RDECOM

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

Implementing Six Sigma Tools in ADEST

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Warfighter Protection and Aerial Delivery Directorate

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on Sunday Globe

NGLAND'S LARGEST NEWSPAPER

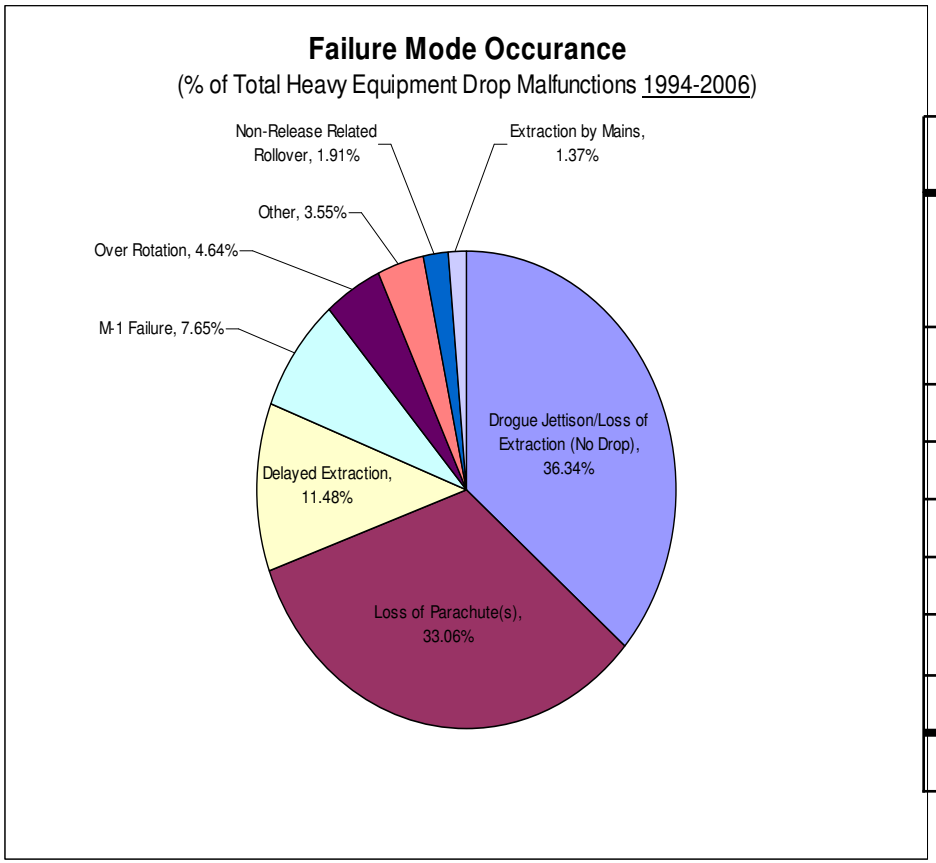
Six Sigma - Why we do it

- Communication
  - within the team
  - with the customer
  - with our suppliers
- Data driven decisions
  - Defining the problem
  - Confirming we have a solution
  - Monitoring the health of the process

Evolution of a Project – Define the Problem

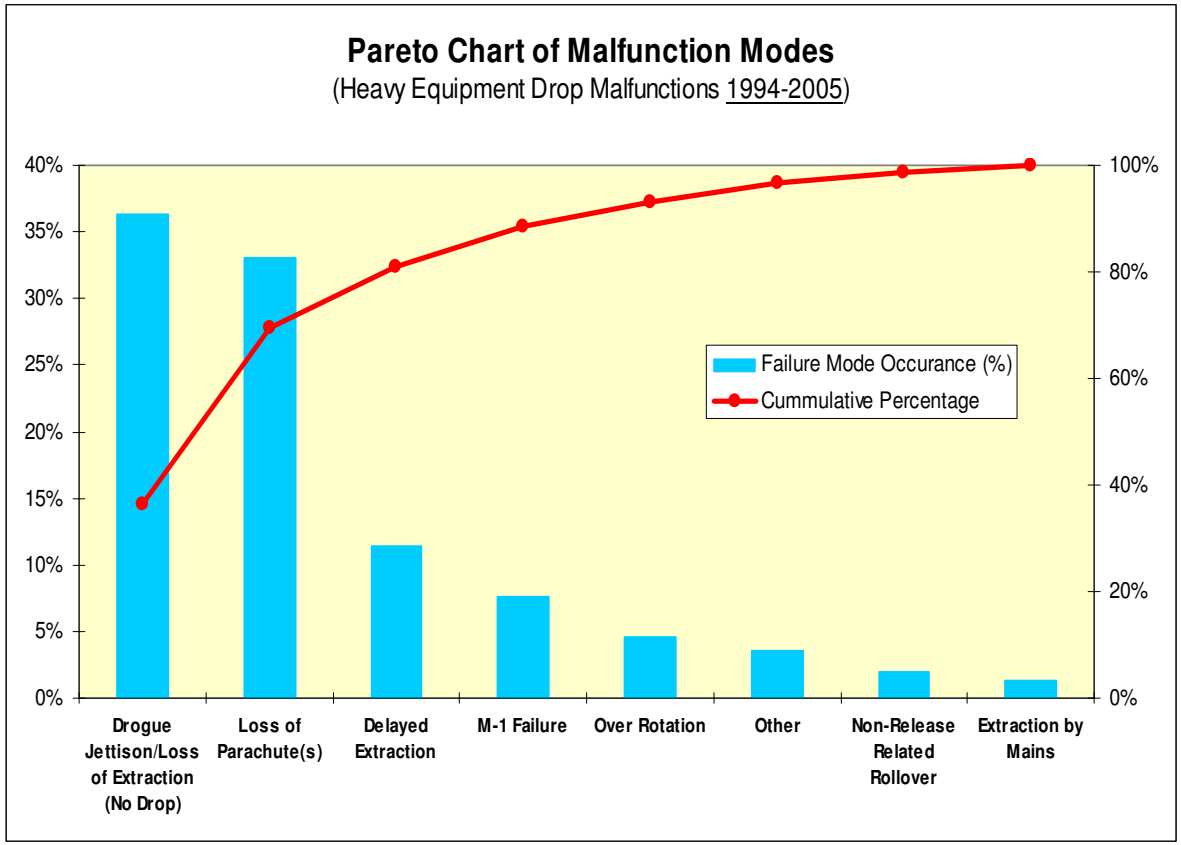
- During a training exercise, several loads rolled over due to the M-1 Canopy Release not activating
- A General Officer was present and issued a memorandum directing the design of a replacement release

Get some data - malfunction reports

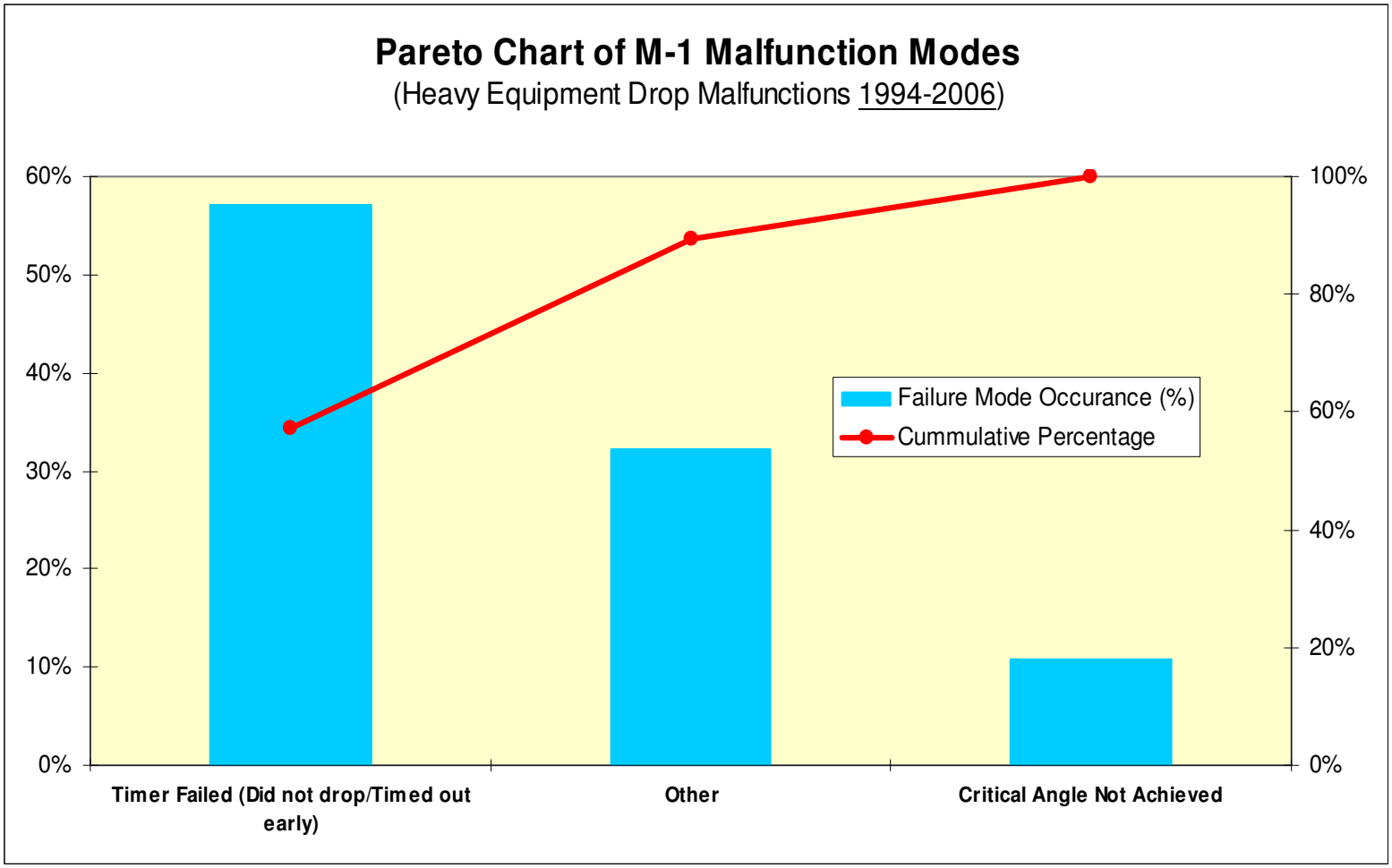


Description	Occurrence
Drogue Jettison/Loss of Extraction (No Drop)	133
Loss of Parachute(s)	121
Delayed Extraction	42
M-1 Failure	28
Over Rotation	17
Other	13
Non-Release Related Rollover	7
Extraction by Mains	5
Total	366

Do we Need an Improved Canopy Release?



Do we really need to redesign from scratch? Is it a quality issue?



HSL Pendant – 50 Foot

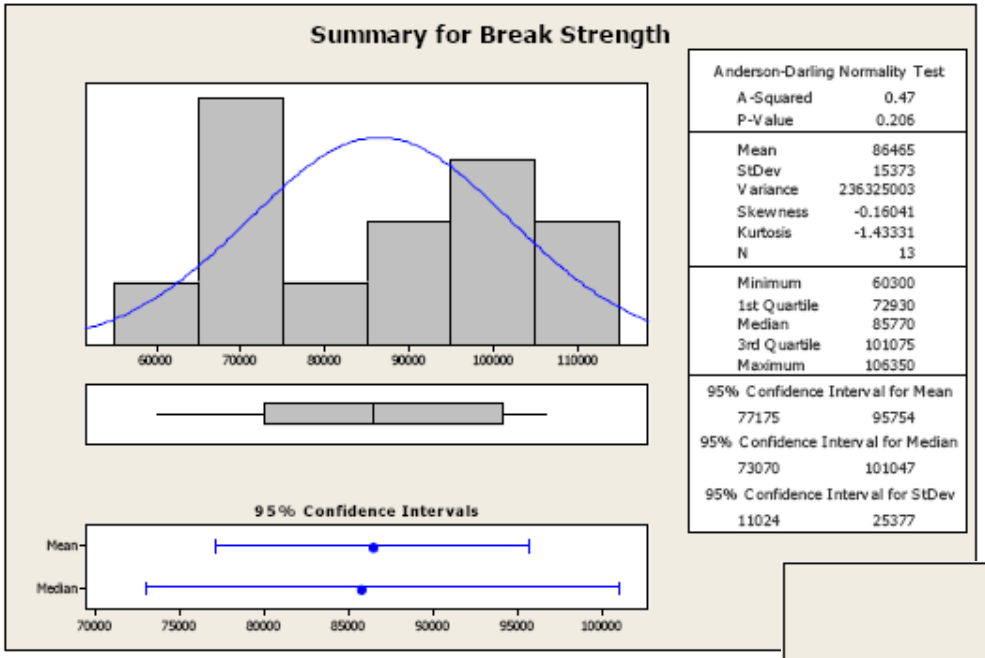
MISSION: Improve helicopter sling load (HSL) operations in adverse environmental conditions.

Item Characteristics

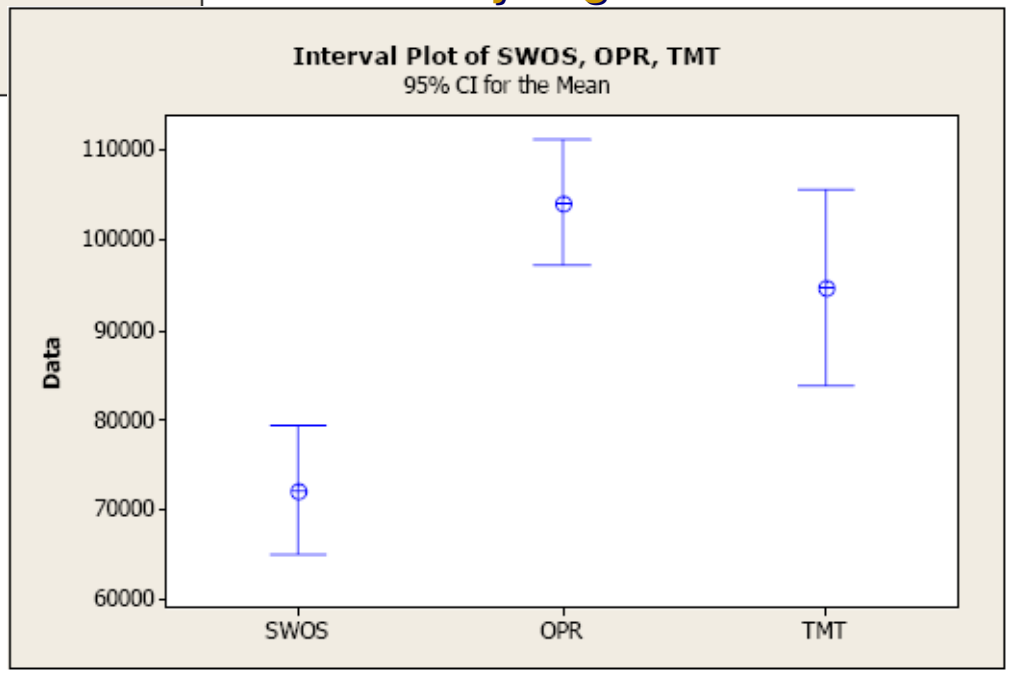
- Length: 50 ft
- 15,000-pound capacity
- Constructed from loops of braided VECTRAN
- Improved sand resistance (extruded cover)

Problem

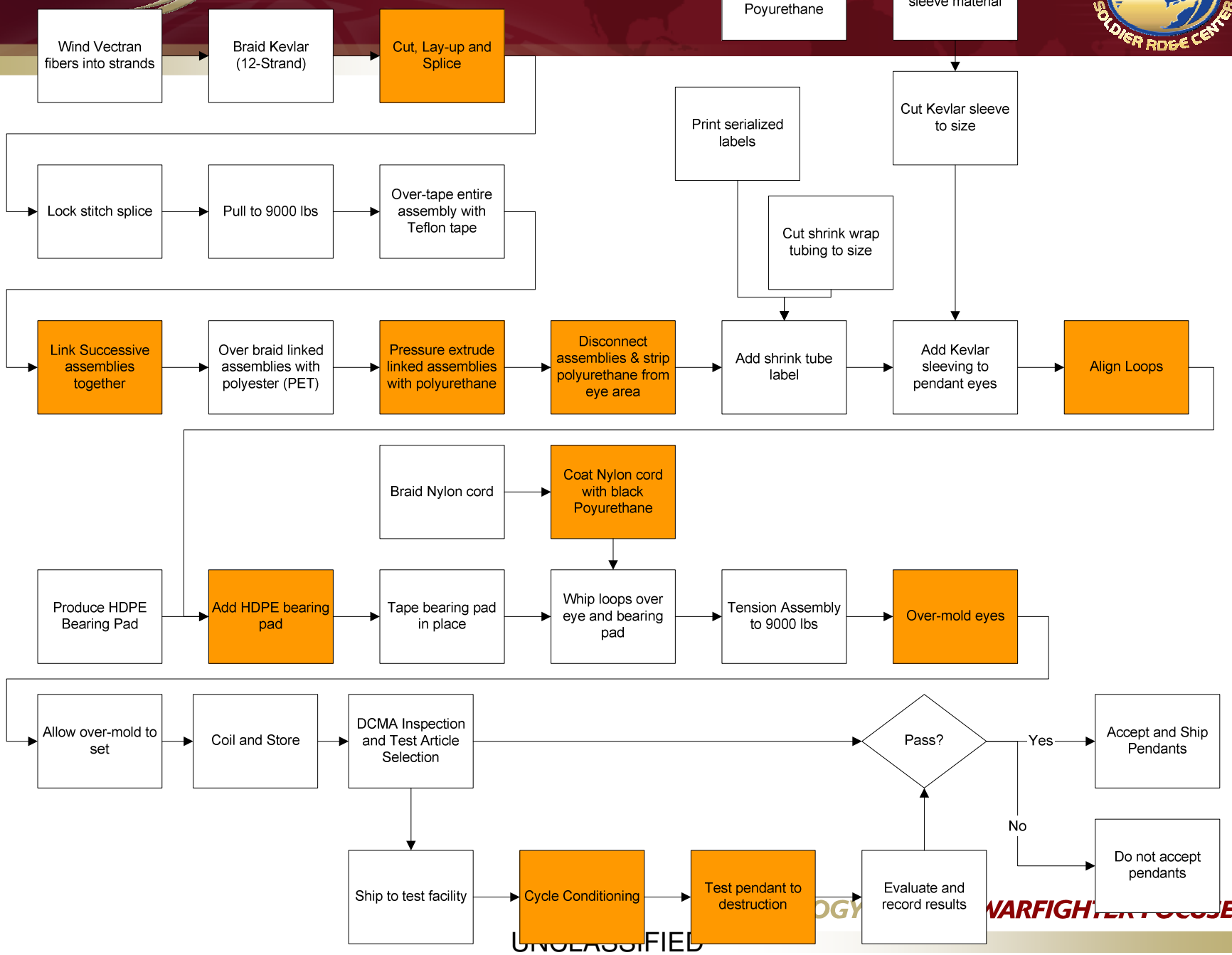
- Initial production lot failed to meet strength requirement – 75 kip
- Critical need for 101st during current deployment

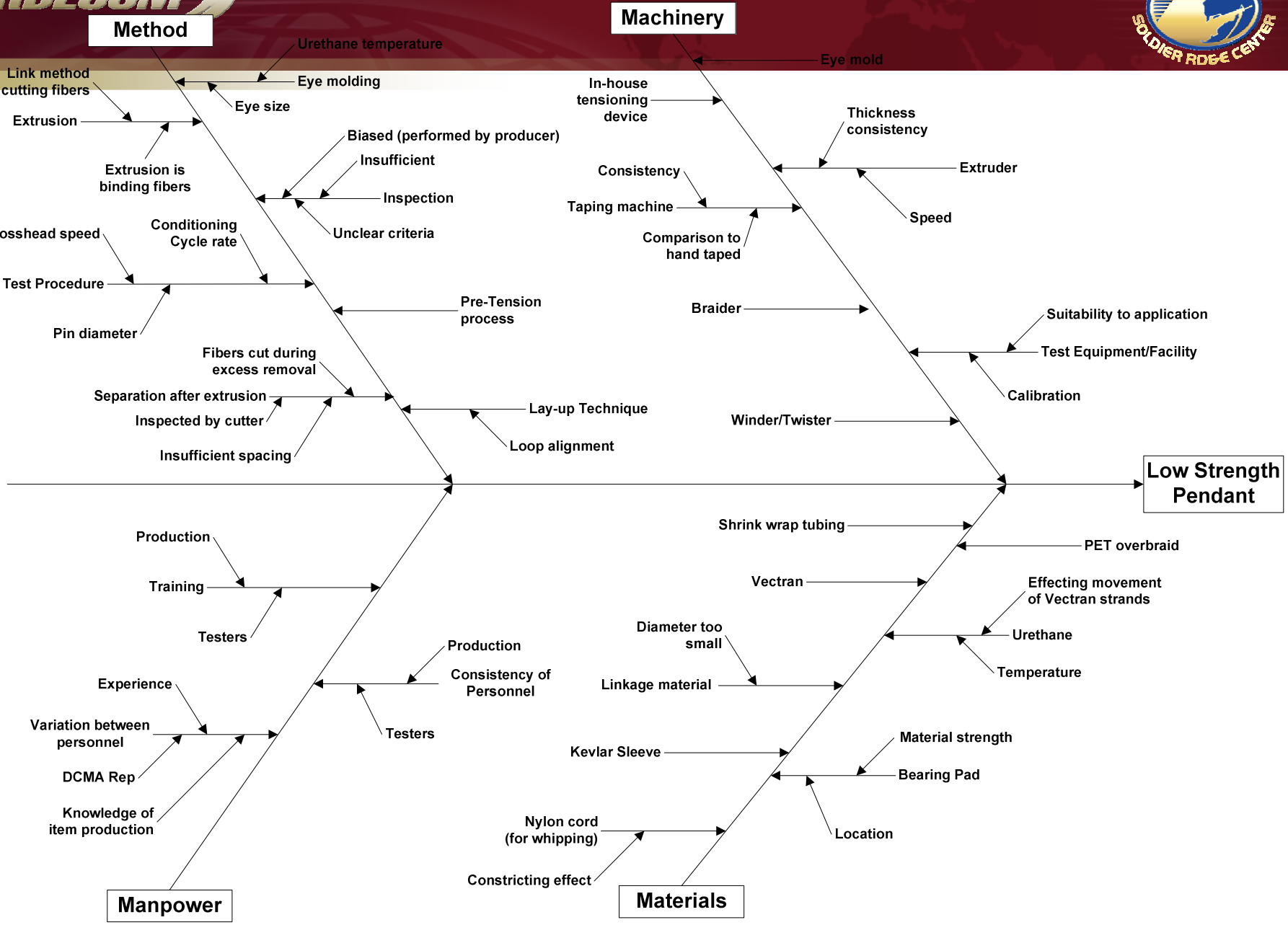


Test Facility Gage R&R



50-Foot Pendant Production Process - Analyze

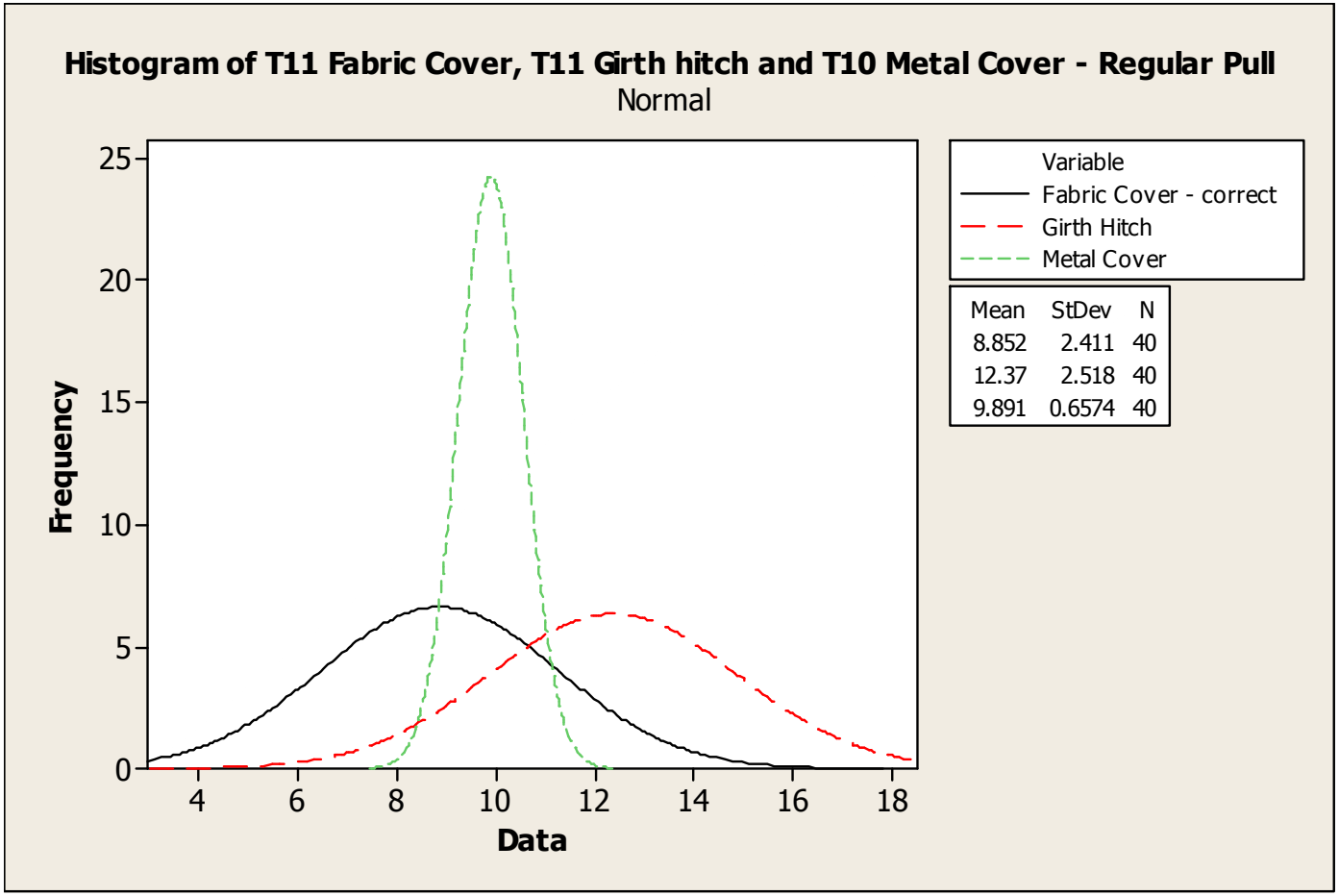



Method
Urethane temperature
Eye molding
Eye size
Link method is cutting fibers
Extrusion
Extrusion is binding fibers
Biased (performed by producer)
Insufficient
Inspection
Unclear criteria
Crosshead speed
Conditioning Cycle rate
Test Procedure
Pin diameter
Pre-Tension process
Fibers cut during excess removal
Separation after extrusion
Inspected by cutter
Insufficient spacing
Lay-up Technique
Loop alignment
Machinery
Eye mold
In-house tensioning device
Thickness consistency
Extruder
Speed
Consistency
Taping machine
Comparison to hand taped
Braider
Suitability to application
Test Equipment/Facility
Calibration
Winder/Twister
Low Strength Pendant
Shrink wrap tubing
PET overbraid
Vectran
Effecting movement of Vectran strands
Urethane
Temperature
Diameter too small
Linkage material
Kevlar Sleeve
Material strength
Bearing Pad
Location
Nylon cord (for whipping)
Constricting effect
Materials
Manpower
Production
Training
Testers
Production
Consistency of Personnel
Testers
Experience
Variation between personnel
DCMA Rep
Knowledge of item production

Breaking Strength Statistics

- Early Production
  - Mean: 85,176 lbs
  - SD: 7,096 lbs
  - Confidence (breaking strength > 75,000 lbs): 91.17%
  - Cpk = 0.48
- After implementing improvements
  - Mean: 98,550 lbs
  - SD: 3,746 lbs
  - Confidence (breaking strength > 75,000 lbs): 99.44%
  - Cpk = 2.10

Go Argue with the Data



Old CRA vs. New CRA Statistics

	Total Jumps	Failures	Reliability at 95% Confidence
Old CRA Design	2855	1	99.834%
New CRA Design	308	2	97.970%

Two-Sample Proportion Test

	Sample 1	Sample 2
Sample Size	2855	308
Failures	1	2
Proportion	0.00035	0.00649
Null Hypothesis:	P1 = P2	
Alternative Hyp:	P1 <> P2	
Difference	-0.00614	
SE (diff)	0.00185	
Z (uncorrected)	-3.33	P 0.0009
Z (corrected)	-2.35	P 0.0186

What This Means

There is a Statistical difference between the Old CRA and the New CRA design.

Even though testing has shown that it is more likely for the Old Fabric cover to come off. The New CRA is more likely to fail.

MC-6 Production Contract

- to multiple manufacturers
  - Ensure that all manufactures can build the part
  - Ensure that all parts from all manufactures look, function and perform the same
  - Once in production - need to make sure the process stays in control

Get the data

- Data from:
  - Multiple vendors
  - Measured by 3 sources
    - Where and How to Measure non-rigid Textile items
    - Hand tension vs. load cell

Finished Dimensions

SF-10A Inspection Sheet

Serial Number:

Location | *Cage Code* | *Date of Manufacture* | Inspection Date

	Overall Main Seam	Extended Gore 2nd Panel Main Seam	Braking Gore 2nd Panel Main Seam	2nd Panel Main Seam	Brake Slot Distance	Suspension Line Loop	Line Attachment	Line Attachment Offset	Drive Vent Mesh Main Seam	Brake Slot Main Seam	Vent Line Attachment	Upper Vent Line Attachment Offset	Lower Vent Line Attachment Offset	LLB Cross Seam	Lower Drive Vent Mesh Cross Seam
Location	Sheet 2 View H	Sheet 6 View L	Sheet 6 View L	Sheet 6 View L	Sheet 6	Sheet 5	Sheet 5	Sheet 5	Sheet 4	Sheet 4	Sheet 7 Detail H	Sheet 7 Detail H	Sheet 7 Detail H	Sheet 2	Sheet 2
Dimension	G	Note 1a	Note 1b	Note 1c		Note 1		Note 2	A	B				A	B
Measuring Points	Outside - Outside	Inside - Inside	Inside - Inside	Inside - Inside	EoS - EoT	Girth Hitch - LLB	LLB - EoT	EoT - EoS	Outside - Inside	Outside - Inside	EoT - EoVB	EoT - EoS	EoS - EoT	Outside - Inside	Outside - Inside
Tension	1 lb	1 lb	1 lb	1 lb	1 lb	HT	HT	HT	HT	HT	HT	HT	HT	HT	HT
1															
2															
3															
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Average	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!			#DIV/0!	#DIV/0!
STD DEV	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!			#NUM!	#NUM!
Median	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!			#NUM!	#NUM!
Range	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000			0.000	0.000
Target	175.500	106.000	105.000	104.000	(66.5)	17.500	5.500	0.875	22.750	2.000	3.500			26.000	30.250
Maximum	178.500	107.000	106.000	105.000	72.500	18.000	5.625	1.125	23.250	2.250	3.375			27.000	31.000
Minimum	172.500	105.000	104.000	103.000	60.500	17.000	5.375	0.675	22.250	1.750	3.625	0.500	0.500	25.000	29.500

Lower 2nd Panel Cross Seam	Upper Drive Vent Mesh Cross Seam	Upper Slotted Gore Cross Seam	Lower 3rd Panel Cross Seam	Lower 3rd Panel Cross Seam	Upper 3rd Panel Cross Seam	Vent Band Cross Seam	Suspension Line	Suspension Line Attachment	Lower Control Line	Extended Gore Line Limiter	Control Line Limiter A	Middle Control Line	Control Line Limiter B	Control Line Limiter C
Sheet 2	Sheet 4	Sheet 4	Sheet 2	Sheet 2	Sheet 2	Sheet 7 Detail BJ	Sheet 7	Sheet 7	Sheet 7	Sheet 7 FN 48	Sheet 7 FN 46	Sheet 7 FN 42	Sheet 7 FN 46	Sheet 7 FN 46
F	C	D	D	C	E						Ring to Skirt	Ring to Split	Split to Control Line	Split to Susp. Line
Outside - Inside	Outside - Inside	Outside - Inside	Outside - Inside	Outside - Inside	Outside - Inside	Outside - Inside	IEoCL - EoL	IEoCL - EoC	EoC - EoL	MM - MM	MM - MM	MM - MM	MM - MM	MM - MM
HT	HT	HT	HT	HT	HT	HT	1 lb	HT	1 lb	1 lb	1 lb	1 lb	1 lb	1 lb

EoS = End of Stitching | EoT = End of Tape | LLB = Lower Lateral Band | EoVB = End of Vent Band | IEoCL = Inside Edge of Connector Link | EoC = End of Cord | EoL = End of Loop | MM = Match Mark

Version 1 — MP 17 Jan 2006

SF-10A Inspection Sheet

Serial Number: 0

Inspector Name | Temperature | Humidity

	Lower 2nd Panel Cross Seam	Upper Drive Vent Mesh Cross Seam	Upper Slotted Gore Cross Seam	Lower 3rd Panel Cross Seam	Lower 3rd Panel Cross Seam	Upper 3rd Panel Cross Seam	Vent Band Cross Seam	Suspension Line	Suspension Line Attachment	Lower Control Line	Extended Gore Line Limiter	Control Line Limiter A	Middle Control Line	Control Line Limiter B	Control Line Limiter C
Location	Sheet 2	Sheet 4	Sheet 4	Sheet 2	Sheet 2	Sheet 2	Sheet 7 Detail BJ	Sheet 7	Sheet 7	Sheet 7	Sheet 7 FN 48	Sheet 7 FN 46	Sheet 7 FN 42	Sheet 7 FN 46	Sheet 7 FN 46
Dimension	F	C	D	D	C	E						Ring to Skirt	Ring to Split	Split to Control Line	Split to Susp. Line
Measuring Points	Outside - Inside	Outside - Inside	Outside - Inside	Outside - Inside	Outside - Inside	Outside - Inside	Outside - Inside	IEoCL - EoL	IEoCL - EoC	EoC - EoL	MM - MM	MM - MM	MM - MM	MM - MM	MM - MM
Tension	HT	HT	HT	HT	HT	HT	HT	1 lb	HT	1 lb	1 lb	1 lb	1 lb	1 lb	1 lb
1															
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Average	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!			#DIV/0!	#DIV/0!
STD DEV	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!			#NUM!	#NUM!
Median	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!			#NUM!	#NUM!
Range	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000			0.000	0.000
Target	31.500	29.750	31.750	26.250	25.500	14.375	1.875	(249)	3.675	289.000	32.000	32.500	23.500	30.500	33.750
Maximum	32.500	30.250	32.250	26.750	26.000	15.375	2.000	259.000	3.750	291.000	32.500	33.000	24.000	31.000	34.250
Minimum	30.500	29.250	31.250	25.750	25.000	13.375	1.500	240.000	3.500	287.000	31.500	32.000	23.000	30.000	33.250

EoS = End of Stitching | EoT = End of Tape | LLB = Lower Lateral Band | EoVB = End of Vent Band | IEoCL = Inside Edge of Connector Link | EoC = End of Cord | EoL = End of Loop | MM = Match Mark

Version 1 — MP 17 Jan 2006

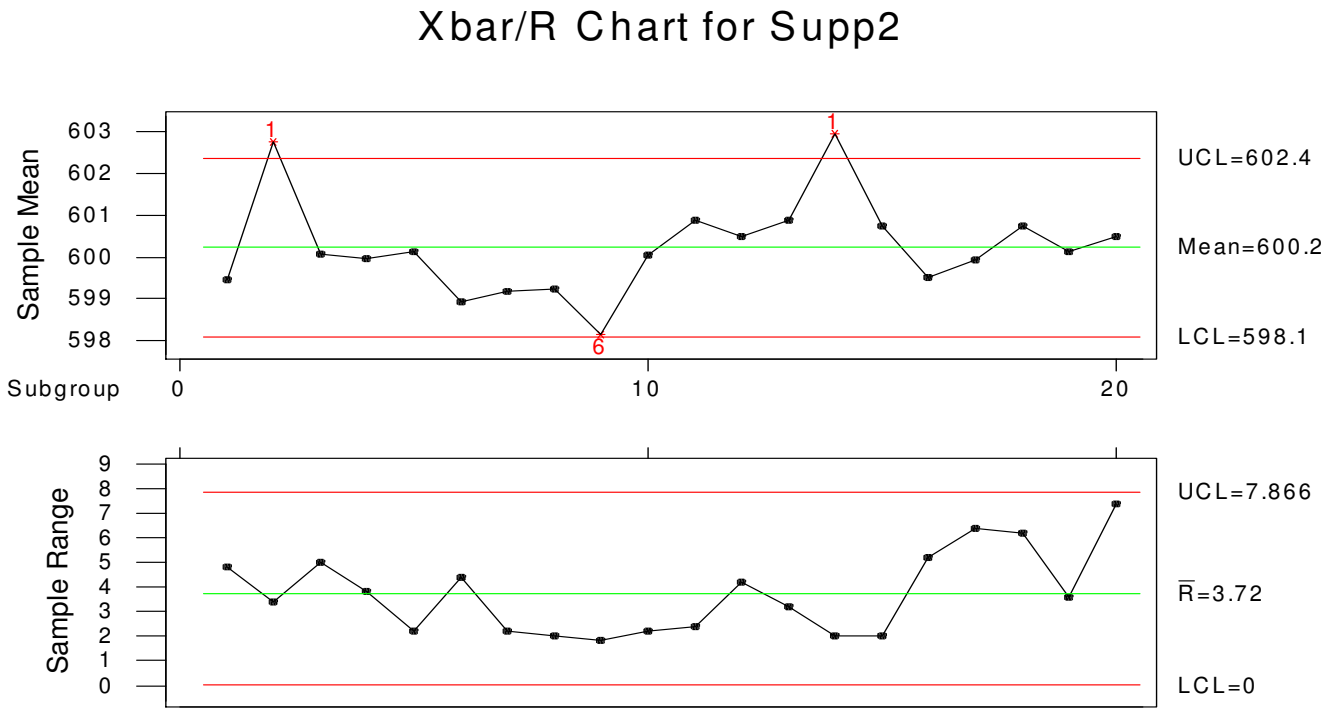
Overall System: **Drawing 11-1-7407, SF-10A Main Parachute Assembly**

Sub System: Canopy Assembly

Drawing	Sheet	Zone	Description	Dimension	Location	Tension
11-1-7401	3	F5	Skirt Band	26 - 28 Symmetry 1 1/2	Inside Edge of Seam to Outside Edge of Seam for Gores 1, 11, 18, 22 and 26	Hand Tension
11-1-7401	4	F3	Basic Gore Main Seam	180 ± 2 1/2	Outside Edge of Vent to Outside Edge of Skirt, Pairs Shall be Within 2 inches of Each Other	3 ± 1/2 lbs
11-1-7401	5	G5	Slotted Gore Main Seam	180 ± 2 1/2	Outside Edge of Vent to Outside Edge of Skirt, Pairs Shall be Within 2 inches of Each Other	3 ± 1/2 lbs
11-1-7401	5	C6	Drive Vent Gore Main Seam	179 1/8 ± 2 1/2	Outside Edge of Vent to Outside Edge of Skirt, Pairs Shall be Within 2 inches of Each Other	3 ± 1/2 lbs
11-1-7401	6	D5	Blank Gore Main Seam	178 5/8 ± 2 1/2	Outside Edge of Vent to Outside Edge of Skirt, Pairs Shall be Within 2 inches of Each Other for Gores 6 and 23	3 ± 1/2 lbs
11-1-7401	6	D4	Blank Gore Main Seam	180 ± 2 1/2	Outside Edge of Vent to Outside Edge of Skirt, Pairs Shall be Within 2 inches of Each Other for Gores 7 and 22, 5 and 24	3 ± 1/2 lbs
11-1-7401	6	D1	Braking Gore Main Seam	179 1/4 ± 2 1/2	Outside Edge of Vent to Outside Edge of Skirt, Pairs Shall be Within 2 inches of Each Other	3 ± 1/2 lbs
11-1-7401	11	D8	Overall Brake Slot Length	Within 1 inch of Each Other	End of Tape to End of Bartack. Record both lengths and subtract for length difference.	Hand Tension
11-1-7401	13	D1	Suspension Line Length	256 1/2 ± 2 1/4	Top of Connector Link to Match Mark for Gores 1, 11, 18, 22, and 26	14 lbs
11-1-7401	14	C3	FN 42 - FN 46 Control Line Grouping Length	See Table	See Table	Hand Tension
11-1-7401	14	B7	Control Line Routing	See Detail E	See Detail E	
11-1-7401	18	E3	Extended Gore Trailing Edge (Dimension "B")	134 1/2 ± 1 1/4	Inside to Inside of Horizontal Tapes	Hand Tension

Control

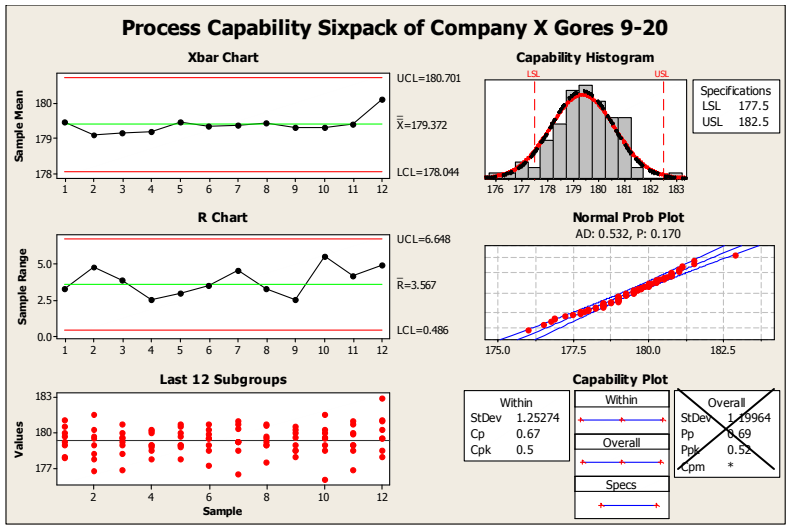
- Production lot sampling
- CTQ data recorded
- Control Charts



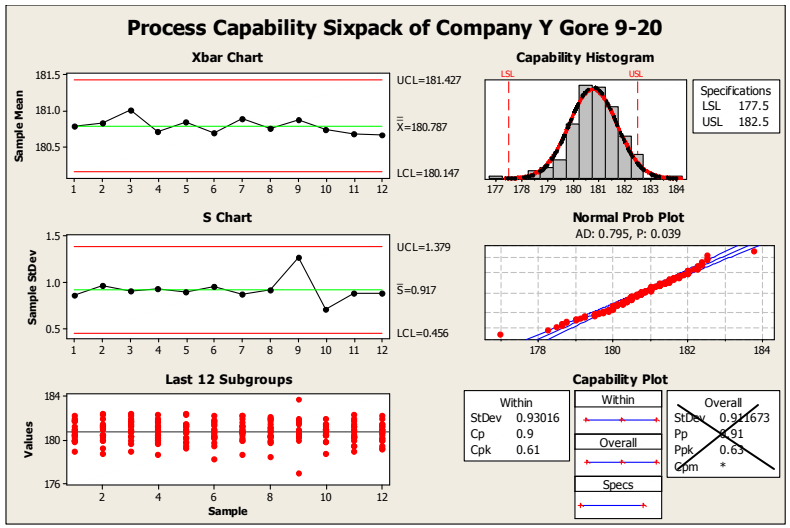
Bottom Line

- Just another tool in our toolbox
- Appreciate all the efforts of our suppliers
- Will be used in other programs, e.g. T11, JPADS, etc.

Gores 9 - 20



- Company X
  - Cp = .67
  - Cpk = .5
  - P = .170
  - StDev = 1.253



- Company Y
  - Cp = .9
  - Cpk = .61
  - P = .039
  - StDev = 0.930