

Dogpatch Compressor Plant

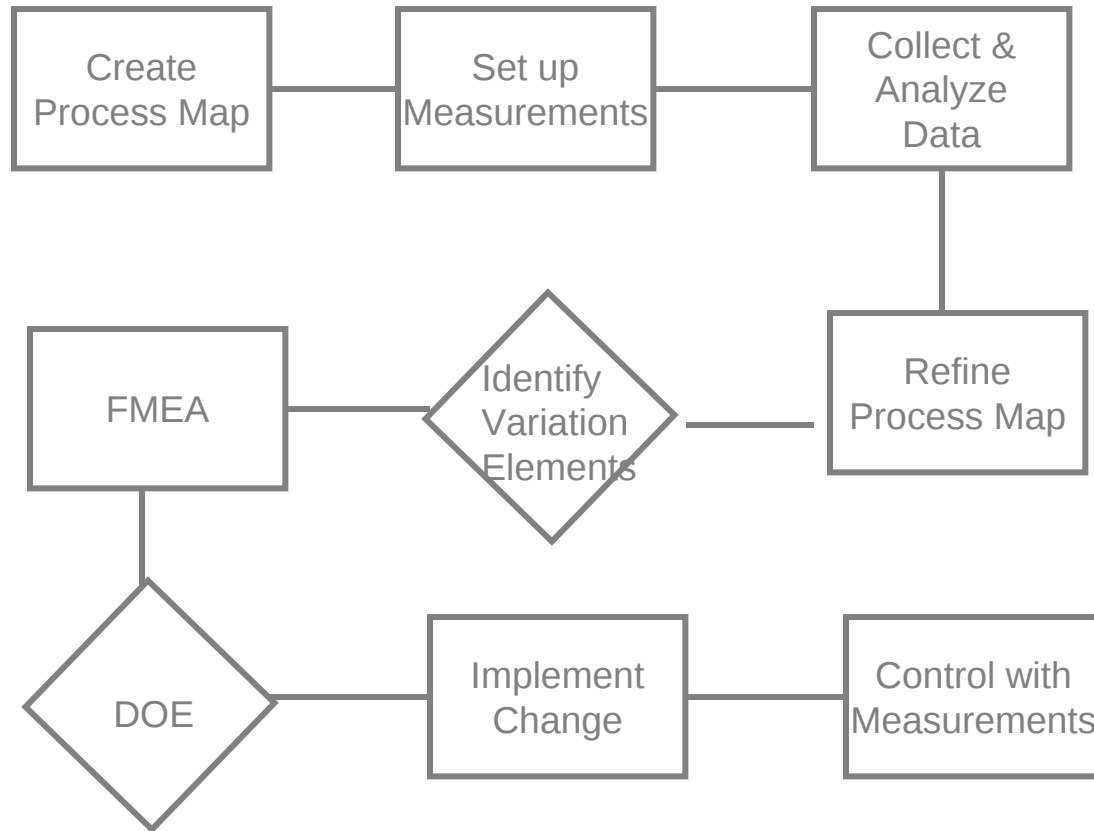
COIL BRAZING PROJECT EAST DOGPATCH COIL PLANT

FEBRUARY 1999

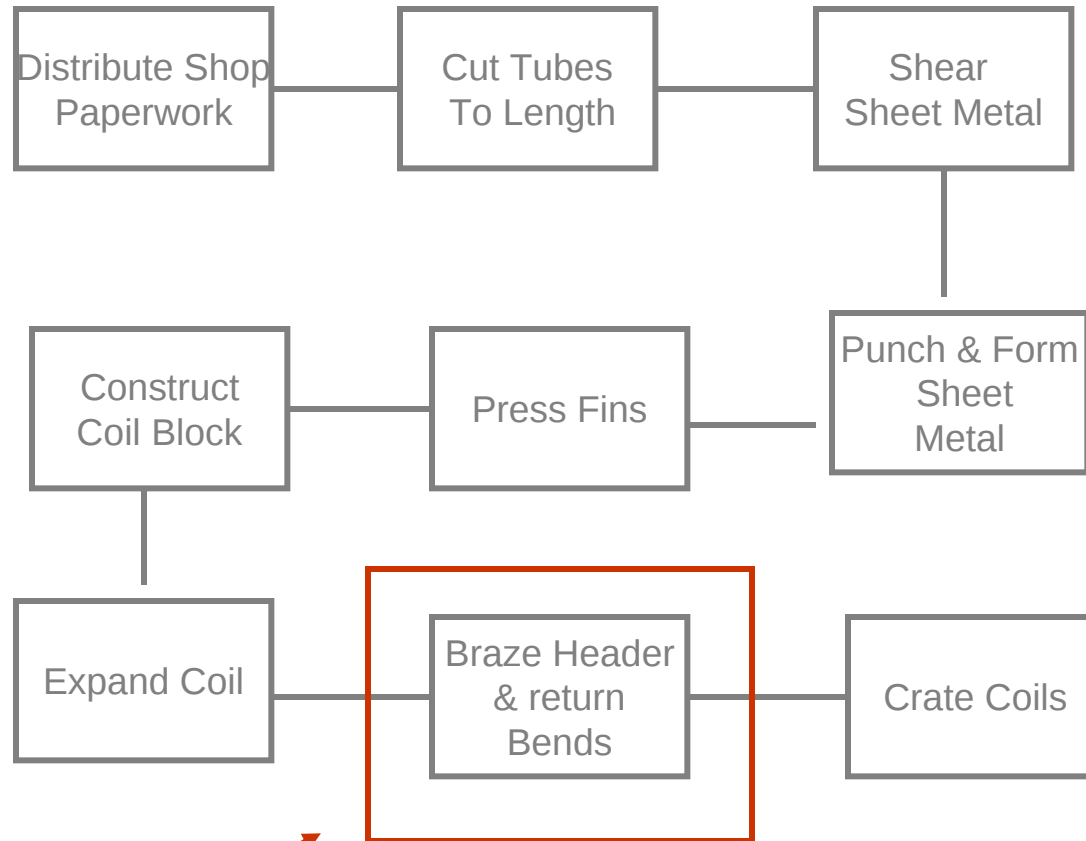
Project Statement

- Problem - suspected high rework in the brazing operation due to leaks
- Objective - Determine failure rate and rework rate. Implement change to reduce by 30%

Thought Process



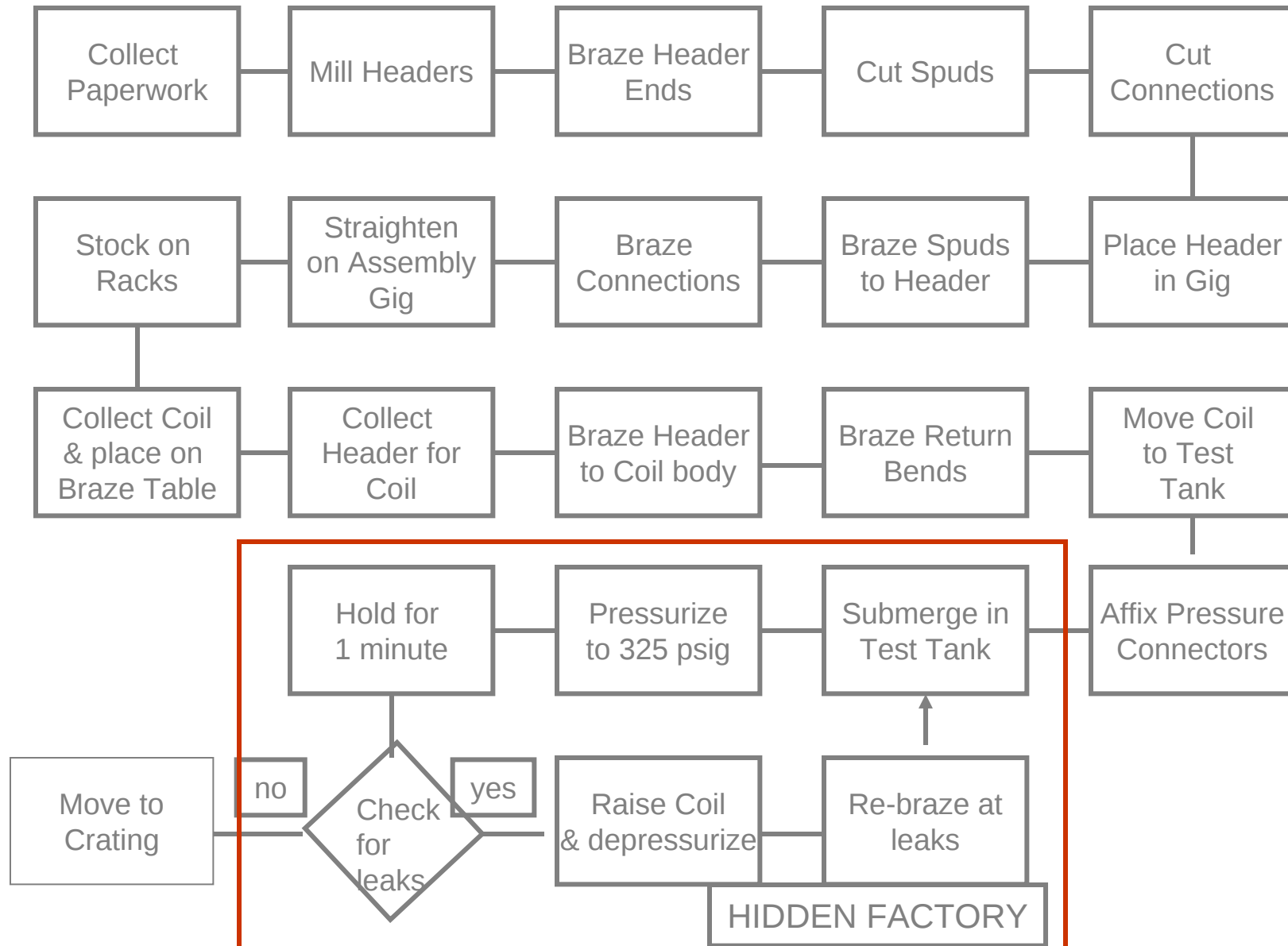
Coil Process Map



Area of Interest



Brazing Process Map



Failure Data

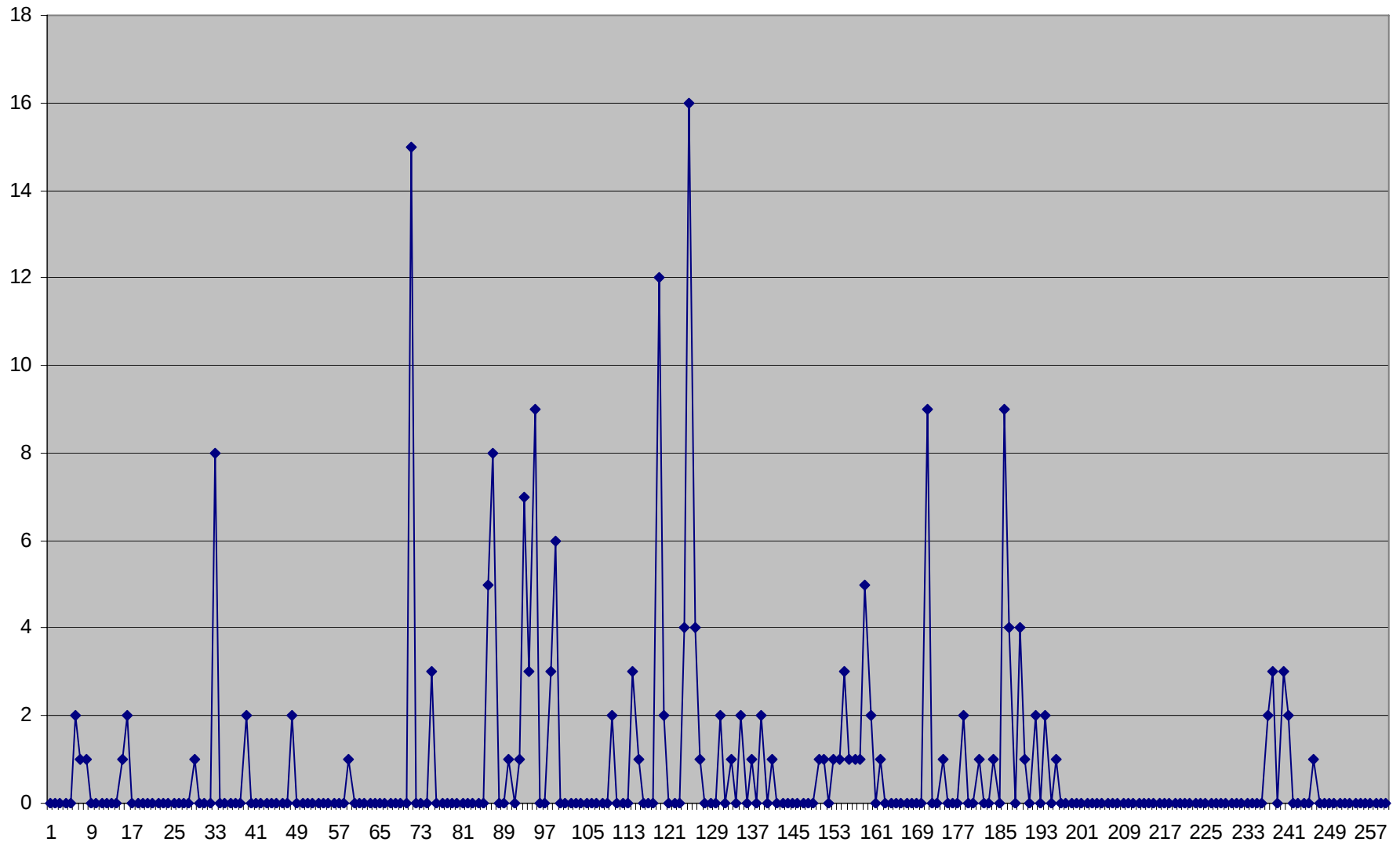
- Measurement
 - # of coils with leaks
 - # of leaks per bad coil
 - Location of leak - return bends, header end, header body
 - Brazer
 - Repair Time

Benchmark Data

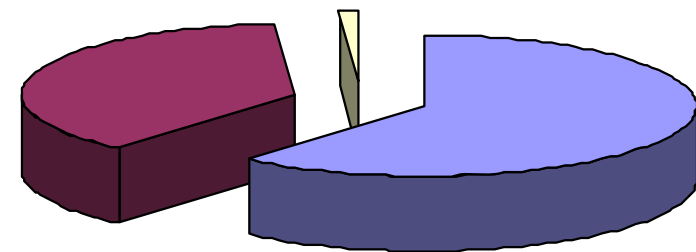
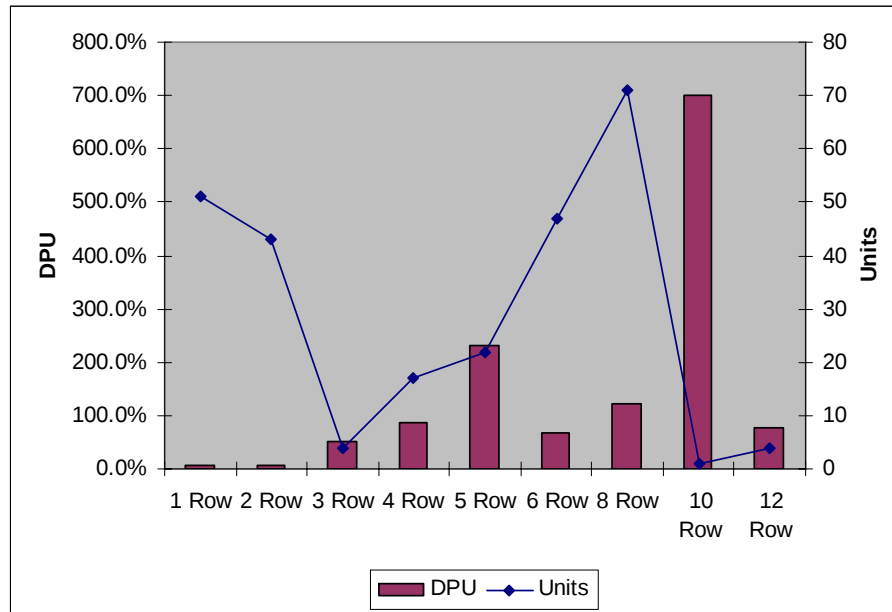
- Number of coils tested = 480
- Total number of leaks = 328, DPU = 68%
- % first pass yield = 78% (376 coils leak free)
- Average # of leaks per bad coil = 3.15
- Total repair time = 17.3 hours (7% of total brazing hours)

Measurement Results - # leaks per coil

total leaks



Failure Data -Failure rate by coil depth



■ return bends ■ header end ■ header body

Failure Data

Stratification & Special Cause Analysis

- Special Causes - cleanable coils (5 cleanable coils produced 26 leaks)
- Stratified data by coil row group

Row Group	total # Coils	Leak Free	# of Leaks	DPU
1-3 Row	199	190	13	7%
4-12 Row	281	186	315	112%
TOTAL	480	376	328	68%

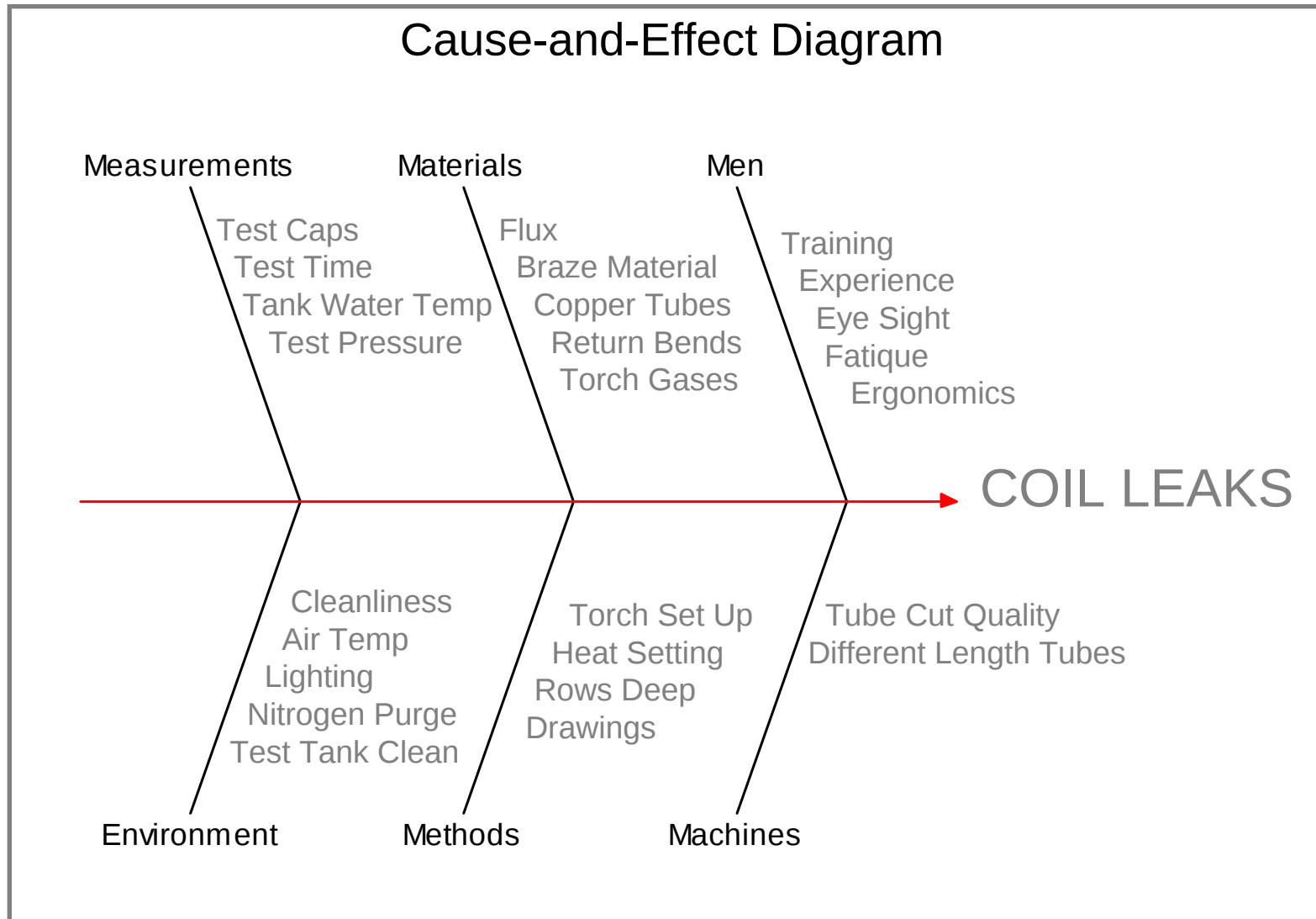
Cost of Poor Quality

- Components of COPQ
 - 1998 Warranty = \$30,300 Annually
 - Non Reported warranty = reported warranty, absorbed in start up
 - Rework = \$18,000 (does not include O.T.)
- TOTAL IMPACT = \$78,600 annually

Quality Tools Employed

- Data Gathering
- Histograms
- Fishbone Diagram
- Design of Experiment

Coil Leaks Fishbone Diagram



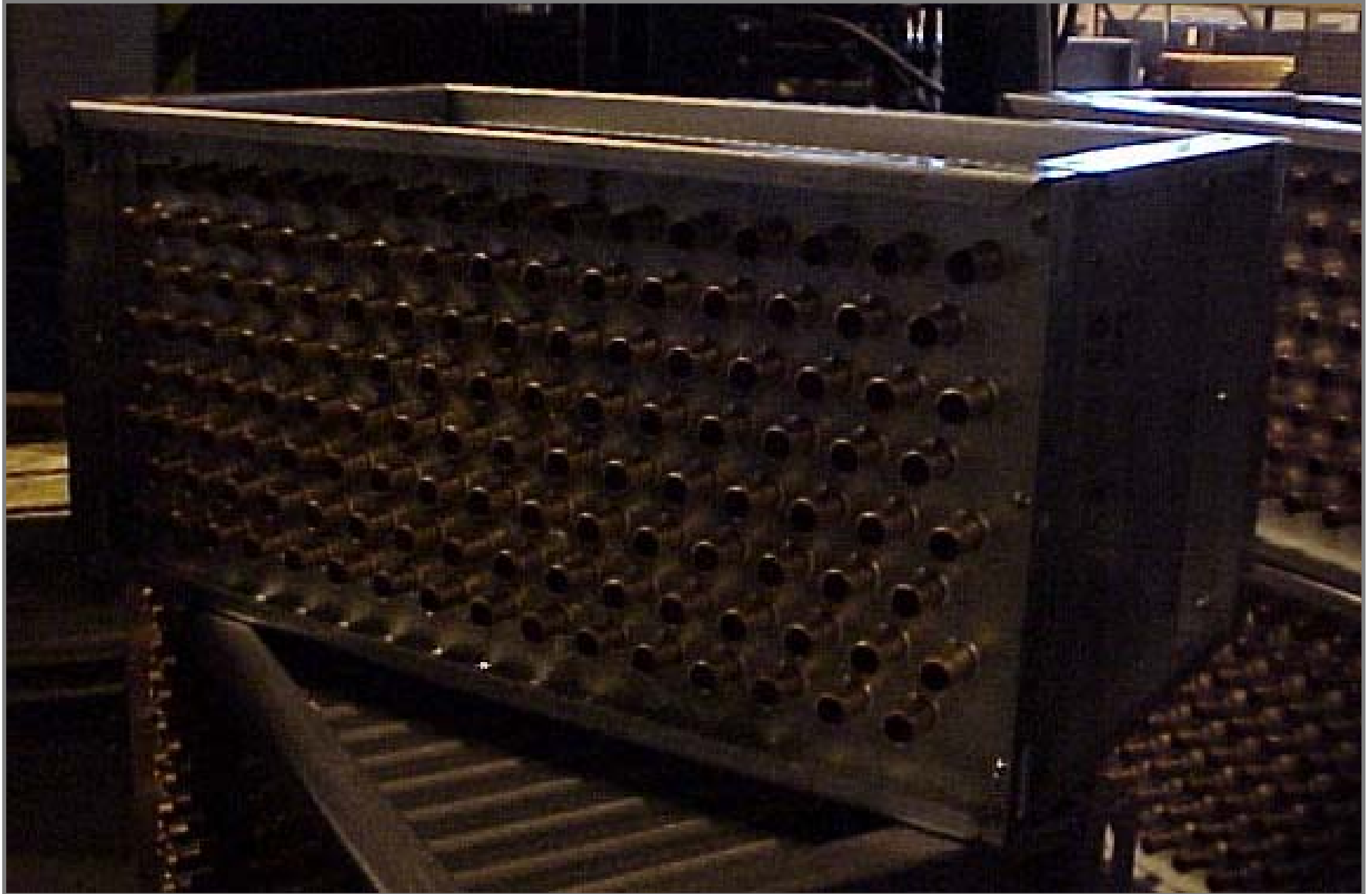
Design of Experiment

- Identified 4 factors to test impact on leak rates
 - Braze joint cleanliness
 - Skill of Brazier
 - Quality of Tube Cut
 - Use of Flux
- Designed full factorial in order to cover each permutation and reduce aliasing of factors

Brazing DOE

run	CenterPt	Blocks	Tube Cut	Skill	flux	Cleaned
1	1	1	-1	-1	-1	-1
2	1	1	1	-1	-1	-1
3	1	1	-1	1	-1	-1
4	1	1	1	1	-1	-1
5	1	1	-1	-1	1	-1
6	1	1	1	-1	1	-1
7	1	1	-1	1	1	-1
8	1	1	1	1	1	-1
9	1	1	-1	-1	-1	1
10	1	1	1	-1	-1	1
11	1	1	-1	1	-1	1
12	1	1	1	1	-1	1
13	1	1	-1	-1	1	1
14	1	1	1	-1	1	1
15	1	1	-1	1	1	1
16	1	1	1	1	1	1

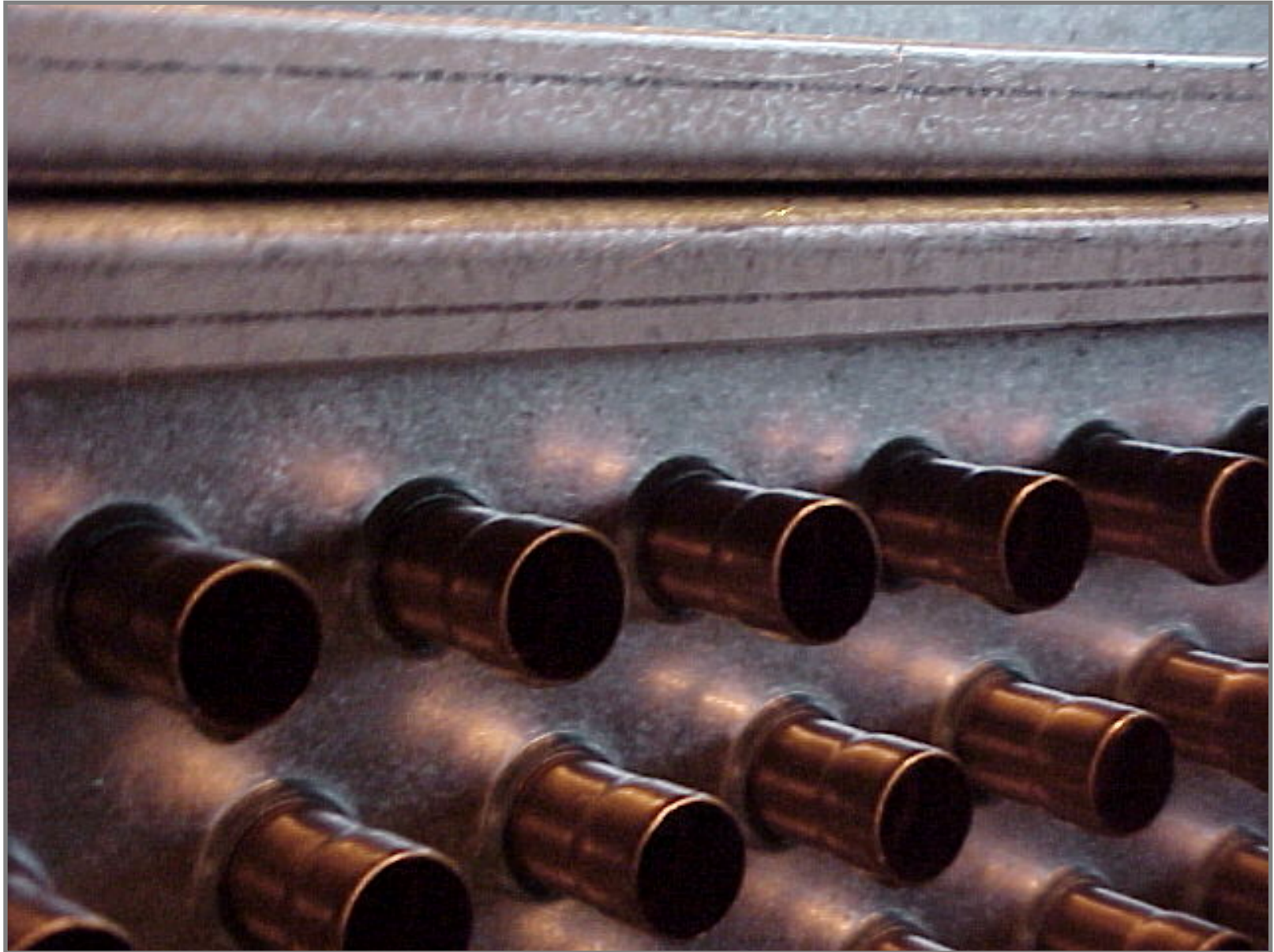
Brazing DOE



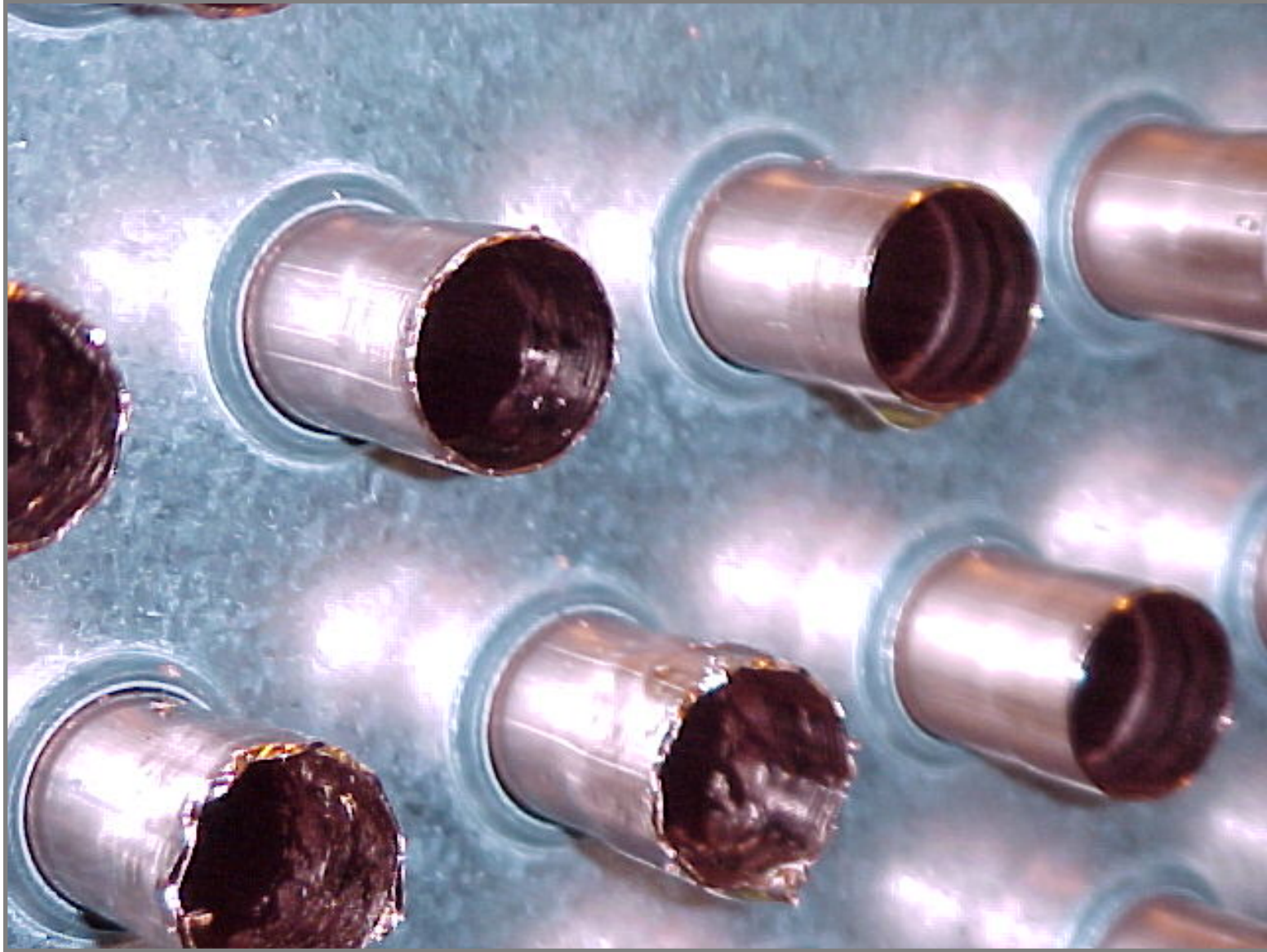
Brazing DOE



Brazing DOE



Brazing DOE

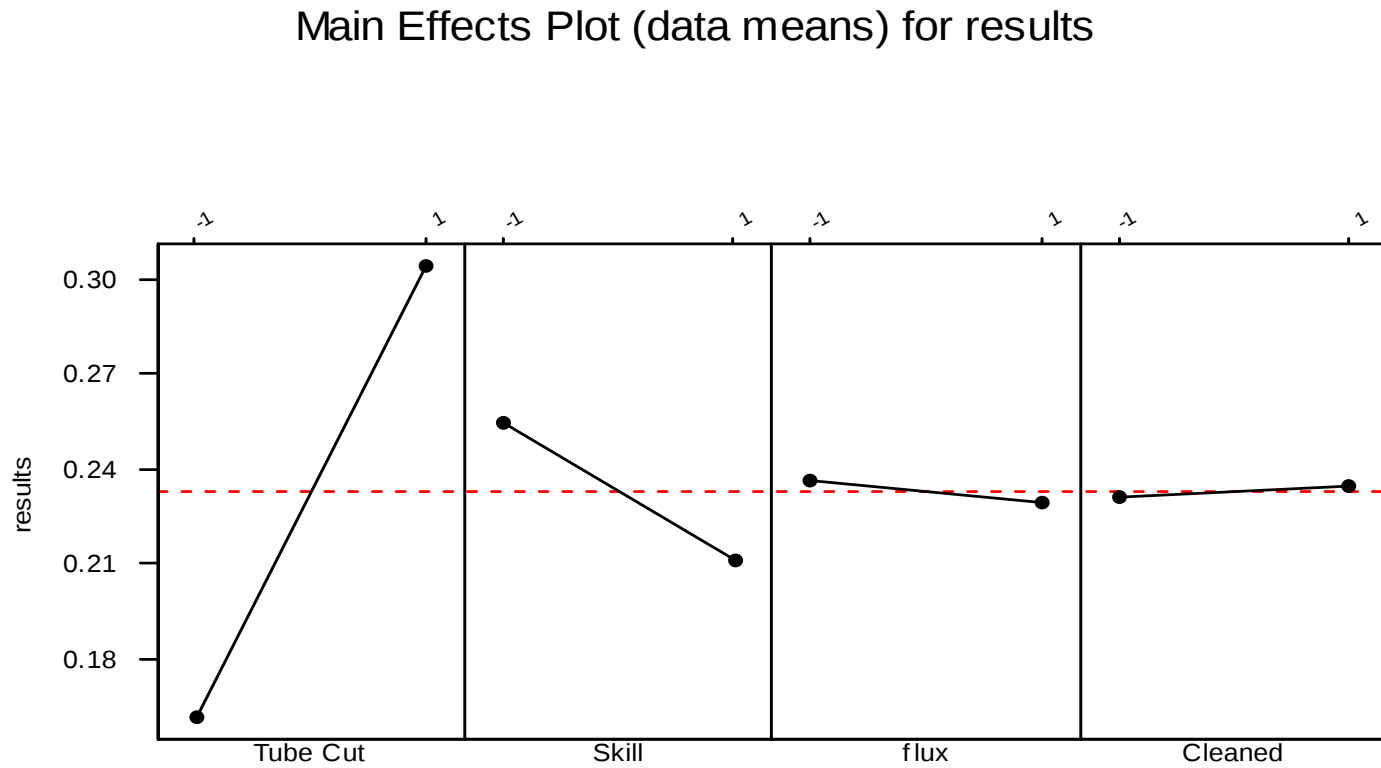


DOE Procedure

- 16 Coil Treatment Surfaces built
- Each Treatment group with possible 128 braze joints
- Once brazing process performed, each braze joint cut open and inspected to see if braze process complete
- Results are percentage of braze joints Incomplete- higher the percentage, the worse the results

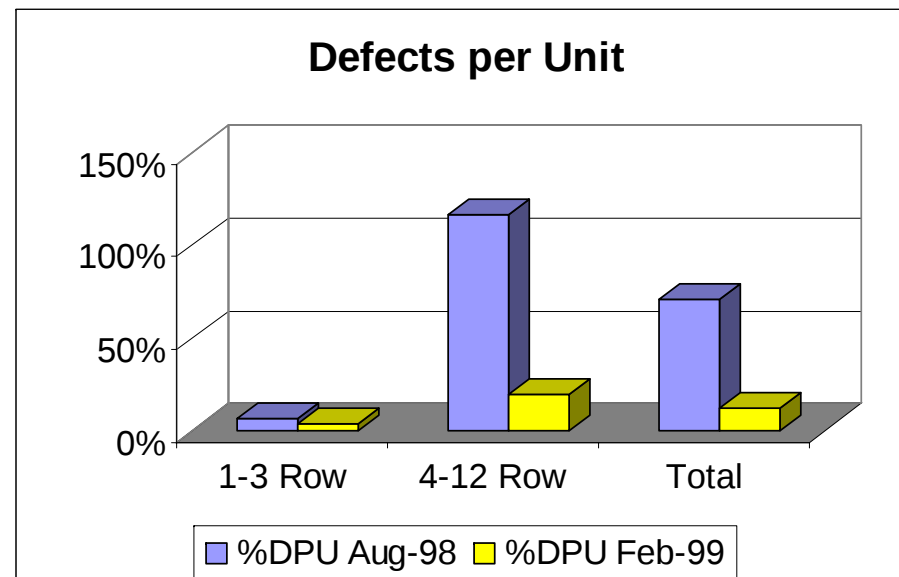
DOE Results

Good



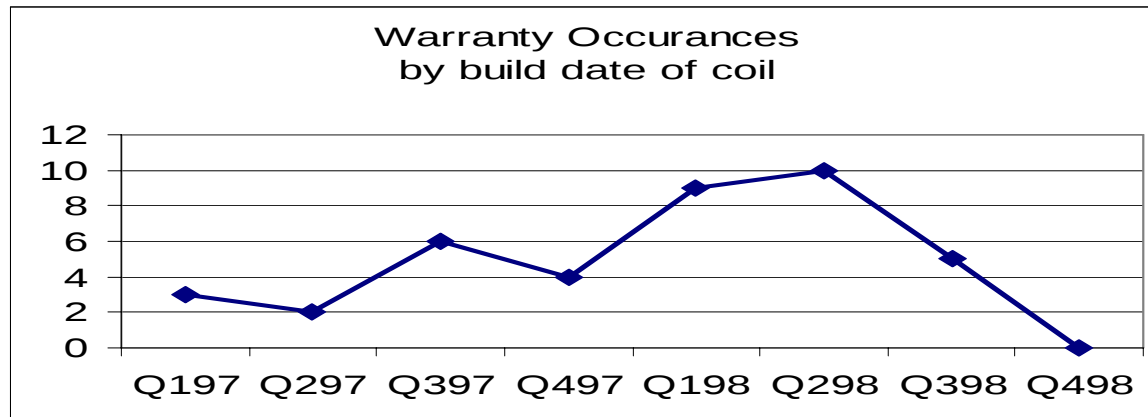
Action Steps - Skill Training

- Skill Training -
 - All brazers started skill training Jan 12, 99
 - Classroom and workshop
 - Poor performers given additional help
- Results after skills training - total DPU dropped from 71% to 19%



Action Steps - Skill Training

- Results extremely encouraging, but we remain cautious, Improvement likely due to
 - Skills Training
 - Increased Focus on Brazing quality
- Tempered by concern that the testers may not be recording all leaks found
- Improvement also seen in warranty records



Action Steps - Tube Cut

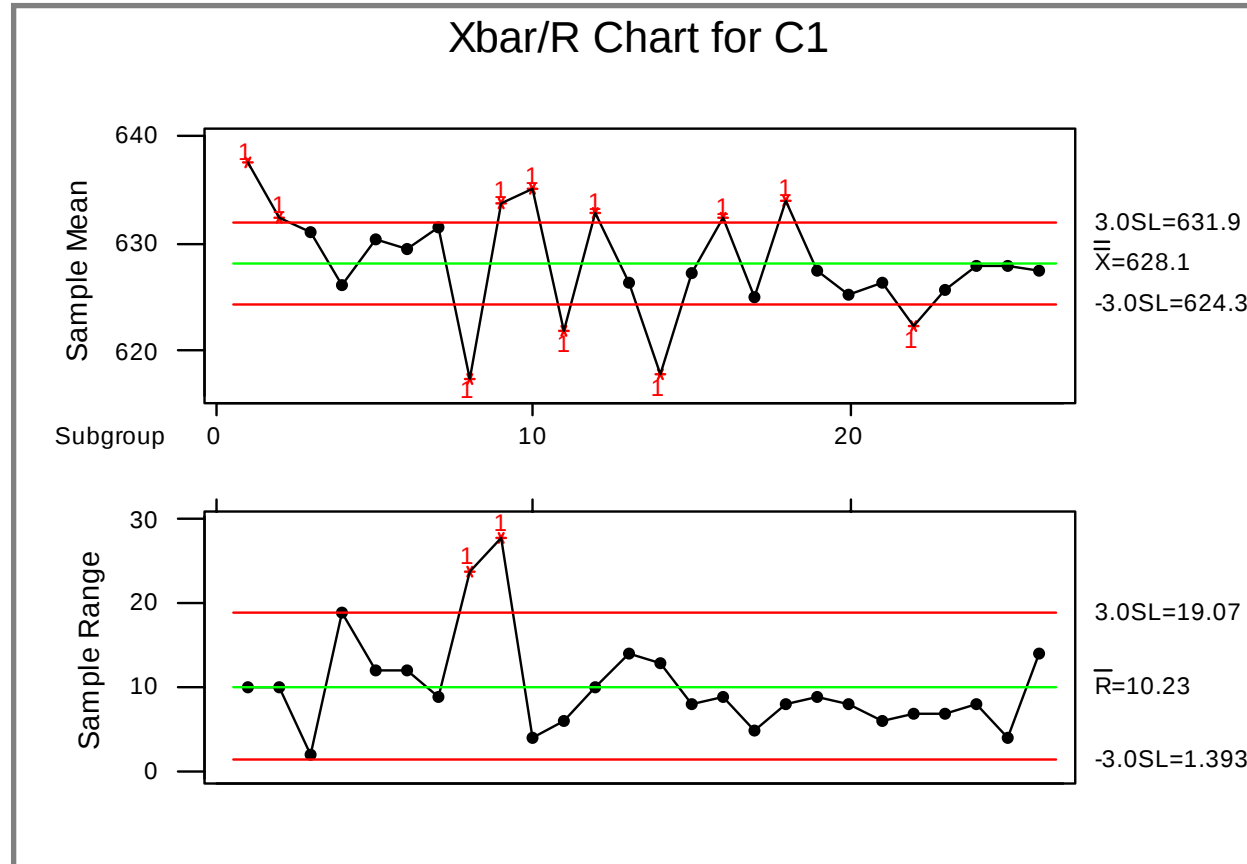
- **Tube Cut**

- Step back upstream in process to analyze process capability in tube cut & return bends
- Three tube cuts of concern - OD of return bends (purchased component), ID of tube cutter end, and ID of expander beller head end
- Specified dimensions & tolerances:

	OD RETURN BENDS	ID TUBE CUTTER	ID EXPANDER
Nominal	.625	.630	.635
Range	.622-.626	.627-.631	

Action Steps - Tube Cut

- Data gathered indicates that the beller head operation is out of control



Next Steps

- Continue monitoring and publishing braze leaks to sustain improvement
- Confirm nominal design values and tolerances for return bends, tube cutter and beller head operation
- Continue to gather data on actual cut diameters
- Re-design beller head to get process in control.

Conclusions

- We have increased process knowledge with use of tools
- We have introduced the discipline of gathering and analyzing data
- We think the breakthrough that we can capitalize on is the tube cut - improving both quality of braze and productivity by eliminating tube reaming process
- Gains are being made and can be sustained.