TEAM PROJECT PLANNING WORKSHEET

OBJECTIVE	Reduce the final product rejections of Leading Edge Assmblies
TEAM WORK LOCATION	Stony Brook University
TEAM NAME	Legion
DURATION	Fall 2015

TEAM MEMBERS	**TEAM MEMBER 1**	Parminder Singh (TEAM LEADER)	**TEAM INFORMATION**
	TEAM MEMBER 2	Michael Cusimano	
	TEAM MEMBER 3	Rahul Chhajed	
	TEAM MEMBER 4	Shashank Sharma	
	TEAM MEMBER 5	Kaza Sai Ronit	

MEETING

#	DATE	TIME	ATT	#	DATE	TIME	ATT	#	DATE	TIME	ATT
1	8/15/2015	8.00 PM		9	11/22/2015	6.30 PM	TELECONF				
2	8/23/2015	10.00 AM		10	11/30/2015	TBD	TBD				
3	8/31/2015	4.00 PM									
4	9/14/2015	4.00 PM	TELECONF								
5	9/25/2015	8.00 PM									
6	10/10/2015	8.00 PM									
7	10/17/2015	8.00 PM									
8	11/15/2015	8.00 PM									

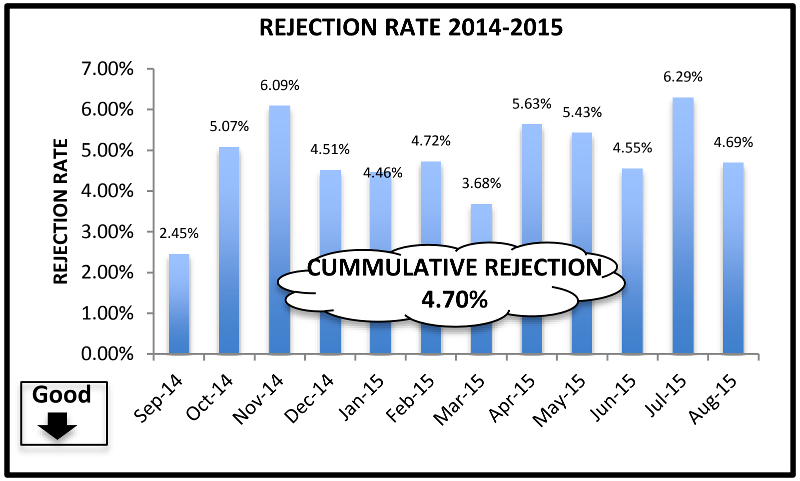
OUTLINE OF AC

SCHEDULED ACTUAL

	Sep-15				Oct-15				Nov-15				Dec-15		
	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15	**COMMENTS (HOW EACH STEP WAS DONE)**
REASON FOR IMPROVE-MENT																Established the gap
CURRENT SITUATION																Stratified gap Defined the problem
ANALYSIS																Used Cause &Effect , Pareto, Histogram
COUNTER-MEASURES																Used Countermeasure Matrix. Action Plan
RESULTS																RESULTS OF TESTS
REPORT																Report preparation, discussion with Dr. Sharma
SUBMIT																Submit report

REASON FOR IMPROVEMENT

THE TEAM REVIEWED THE REJECTION RATE FOR EACH MONTH OF THE PAST ONE YEAR



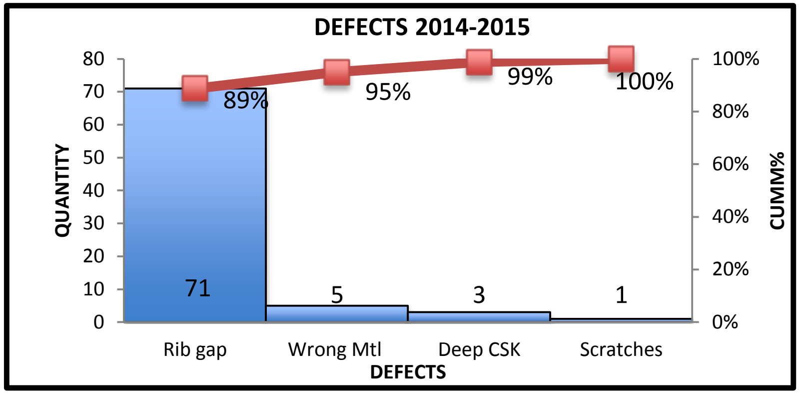
CUMMULATIVE REJECTION RATE OF 4.7% IS MORE THAN CUSTOMER EXPECTATION OF .05%

4.7% EQUATES TO 47000 PPM DEFECTIVE

THE CUMMULATIVE REJECTION RATE 4.7% WAS CONVERTED INTO NUMBER OF PIECES TO ASIST ANALYSIS:

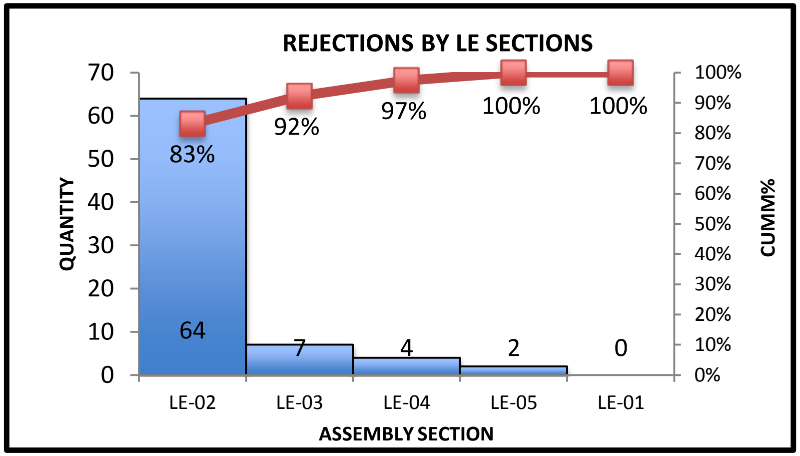
4.7%	X	1639	=	77
REJECTION RATE		UNITS INSPECTED		UNITS REJECTED

WE DECIDED TO LOOK AT THE REASONS FOR REJECTIONS IN 77 UNITS



OVER THE LAST ONE YEAR, 89% OF THE REJECTIONS WERE DUE TO "RIB GAP" ISSUE

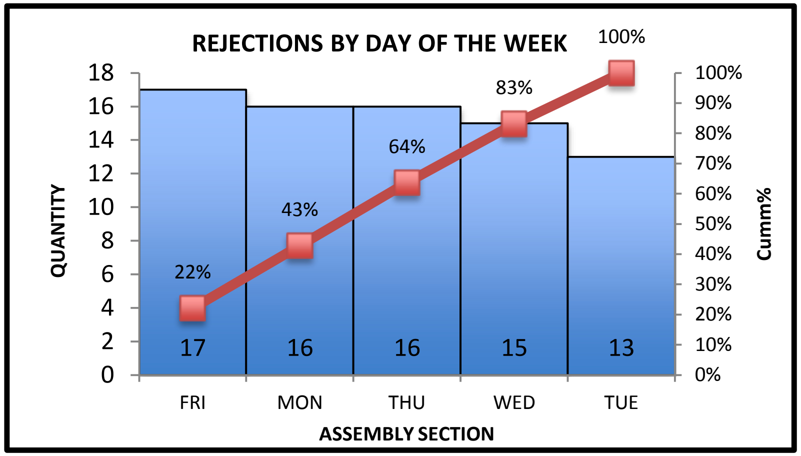
WE EVALUATED THE DEFECT "RIB GAP" BY ASSEMBLY SECTION



83% OF THE DEFECTS ARE FOUND IN LE-02 SECTION

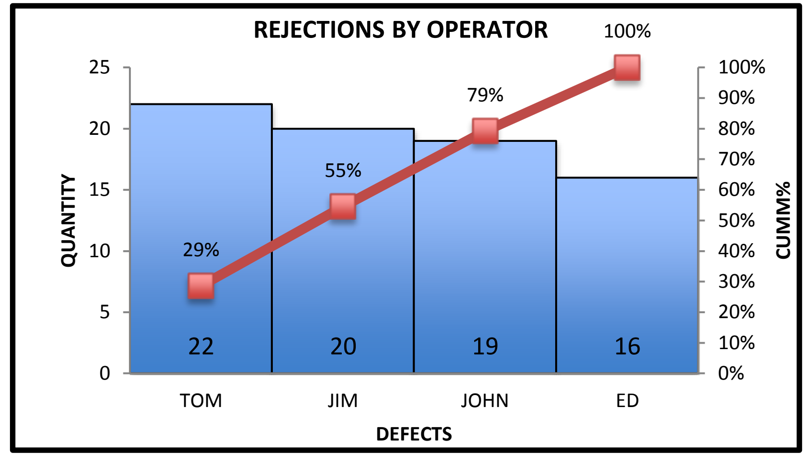
REASON FOR IMPROVEMENT

WE ALSO DECIDED TO LOOK IF THERE WAS ANY RELATION BETWEEN THE REJECTIONS AND THE DAY OF THE WEEK IT WAS CAUSED.



NO SIGNIFICANT RELATIONSHIP WAS NOTED FROM THE PARETO ANALYSIS. THE REJECTIONS SEEMS TO BE FAIRLY CONSTANT IRRESPECTIVE OF THE DAY OF THE WEEK.

THE TEAM THEN REVIEWED THE REJECTION DATA BY THE OPERATOR MANUFACTURING THE ASSEMBLY TO UNDERSTAND IF THE REJECTIONS ARE CAUSED BY ANY PARTICULAR OPERATOR.



THE NUMBER OF REJECTION IS FAIRLY CONSTANT REGARDLESS OF THE OPERATOR
HENCE, THE TEAM COULD NOT ATTRIBUTE THE NUMBER OF REJECTIONS TO ANY PARTICULAR OPERATOR.

THE TEAM NARROWED ITS FINDINGS FROM THE PARETO ANALYSIS TO DEVELOP THE THEME FOR IMRPOVEMENT.

THEME AND INDICATOR

FINDINGS

OVER LAST ONE YEAR, 83% OF THE RIB GAP ISSUES WERE FOUND IN THE LE-02 SECTION

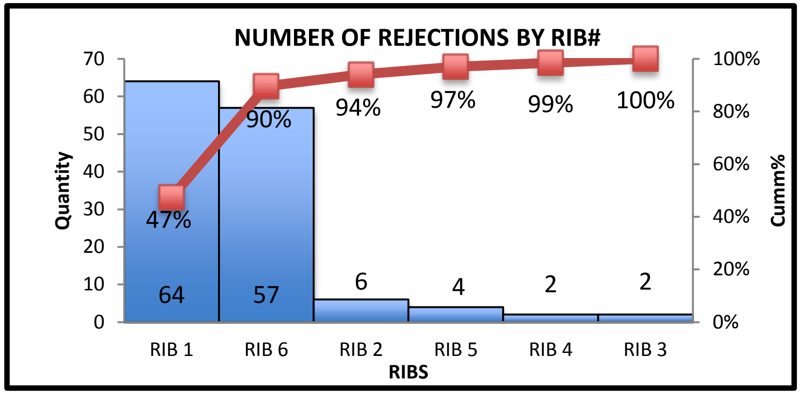
⬇

THEME

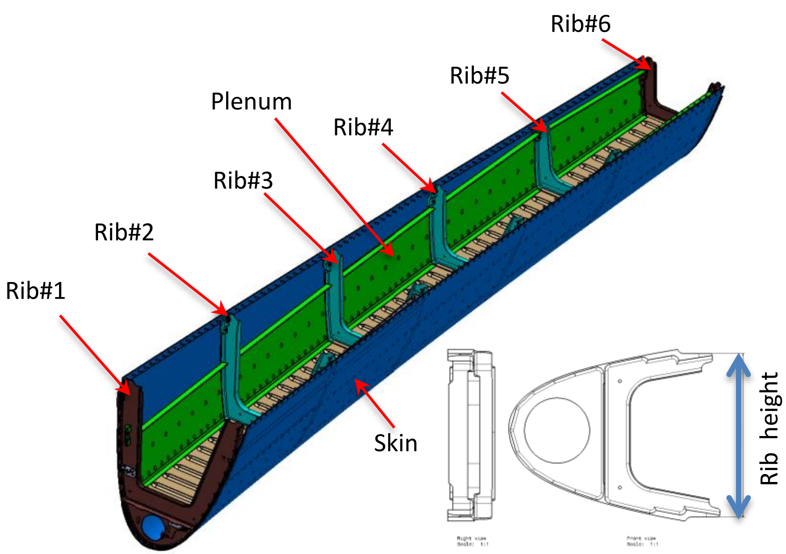
REDUCE THE RIB GAP ISSUE IN LE-02 SECTION

CURRENT SITUATION

THE TEAM REVIEWED THE REJECTION DATA OF 64 LE-02 ASSEMBLIES

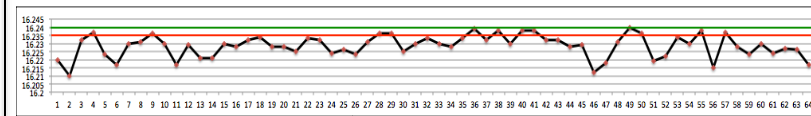


90% OF THE REJECTIONS IN LE-02 ARE CAUSED DUE TO RIB HEIGHT ISSUES IN RIB#1 AND RIB#6



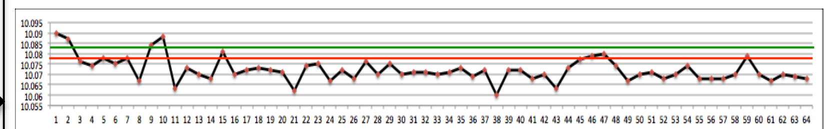
THE RIB HEIGHT DATA OF RIB#1 AND RIB#6 FROM REJECTED UNIT <AS ASSEMBLED CONDITION> WAS ANALYZED

RIB#1



S/B: 16.240 +0/-.005
MAX: 16.240
MIN: 16.210
RANGE OF OOT: .0030

RIB#6



S/B: 10.082 +0/-.005
MAX: 10.090
MIN: 10.060
RANGE OF OOT: .0030

THE RIB HEIGHT DATA OF DETAILED RIB#1 AND RIB#6 WAS ALSO ANALYZED AND FOUND TO BE IN TOLERANCE

THIS ANALYSIS SHOWED THAT RIBS ARE FOLLOWING OOT AFTER ASSEMBLY PROCESS

CURRENT SITUATION

TO BETTER UNDERSTAND THE REASONS FOR REJECTION, THE TEAM REVIEWED THE ASSEMBLY PROCESS OF LE-02 SECTION.

(1) LOAD SKIN AND RIBS ON TO AF → **(2)** DRILL HOLES C/T MOUNTING STRAPS AND RIBS USING DJ → **(3)** DEBURR, CSK AND ATTACH THE RIBS TO THE SKIN USING HI-LOKS → **(4)** LOCATE PLENUMS AND TRANSFER DRILL HOLES TO THE SKIN → **(5)** DEBURR, CSK AND ATTACH THE PLENUMS TO SKIN USING RIVETS → **(6)** FINAL FINISH AND INSPECTION

RIB HIEGHT MEASUREMENTS ON RIB #1 AND RIB# 6 WERE TAKEN AT EACH STEP OF THE BUILD PROCESS FOR TWO CONSECUTIVE UNITS

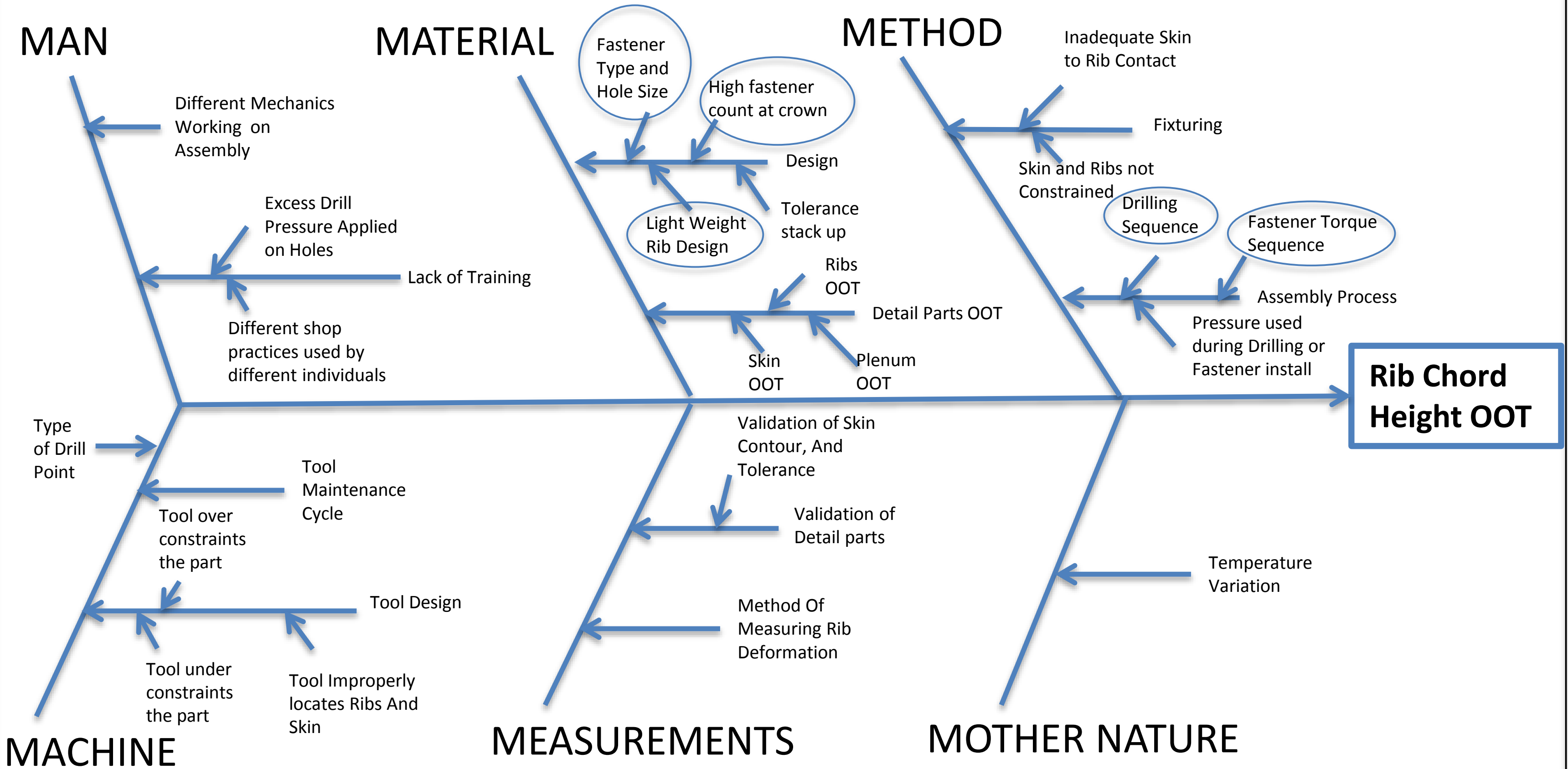
LE02 S.NO 227		NOMINAL +0/-.005	Detail part	Delta from nominal	(1) Constraint in AF	Delta from nominal	(3) Installation of Hiloks	Delta from nominal	(5) Installation of Plenum	Delta From Nominal
RIB # 1	LE02 INBD	16.24	16.236	-0.004	16.24	0	16.226	-0.014	16.226	-0.014
RIB# 6	LE02 OUTBD	10.082	10.080	-0.002	10.088	0.006	10.067	-0.015	10.069	-0.013

LE02 S.NO 228		NOMINAL +0/-.005	Detail part	Delta from nominal	(1) Constraint in AF	Delta from nominal	(3) Installation of Hiloks	Delta from nominal	(5) Installation of Plenum	Delta From Nominal
RIB# 1	LE02 INBD	16.24	16.239	-0.001	16.237	-0.003	16.216	-0.024	16.217	-0.023
RIB# 6	LE02 OUTBD	10.082	10.081	-0.001	10.081	-0.001	10.067	-0.015	10.068	-0.014

MAJOR DEVIATION IN THE RIB HEIGHT IS OBSERVED AFTER THE INSTALLATION OF HILOKS WHICH ARE USED TO SECURE THE RIB TO THE SKIN.

ANALYSIS

THE TEAM STUDIED THE PROCESS AND BRAINSTORMED POTENTIAL CAUSES FOR RIB CHORDAL HEIGHT OOT CONDITION.



THE TEAM REACHED FOLLOWING CONSENSUS ON THE PROBABLE ROOT CAUSES

1. DRILLING SEQUENCE AND FASTENER INSTALLATION PROCESS DURING THE ASSEMBLY PROCESS
2. THE DESIGN OF THE ASSEMBLY
   A. NUMBER OF FASTENERS IN THE CROWN AREA AND THE FIT OF FASTENERS
   B. THE LIGHT WEIGHT DESIGN OF THE RIB

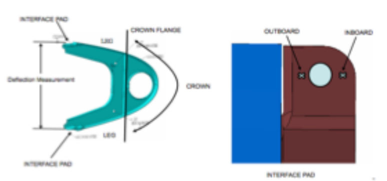
ANALYSIS…..CONT'D

THE TEAM PROPOSED AND CONDUCTED TESTS TO VERIFY PROBABLE ROOT CAUSES.

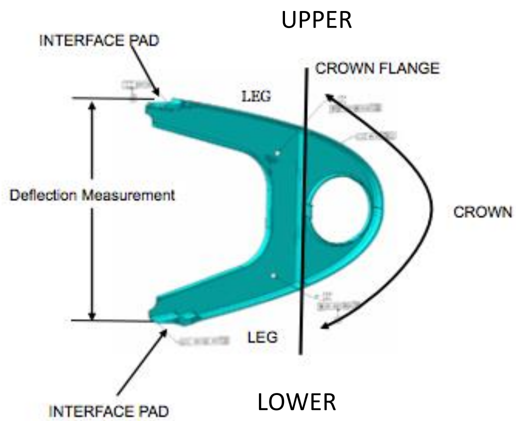
SUMMARY OF TERMINOLOGY AND MEASUREMENTS:
IN THE FOLLOWING TESTS, CRITERIA WERE ESTABLISHED FOR RIB TERMINOLOGY AND STANDARD POINTS OF MEASURE
A STANDARD CHECK SHEET WAS DEVELOPED TO RECORD THE DATA AS SHOWN BELOW.
RIB# 1 WAS SELECTED FOR THESE TESTS.

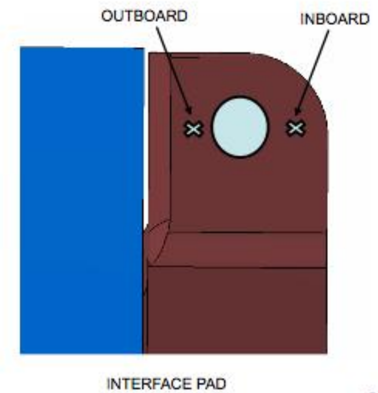
CHECK SHEET LE-02 ASSY

DATE:	
RIB #	1
OPERATOR	TOM
INSPECTOR	RIAN
DIAGRAM	



	STEP	INSTRUCTIONS	MEASUREMENTS	
	1	INITIAL MEASUREMENT	INBOARD	OUT BOARD
CROWN	2	DRILL AND INSTALL 2 FASTENERS		
	3	DRILL AND INSTALL 2 FASTENERS		
	4	DRILL AND INSTALL 2 FASTENERS		
LEG (BEYOND CROWN)	5	DRILL AND INSTALL 2 FASTENERS		
	6	DRILL AND INSTALL 2 FASTENERS		
	7	DRILL AND INSTALL 2 FASTENERS		
	8	DRILL AND INSTALL 2 FASTENERS		
	9	DRILL AND INSTALL 2 FASTENERS		





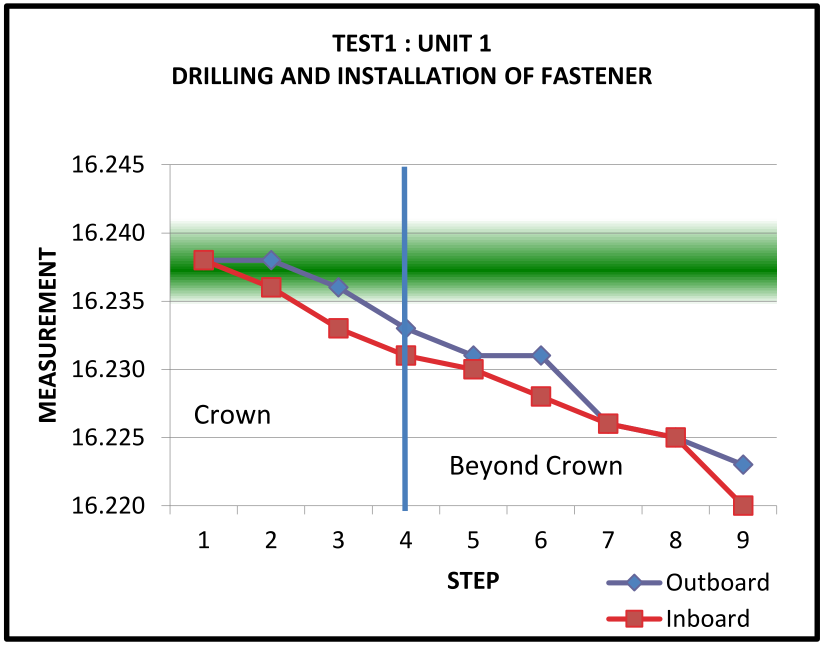
MEASUREMENTS WERE TAKEN AT BOTH INBOARD AND OUTBOARD LOCATION OF THE RIB AS SHOWN FOR ALL THE TESTS

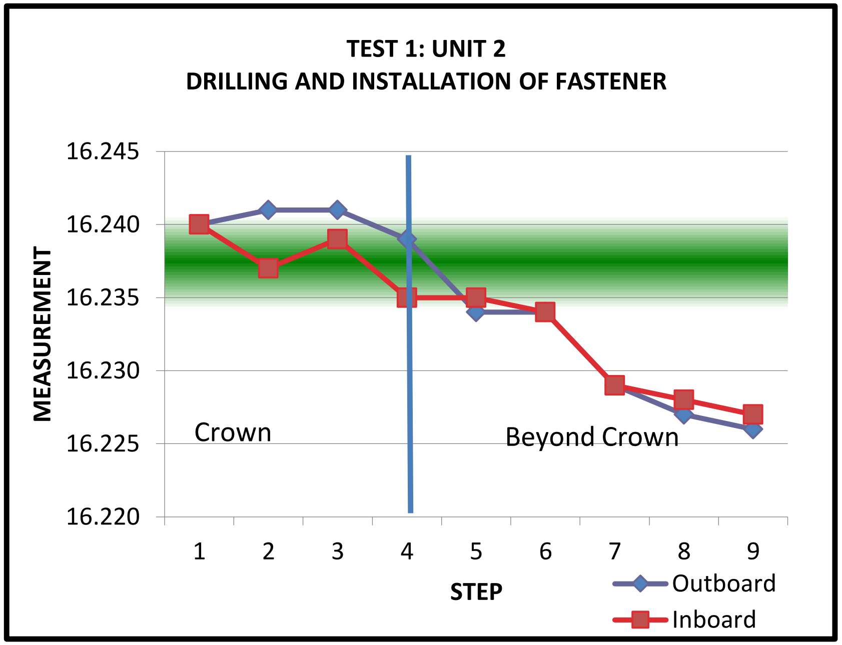
WE ENSURED THAT ALL THE TESTS WERE CONDUCTED BY THE SAME OPERATOR AND THAT ALL THE MEASUREMENTS WERE TAKEN BY THE SAME INSPECTOR

ANALYSIS.....CONT'D

TEST 1

TEST WAS CONDUCTED TO MEASURE THE DEFELECTION DURING THE DRILLING AND FASTENER INSTALLATION PROCESS FOR TWO DIFFERENT ASSEMBLIES. THE MEASUREMENTS WERE TAKEN AT EACH PROCESS STEP OF DRILLING AND INSTALLING TWO FASTENERS. THE MEASUREMENTS WERE RECORDED AT EACH STEP.





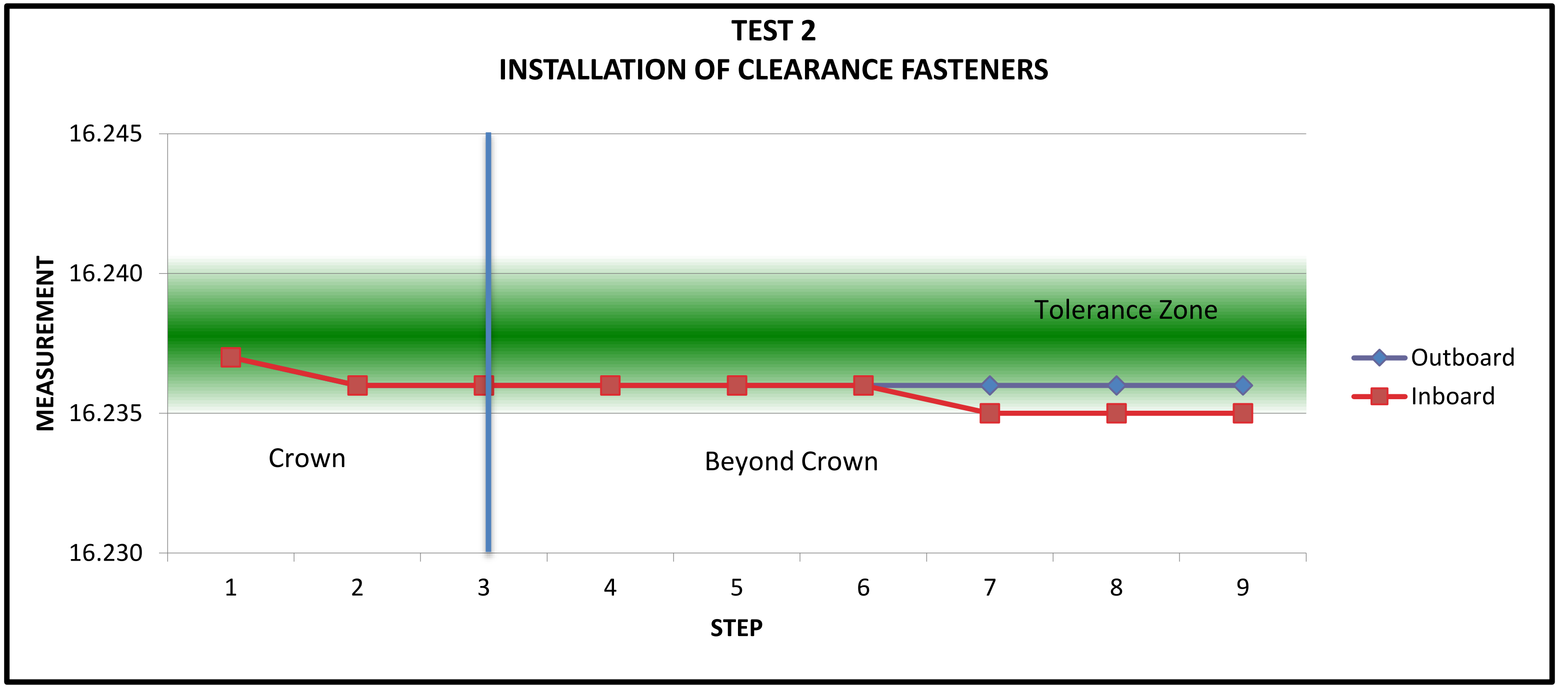
SIGNIFICANT RESULTS NOTED

1) THE RIB BEGIN TO DEFLECT AS FASTENERS IN THE CROWN AREA WERE INSTALLED AND TORQUED TO FINAL COLLAR BREAKOFF.
2) MEASUREMENTS BETWEEN INBOARD AND OUTBOARD POINTS OF MEASURE ON THE INTERFACE PADS INDICATED THAT THE RIB LEGS TWISTED FROM THEIR FREE STATE CONDITION.
3) DEFLECTION OF .015 OUTBOARD AND .020 INBOARD WAS NOTED.

ANALYSIS.....CONT'D

TEST 2

TEST 2 WAS CONDUCTED ON AN ASSEMBLY TO INSTALL CLEARANCE FIT FASTENERS AT THE CROWN AREA TO VALIDATE THE EFFECT OF FASTENER FIT IN THE HOLES.



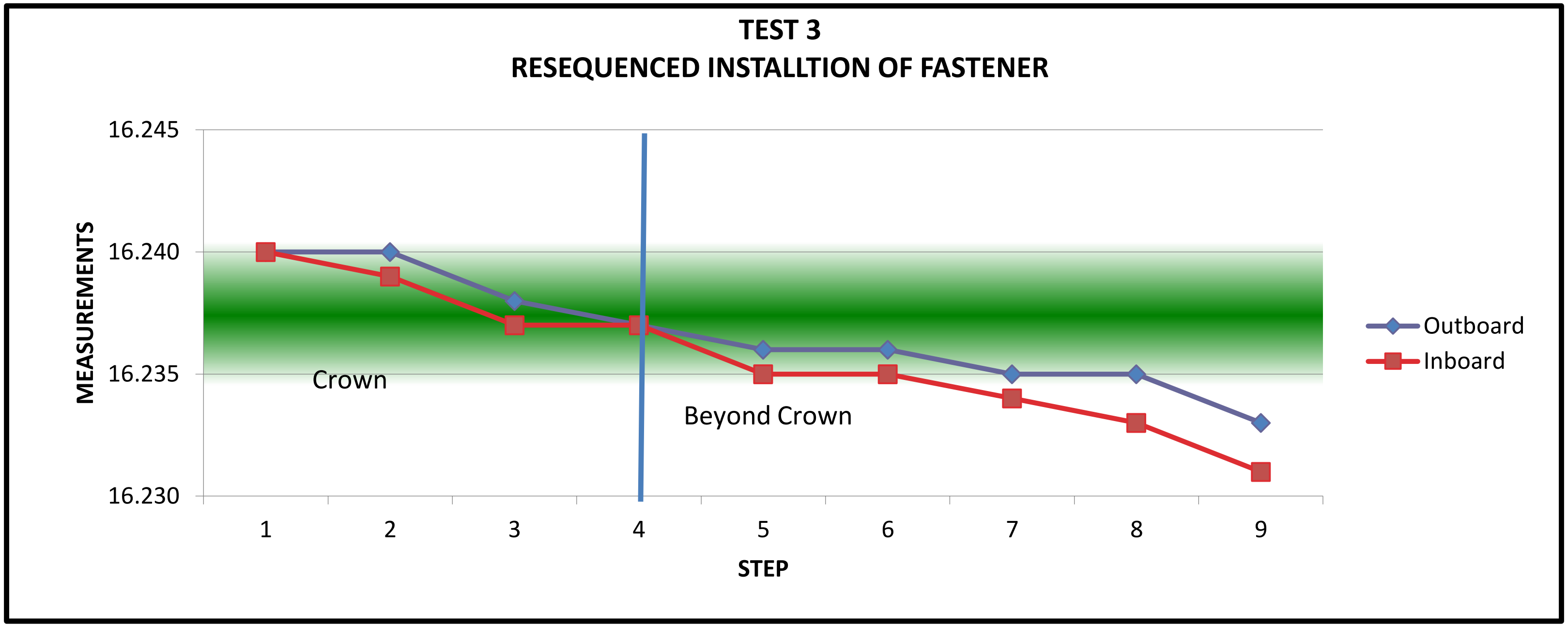
SIGNIFICANT RESULTS NOTED

1) THE RIB DIMENSIONS REMAINED STABLE AS FASTENERS OVER THE ENTIRE RIB WERE DRILLED, INSTALLED AND TORQUED TO FINAL COLLAR BREAKOFF.
2) MEASUREMENTS BETWEEN INBOARD AND OUTBOARD POINTS OF MEASURE ON THE RIB INTERFACE PADS INDICATED THAT THE RIB LEGS DID NOT TWIST FROM THEIR FREE STATE CONDITION.

ANALYSIS…..CONT'D

TEST 3

TEST 3 WAS CONDUCTED ON AN ASSEMBLY TO RE-SEQUENCE THE DRILLING AND INSTALLATION OF FASTENERS TO START FROM CROWN AND MOVE TOWARDS THE LEG AND ALTERNATING FROM UPPER TO LOWER LEGS



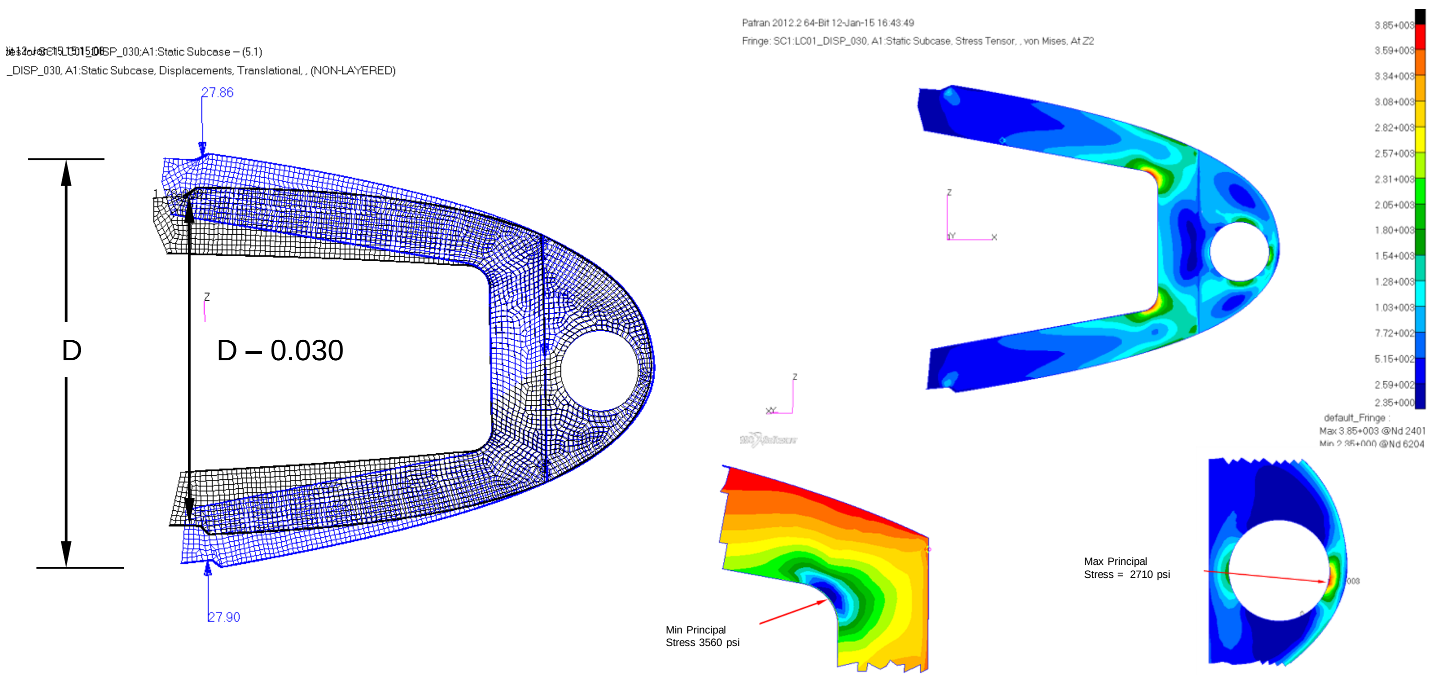
SIGNIFICANT RESULTS NOTED

1) THE RIB DIMENSIONS SHOWED DEFLECTION BUT WERE ONLY .003" BEYOND LOW LIMIT.
2) MEASUREMENTS BETWEEN INBOARD AND OUTBOARD POINTS OF MEASURE ON THE RIB INTERFACE PADS INDICATED THAT THE RIB LEGS SHOWED TWISTING FROM THEIR FREE STATE CONDITION.

ANALYSIS…..CONT'D

TEST 4

IN TEST 4, FINITE ELEMENT ANALYSIS WAS CONDUCTED TO DEMONSTRATE LOCATION OF STRESS CONCENTRATIONS IN THE PRESENT RIB DESIGN USING A SIMPLE LOADING CONDITION. THE TEST WAS CONDUSCTED TO VALIDATE THE LIGHT WEIGHT DESIGN OF THE RIB



SIGNIFICANT RESULTS NOTED

LESS THAN 30 LB. IS REQUIRED TO "CLOSE" THE RIB 0.030 IN.

THE TEAM WAS NOW READY TO DEVELOP THE CORRECTIVE ACTIONS FOR THE ROOT CAUSES WHICH WERE ESTABLISHED BY TEST 1, 2, 3 AND 4

COUNTERMEASURES

COUNTERMEASURE MATRIX

PROBLEM	ROOT CAUSES	COUNTERMEAUSRE	PRACTICAL METHODS	EFF.	FEAS.	Y/N?
RIB HEIGHT OUT OF TOLERANCE	DRILLING SEQUENCE	RE-SEQUENCE THE DRILLING AND INSTALLATION OF FASTENERS	A: REVISE THE OPERATION WORK SHEET	3	5	15
			B: TRAIN THE OPERATORS WITH NEW SEQUENCE	4	5	20
	DESIGNED TRANSITION FIT OF FASTENERS	RE-DESIGN FOR CLEARANCE FIT OF FASTENERS	C: DRILL THE HOLES TO HIGH END OF TOLERANCE	2	3	6
			D: REQUEST CUSTOMER TO UPDATE THE HOLE TOLERANCE	4	5	20
	LIGHT WEIGHT RIB DESIGN	RE-DESIGN THE RIBS FOR LESS DEFLECTION	E: REQUEST CUSTOMER FOR STRENGTHENING THE RIB LEGS	5	4	25

LEGENDS

A → E = PRACTICAL METHODS

1 → 5
LOW HIGH

FOUR (4) PRACTICAL METHODS WERE SELECTED FOR IMPLEMENTATION

BARRIERS AND AIDS

BARRIERS	AIDS
CUSTOMER'S WILLINGNESS	REDUCED REJECTION
COST	INCREASED CUSTOMER SATISFACTION
TIME	REDUCED LEAD TIME
ENGINEERING MANPOWER	REDUCED REWORK
	IMPROVED FLOW
	MEET SCHEDULE

RESULTS

TO BE DETERMINED

THE COUNTERMEASURES WERE PROPOSED AND HAVE NOT BEEN IMPLEMENTED YET.

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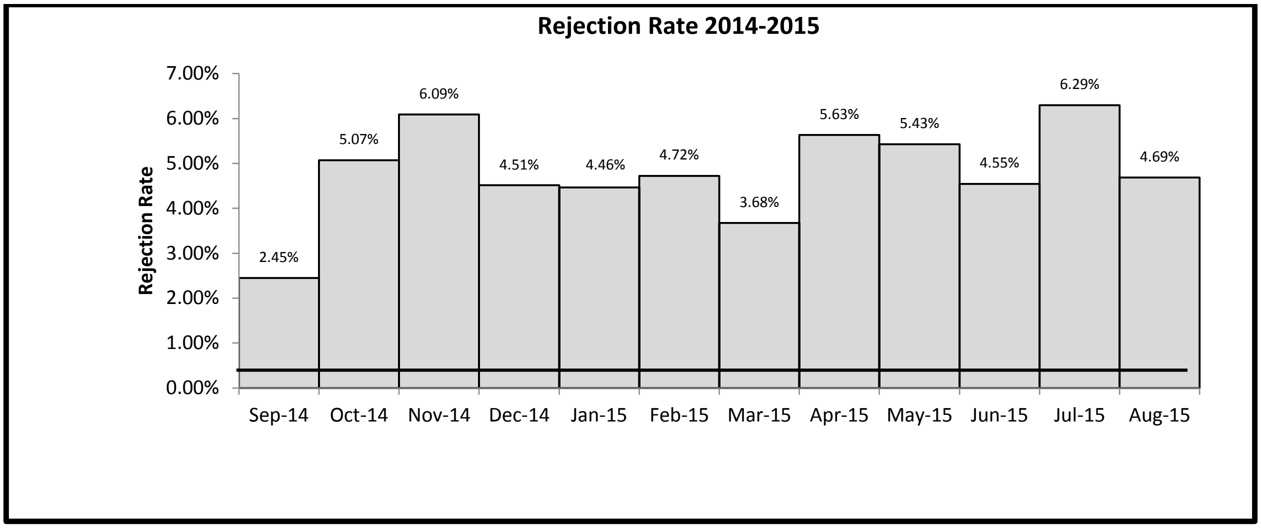
STANDARDIZATION

TO BE DETERMINED

Problem Statement and Current Situation

XX Corporation is a manufacturer of parts for aircrafts. One of the products they manufacture is the Leading Edge (LE) assembly for the aircraft wings. The company is facing High Rejection rates of LE assemblies at final inspection, which in turn leads to customer dissatisfaction. Overall 4.70% or 47000 PPM of total assemblies were noted to be out of tolerance during the last 12 months period. Rejection rate graph is shown below.



The customer rejected the HE assemblies that were out of tolerance. XX Corporation made about 1650 LE assemblies in past one year out of which customer rejected about 83 assemblies. Repair of each assembly costs approximately $550 making total repair cost of $45650. Out of these 83 assemblies, XX Corporation had to scrap 15 assemblies. Average cost of each assembly was $18000. Thus, the scraped assemblies costed XX Corporation $270000.

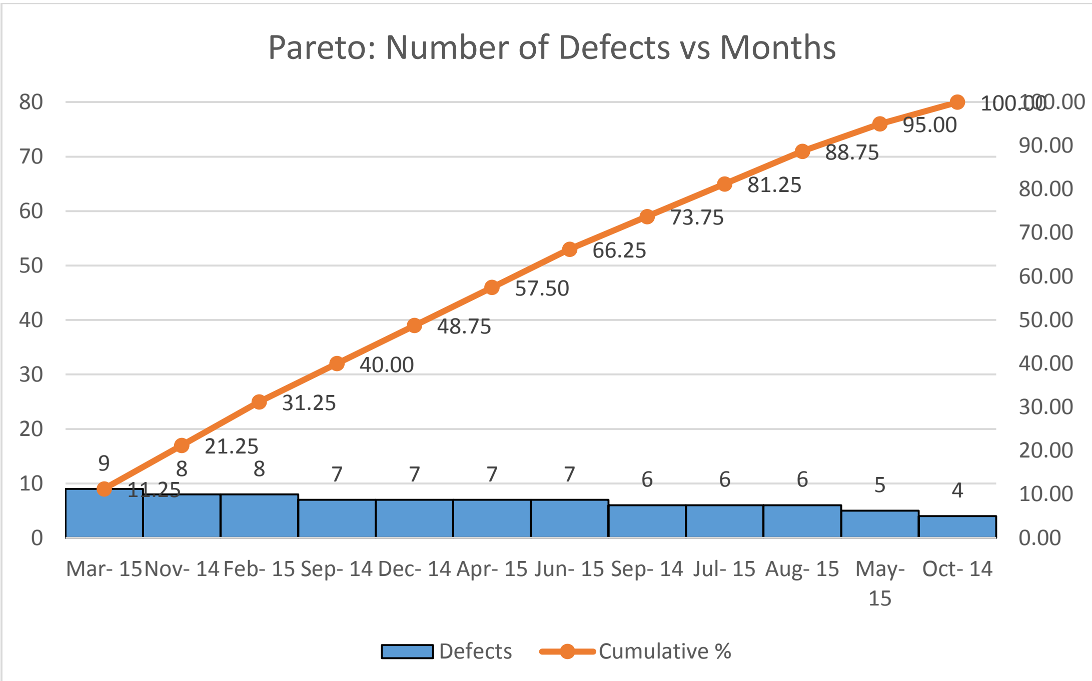
To narrow down on the reason for defective assemblies, data was collected using check sheet for a duration of 12 months documenting the number of defects, type of defects and time when the defect occurred. The check sheet were then analyzed using Pareto charts to get better insight of the root cause causing defects.

Check-sheet:-

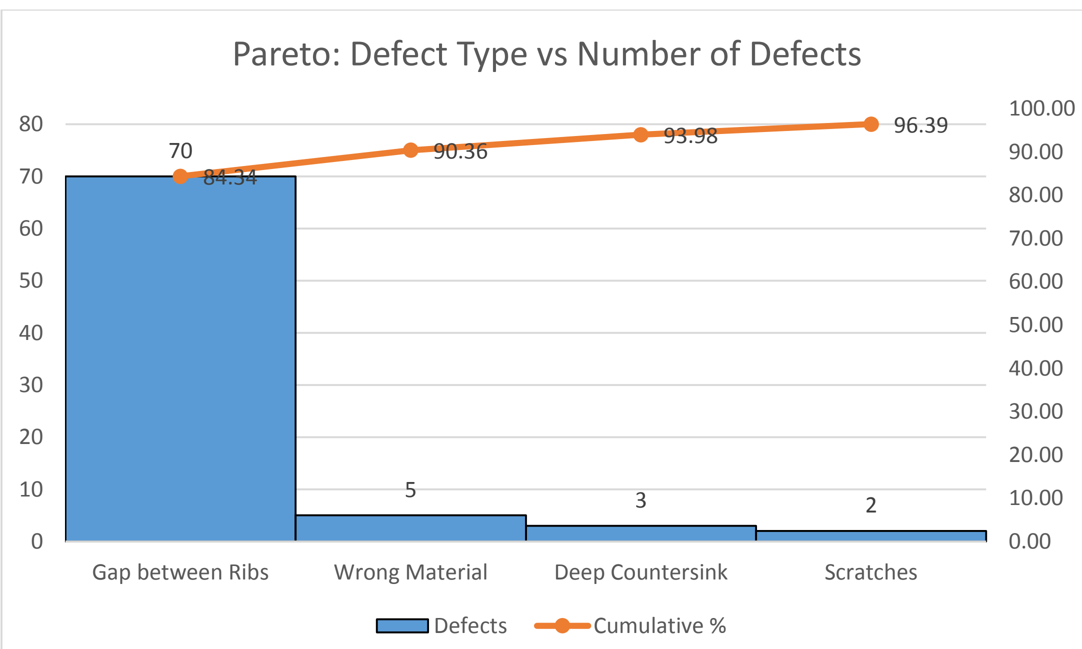
Project Name:	'# 632110: Reduction in Assembly variation in LE asser
Name of Data Recorder:	Carl Franken
Location:	LE assembly lines 1,2,3,4,5
Data Collection Dates:	Monthly report from Assembly line

Defect Types/ Event Occurrence	Dates												
	Sep-14	Oct-14	Nov-14	Dec-14	Jan-15	Feb-15	Mar-15	Apr-15	May-15	Jun-15	Jul-15	Aug-15	TOTAL
Gap between Ribs	6	4	7	6	6	5	7	5	5	7	6	6	70
Wrong Material	1	0	0	1	0	2	1	0	0	0	0	0	5
Deep Countersink	0	0	0	0	0	1	1	1	0	0	0	0	3
Scratches	0	0	1	0	0	0	0	1	0	0	0	0	2
Assembly Delays	0	1	0	0	0	0	0	0	0	0	0	0	1
Assembly line shutdown	0	0	0	0	0	0	0	0	0	1	0	0	1
Others	0	1	0	0	0	0	0	0	0	0	0	0	1
total	7	6	8	7	6	8	9	7	5	8	6	6	
TOTAL	7	6	8	7	6	8	9	7	5	8	6	6	83

The defect type of Assembly delays, Assembly line shutdown and other defects have been ignored in further analysis due to being maintenance issues rather than manufacturing issues.



No significant pattern was observed in the above Pareto chart between Defects and Months. Failures per month is fairly constant which is between 6-9 defects per month.

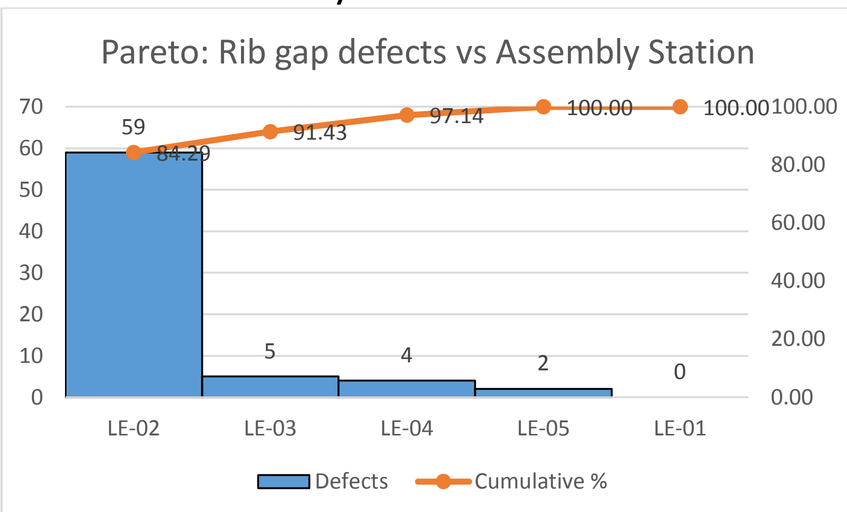


On analyzing the above Pareto chart between Defect Types and Number of Defects, we find that 84% of defective products have a Rib Gap.

To evaluate the causes for Rib Gab defects, variation was analyzed using Pareto Charts for following parameters:-

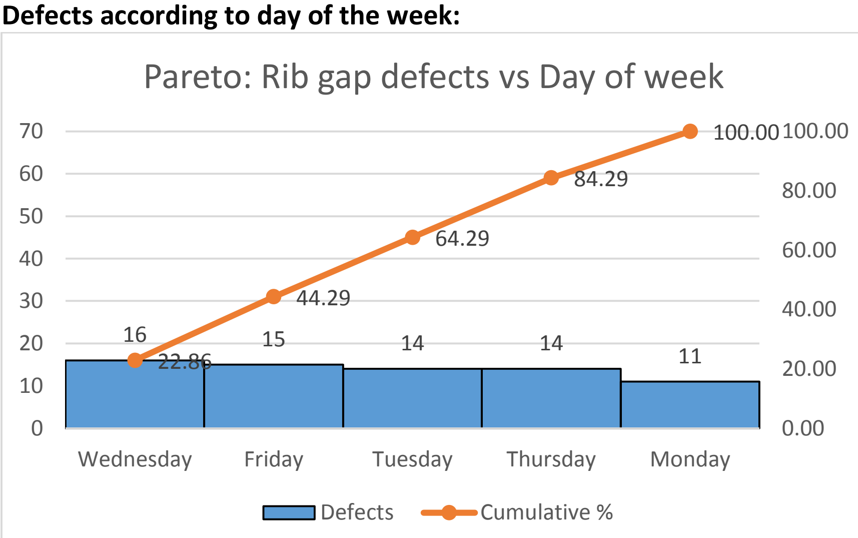
1. Variation according to assembly station
2. Variation due to operators
3. Based on number of days
4. Monthly defects

Defects on various assembly sections:



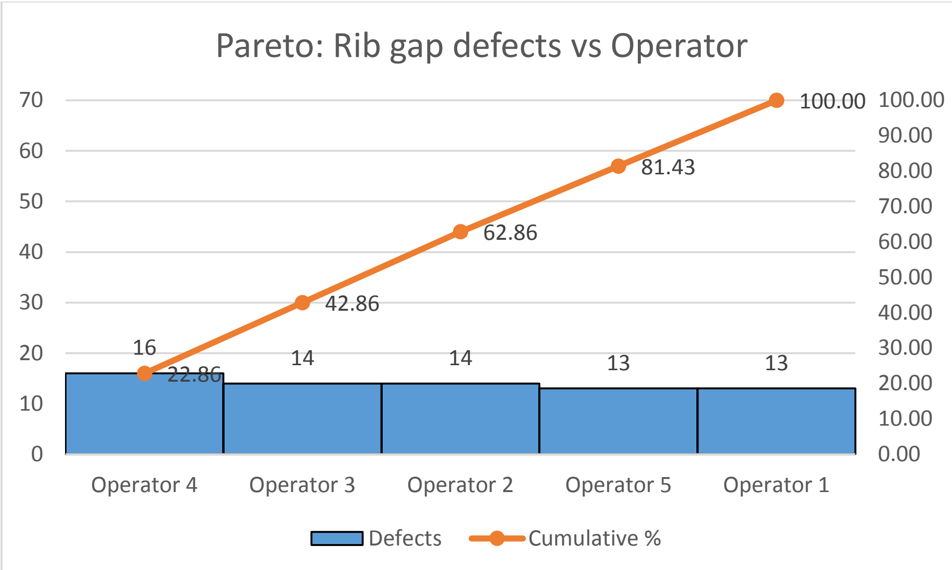
This Pareto clearly indicates LE-02 assembly station has more problem than any other station.

Defects according to day of the week:



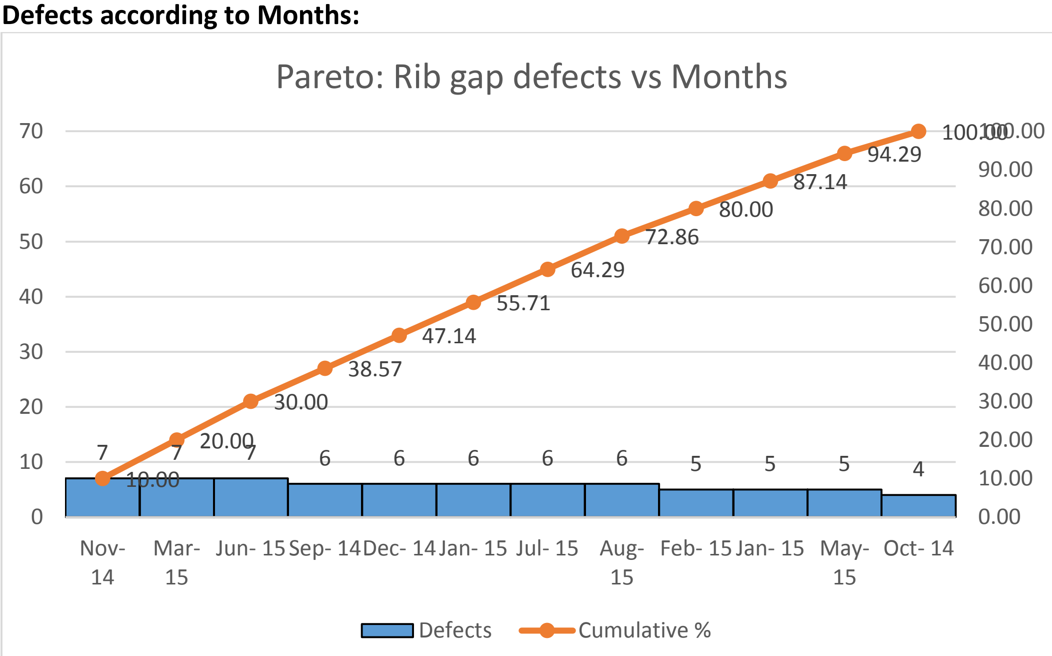
No significant conclusion could be drawn from the above Pareto chart as there was no significant difference between the number of Defects.

Defects according to Operators:



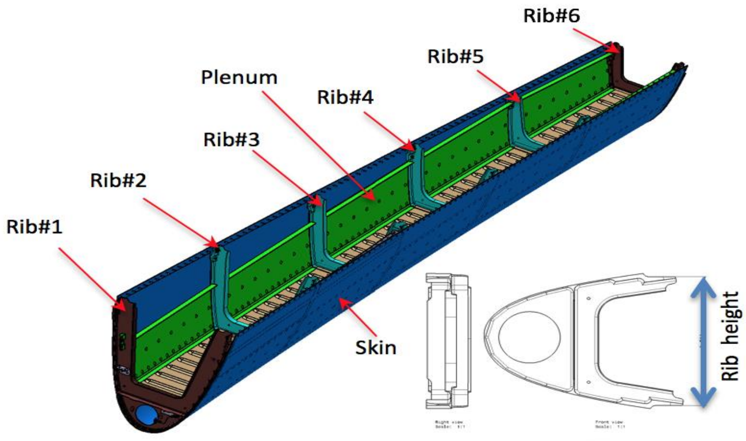
Even though Operator 4 is producing higher defective components, yet co conclusion can be drawn from the above Pareto chart as there is no significant change in the number of defects produced by different operators.

Defects according to Months:



For all the months for which data was made available there was number of defects produced were roughly constant.

Based on above analysis, over 83% of rib gap issues were identified in assembly section of LE-02. Other variables were fairly constant. Hence, we decided to do further analysis. The rib gap issue was attributed to variation in rib height.

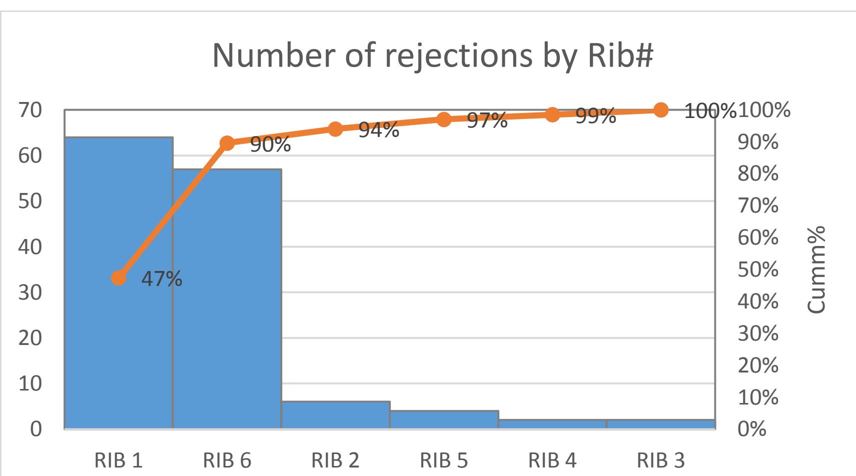


The criteria to reject a part due to Rib height are as follows:-

a. Design Specifications under consideration:
*The distance between the outer surfaces of the machined ribs in the Leading Edge Assembly that mate to the upper and lower leading edge clips (connected to the forward spar of the wing) should be within +0.000/-0.005 inch within tolerance range from design dimen*sions according to R&D.

b. Failure type and acceptance criteria
Upon assembly of this machined rib in the leading edge assembly, the distance between the upper and lower surface deviates greater than .015 inches, either too narrow or too wide. Maximum of 0.5 % of the LE assemblies are allowed to be out of tolerance limit.

The team further investigated the variation in rib height by performing the Pareto analysis of the rib height issue by Rib # in the LE-02 section.



Height of rib number 1 and rib number 6 caused about 90% of total failures. The team decided to work on rib height issue in Rib #1 and #6 of LE02 assembly in accordance with Juran's ideology.

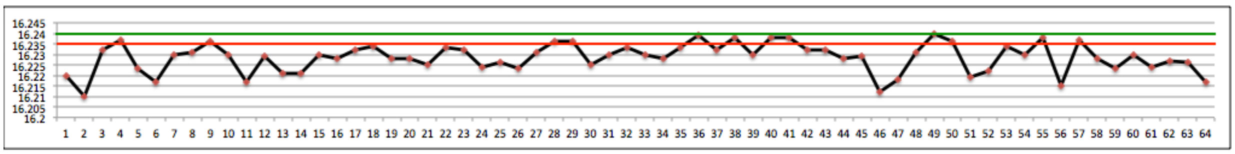
Root Cause Analysis:

The team started with incoming inspection of the parts. The problem will arise if

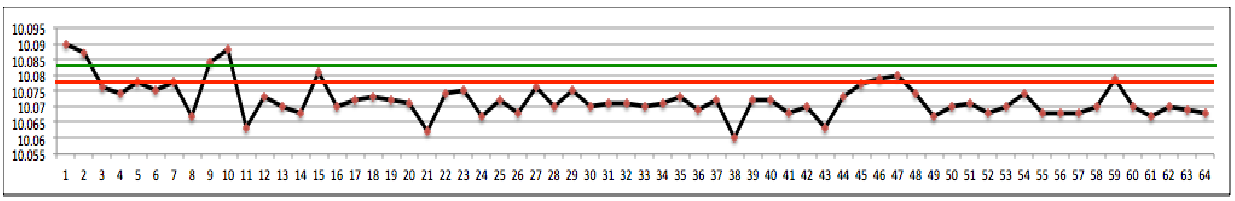
a. We received out of tolerance parts
b. During installation at our premises

The incoming inspection data of rib height was analyzed and found to be in tolerance. The measurements below showed ribs were within tolerance limit before assembly.

Final inspection data of the assembly was analyzed. Ribs were falling out of tolerances after assembly.

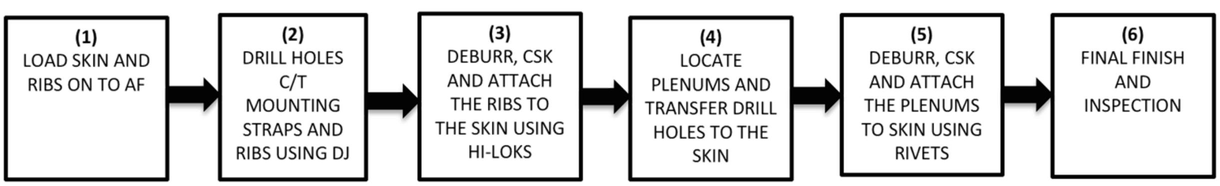


Height variation of Rib # 1



Height variation of Rib # 6

The team studied the assembly processes to determine the root cause of the issue and decided to measure the rib height at process step. The process flow of the LE was noted to be as follows:-



Process flow of LE 02 Section

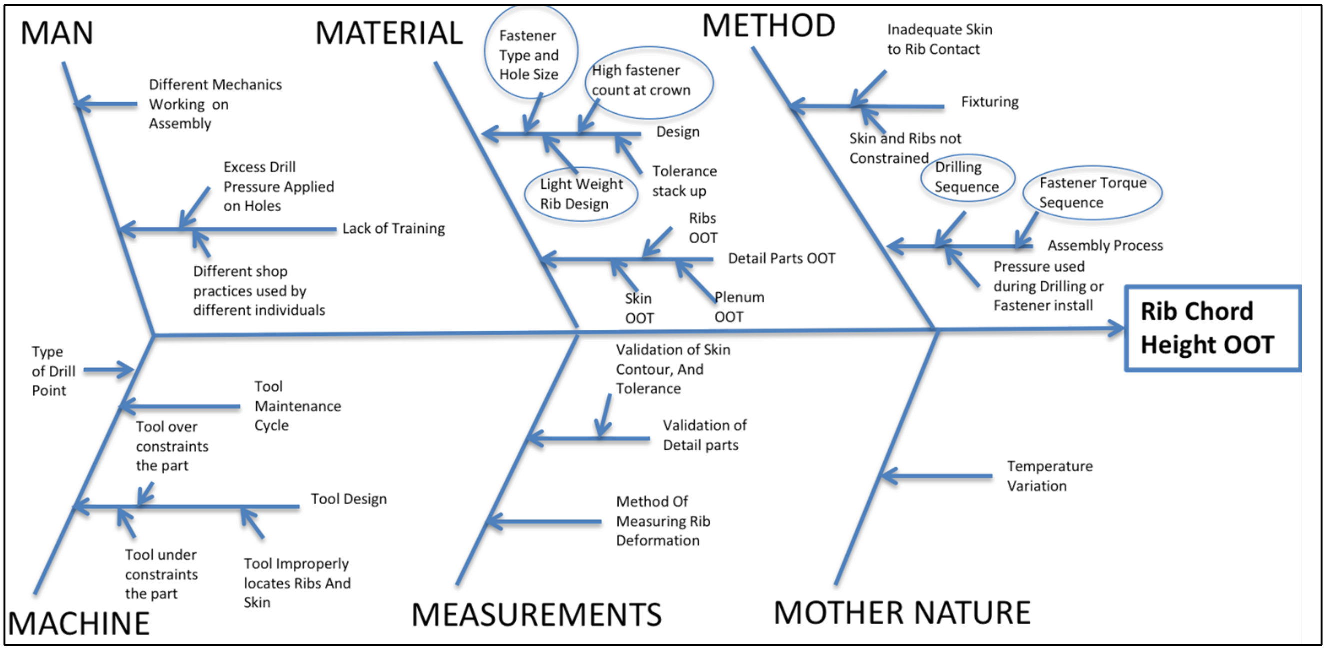
After each assembly operation measurements were taken and recorded in the following tables.

LE02 S.NO 227		NOMINAL +0/-.005	Detail part	Delta from nominal	(1) Constraint in AF	Delta from nominal	(3) Installation of Hiloks	Delta from nominal	(5) Installation of Plenum	Delta From Nominal
RIB # 1	LE02 INBD	16.24	16.236	-0.004	16.24	0	16.226	-0.014	16.226	-0.014
RIB# 6	LE02 OUTBD	10.082	10.080	-0.002	10.088	0.006	10.067	-0.015	10.069	-0.013

LE02 S.NO 228		NOMINAL +0/-.005	Detail part	Delta from nominal	(1) Constraint in AF	Delta from nominal	(3) Installation of Hiloks	Delta from nominal	(5) Installation of Plenum	Delta From Nominal
RIB# 1	LE02 INBD	16.24	16.239	-0.001	16.237	-0.003	16.216	-0.024	16.217	-0.023
RIB# 6	LE02 OUTBD	10.082	10.081	-0.001	10.081	-0.001	10.067	-0.015	10.068	-0.014

Height Variation of ribs after every operation

From above table, it was clear that after installing Hiloks there was major deviation from the nominal value. With better understanding of the assembly process and issues thereof, the team decided to move on with Ishikawa diagram or cause effect diagram. Team discussed and brainstormed the ideas with manufacturing supervisors, operators and with quality department.



Cause and Effect Diagram

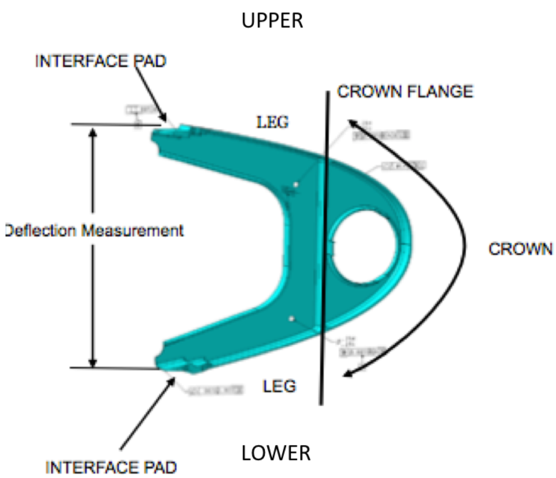
Following key root causes were identified based on discussion with cross functional experts and brainstorming within team

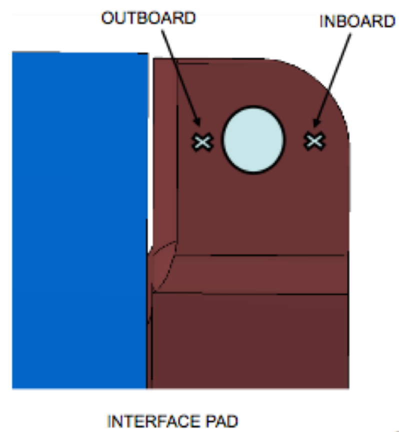
1. Improper drilling sequence and fastener installation could cause deformation of parts
2. Design parameters such as
   a. High number of fasteners in crown area could cause rib structures to deform due to tight pitch (13 hiloks fasteners in 5 inch spaces).
   b. Type of fit of fasteners and dimensions of fastener holes- The accumulated interference from the crown to leg could cause the rib to bend.
   c. Light weight design of rib- the sub pressure defects with minimal

Team proposed following tests and analysis to be performed to understand the problem further and effect of each of variable

SR	Test to be performed	Frequency
1	**Measurement of deflection during drilling and fastener installation process**	**2 units**
2	**Clearance fit on fasteners at crown area over interference fit i.e. effect of instability**	**1 unit**
3	**Re-sequence assembly process start mounting fasteners from crown to leg**	**1 units**
4	**FEA analysis to identify for weak sections and load required to deflect the rib by .03 inches**	**NA**

Terminologies:

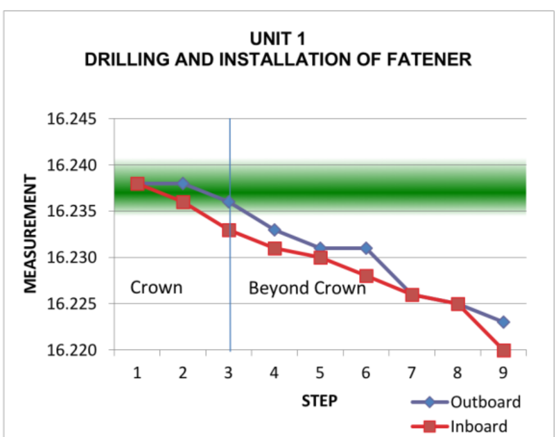


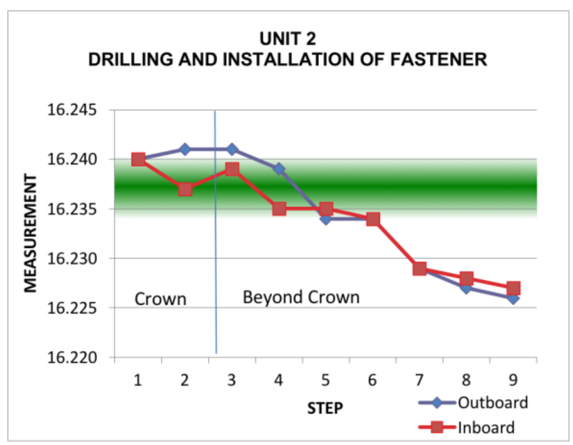


Measurements were taken at both inboard as well as outboard locations. The measurements were taken under supervision of quality department of xx corporation.

These tests gave us following results

Test 1: Deflection during drilling and installation process



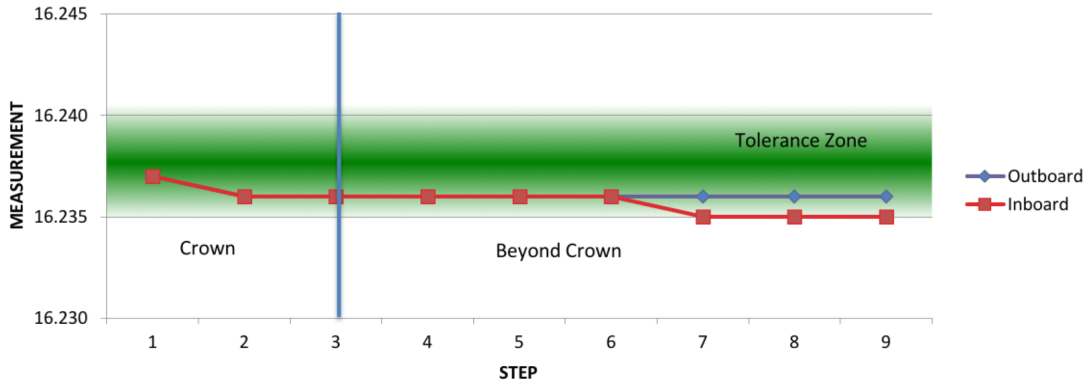


Deflection during drilling and installation process

Key Observations:

1. Rib begin to deflect as fasteners in crown area were installed & torqued to final collar breakoff
2. Outboard and inboard measurements show that rib legs are twisted from from free state condition
3. Inboard deflection is 0.02 inch and outboard deflection 0.015 inch

Test 2: Clearance fit on fasteners at crown area over interference fit

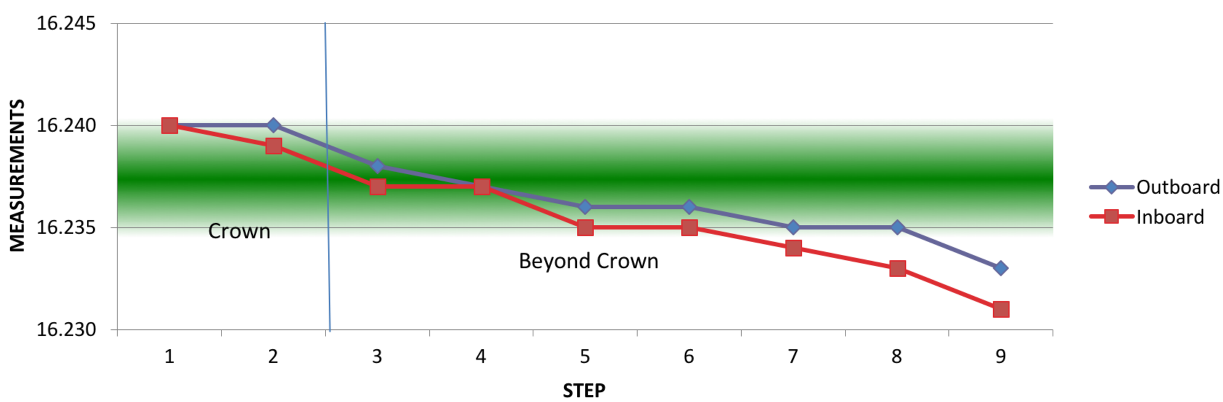


Clearance fit on fasteners at crown area over interference fit

Key Observations:

1. Throughout assembly process the rib dimensions remained constant.
2. Rib legs did not twist as we observed find during test 1

Test 3: Re-sequence drilling and installing from crown toward leg

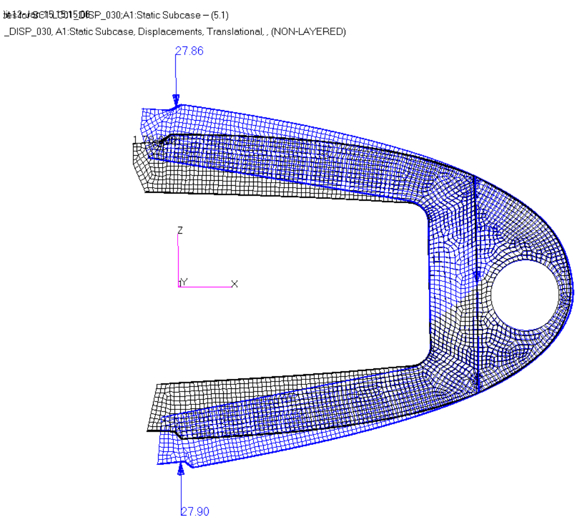


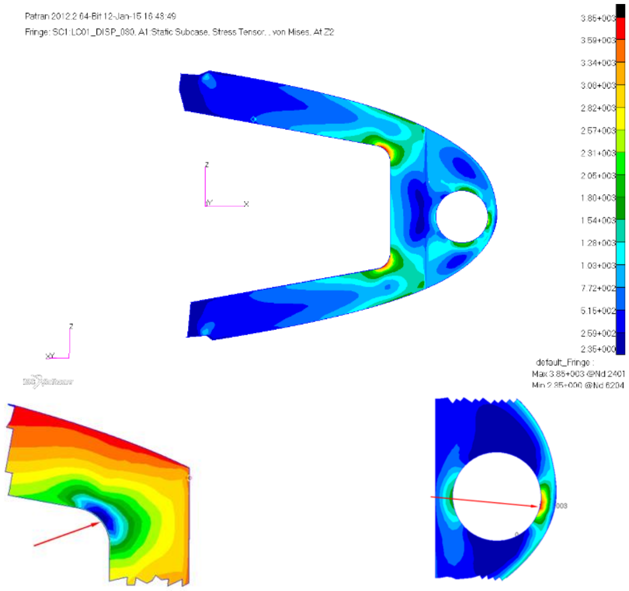
Re-sequence drilling and installing from crown toward leg

Observations:

1. Rib was deformed by about 0.003 inch below lower limit
2. Rib legs are twisted from their free state position

Test 4: FEA analysis





FEA analysis

Observations:

1. Design of rib is comparatively weak. Maximum force it can take without any permanent deformation is about 30 lb.
2. About 45 lb. force need to be applied during assembling causing rib to close before its desired limit.

Countermeasures:

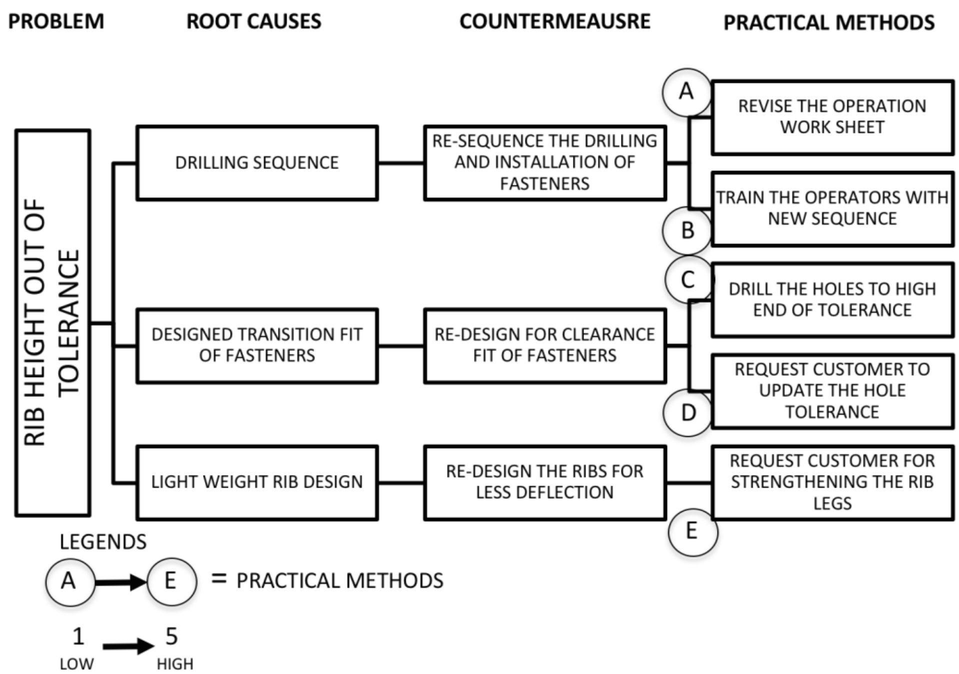
Based on study performed we decided the problem was caused because of following reasons

1. Wrong drilling and installation sequence of fasteners
2. Type of fit on fasteners
3. Weak design of rib

Tests and FEA analysis showed that following workable countermeasure can be taken

1. Re-sequence the drilling and installation sequence
2. Change transition fit to clearance fit (Test 3 clearly shows much improvement)
3. Redesign ribs with increased strength (FEA analysis shows why this is needed). Since these parts are proprietary design from a customer, a request was made to customer to improve on design.

Countermeasure Matrix:
Based on the arguments presented in previous section countermeasure matrix was prepared.



EFF.	FEAS	Y/N?
3	5	15
4	5	20
2	3	6
4	5	20
5	4	25