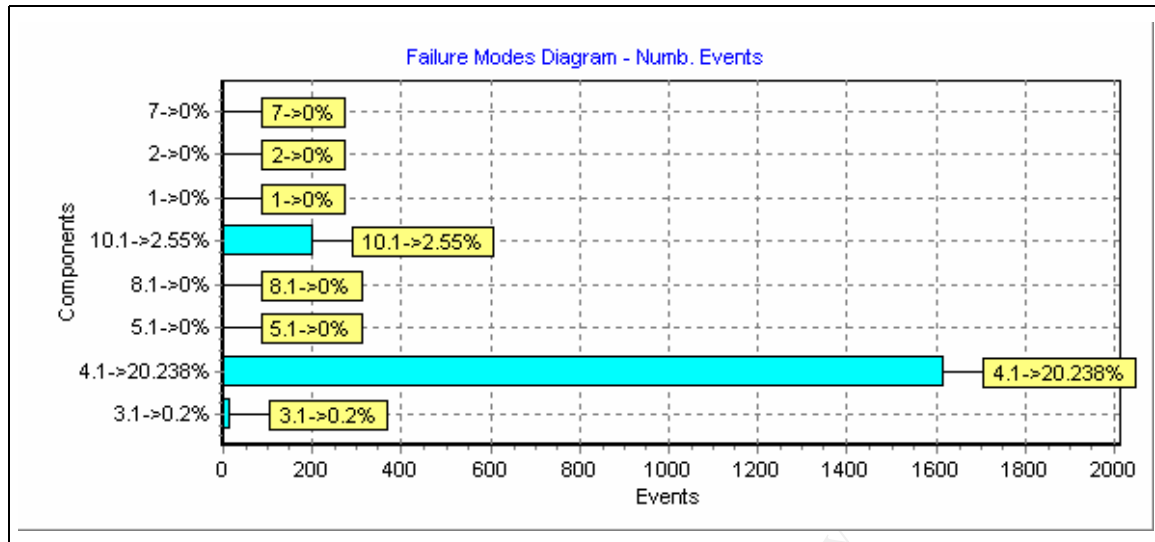


Figure 121 – Failure modes counter

Component Failure

3.1 : 16
4.1 : 1619
10.1 : 204

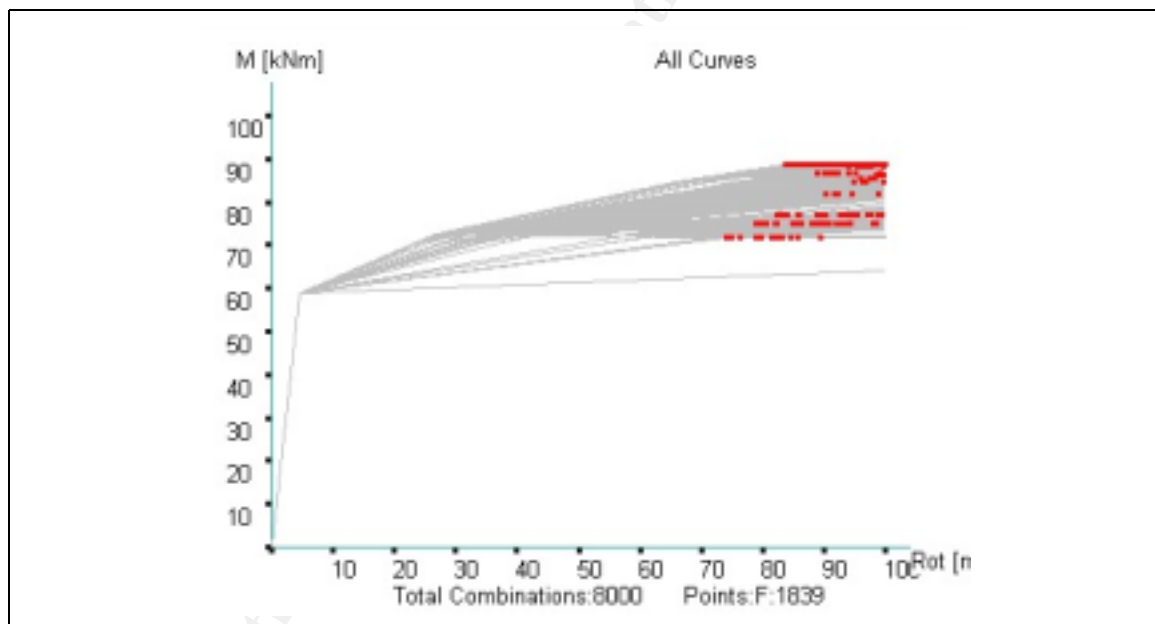


Figure 122 – All failures.

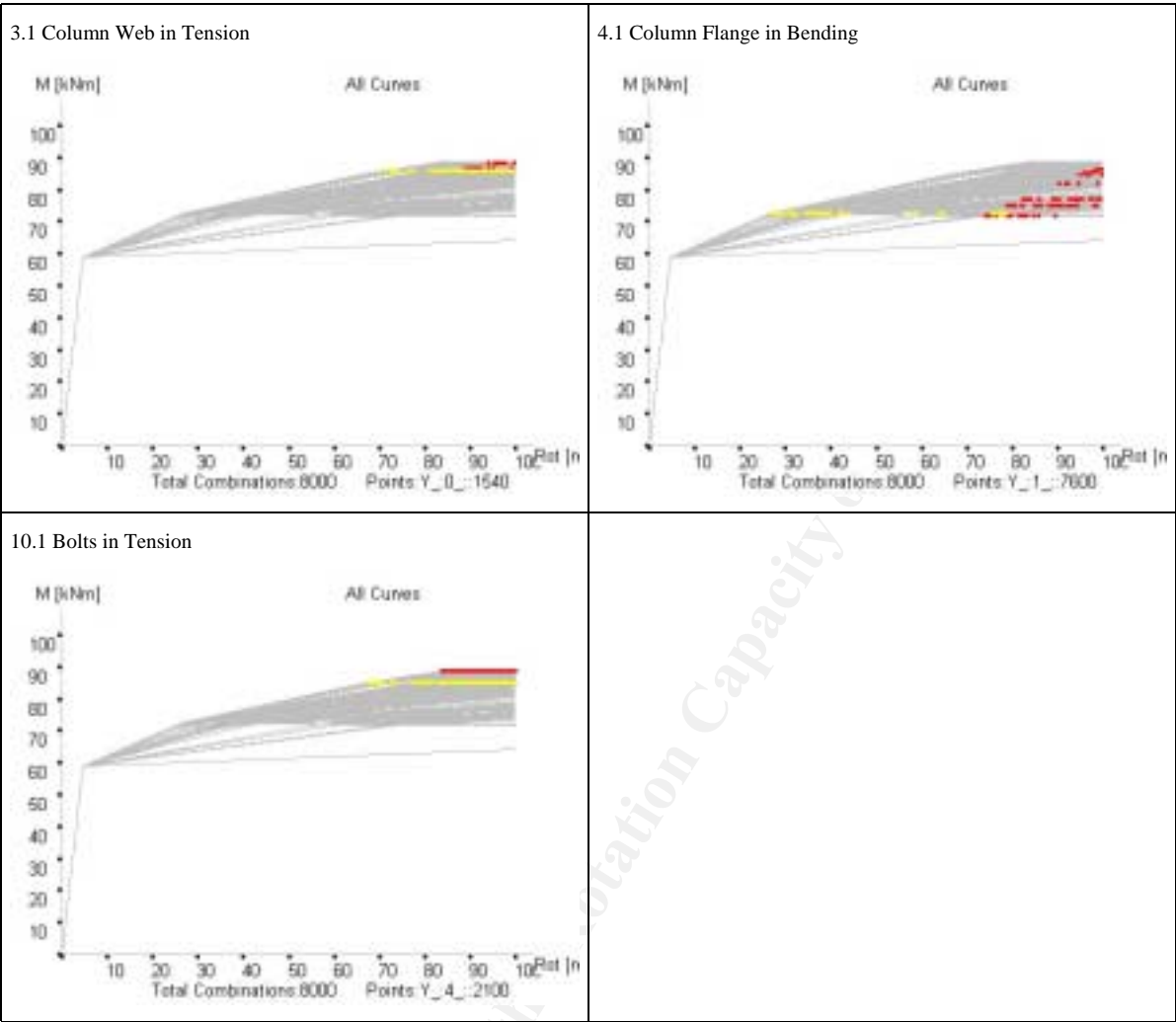
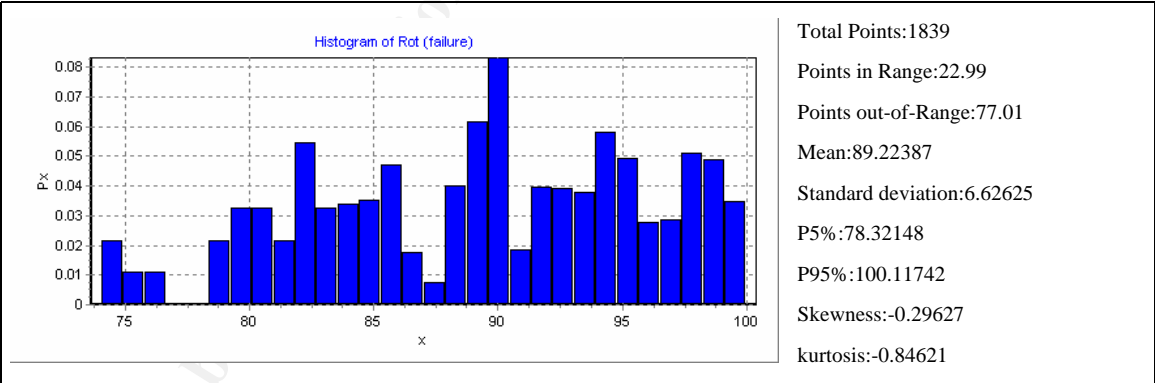


Figure 123 – Failures by component



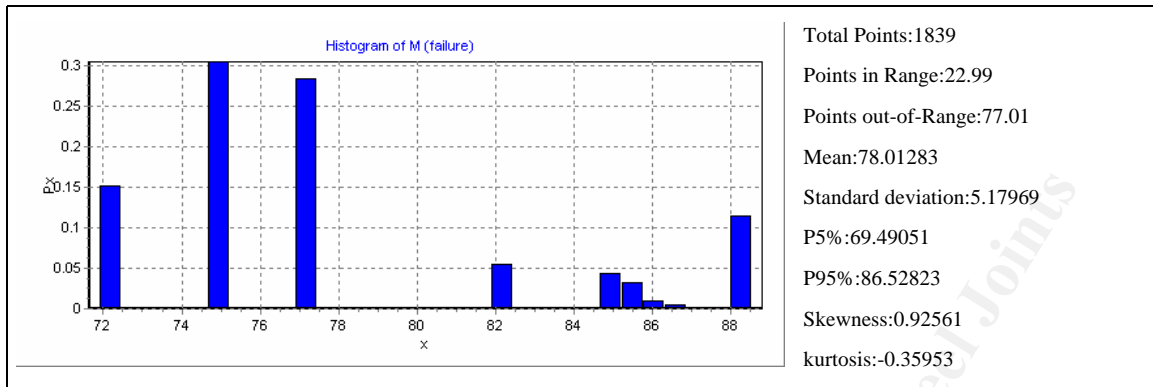
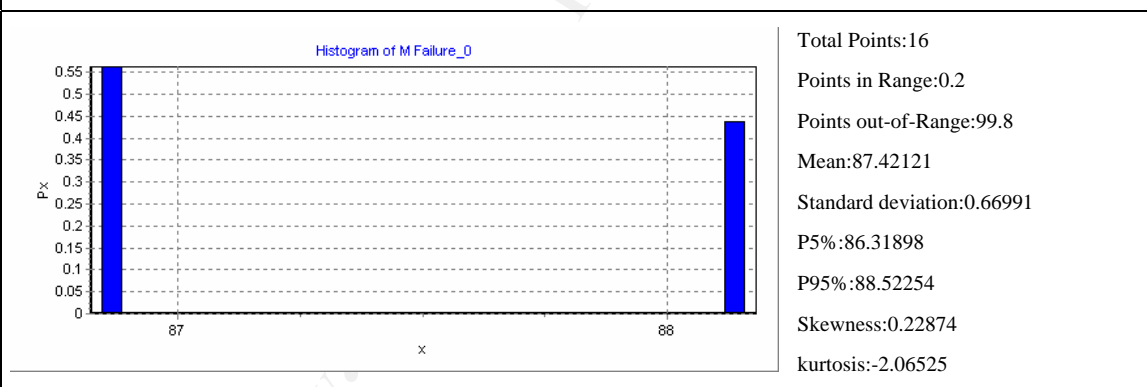
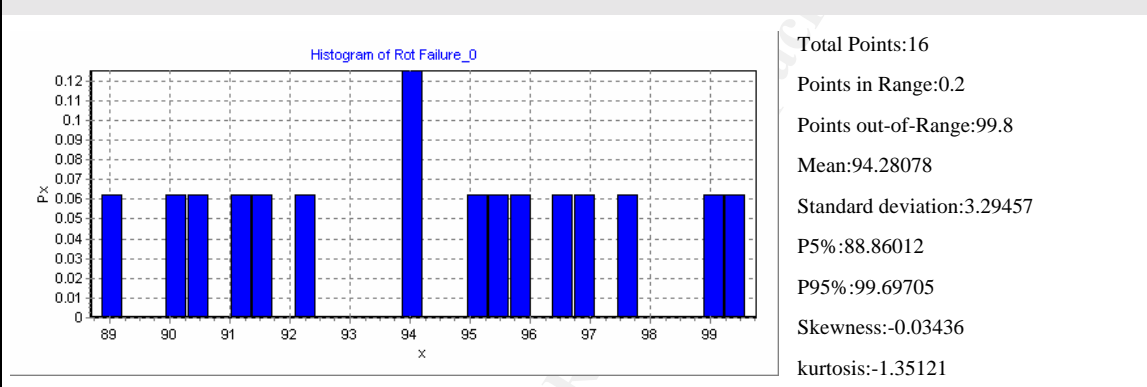
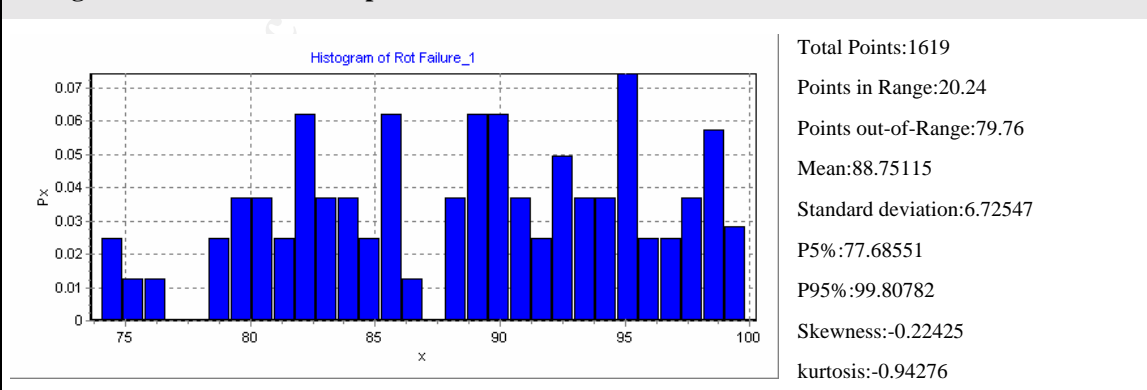


Figure 124 - Histograms of rotations and bending moments at failure.

Histograms for failures of component 3.1



Histograms for failures of component 4.1



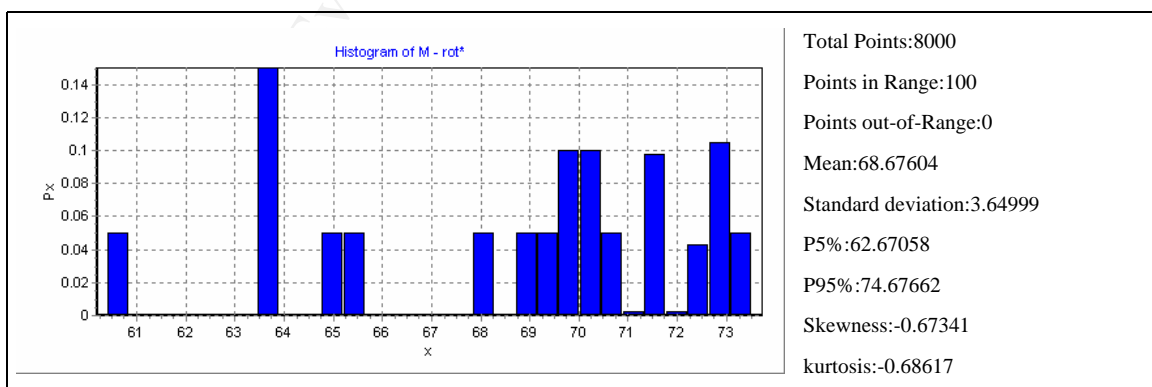
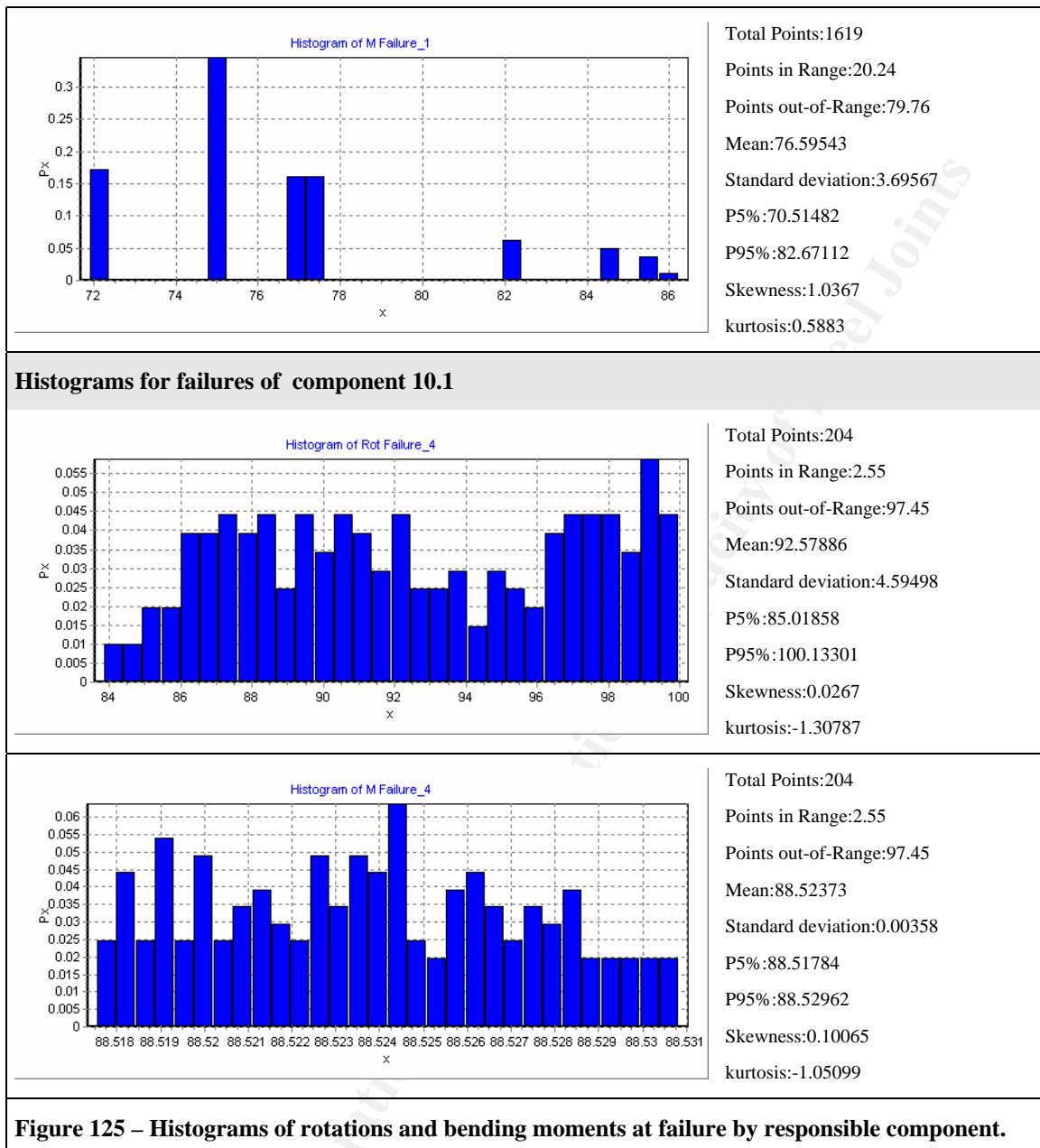


Figure 126 – Histogram for rotation=30 mrad

1.2.2.6 A.3d) nominal F^Y (1.000 Combinations) (Component [3], [4], [5])

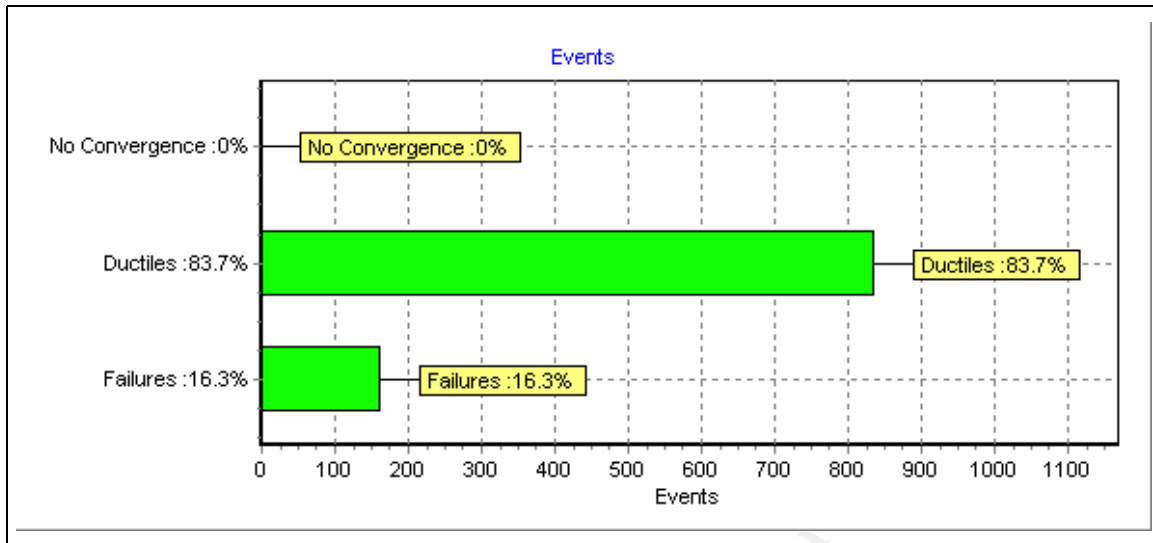


Figure 127 – Calculation summary.

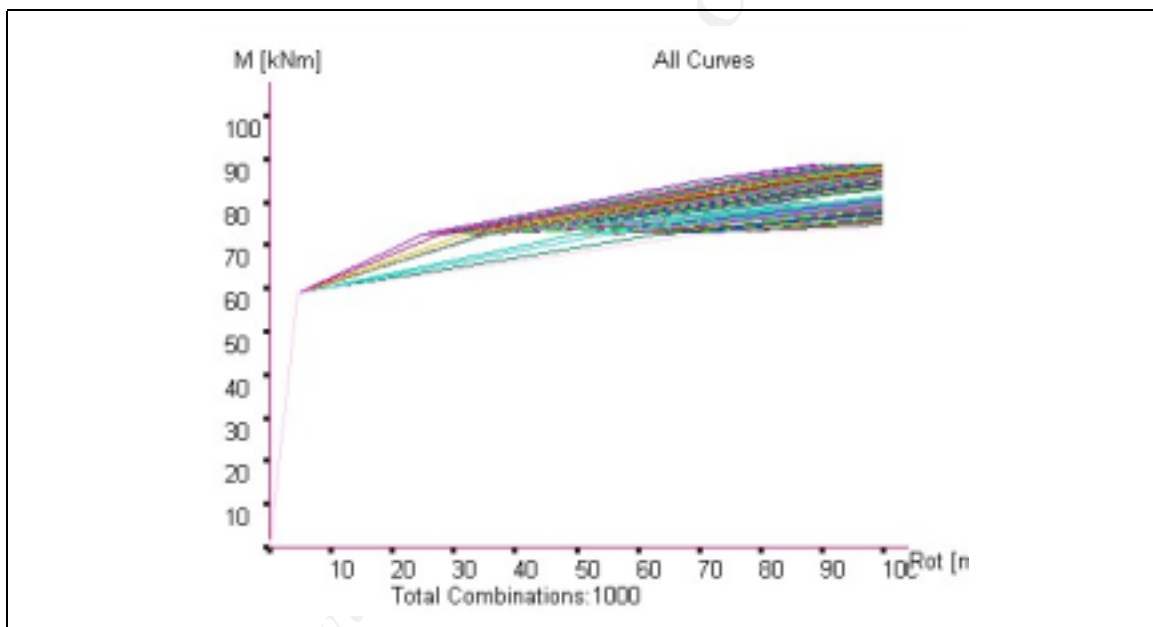


Figure 128 – All curves.

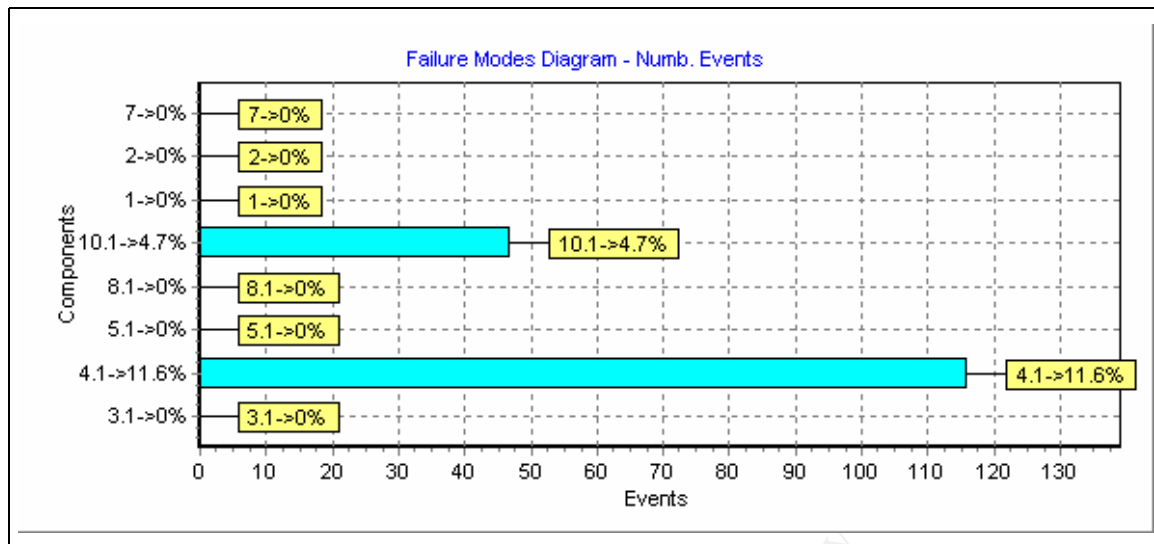


Figure 129 – Failure modes counter

4.1 : 116

10.1 : 47

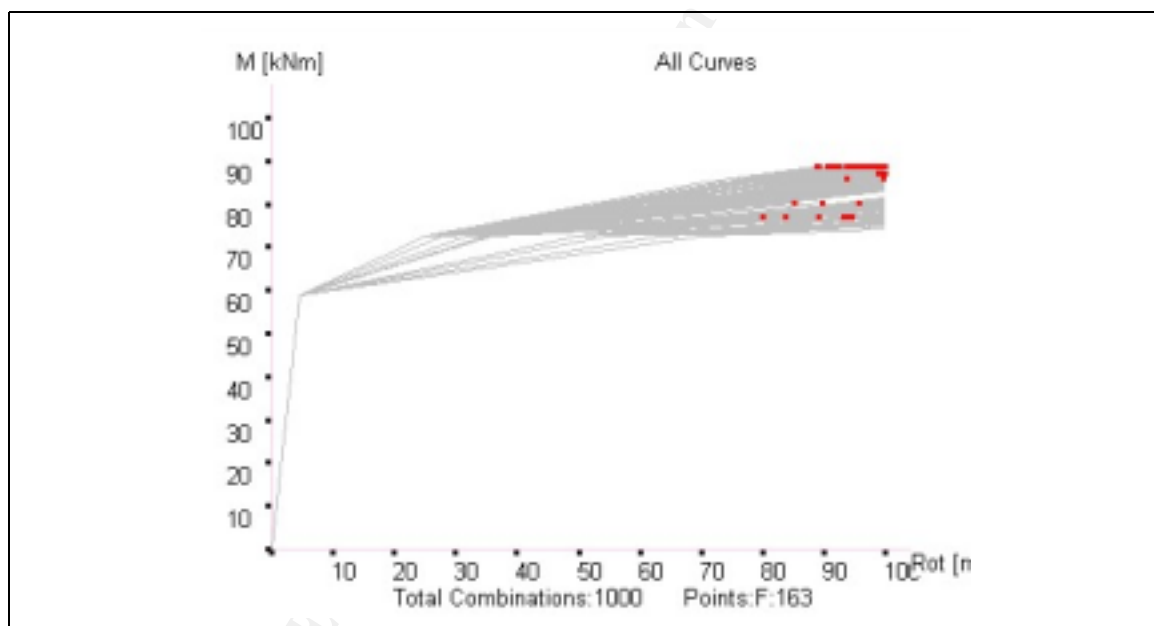


Figure 130 – All failures.

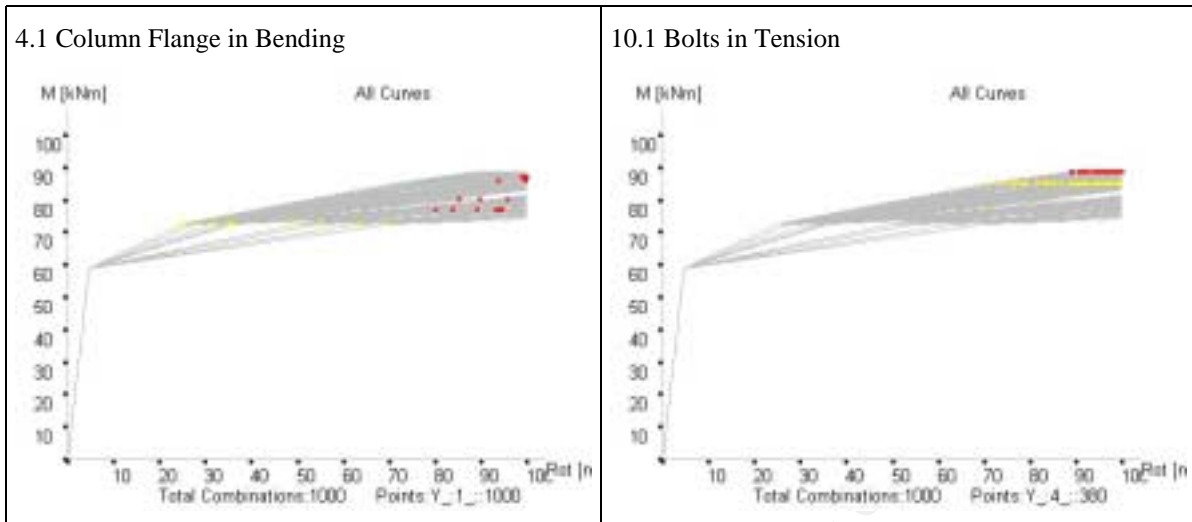


Figure 131 – Failures by component

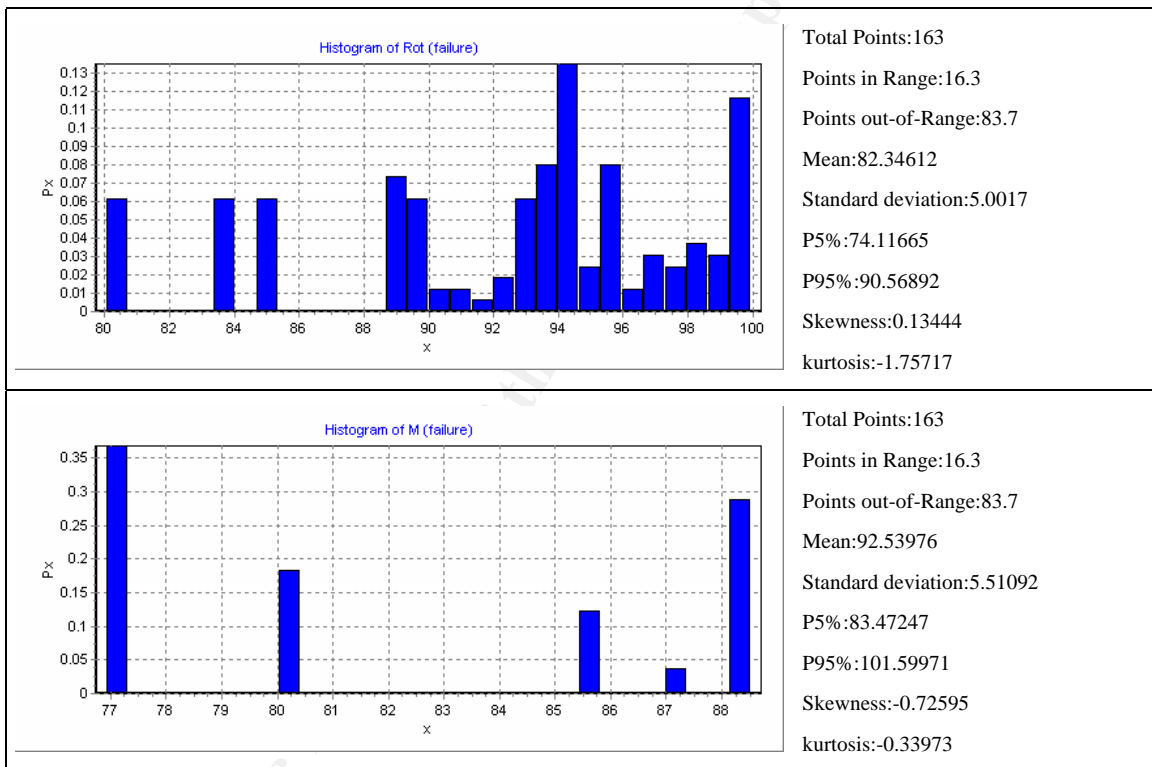


Figure 132 - Histograms of rotations and bending moments at failure.

Histograms for failures of component 4.1

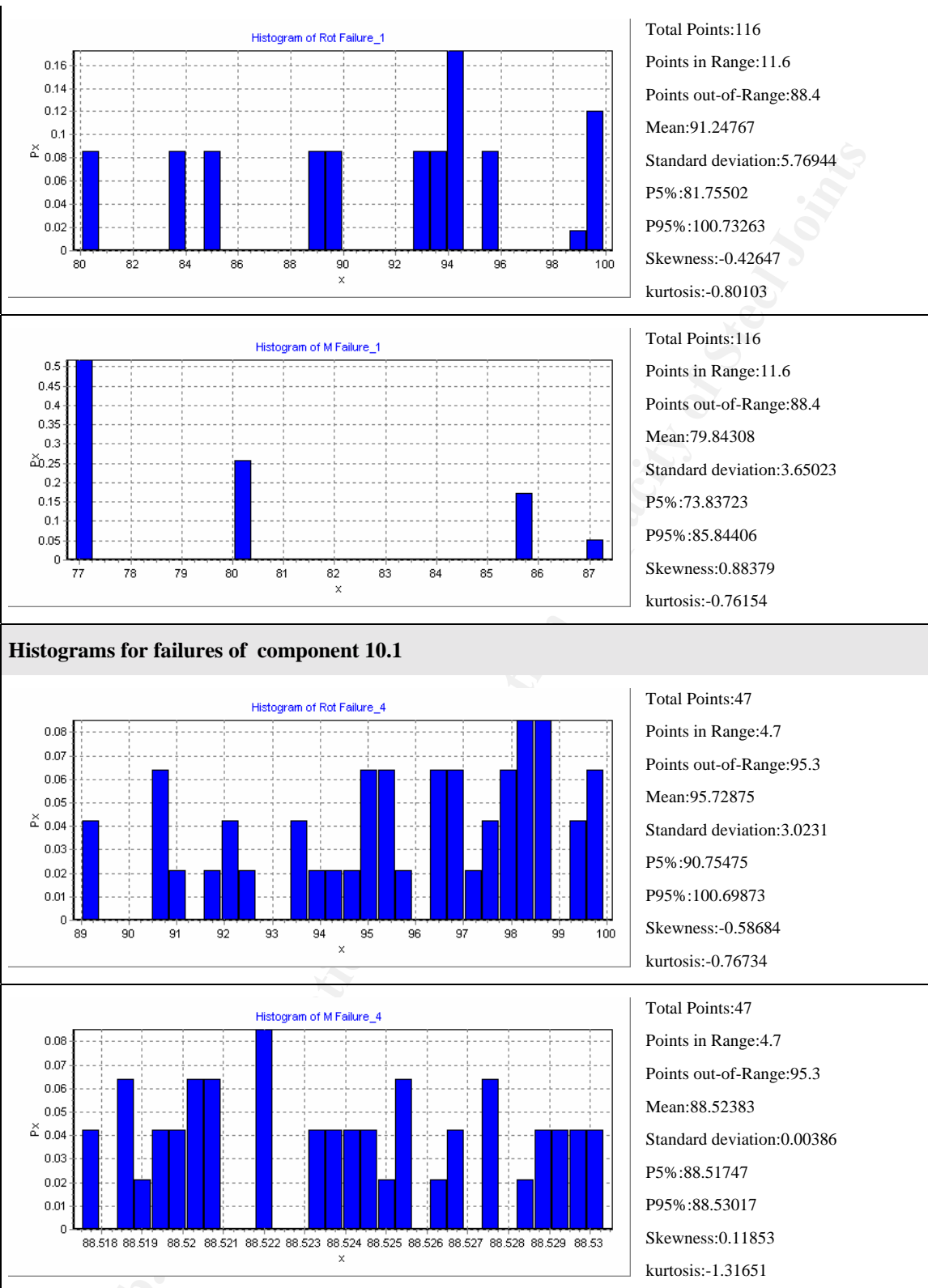


Figure 133 – Histograms of rotations and bending moments at failure by responsible component.

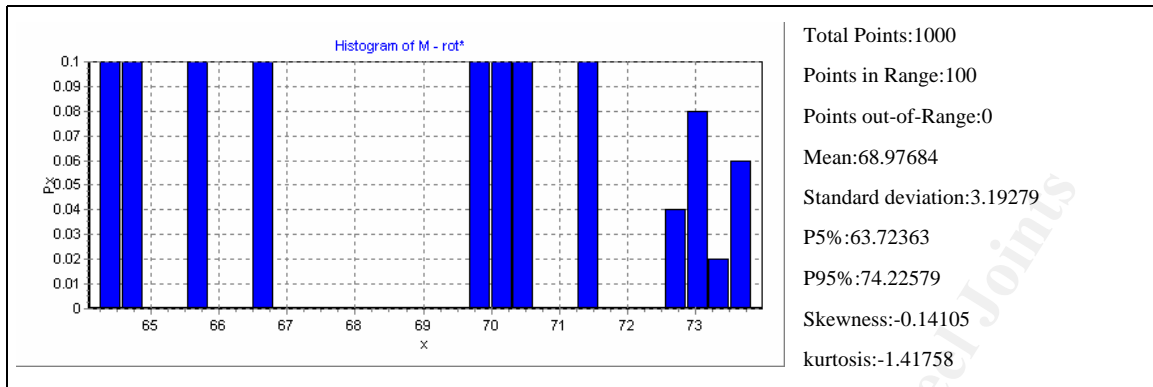


Figure 134 – Histogram for rotation=30 mrad

1.2.3 Case B – Variability of K_p and F^Y of the components in tension zone

1.2.3.1 B.1) F^Y normal + K_p (Component [3], [4], [5])

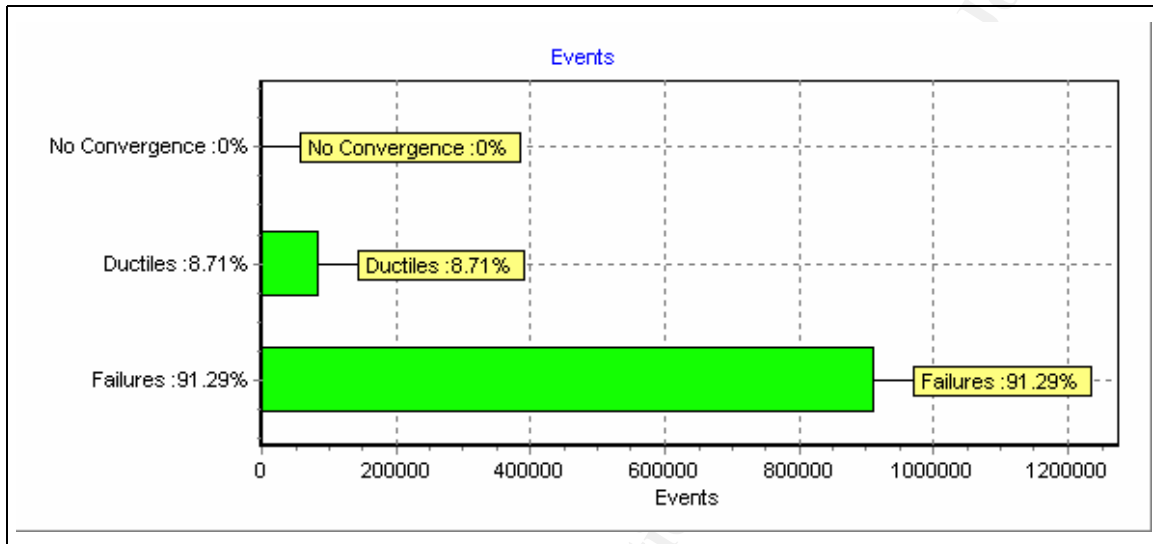


Figure 135 – Calculation summary.

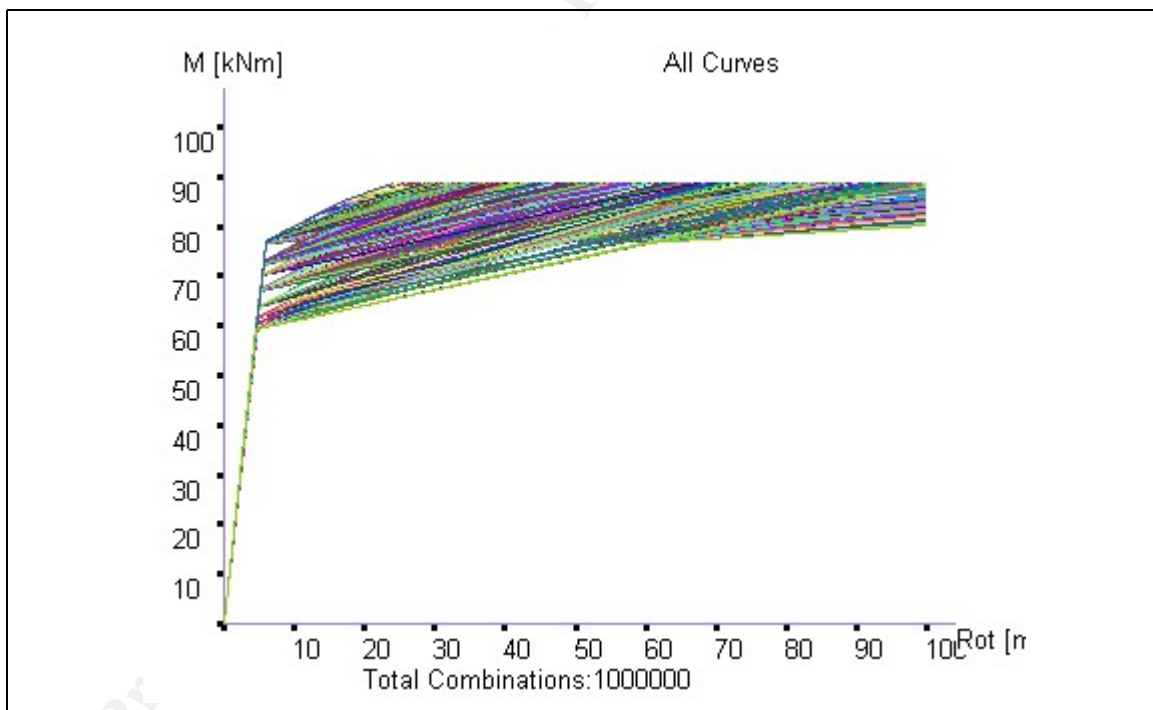


Figure 136 – All curves.

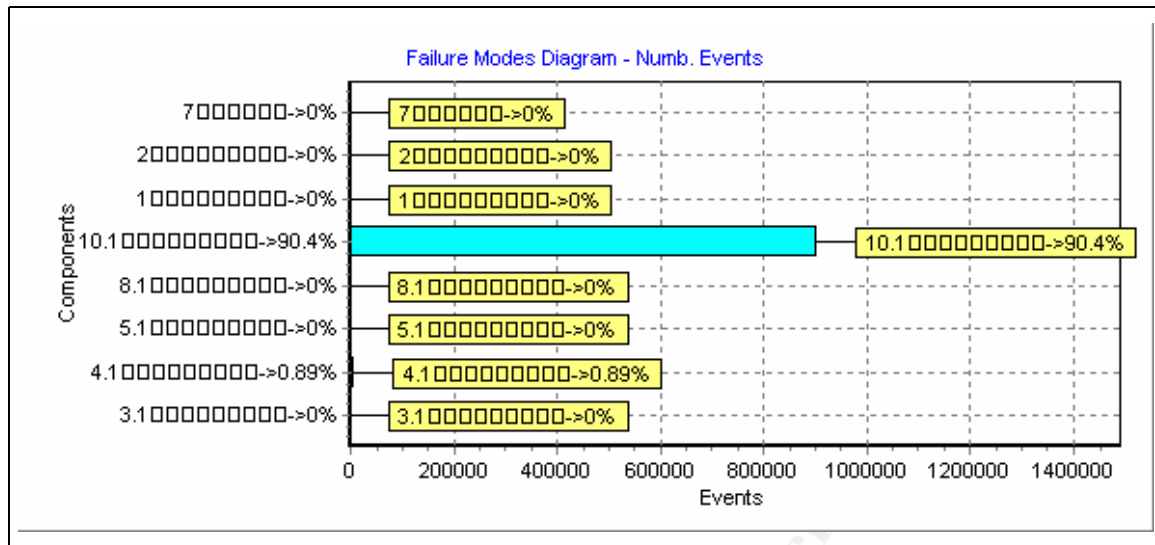


Figure 137 – Failure modes counter

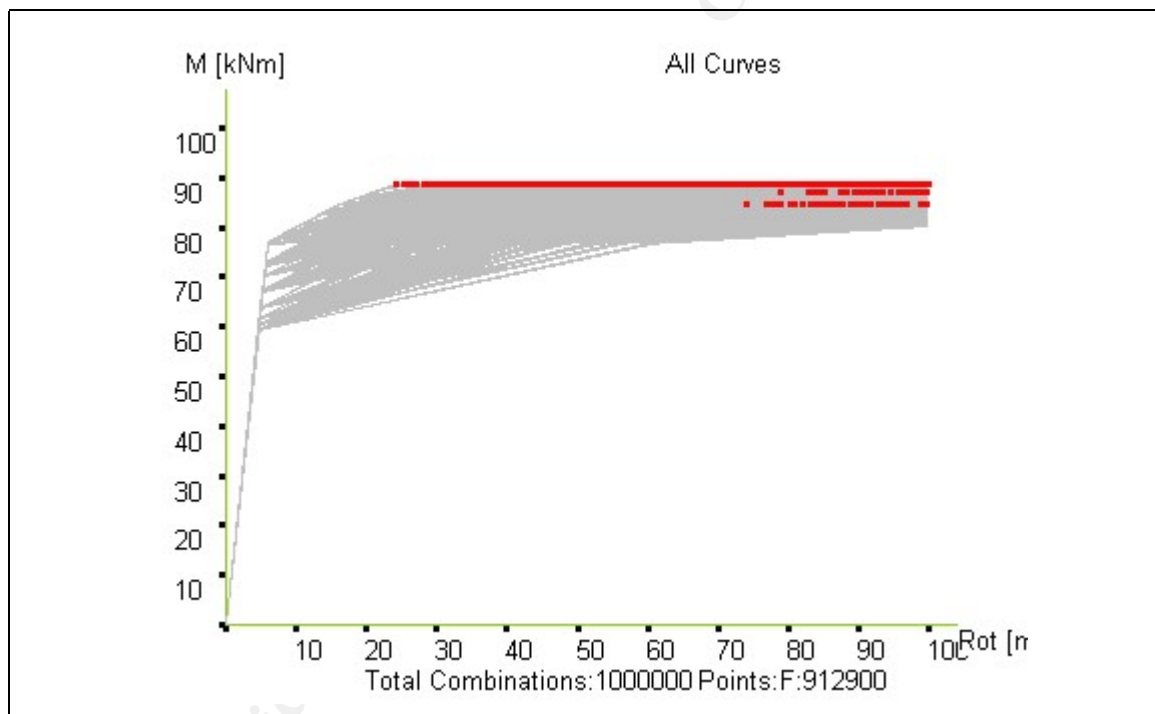


Figure 138 – All failures.

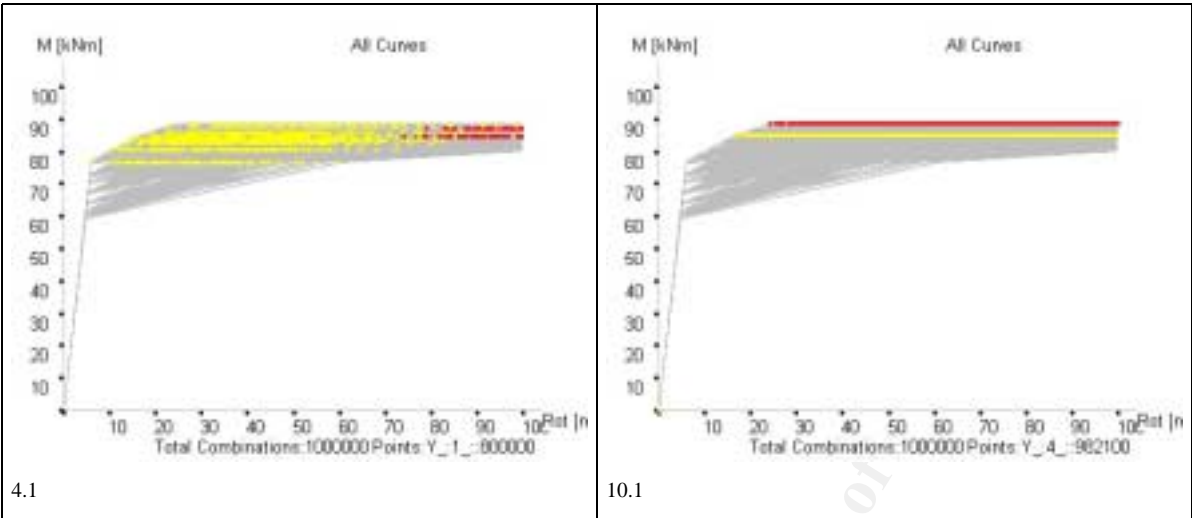


Figure 139 – Failures by component

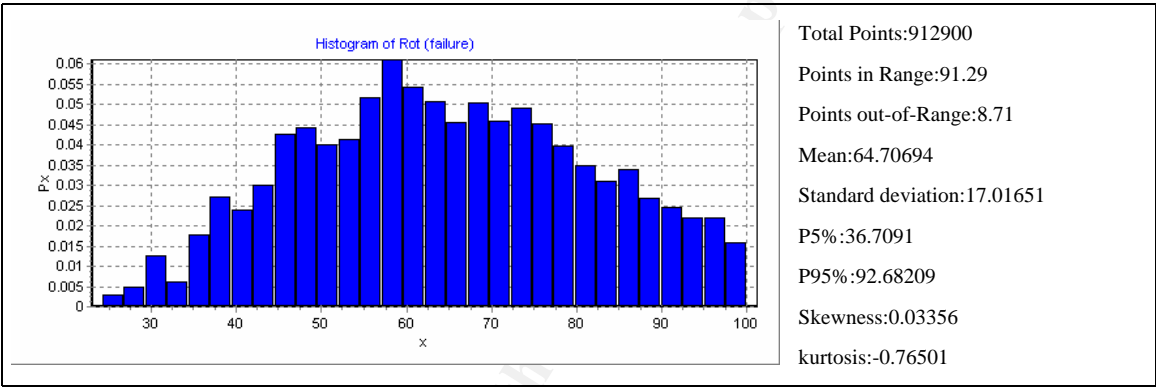


Figure 140 – Histogram of rotation at failure.

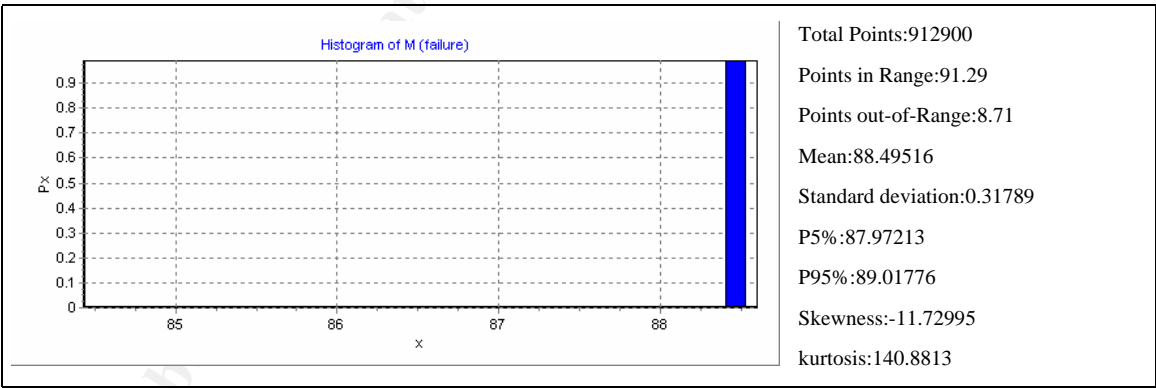
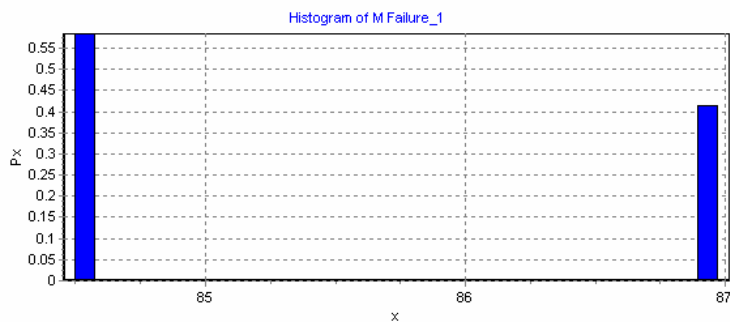
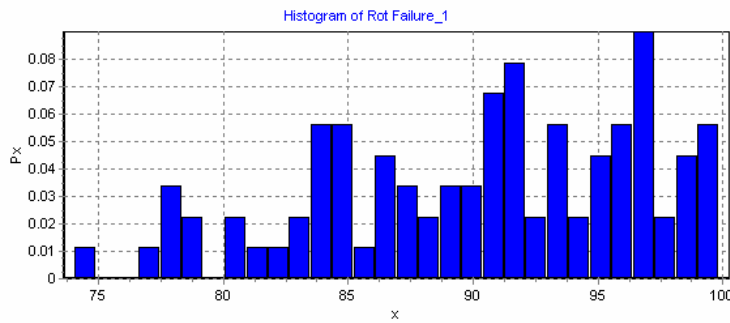
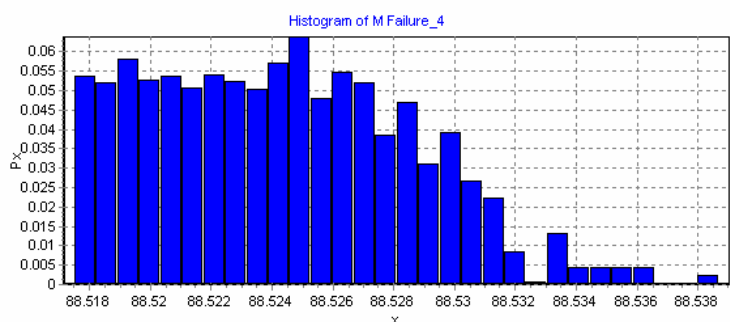
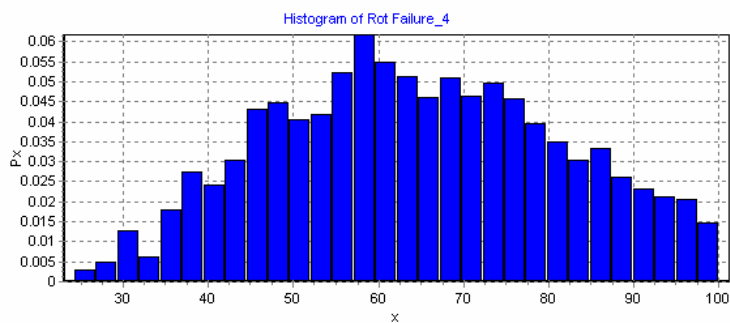


Figure 141 – Histogram of moment at failure.

Histograms for failures of component 41

Histograms for failures of component 10.1

Figure 142 – Histograms of rotations and bending moments at failure by responsible component.

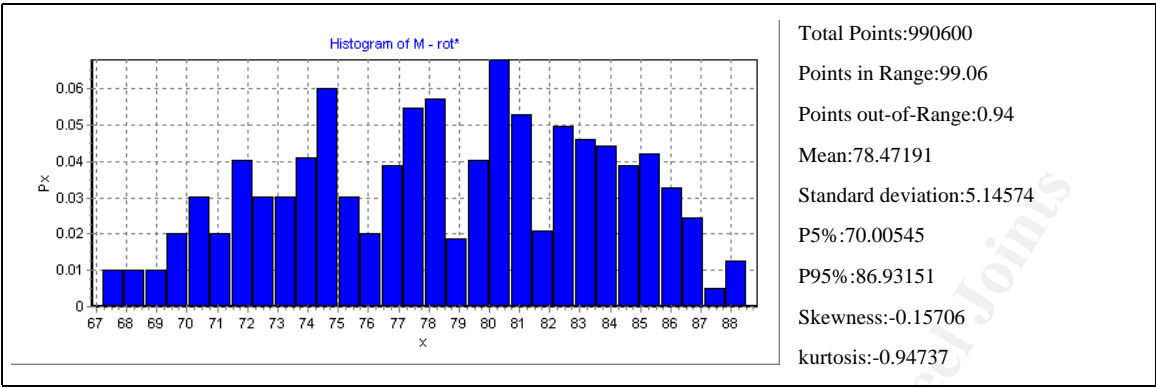


Figure 143 – Histogram for rotation=30 mrad

1.2.3.2 B.2) F^Y binormal + K_p (Component [3], [4], [5])* exclude the less relevant from B.1

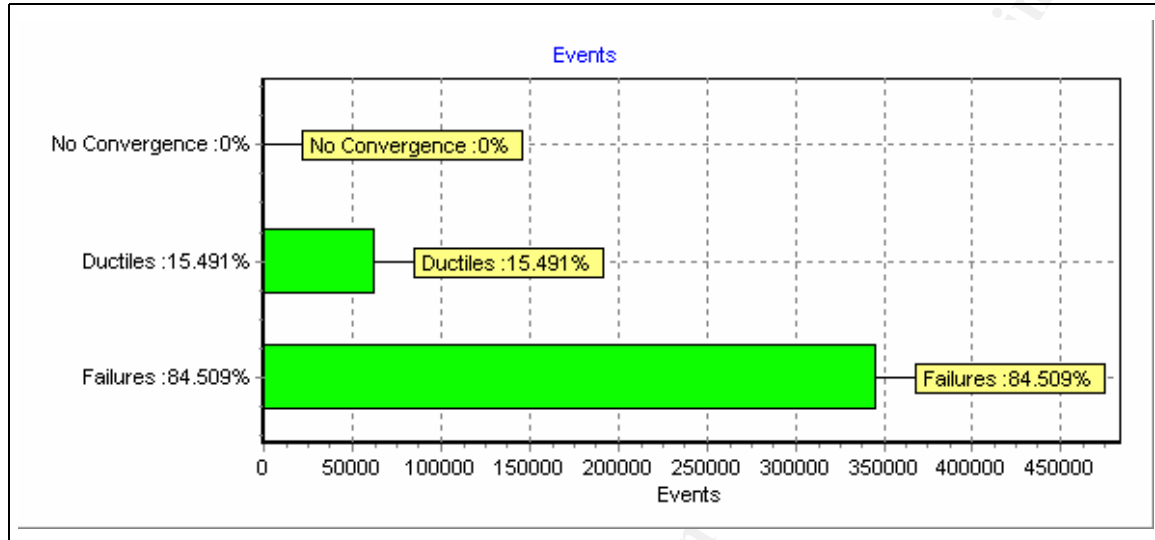


Figure 144 – Calculation summary.

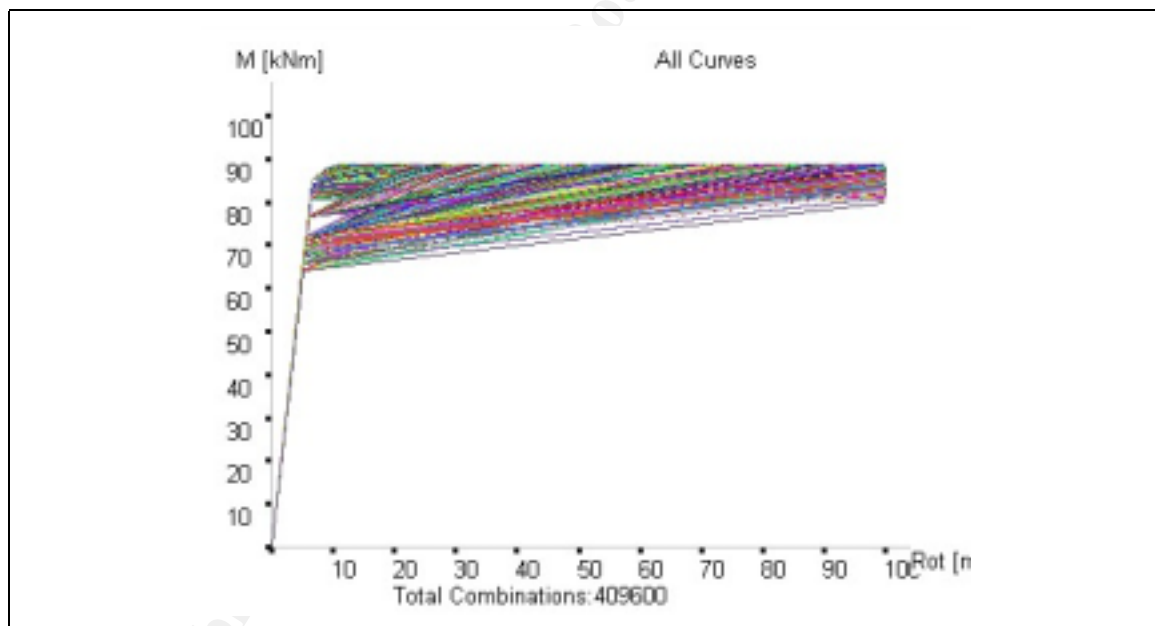


Figure 145 – All curves.

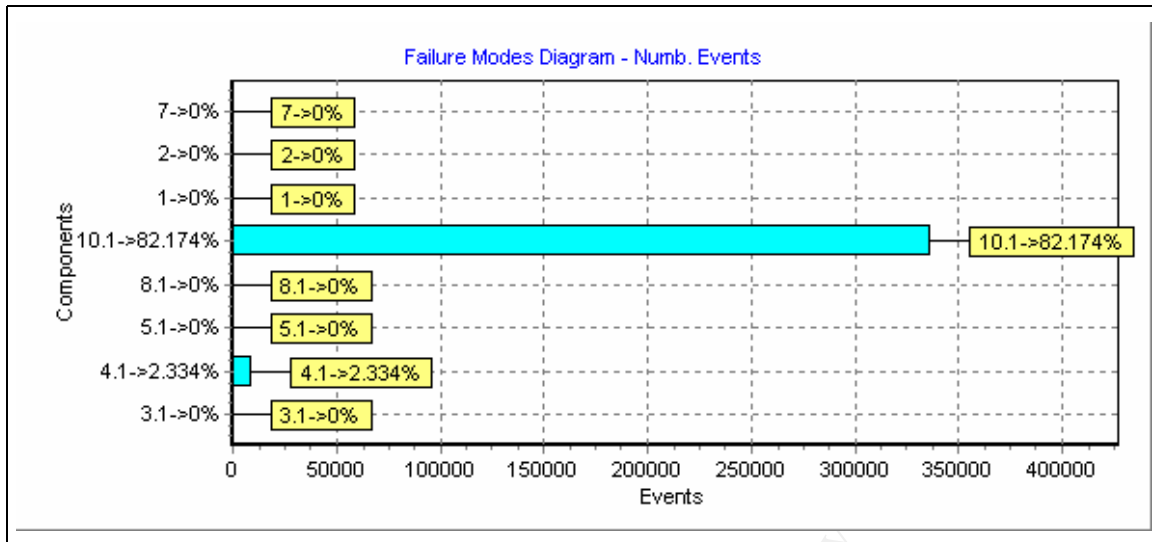


Figure 146 – Failure modes counter

Component Failure

4.1 : 9561

10.1 : 336586

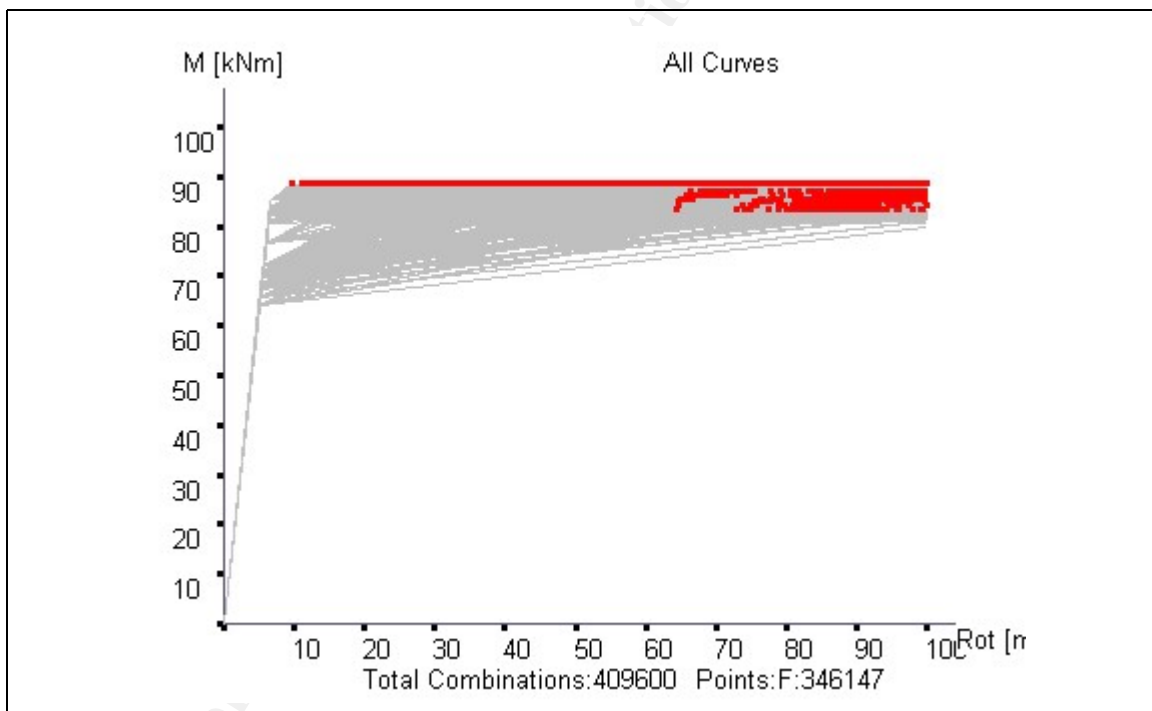


Figure 147 – All failures.

4.1 Column Flange in Bending

10.1 Bolts in Tension

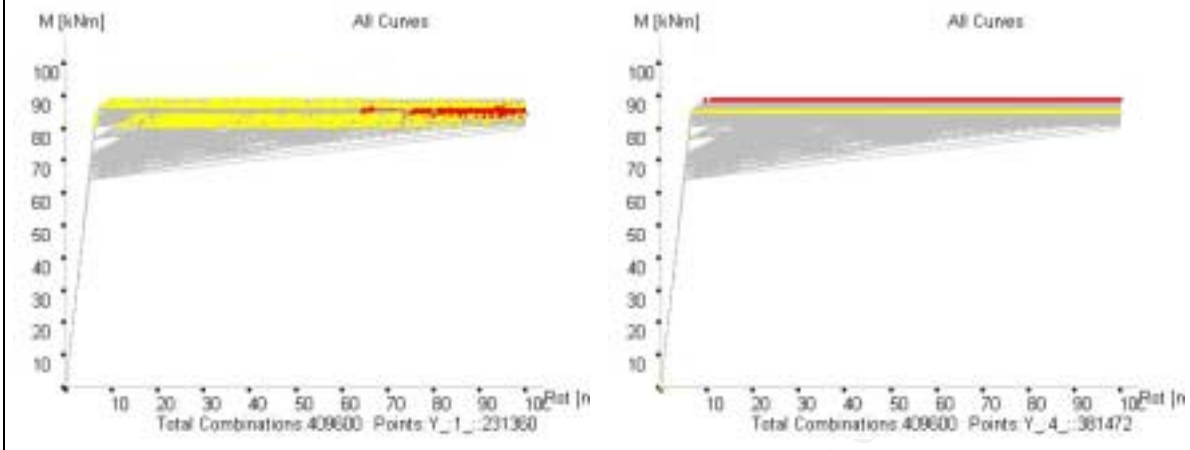


Figure 148 – Failures by component

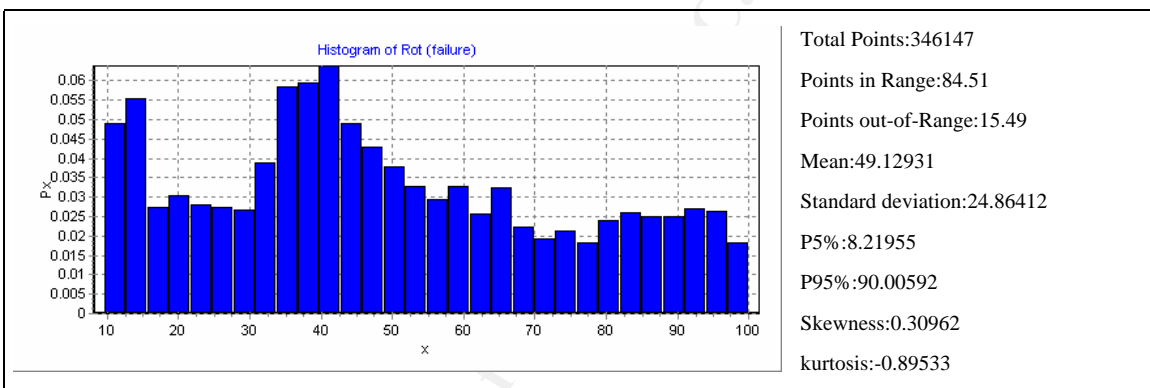


Figure 149 — Histogram of rotation at failure.

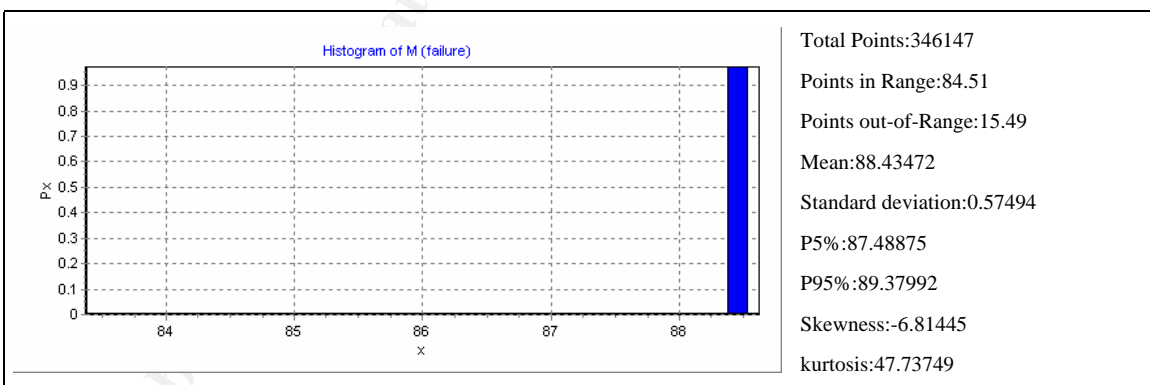
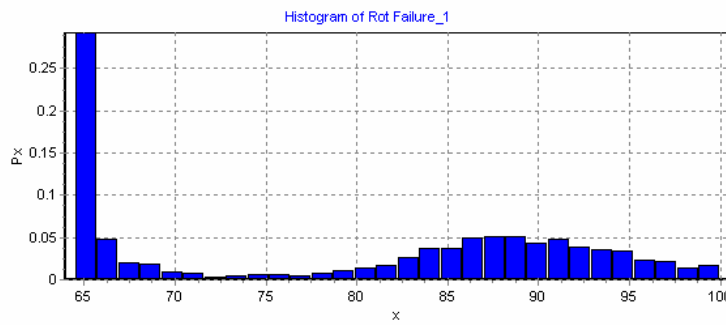
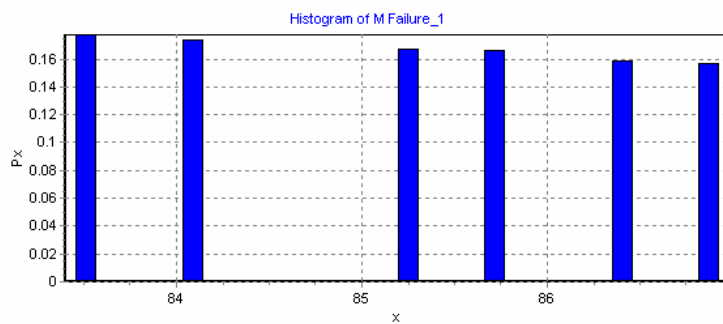


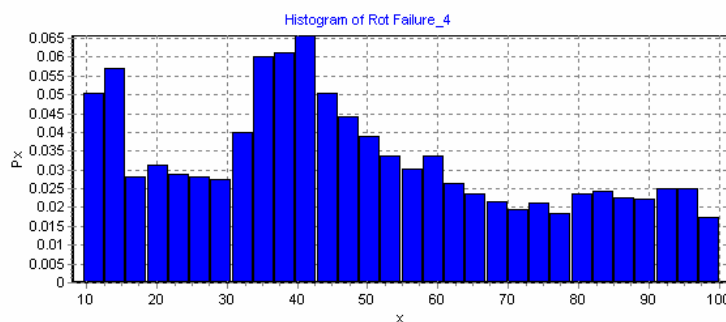
Figure 150 – Histogram of moment at failure.

Histograms for failures of component 4.1

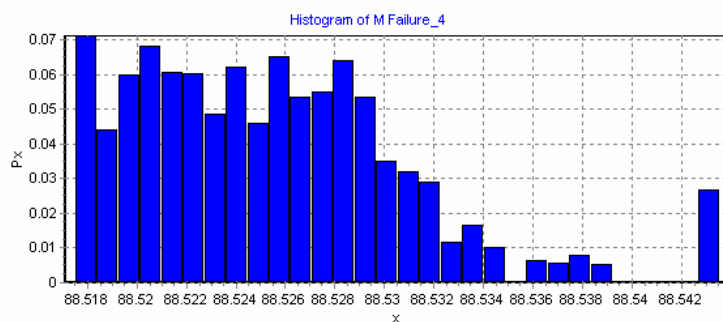
Total Points:9561
 Points in Range:2.33
 Points out-of-Range:97.67
 Mean:79.46213
 Standard deviation:12.13973
 P5%:59.48822
 P95%:99.41985
 Skewness:-0.07749
 kurtosis:-1.61083



Total Points:9561
 Points in Range:2.33
 Points out-of-Range:97.67
 Mean:85.23904
 Standard deviation:1.21001
 P5%:83.24817
 P95%:87.2283
 Skewness:-0.13767
 kurtosis:-1.32062

Histograms for failures of component 10.1

Total Points:336586
 Points in Range:82.17
 Points out-of-Range:17.83
 Mean:48.26768
 Standard deviation:24.59109
 P5%:7.80715
 P95%:88.69543
 Skewness:0.35564
 kurtosis:-0.82531



Total Points:336586
 Points in Range:82.17
 Points out-of-Range:17.83
 Mean:88.52549
 Standard deviation:0.00557
 P5%:88.51633
 P95%:88.53465
 Skewness:0.9966
 kurtosis:1.26489

Figure 151 – Histograms of rotations and bending moments at failure by responsible component.

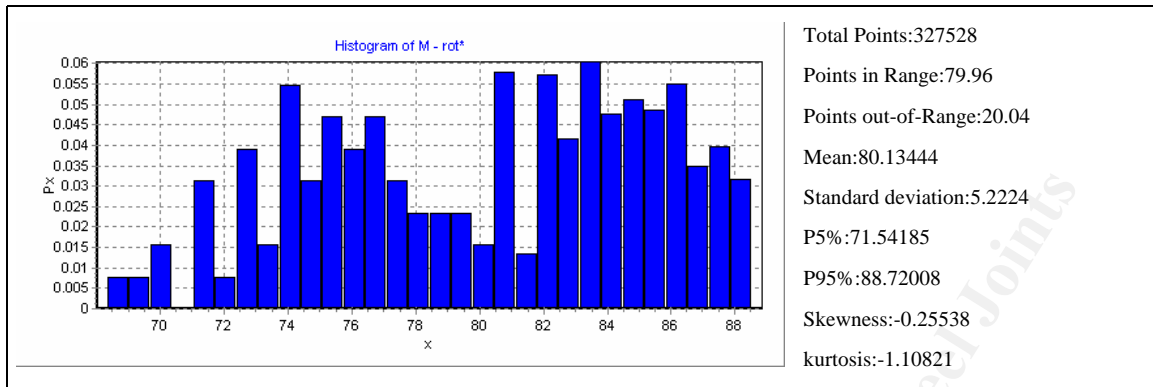


Figure 152 – Histogram for rotation=30 mrad

1.2.4 Case C – Variability of K_p and F^Y and Δf .

1.2.4.1 C.1) K_p , (Component [3], [4], [5]), Δf ([3])

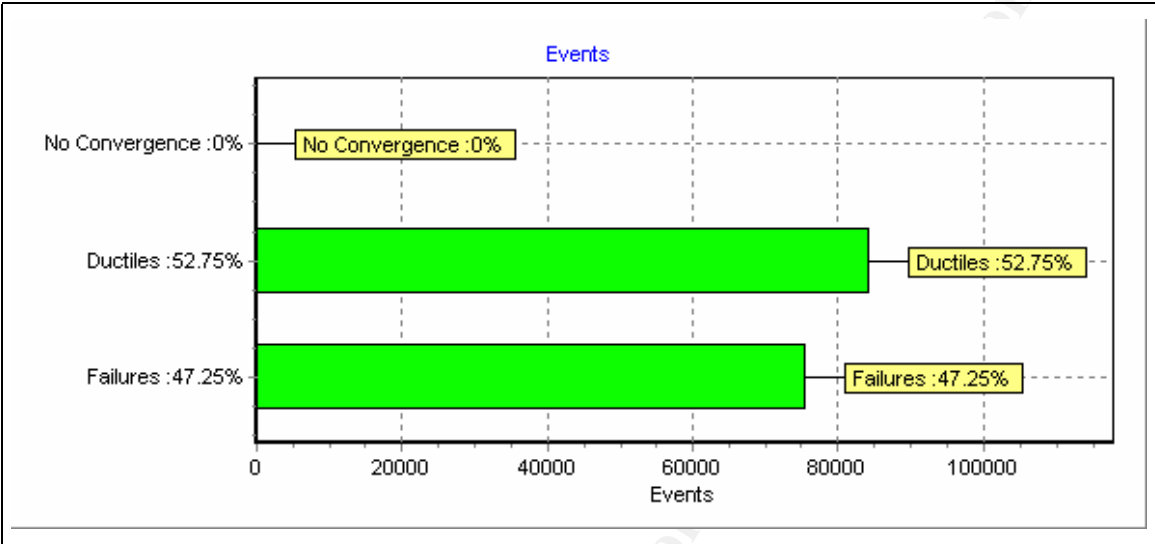


Figure 153 – Calculation summary.

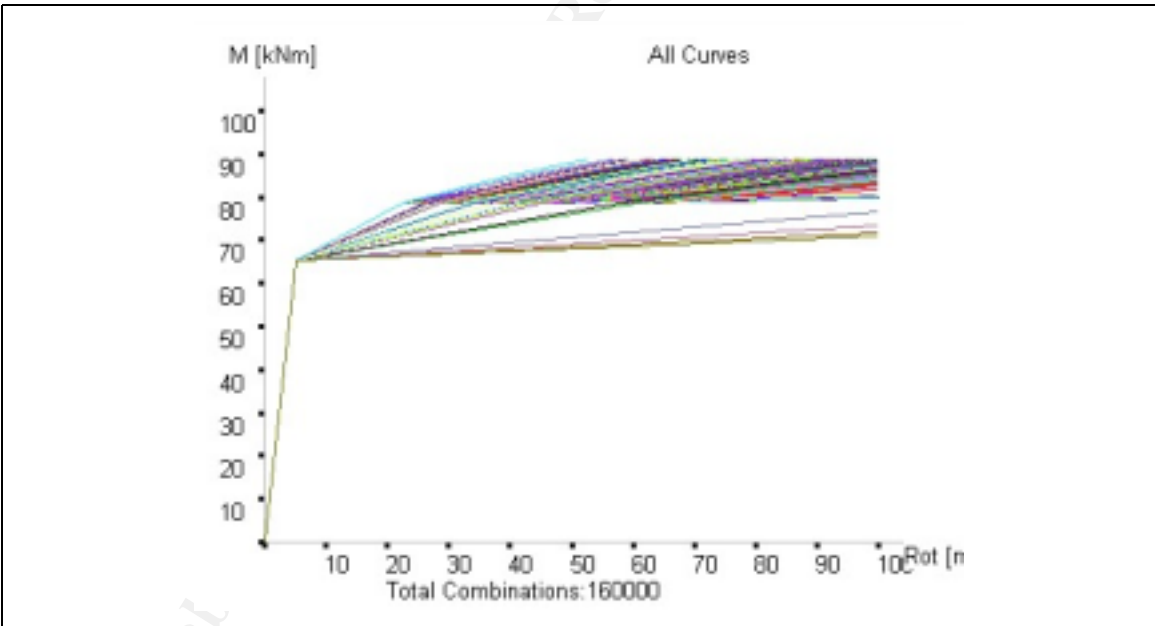


Figure 154 – All curves.

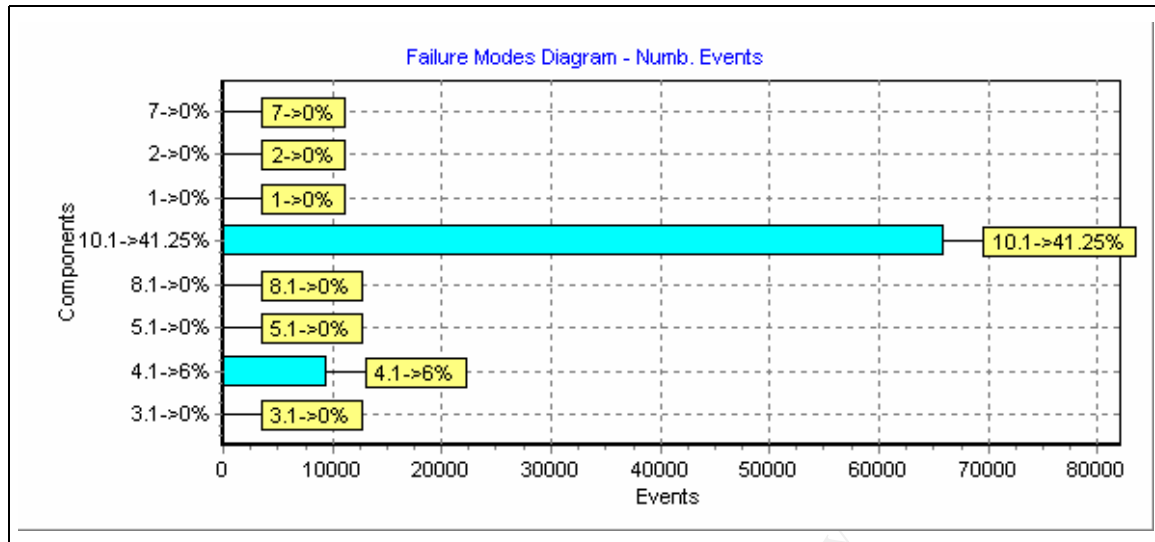


Figure 155 – Failure modes counter

Component Failure

4.1 : 9600

10.1 : 66000

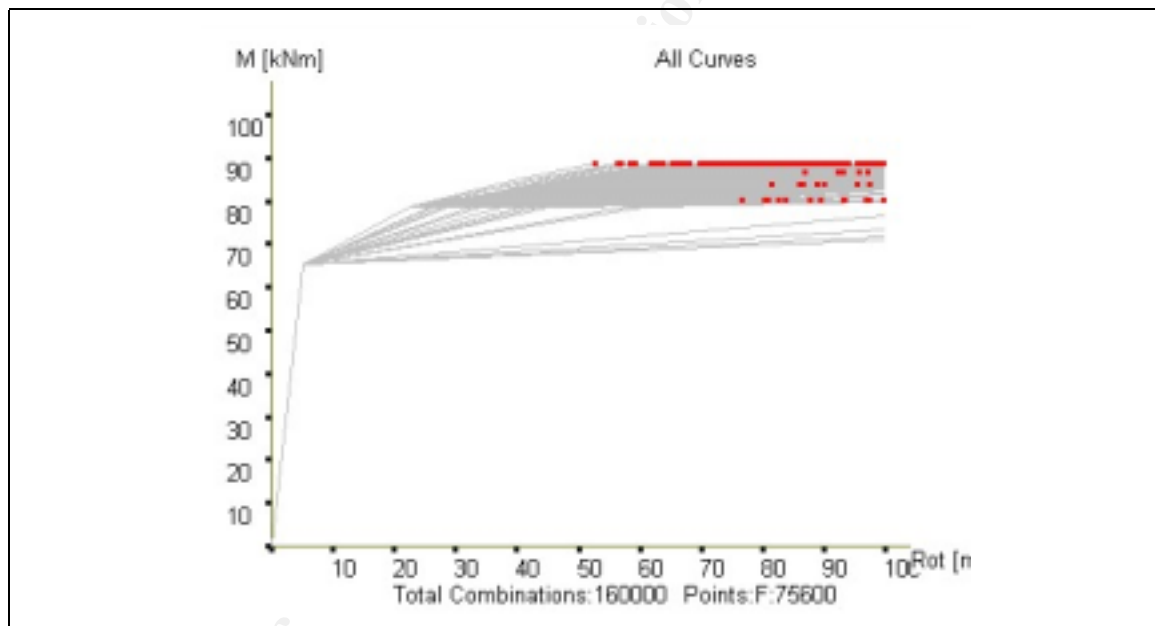


Figure 156 – All failures.

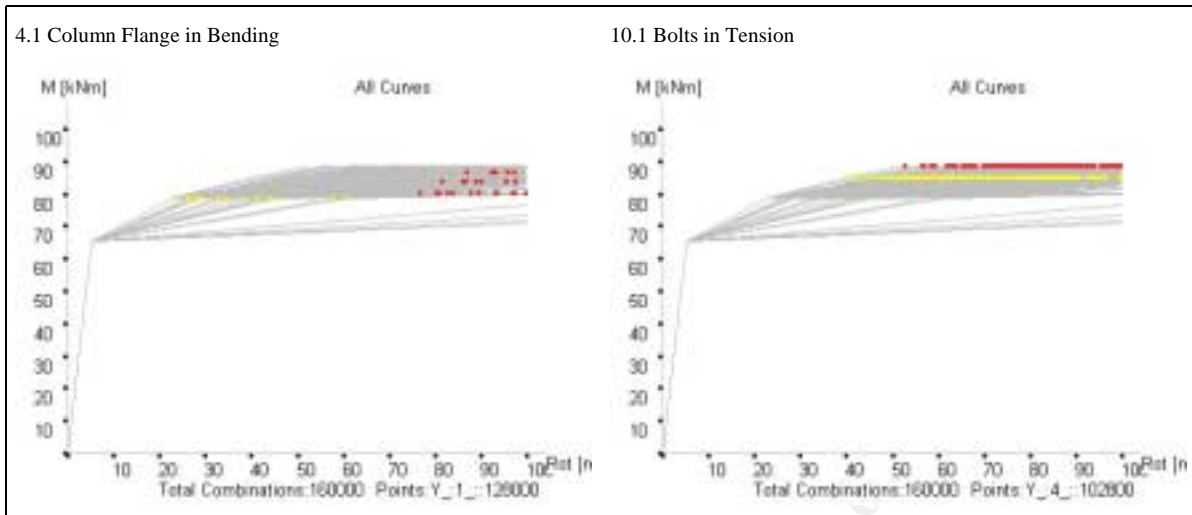


Figure 157 – Failures by component

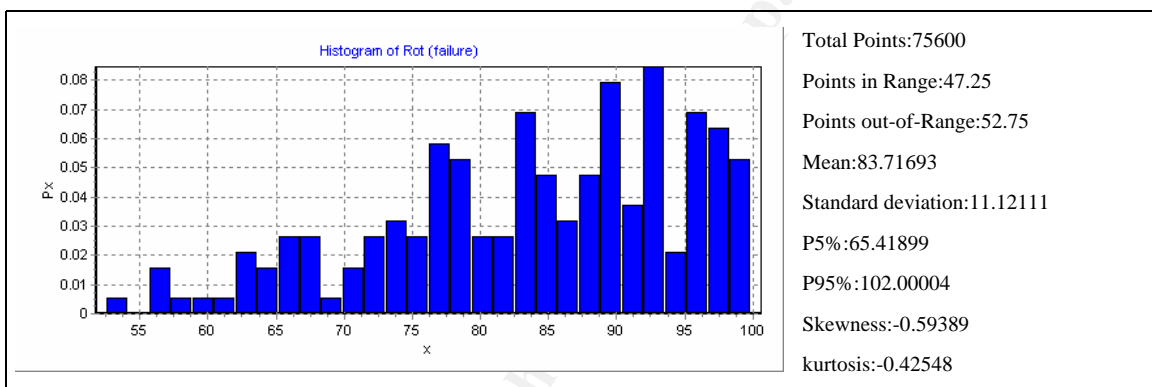


Figure 158 – Histogram of rotations at failure

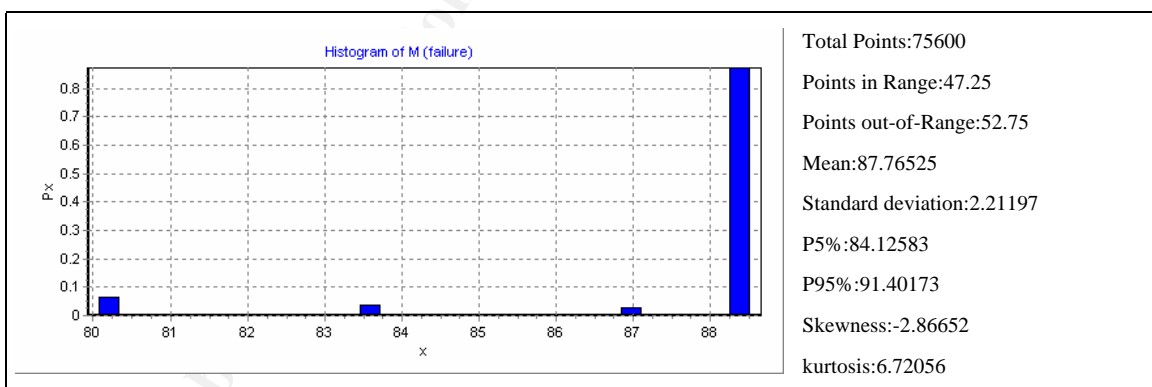
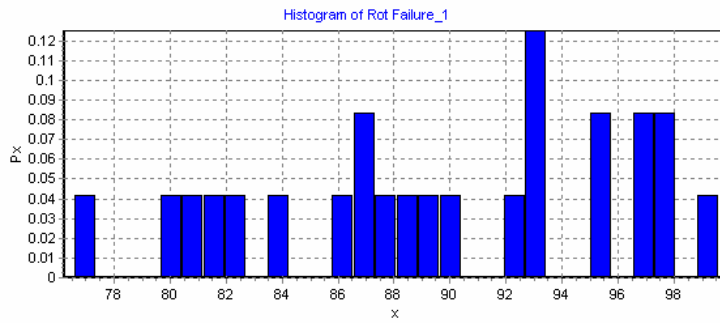
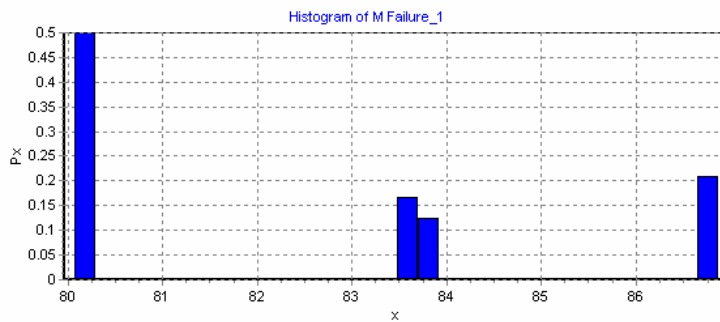


Figure 159 – Histogram of bending moments at failure.

Histograms for failures of component 4.1

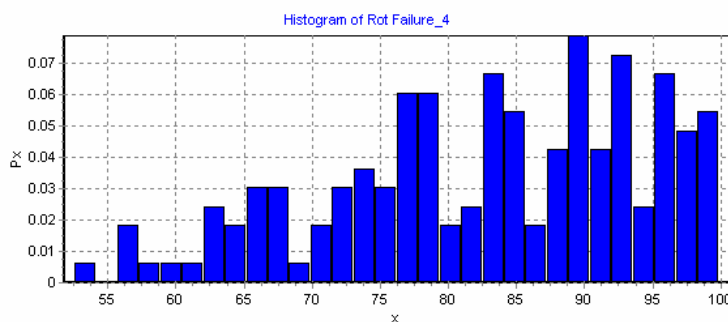


Total Points:9600
 Points in Range:6
 Points out-of-Range:94
 Mean:89.68228
 Standard deviation:6.33488
 P5%:79.25929
 P95%:100.09683
 Skewness:-0.29278
 kurtosis:-0.99679

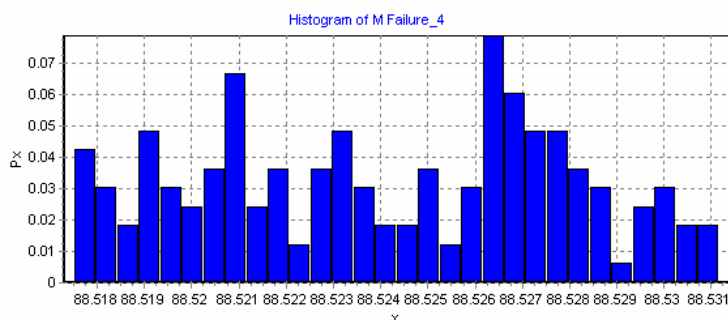


Total Points:9600
 Points in Range:6
 Points out-of-Range:94
 Mean:82.54794
 Standard deviation:2.71133
 P5%:78.08689
 P95%:87.00537
 Skewness:0.48927
 kurtosis:-1.29133

Histograms for failures of component 10.1



Total Points:66000
 Points in Range:41.25
 Points out-of-Range:58.75
 Mean:82.84924
 Standard deviation:11.39752
 P5%:64.09653
 P95%:101.58676
 Skewness:-0.48723
 kurtosis:-0.60728



Total Points:66000
 Points in Range:41.25
 Points out-of-Range:58.75
 Mean:88.52413
 Standard deviation:0.00377
 P5%:88.51793
 P95%:88.53033
 Skewness:-0.05227
 kurtosis:-1.18351

Figure 160 – Histograms of rotations and bending moments at failure by responsible component.

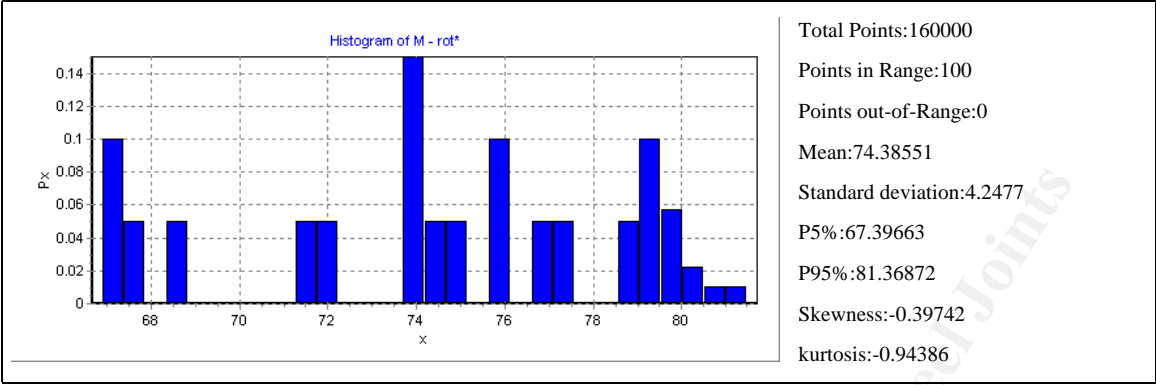


Figure 161 – Histogram for rotation=30 mrad

1.2.4.2 C.2) K_p (Component [3], [4], [5]), F^Y ([3], [4]), Δf (Component [3])

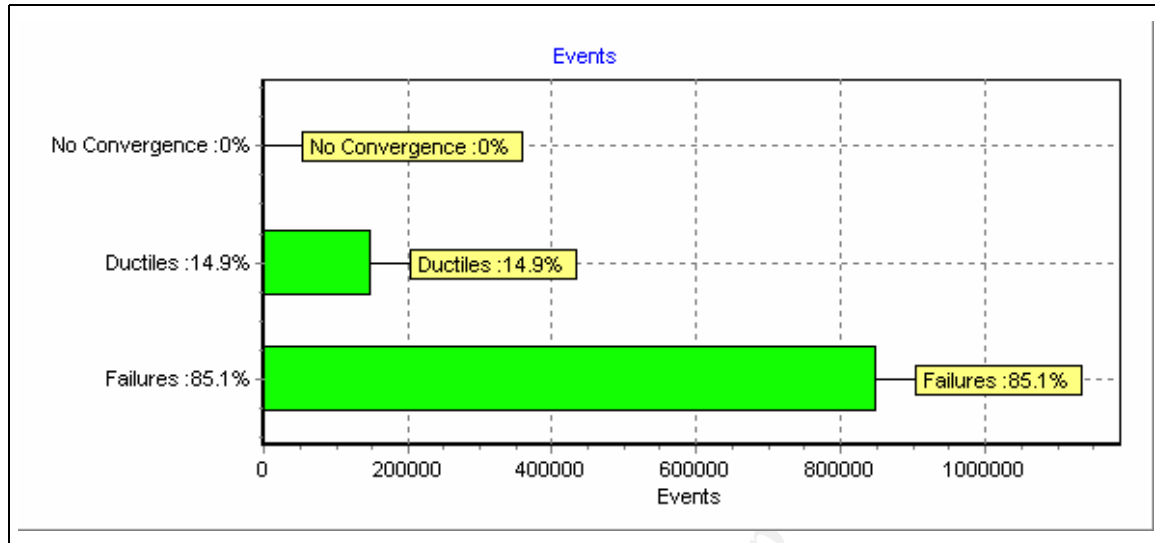


Figure 162 – Calculation summary.

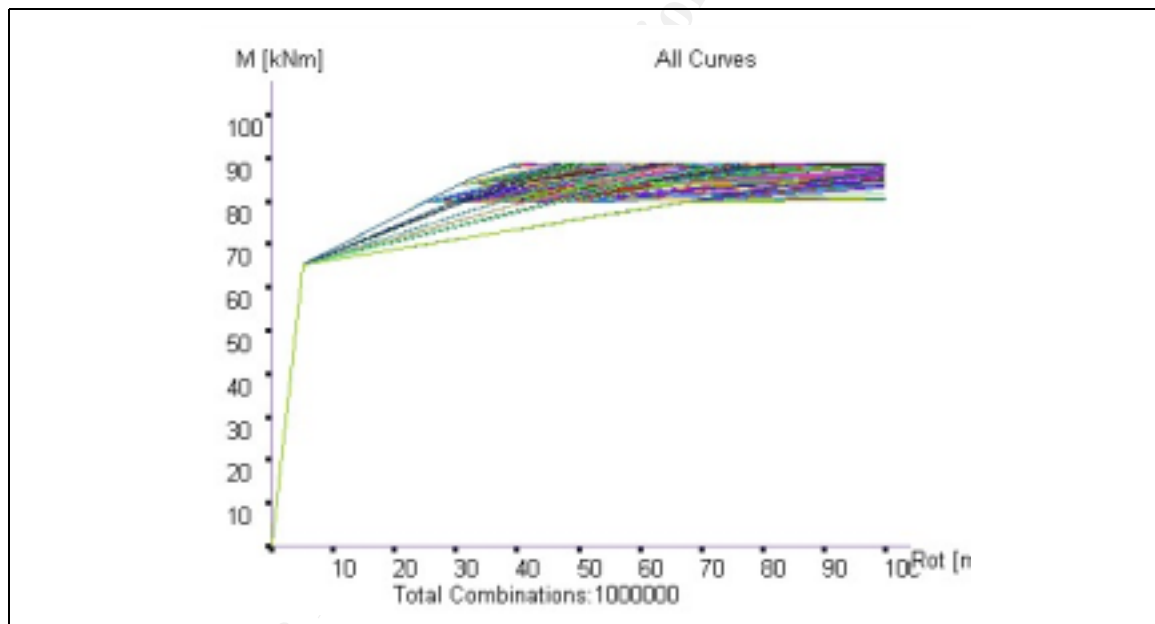


Figure 163 – All curves.

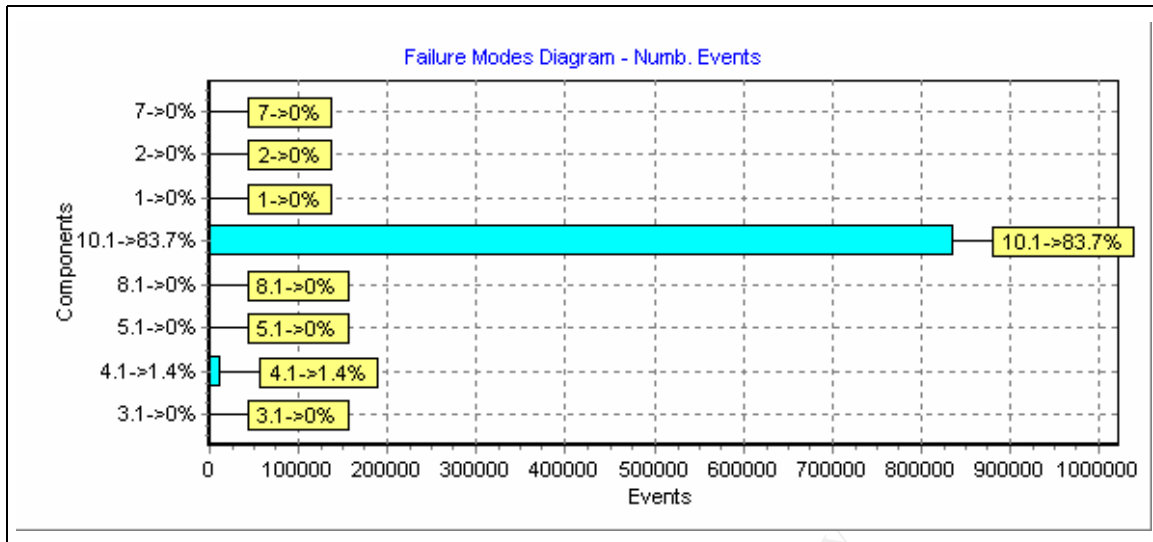


Figure 164 – Failure modes counter

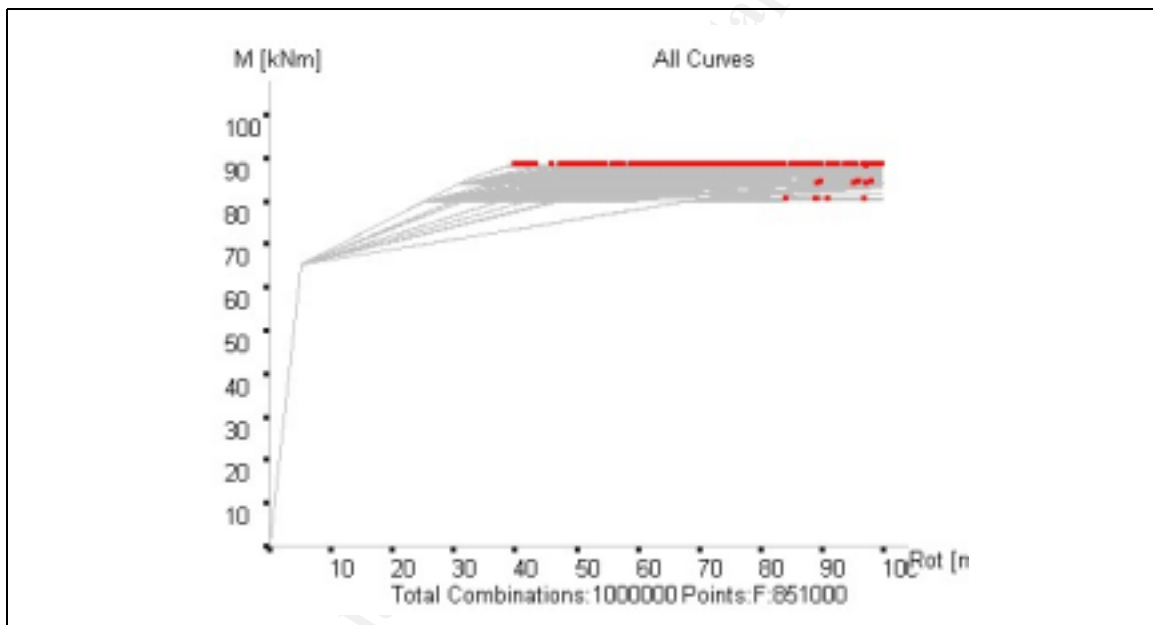


Figure 165 – All failures.

Total Combinations: 1000000

Points: F: 851000

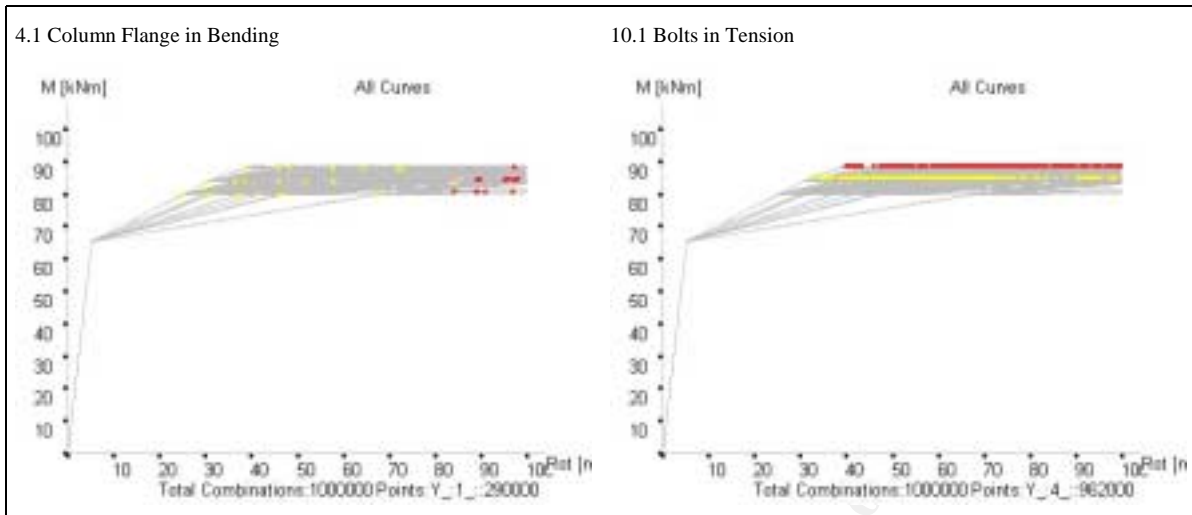


Figure 166 – Failures by component

Total Combinations:1000000

Points:F_1_::14000

Points:Y_1_::290000

Points:F_4_::837000

Points:Y_4_::962000

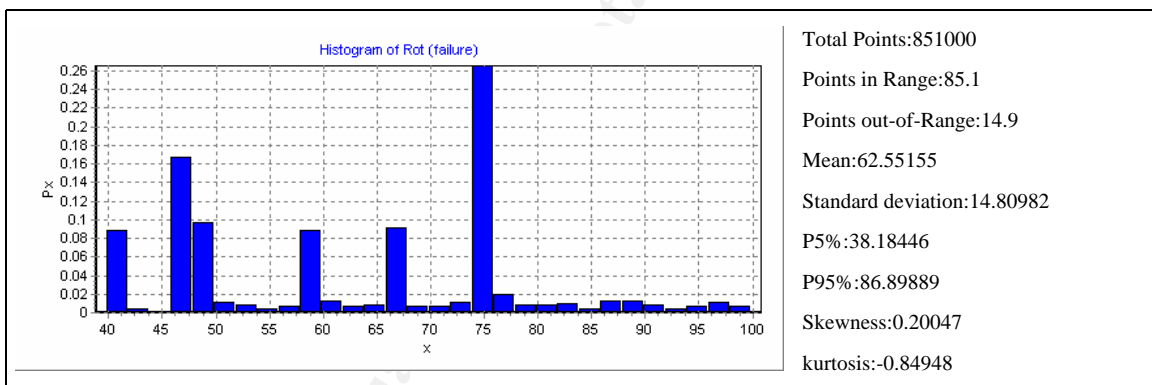


Figure 167 – Histogram of rotations at failure

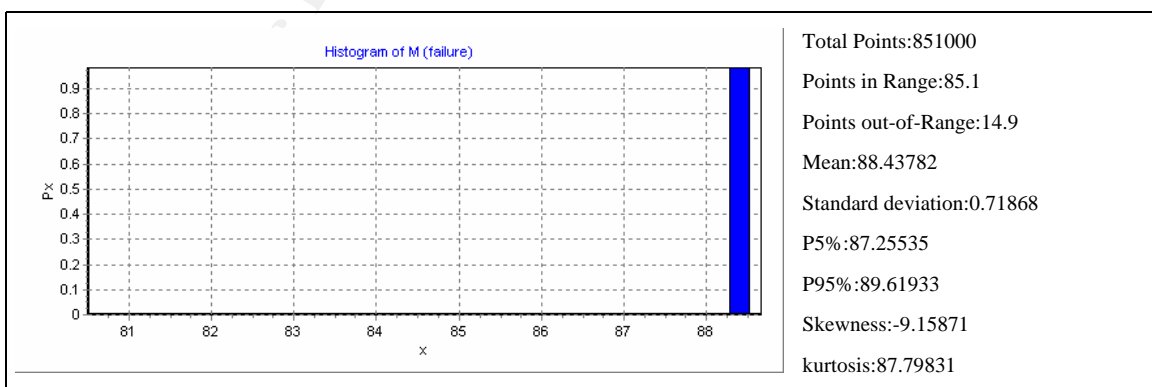
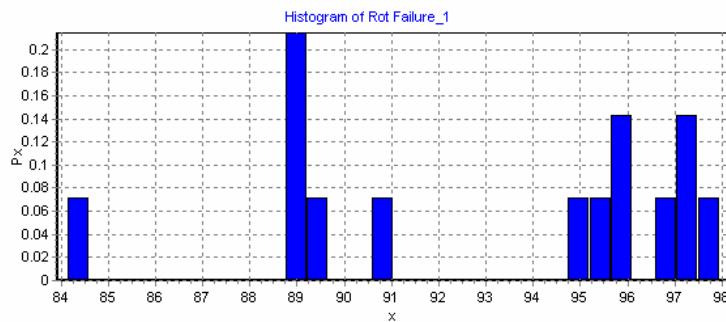
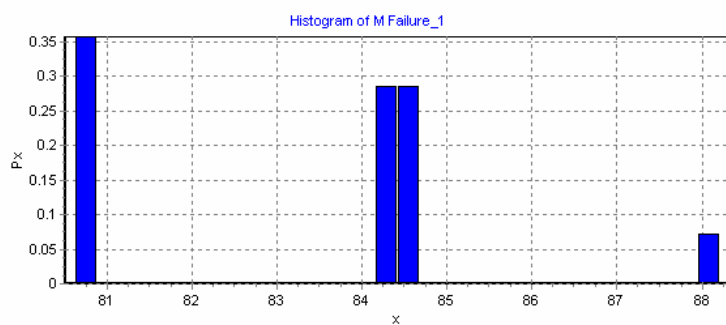


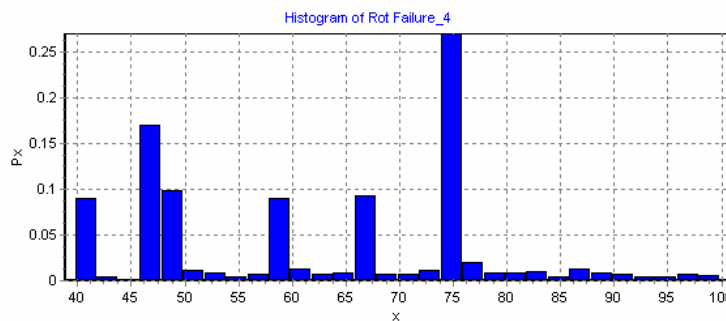
Figure 168 – Histogram of bending moments at failure.

Histograms for failures of component 4.1

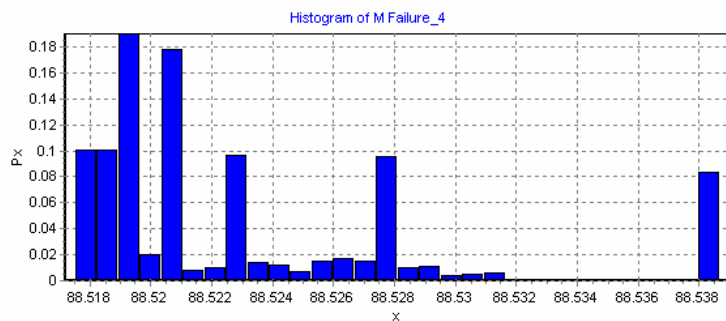
Total Points:14000
 Points in Range:1.4
 Points out-of-Range:98.6
 Mean:93.0765
 Standard deviation:4.14565
 P5%:86.25552
 P95%:99.89195
 Skewness:-0.59199
 kurtosis:-0.87671



Total Points:14000
 Points in Range:1.4
 Points out-of-Range:98.6
 Mean:83.34205
 Standard deviation:2.23452
 P5%:79.66551
 P95%:87.01561
 Skewness:0.17522
 kurtosis:-0.5899

Histograms for failures of component 10.1

Total Points:837000
 Points in Range:83.7
 Points out-of-Range:16.3
 Mean:62.04098
 Standard deviation:14.38284
 P5%:38.37642
 P95%:85.68636
 Skewness:0.16055
 kurtosis:-0.90197



Total Points:837000
 Points in Range:83.7
 Points out-of-Range:16.3
 Mean:88.52305
 Standard deviation:0.00578
 P5%:88.51355
 P95%:88.53255
 Skewness:1.59827
 kurtosis:1.75981

Figure 169 – Histograms of rotations and bending moments at failure by responsible component.

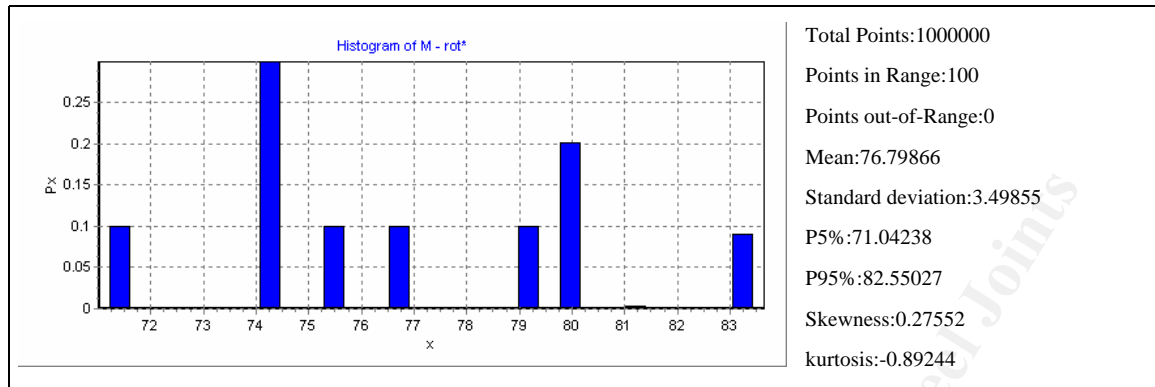


Figure 170 – Histogram of bending moment for rotation=30 mrad

1.2.4.3 C.3) Kp (Component [3], [4], [5]), Δf ([3], [4])

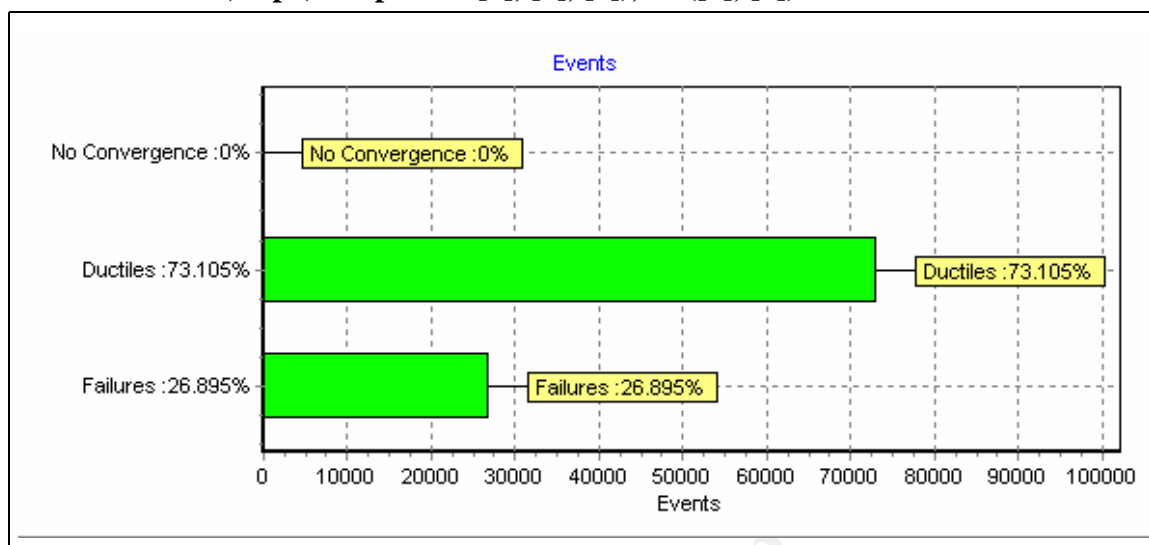


Figure 171 – Calculation summary.

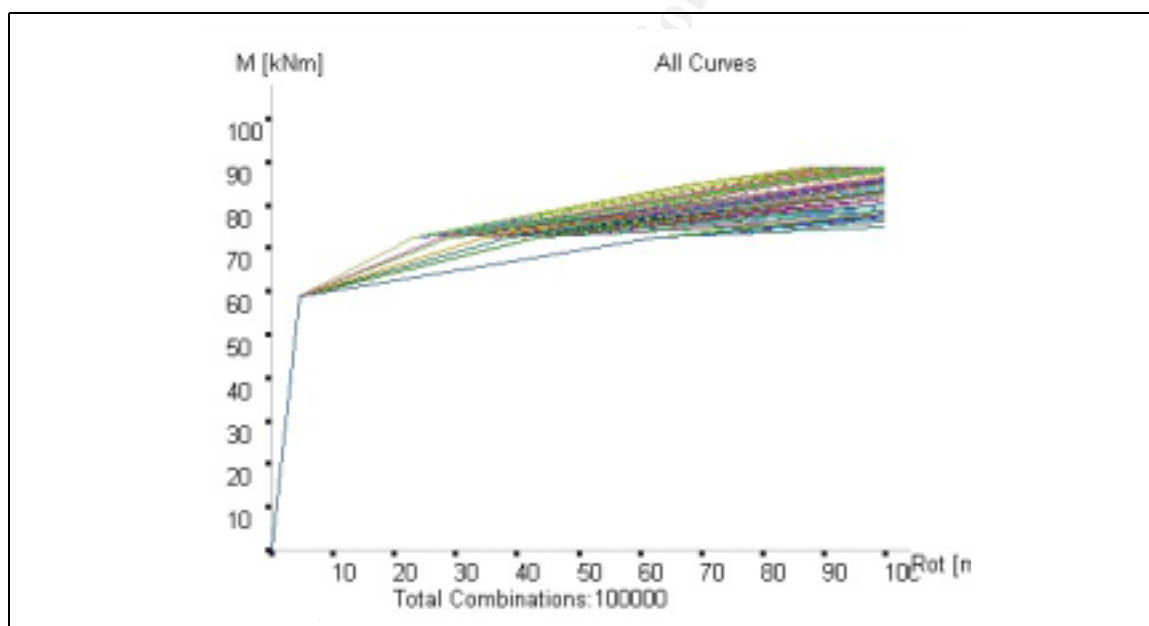


Figure 172 – All curves.

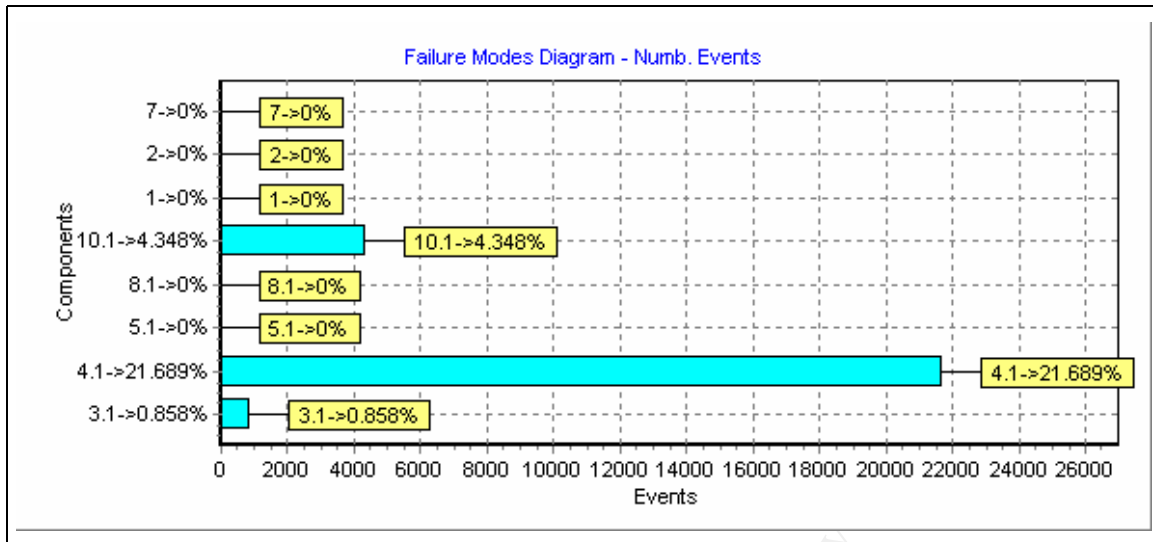


Figure 173 – Failure modes counter

3.1 : 858
4.1 : 21689
10.1 : 4348

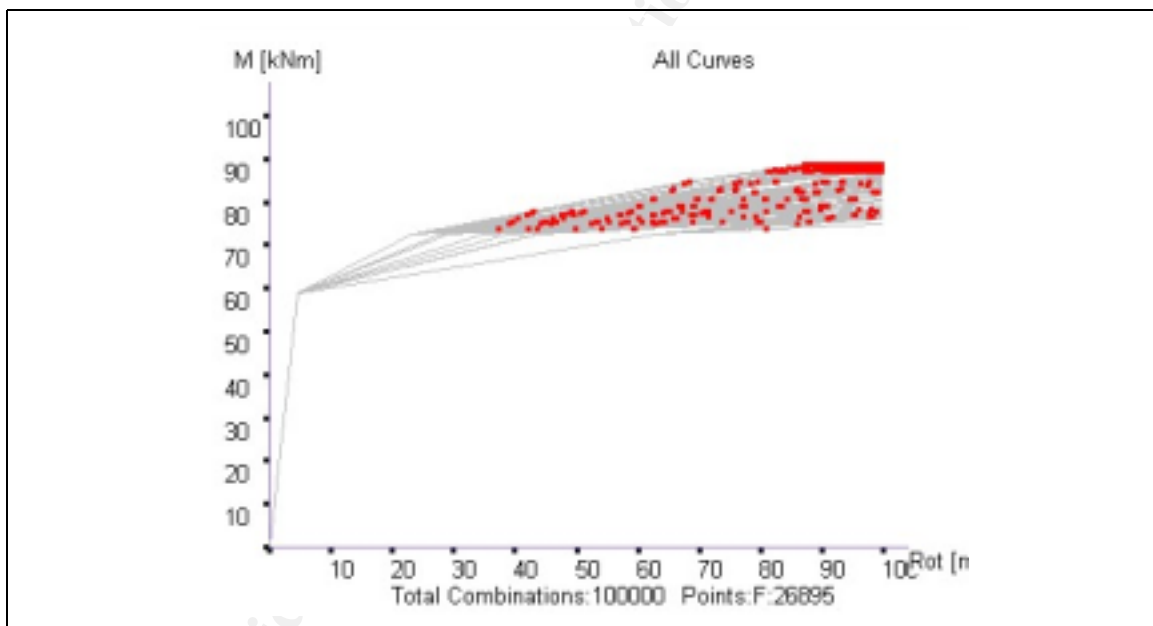


Figure 174 – All failures.

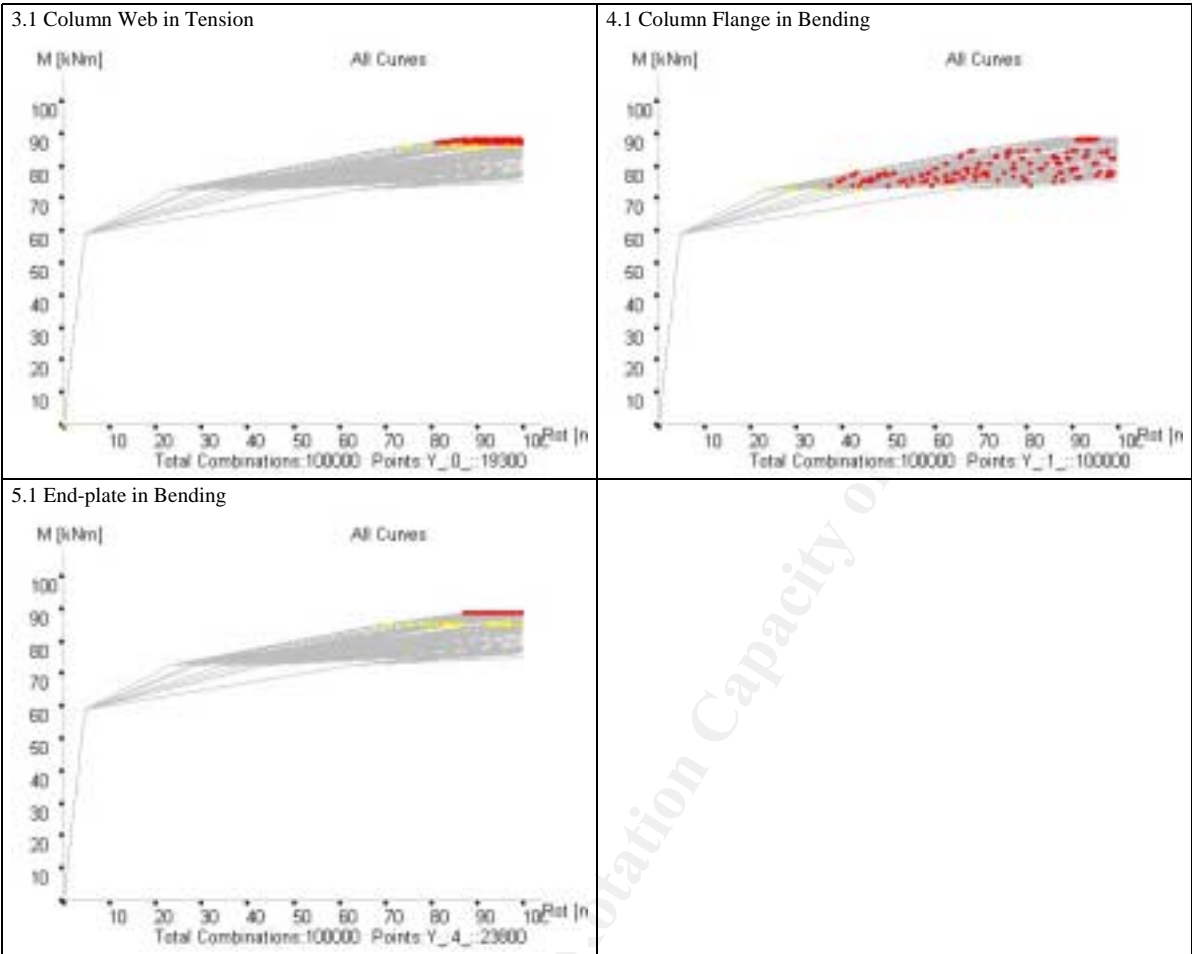


Figure 175 – Failures by component

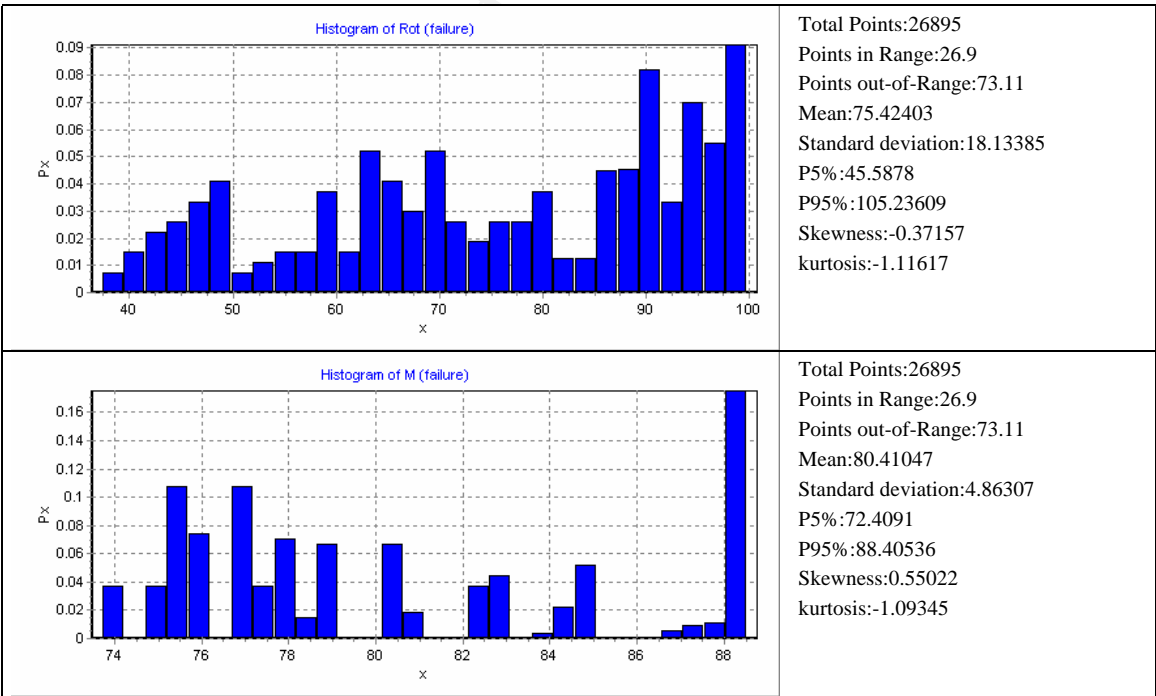
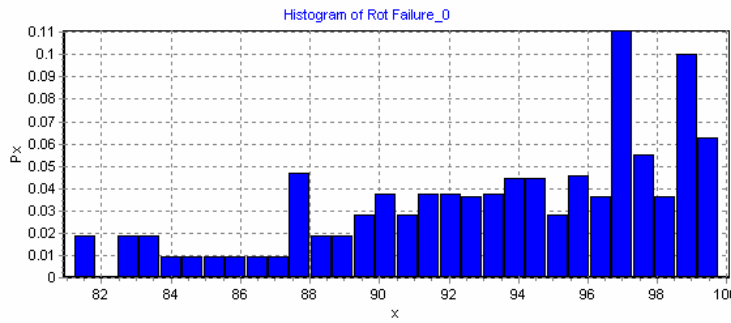
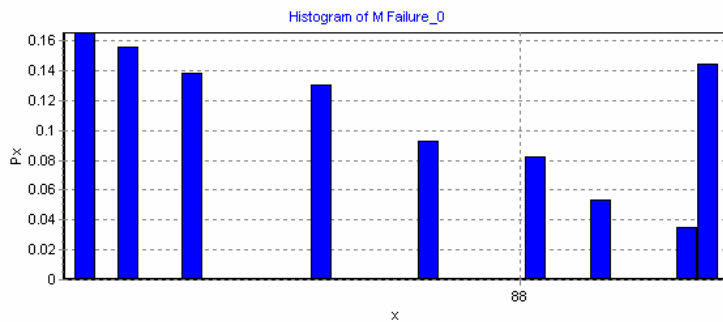


Figure 176 - Histograms of rotations and bending moments at failure.

Histograms for failures of component 3.1

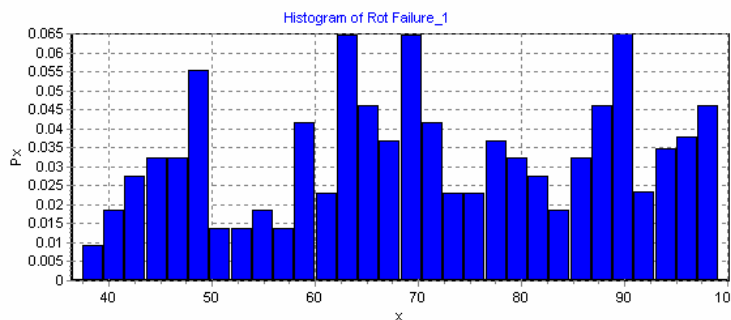


Total Points:858
 Points in Range:0.86
 Points out-of-Range:99.14
 Mean:93.55382
 Standard deviation:4.79552
 P5%:85.66358
 P95%:101.43766
 Skewness:-0.74035
 kurtosis:-0.34788

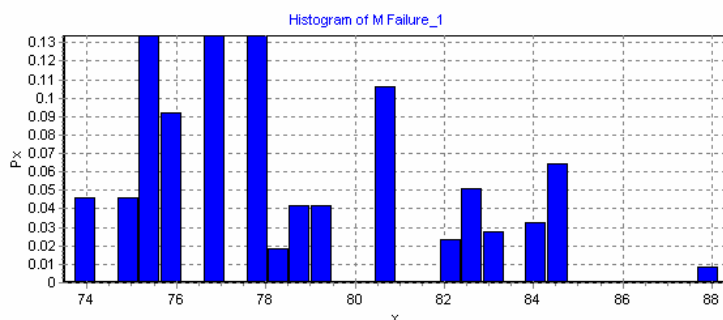


Total Points:858
 Points in Range:0.86
 Points out-of-Range:99.14
 Mean:87.61651
 Standard deviation:0.50813
 P5%:86.78046
 P95%:88.45187
 Skewness:0.39037
 kurtosis:-1.3419

Histograms for failures of component 4.1



Total Points:21689
 Points in Range:21.69
 Points out-of-Range:78.31
 Mean:70.79188
 Standard deviation:17.11644
 P5%:42.62964
 P95%:98.9313
 Skewness:-0.10368
 kurtosis:-1.09699



Total Points:21689
 Points in Range:21.69
 Points out-of-Range:78.31
 Mean:78.49897
 Standard deviation:3.22674
 P5%:73.18991
 P95%:83.80373
 Skewness:0.68689
 kurtosis:-0.42936

Histograms for failures of component 10.1

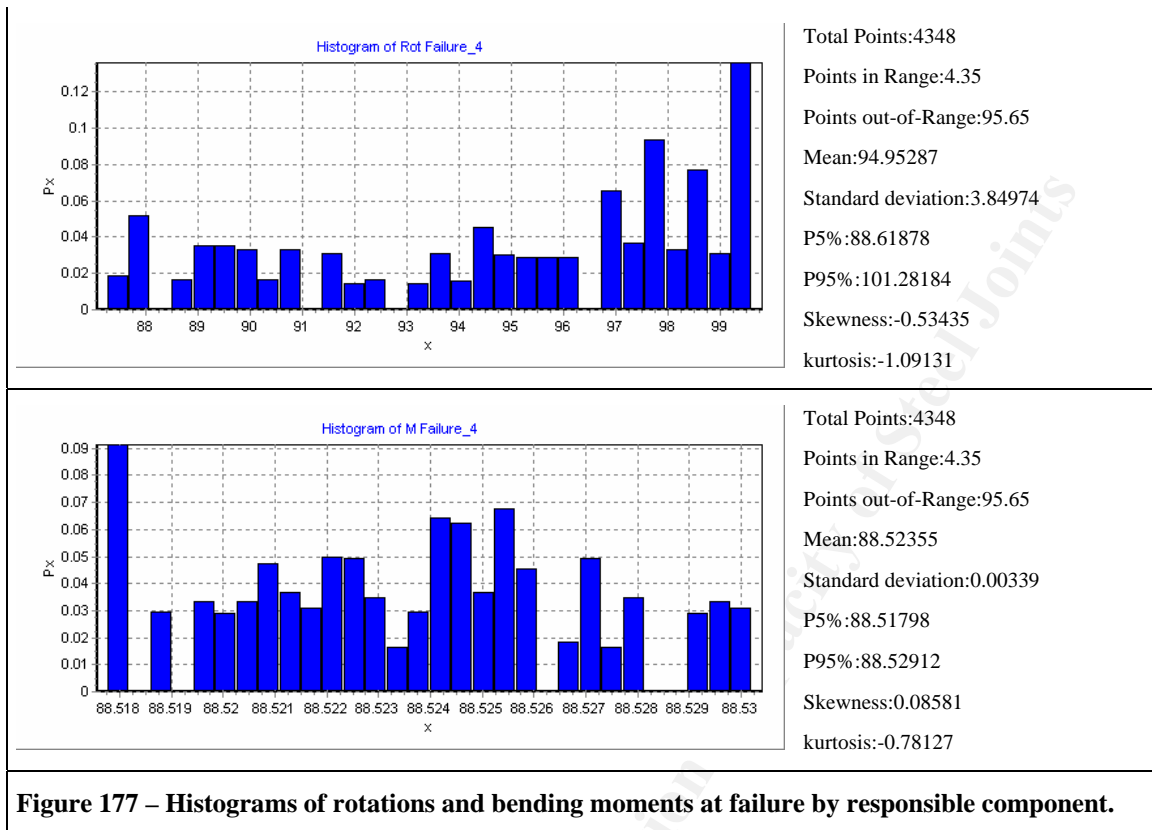


Figure 177 – Histograms of rotations and bending moments at failure by responsible component.

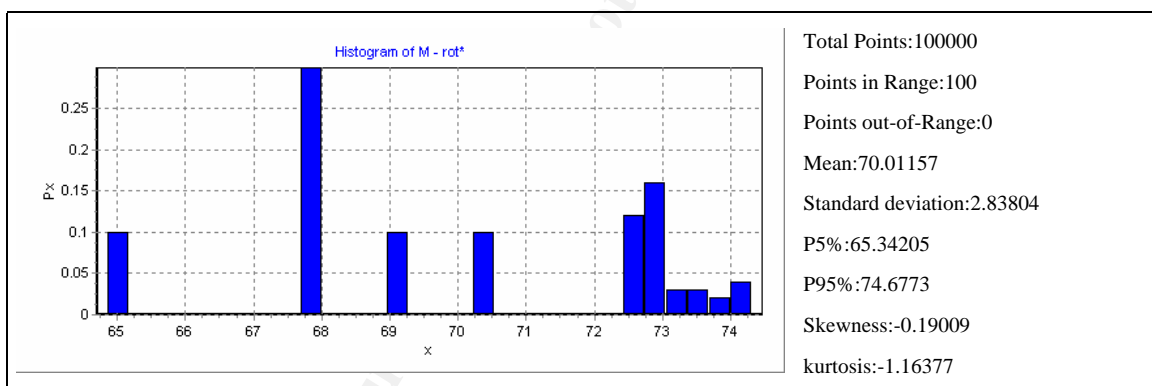


Figure 178 – Histogram for rotation=30 mrad

1.2.4.4 C.3b) K_p (Component [3], [4], [5]), Δf ([3], [4])

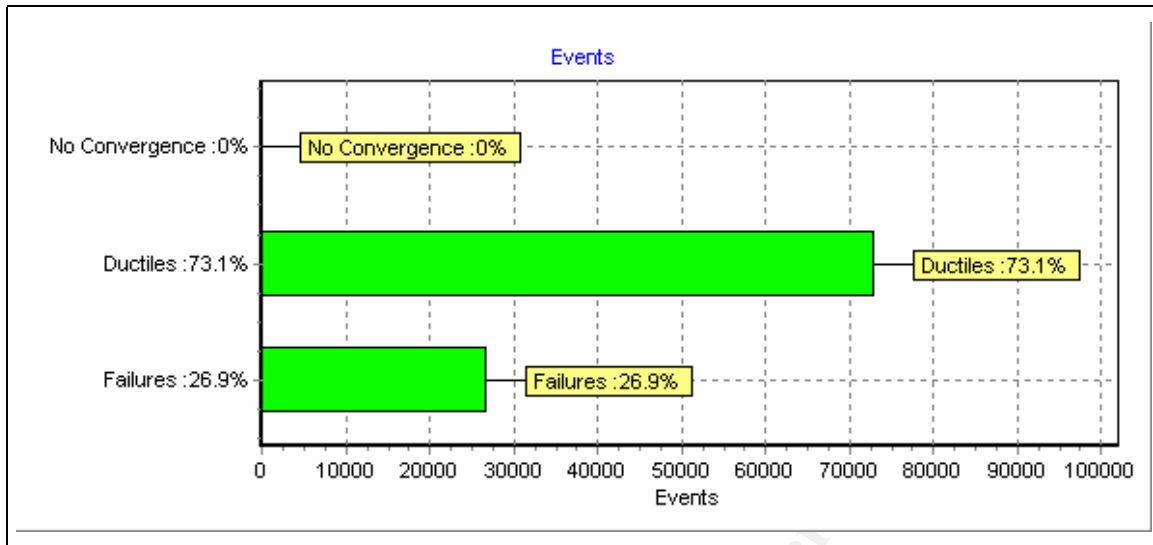


Figure 179 – Calculation summary.

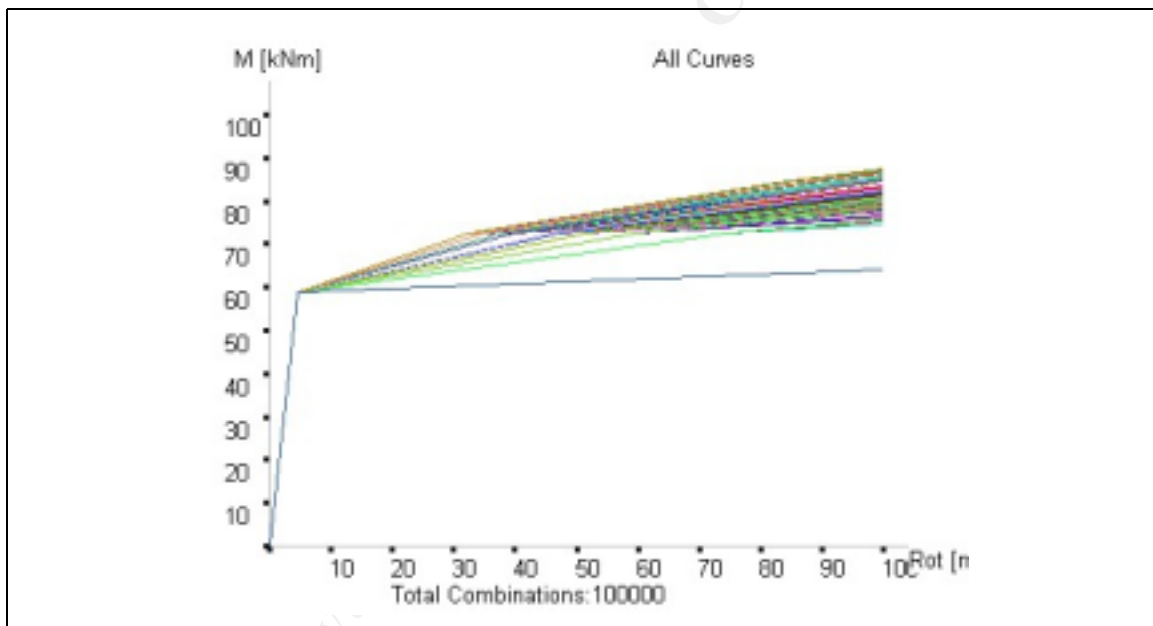


Figure 180 – All curves.

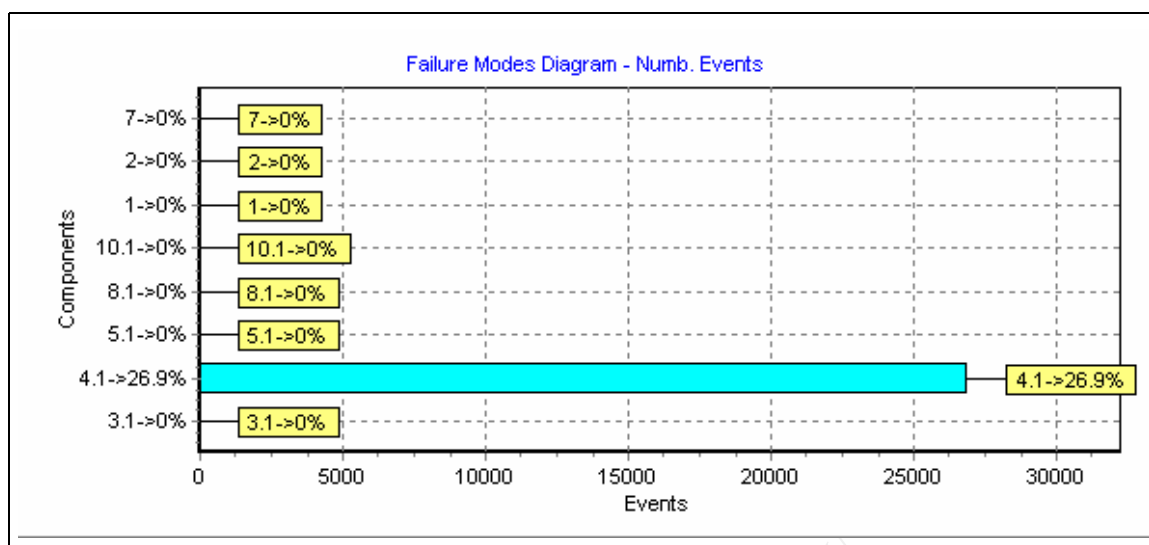


Figure 181 – Failure modes counter

4.1 : 26900

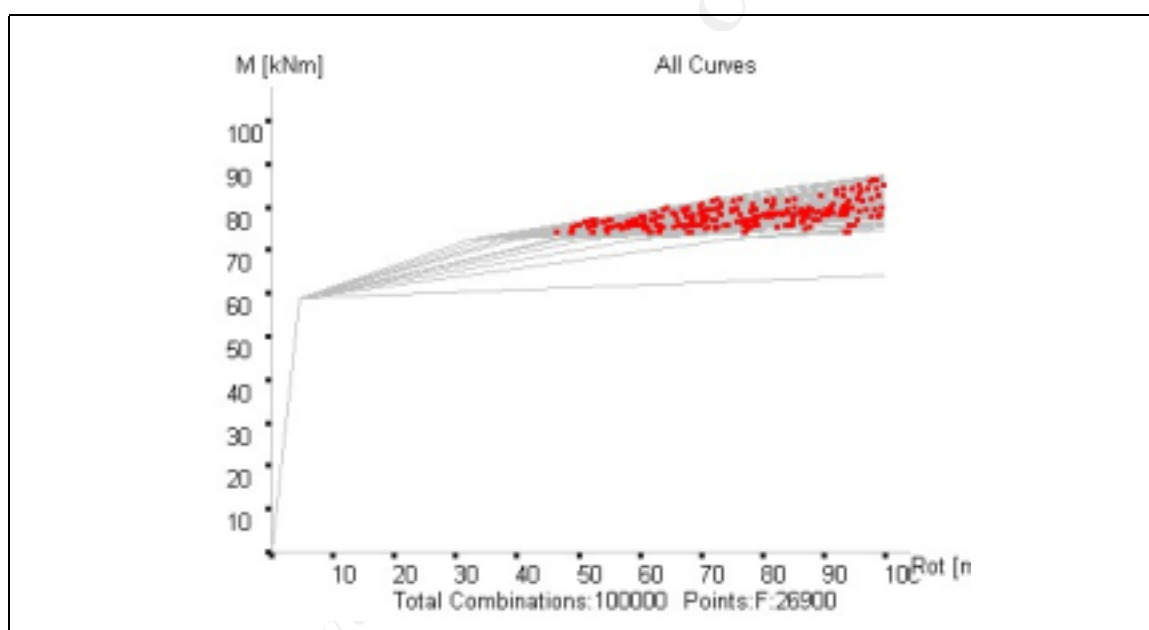


Figure 182 – All failures.

4.1 Column Flange in Bending

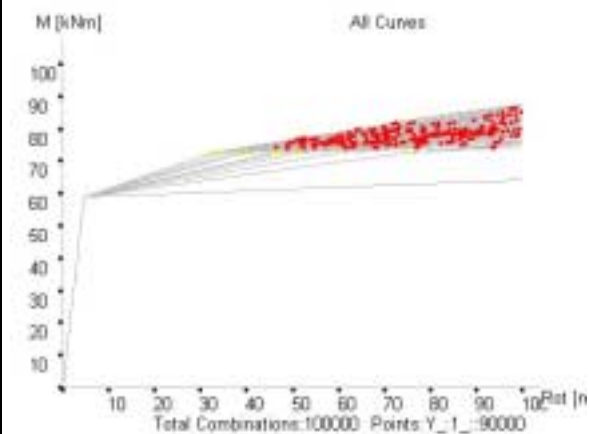


Figure 183 – Failures by component

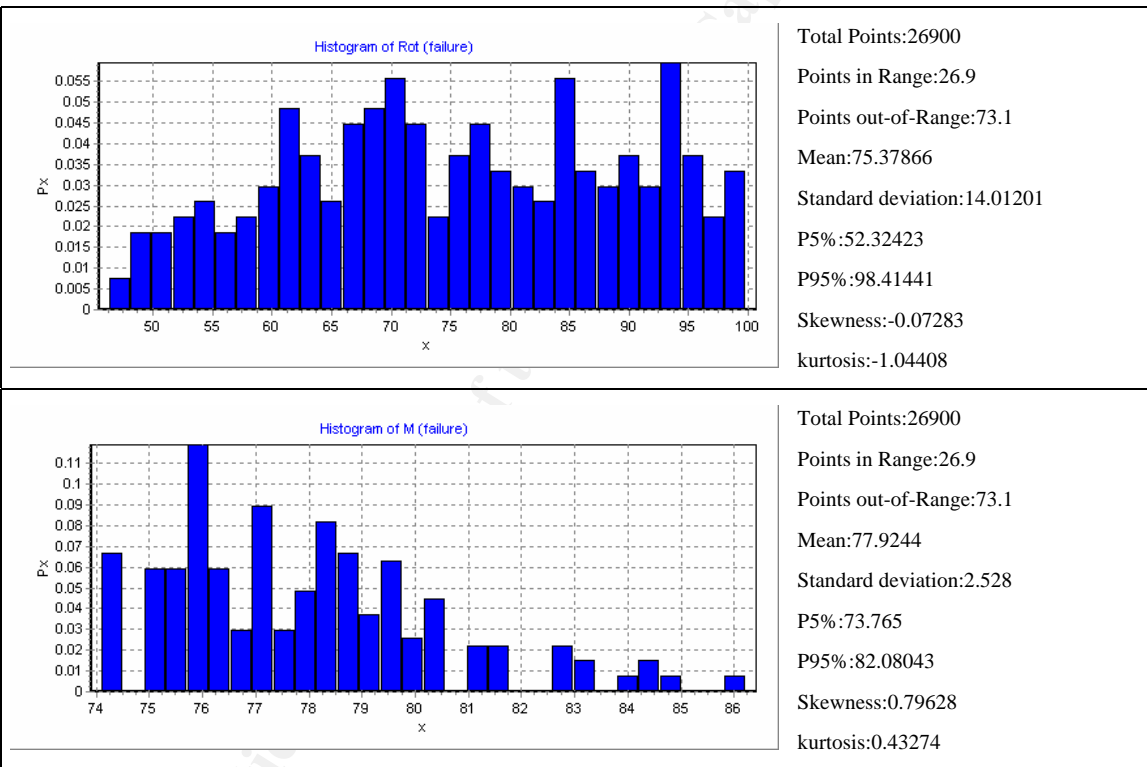
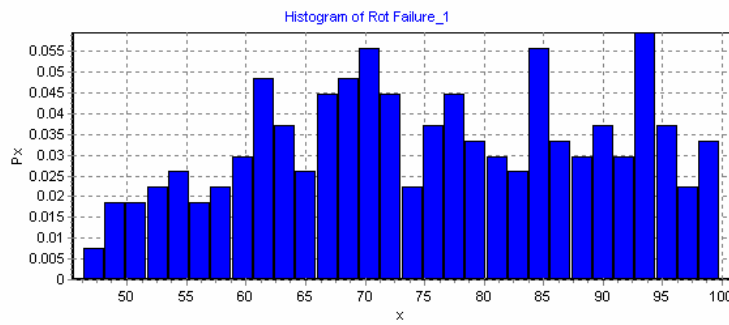
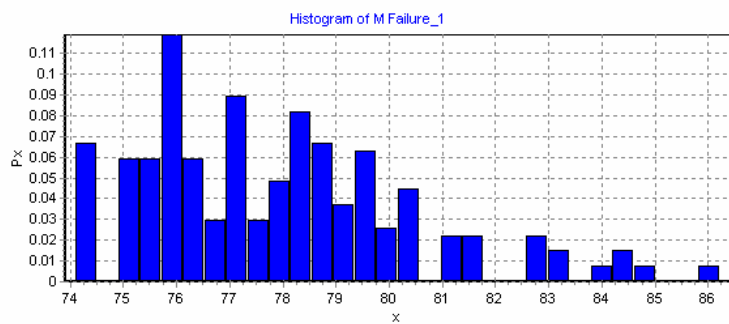


Figure 184 - Histograms of rotations and bending moments at failure.

Histograms for failures of component 4.1

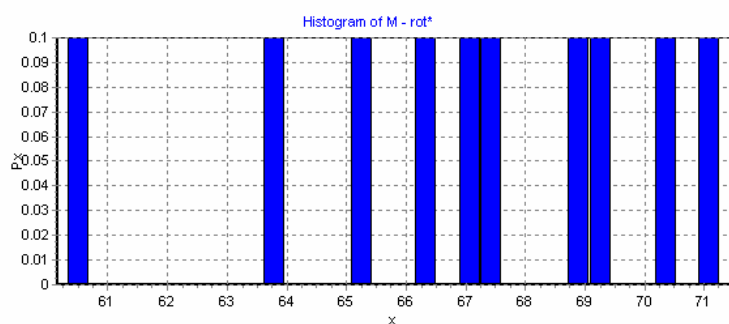


Total Points:26900
 Points in Range:26.9
 Points out-of-Range:73.1
 Mean:75.37866
 Standard deviation:14.01201
 P5%:52.32423
 P95%:98.41441
 Skewness:-0.07283
 kurtosis:-1.04408



Total Points:26900
 Points in Range:26.9
 Points out-of-Range:73.1
 Mean:77.9244
 Standard deviation:2.528
 P5%:73.765
 P95%:82.08043
 Skewness:0.79628
 kurtosis:0.43274

Figure 185 – Histograms of rotations and bending moments at failure by responsible component.



Total Points:100000
 Points in Range:100
 Points out-of-Range:0
 Mean:66.97244
 Standard deviation:3.09674
 P5%:61.87727
 P95%:72.06349
 Skewness:-0.6434
 kurtosis:-0.21043

Figure 186 – Histogram of bending moments for rotation=30 mrad

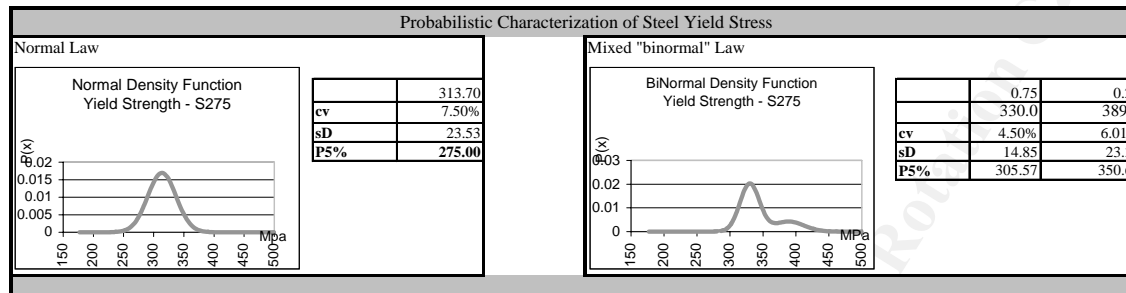
1.3 Lima FE1 connection modified

*With endplate thickness=13mm (verifying the EC3 requirements for guaranteeing sufficient rotation capacity)

1.3.1 Simulation details, statistical properties and studied cases

Flush Connection (Luciano Lima modified test)

Critical Component in Tension Zone



Real (measured) Steel properties			
	Fy Nominal	fyreal	fu
	[N/mm2]	[N/mm2]	[N/mm2]
Column			
Flange	275	342.9	477.3
Web	275	372.0	448.8
Beam			
Flange	275	340.1	448.2
Web	275	363.4	454.3
Endplate	275	369.4	503.5
Bolts	M20 10.9	900.0	1000.0

	Components	Fy [kN]										ke [kN/m]	kp [kN/m]				Df			
		FYk nominal		real		Normal distribution		Binormal distribution					real	calibrated (109.005)		cv	=	Df/DY		cv
								a=0.75		a=0.25										
		x	(P X>x)*	x	(P X>x)*	a	=a Fvk	cv= 7.5%	cv	cv	cv									
[3.1]	Column Web in Transverse Tension	445.36	98.69%	602.45	4.49%	1.20	534.43	7.50%	534.43	4.50%	630.18	6.01%								
[4.1]	Column Flange in Bending	375.48	98.69%	408.32	89.44%	1.20	450.58	7.50%	450.58	4.50%	531.30	6.01%	8.03E+06	8.03E+03	8.03E+03	50.00%	200.00	200.00	50.00%	
[5.1]	End-Plate in Bending	278.05	98.69%	306.66	85.97%	1.20	333.66	7.50%	333.66	4.50%	393.44	6.01%	9.60E+05	3.84E+03	3.84E+03	50.00%	200.00	200.00	50.00%	
[8.1]	Beam Web in Tension	365.68	98.69%	483.23	8.86%	1.20	438.82	7.50%	438.82	4.50%	517.44	6.01%	1.00E+12	1.00E+10	1.00E+10	50.00%	200.00	200.00	50.00%	
[10.1]	Bolts in Tension	441.00	98.69%	441.00	98.69%	1.20	529.20	7.50%	529.20	4.50%	624.02	6.01%	1.70E+06	3.39E+04	3.39E+04	50.00%	3.00	3.00	83.33%	
[11]	Column Web Panel in Shear	-474.77	98.69%	-642.24	4.48%	1.20	-569.72	7.50%	-569.72	4.50%	-671.80	6.01%	1.37E+06	1.83E+04	6.87E+04	50.00%	200.00	200.00	50.00%	
[2]	Column Web in Transverse Compression	-504.50	98.69%	-632.95	27.20%	1.20	-605.40	7.50%	-605.40	4.50%	-713.87	6.01%	2.12E+06	1.23E+05	6.35E+04	50.00%	12.00	15.00	50.00%	
[7]	Beam Flange in Compression	-438.00	98.69%	-555.57	22.35%	1.20	-525.60	7.50%	-525.60	4.50%	-619.77	6.01%	1.00E+12	1.00E+10	1.00E+10	50.00%	10.00	10.00	50.00%	
[19]	Welds																			

Case B1

	Components	Fy [kN]								ke [kN/m]	kp [kN/m]			Df			
		FYk nominal	real	Normal distribution			Binormal distribution				real	calibrated (109.005)	m	cv	j= Df/DY	m	cv
							a=0.75		a=0.25								
				x	m=x Fyk	cv= 7.5%	m	cv	m	cv							
[3.1]	Column Web in Transverse Tension	445.36	602.45	1.20	534.43	7.50%	534.43	4.50%	630.18	6.01%	1.48E+06	1.48E+04	1.48E+04	50.00%	10.00	10.00	
[4.1]	Column Flange in Bending	375.48	408.32	1.20	450.58	7.50%	450.58	4.50%	531.30	6.01%	8.03E+06	8.03E+03	8.03E+03	50.00%	200.00	200.00	
[5.1]	End-Plate in Bending	278.05	306.66	1.20	333.66	7.50%	333.66	4.50%	393.44	6.01%	9.60E+05	3.84E+03	3.84E+03	50.00%	200.00	200.00	
[8.1]	Beam Web in Tension	365.68	483.23	1.20	438.82	7.50%	438.82	4.50%	517.44	6.01%	1.00E+12	1.00E+10	1.00E+10	50.00%	200.00	200.00	
[10.1]	Bolts in Tension	441.00	441.00	1.20	529.20	7.50%	529.20	4.50%	624.02	6.01%	1.70E+06	3.39E+04	3.39E+04	50.00%	3.00	3.00	
[1]	Column Web Panel in Shear	-474.77	-642.24	1.20	-569.72	7.50%	-569.72	4.50%	-671.80	6.01%	1.37E+06	6.46E+05	6.87E+04	50.00%	200.00	200.00	
[2]	Column Web in Transverse Compression	-504.50	-632.95	1.20	-605.40	7.50%	-605.40	4.50%	-713.87	6.01%	2.12E+06	7.51E+05	6.35E+04	50.00%	12.00	15.00	40%
[7]	Beam Flange in Compression	-438.00	-555.57	1.20	-525.60	7.50%	-525.60	4.50%	-619.77	6.01%	1.00E+12	1.00E+10	1.00E+10	50.00%	10.00	10.00	
[19]	Welds																

Case B2

	Components	Fy [kN]								ke [kN/m]	kp [kN/m]			Df			
		FYk nominal	real	Normal distribution			Binormal distribution				real	calibrated (109.005)	m	cv	j= Df/DY	m	cv
				x	m=x Fyk	cv= 7.5%	a=0.75		a=0.25								
							m	cv	m	cv							
[3.1]	Column Web in Transverse Tension	445.36	602.45	1.20	534.43	7.50%	534.43	4.50%	630.18	6.01%	1.48E+06	1.48E+04	1.48E+04	50.00%	10.00	10.00	
[4.1]	Column Flange in Bending	375.48	408.32	1.20	450.58	7.50%	450.58	4.50%	531.30	6.01%	8.03E+06	8.03E+03	8.03E+03	50.00%	200.00	200.00	
[5.1]	End-Plate in Bending	278.05	306.66	1.20	333.66	7.50%	333.66	4.50%	393.44	6.01%	9.60E+05	3.84E+03	3.84E+03	50.00%	200.00	200.00	
[8.1]	Beam Web in Tension	365.68	483.23	1.20	438.82	7.50%	438.82	4.50%	517.44	6.01%	1.00E+12	1.00E+10	1.00E+10	50.00%	200.00	200.00	
[10.1]	Bolts in Tension	441.00	441.00	1.20	529.20	7.50%	529.20	4.50%	624.02	6.01%	1.70E+06	3.39E+04	3.39E+04	50.00%	3.00	3.00	
[1]	Column Web Panel in Shear	-474.77	-642.24	1.20	-569.72	7.50%	-569.72	4.50%	-671.80	6.01%	1.37E+06	2.28E+05	6.87E+04	50.00%	200.00	200.00	
[2]	Column Web in Transverse Compression	-504.50	-632.95	1.20	-605.40	7.50%	-605.40	4.50%	-713.87	6.01%	2.12E+06	3.32E+05	6.35E+04	50.00%	12.00	15.00	40%
[7]	Beam Flange in Compression	-438.00	-555.57	1.20	-525.60	7.50%	-525.60	4.50%	-619.77	6.01%	1.00E+12	1.00E+10	1.00E+10	50.00%	10.00	10.00	
[19]	Welds																

1.3.2 Case B

1.3.2.1 B.2) F^Y binormal + K_p (Component [3], [4], [5])* exclude the less relevant from B.1B2)

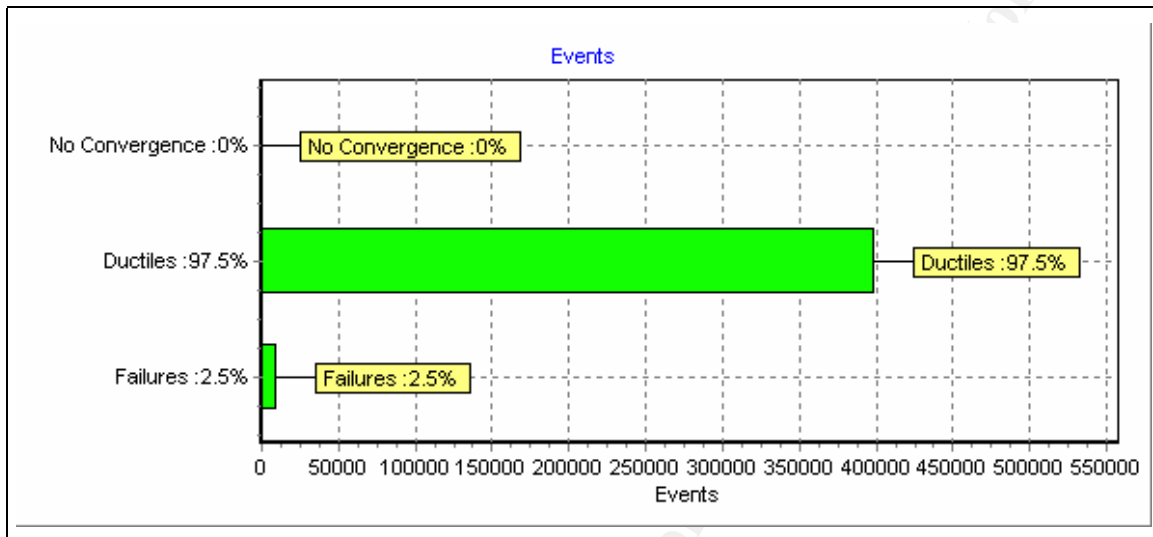


Figure 187 – Calculation summary.

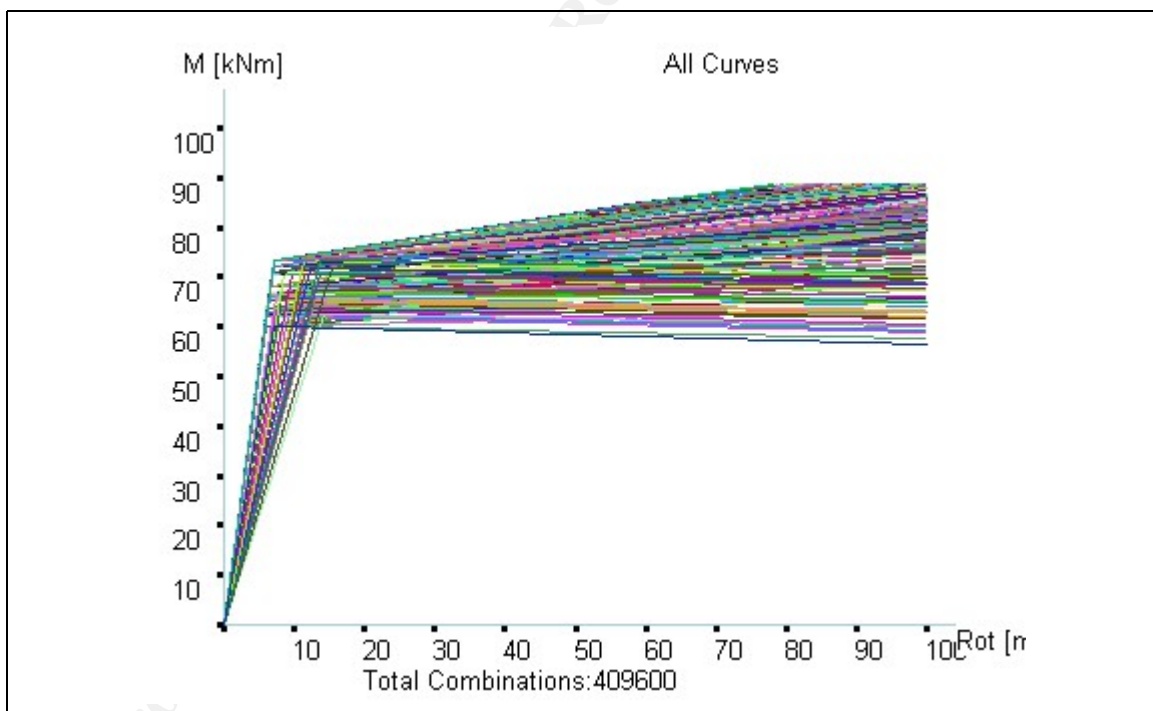


Figure 188 – All curves.

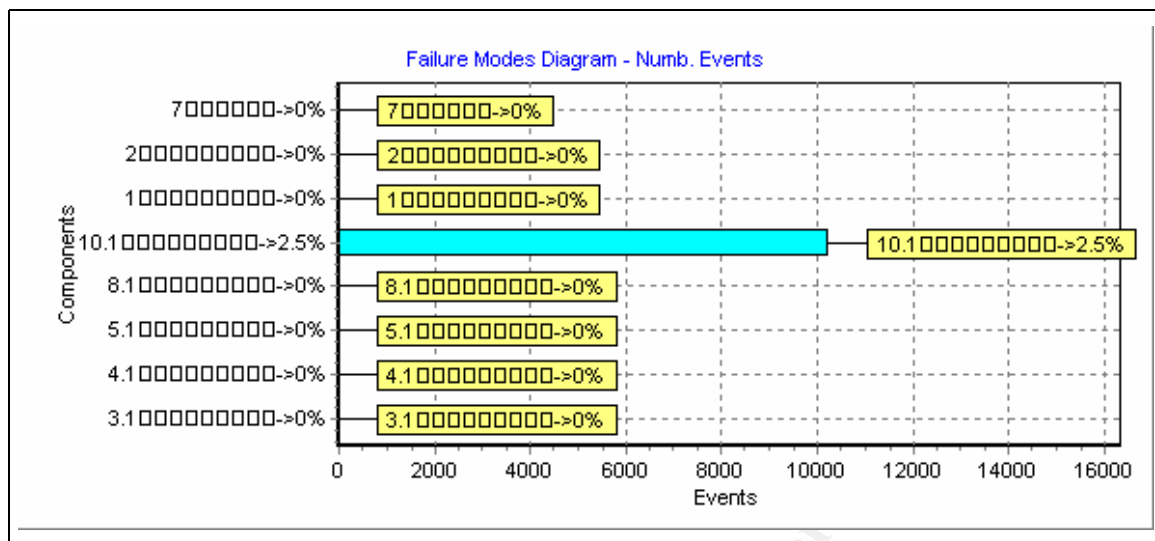


Figure 189 – Failure modes counter

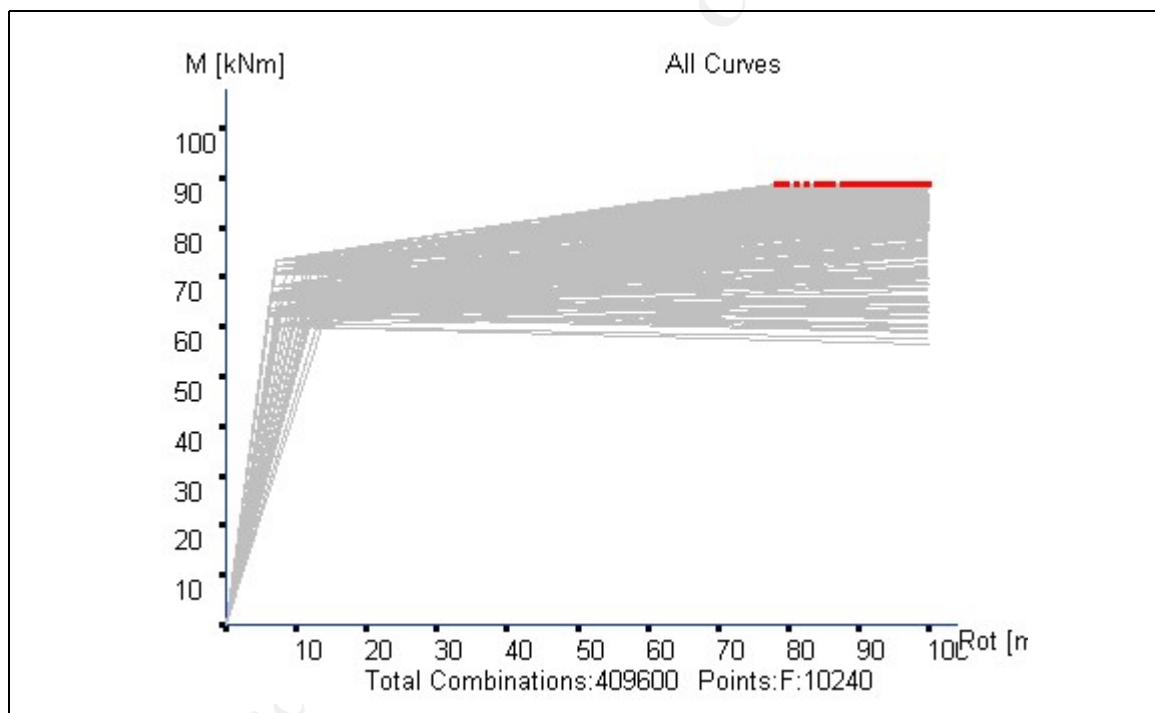


Figure 190 – All failures.

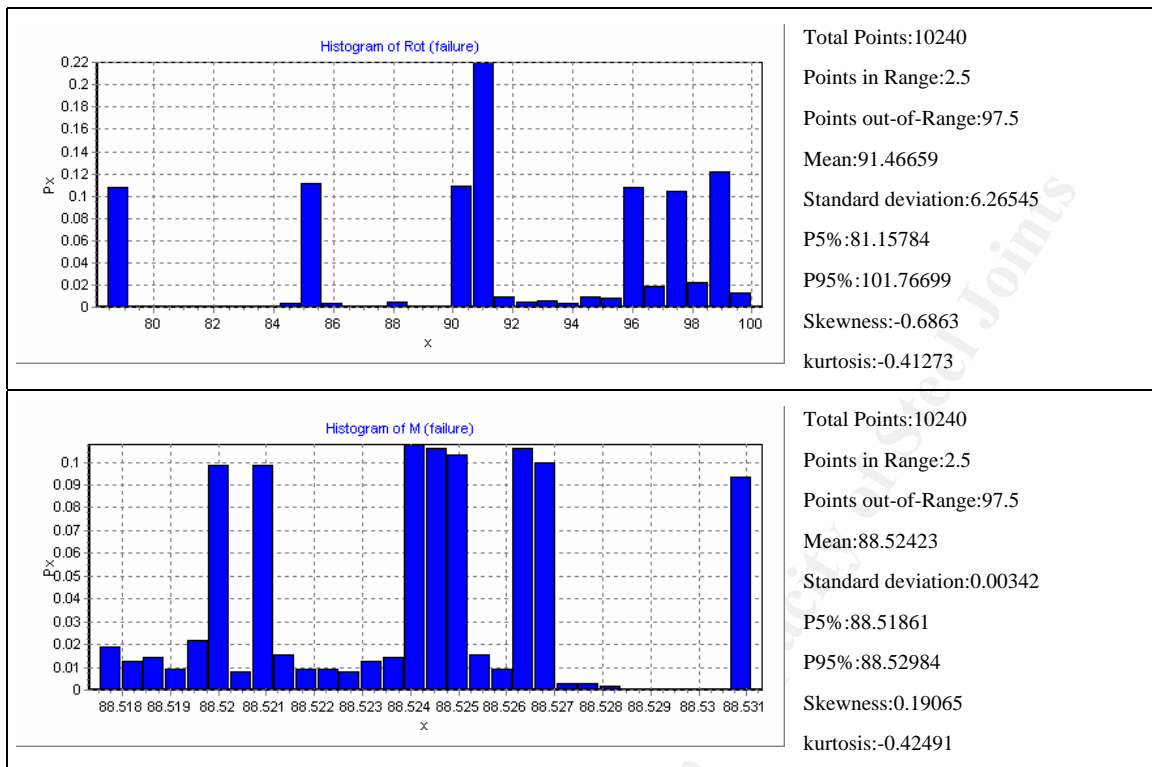


Figure 191 - Histograms of rotations and bending moments at failure.

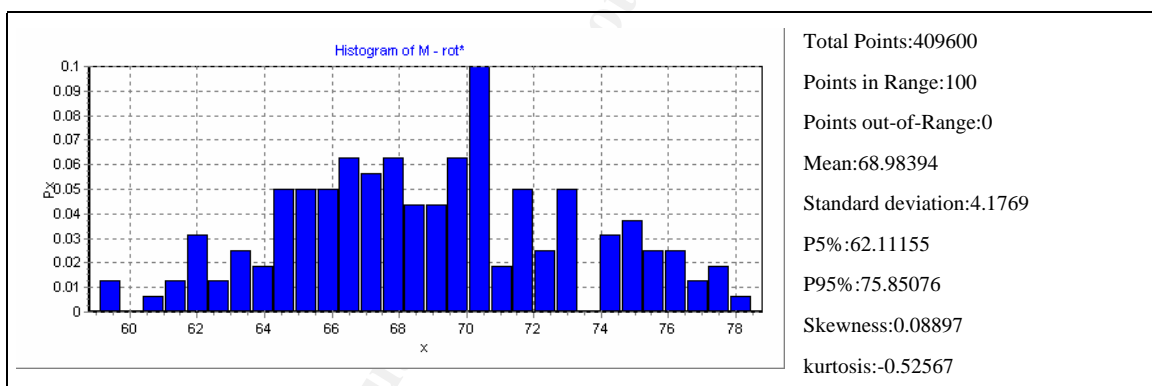


Figure 192 – Histogram of bending moments for rotation=30 mrad