

IPC Alternate Surface Finishes Task Group

*Designed Experiment Status Report
IPC Fall Annual 2002 Meeting*

November, 2002



Objective of experiment

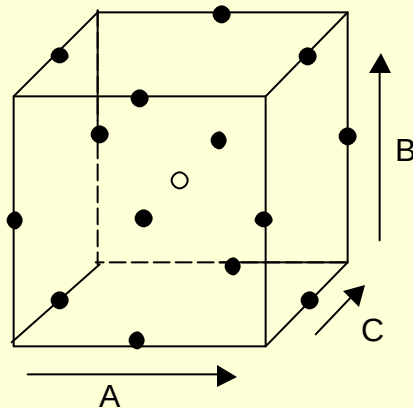
- Support IPC J-003 Standard on solderability testing, particularly as related to Alternate Finishes
- Develop a model which can be used to:
 - Determine screening test conditions to assess board solderability during production.
 - Evaluate solderability process capability for a given surface finish.
 - Evaluate potential new alternative surface finishes and compare solderability performance to current finishes.
- Accumulate data needed to prepare a suitable test method for a variety of finishes.
- NOT to rank finishes in terms of capability

Abbreviations

- Finishes tested
 - Organic solderability protection (OSP)
 - Immersion silver (IS)
 - Reflowed tin lead (RTL)
 - Bare copper (BC)
 - Nickel gold (NG)
 - Immersion tin (IT)
- Wetting balance measurements
 - Time to zero force (T0)
 - Time to 2/3 max force (T23)
 - Maximum force (Fmax)
 - Where possible - recover Force at 2 seconds for analysis
- SERA measurements
 - V2
 - Vf

Experimental Design (Box-Behnken)

Run	A	B	C	$y_1 \dots y_s$	$\bar{y}$	s
1	-	-	0			
2	-	+	0			
3	+	-	0			
4	+	+	0			
5	-	0	-			
6	-	0	+			
7	+	0	-			
8	+	0	+			
9	0	-	-			
10	0	-	+			
11	0	+	-			
12	0	+	+			
13	0	0	0			
14	0	0	0			
15	0	0	0			



- Purpose:
To obtain a model with quadratic terms on quantitative factors by us
- Conditions
 - Time (0, 8, 504, 1000 hours)
 - Temp (50, 72, 95C)
 - RH (30, 62, 95%) ing a fraction of a full factorial
- Used to:
Get all main effects, two way interactions and quadratics
- Notes:
 - Avoids the corners of the design space
 - Only useful for 3 or 4 factors

Test Notes

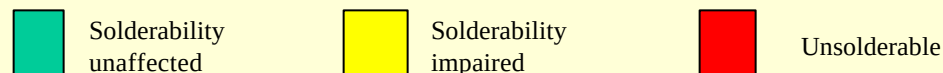
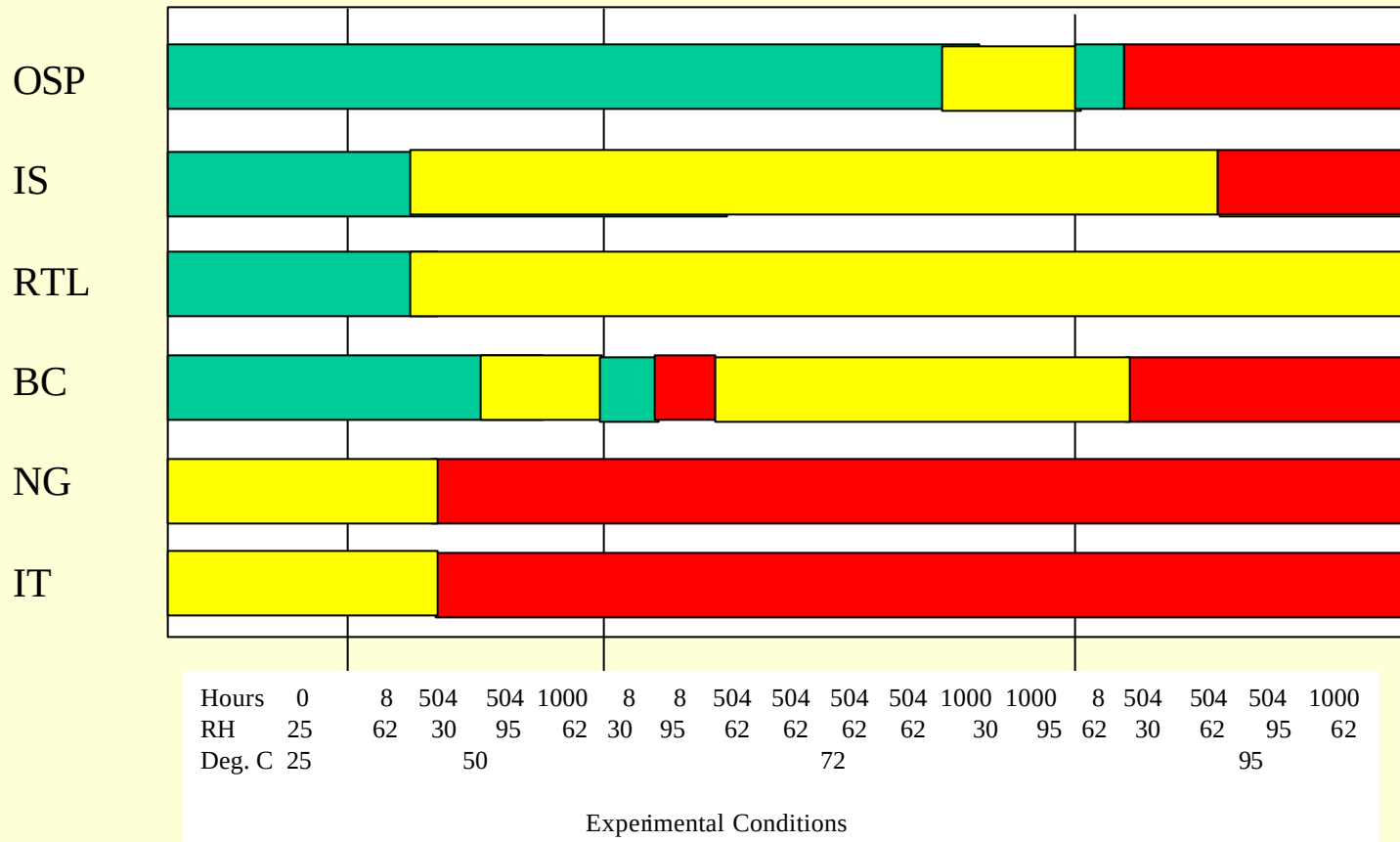
- Testing complete on all runs
- Data received for
 - Wetting balance: Fmax, T0, T2/3
 - SERA: V2, Vf
- Comments
 - Vf and V2 data missing for one run in each material type
 - F2 data not available on many runs
 - P/F data available, but not coverage estimates

Wetting Balance Results Color Code Key

Color	$T0$	$T2/3$	F_{max}	$Visual (P/F)$
Green	$T0 < 2$	$T2/3 < 3$	$F_{max} > 30$	$0 < F < 1$
Yellow	$2 < T0 < 4$	$3 < T2/3 < 4$	$0 < F_{max} < 30$	$2 < F < 3$
Red	$T0 > 4$	$T2/3 > 4$	$F_{max} > 0$	$F \geq 4$

IPC Alternate Finishes DOE

Overall Summary - Temp, Time, RH



Detailed Results for Reflowed Tin Lead and Bare Copper (Baseline)

RTL																		
Fmax	G	G	Y	G	Y	G	G	G	G	G	G	Y	Y	G	Y	Y	Y	Y
To	G	G	Y	G	Y	Y	Y	G	G	G	G	G	Y	Y	Y	Y	Y	Y
T23	G	G	R	Y	Y	Y	Y	G	Y	Y	Y	Y	R	Y	R	R	R	R
P/F	N	0	0	N	0	0	0	0	0	N	N	0	0	0	0	0	2	5
Sum	G	G	Y	G	Y	Y	Y	G	G	G	G	G	Y	Y	Y	Y	Y	R
Hrs	0	8	504	504	1000	8	8	504	504	504	504	1000	1000	8	504	504	504	1000
RH	25	62	30	95	62	30	95	62	62	62	62	30	95	62	30	62	95	62
Deg	25	50	50	50	50	72	72	72	72	72	72	72	72	95	95	95	95	95
BC																		
Fmax	G	G	G	R	Y	G	R	R	G	R	G	Y	R	Y	R	R	R	R
To	G	G	G	R	R	G	R	R	G	R	G	R	R	R	R	R	R	R
T23	G	G	Y	R	R	G	R	R	G	R	G	R	R	R	R	R	R	R
P/F	N	N	0	N	0	0	4	2	4	N	N	2	5	3	5	5	5	5
Sum																		
Hrs	0	8	504	504	1000	8	8	504	504	504	504	1000	1000	8	504	504	504	1000
RH	25	62	30	95	62	30	95	62	62	62	62	30	95	62	30	62	95	62
Deg	25	50	50	50	50	72	72	72	72	72	72	72	72	95	95	95	95	95

Detailed Results For Immersion Finishes - Silver and Tin

IS																		
Fmax	G	G	Y	G	Y	G	G	G	G	G	G	G	G	G	G	R	R	Y
To	G	G	R	G	G	G	G	G	G	G	G	G	Y	G	Y	R	R	R
T23	G	G	R	G	G	G	G	G	G	G	G	G	Y	G	R	R	R	R
P/F	N	N	3	N	0	0	3	3	0	2	N	2	5	2	0	2	5	5
Sum																		
Hrs	0	8	504	504	1000	8	8	504	504	504	504	1000	1000	8	504	504	504	1000
RH	25	62	30	95	62	30	95	62	62	62	62	30	95	62	30	62	95	62
Deg	25	50	50	50	50	72	72	72	72	72	72	72	72	95	95	95	95	95
IT																		
Fmax	Y	G	R	Y	R	R	R	R	R	R	R	R	R	R	R	R	R	R
To	Y	Y	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
T23	R	Y	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
P/F	N	N	1	N	4	1	5	5	5	5	N	5	5	2	5	5	5	5
Sum																		
Hrs	0	8	504	504	1000	8	8	504	504	504	504	1000	1000	8	504	504	504	1000
RH	25	62	30	95	62	30	95	62	62	62	62	30	95	62	30	62	95	62
Deg	25	50	50	50	50	72	72	72	72	72	72	72	72	95	95	95	95	95

Detailed Results for E.Nickel/I.Gold and Organic Solderability Preservative

NG																			
Fmax	G	G	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
To	G	Y	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
T23	Y	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
P/F	N	N	0	N	0	1	5	0	0	0	N	0	2	5	0	3	5	5	
Sum																			
Hrs	0	8	504	504	1000	8	8	504	504	504	504	1000	1000	8	504	504	504	1000	
RH	25	62	30	95	62	30	95	62	62	62	62	30	95	62	30	62	95	62	
Deg	25	50	50	50	50	72	72	72	72	72	72	72	72	95	95	95	95	95	
OSP																			
Fmax	G	G	G	G	Y	G	G	G	G	G	G	Y	R	G	R	R	R	R	R
To	G	G	G	G	G	G	G	G	Y	G	G	R	R	G	R	R	R	R	R
T23	G	G	G	G	G	G	Y	G	Y	Y	Y	R	R	G	R	R	R	R	R
P/F	N	N	0	N	0	0	0	0	0	0	N	0	3	0	5	5	5	5	
Sum																			
Hrs	0	8	504	504	1000	8	8	504	504	504	504	1000	1000	8	504	504	504	1000	
RH	25	62	30	95	62	30	95	62	62	62	62	30	95	62	30	62	95	62	
Deg	25	50	50	50	50	72	72	72	72	72	72	72	72	95	95	95	95	95	

Solderability Visual Exam - Simulates Dip and Look

OSP	N	N	0	N	0	0	0	0	0	0	N	0	3	0	5	5	5	5	
IS	N	N	3	N	0	0	3	3	0	2	N	2	5	2	0	2	5	5	
RTL	N	0	0	N	0	0	0	0	0	N	N	0	0	0	0	0	2	5	
BC	N	N	0	N	0	0	4	2	4	N	N	2	5	3	5	5	5	5	
NG	N	N	0	N	0	1	5	0	0	0	N	0	2	5	0	3	5	5	
IT	N	N	1	N	4	1	5	5	5	5	N	5	5	2	5	5	5	5	
Hours		0	8	504	504	1000	8	8	504	504	504	504	1000	1000	8	504	504	504	1000
RH		25	62	30	95	62	30	95	62	62	62	62	30	95	62	30	62	95	62
Deg. C		25			50						72							95	
Experimental Conditions																			

No failing of five inspected
N = Not examined

Sort order Deg C/Hrs/Humidity

OSP																		
IS																		
RTL																		
BC																		
NG																		
IT																		
Hours	0	8	504	504	1000	8	8	504	504	504	504	1000	1000	8	504	504	504	1000
RH	25	62	30	95	62	30	95	62	62	62	62	30	95	62	30	62	95	62
Deg C	25	50	50	50	50	72	72	72	72	72	72	72	72	95	95	95	95	95

Sort order Humidity/Deg C/Hours

OSP																		
IS																		
RTL																		
BC																		
NG																		
IT																		
Hours	0	504	8	1000	504	8	1000	504	504	504	504	8	504	1000	504	8	1000	504
RH	25	30	30	30	30	62	62	62	62	62	62	62	62	62	95	95	95	95
Deg C	25	50	72	72	95	50	50	72	72	72	72	95	95	95	50	72	72	95

Sort order Humidity/Hours/Deg C

OSP																		
IS																		
RTL																		
BC																		
NG																		
IT																		
Hours	0	8	504	504	1000	8	8	504	504	504	504	504	1000	1000	8	504	504	1000
RH	25	30	30	30	30	62	62	62	62	62	62	62	62	62	95	95	95	95
Deg C	25	72	50	95	72	50	95	72	72	72	72	72	95	50	95	72	50	95

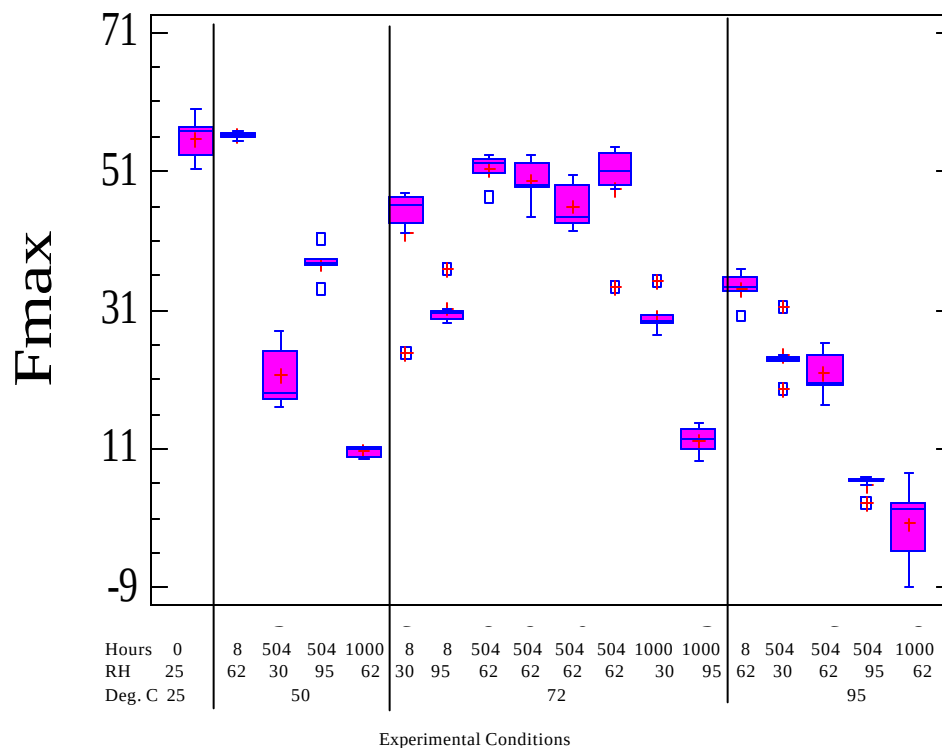
Sort order Hours/Humidity/Deg C

OSP																		
IS																		
RTL																		
BC																		
NG																		
IT																		
Hours	0	8	8	8	8	504	504	504	504	504	504	504	504	504	1000	1000	1000	1000
RH	25	30	62	62	95	30	30	62	62	62	62	62	95	95	30	62	62	95
Deg C	25	72	50	95	72	50	95	72	72	72	72	95	50	95	72	50	95	72

Sort order Hours/Deg C/Humidity

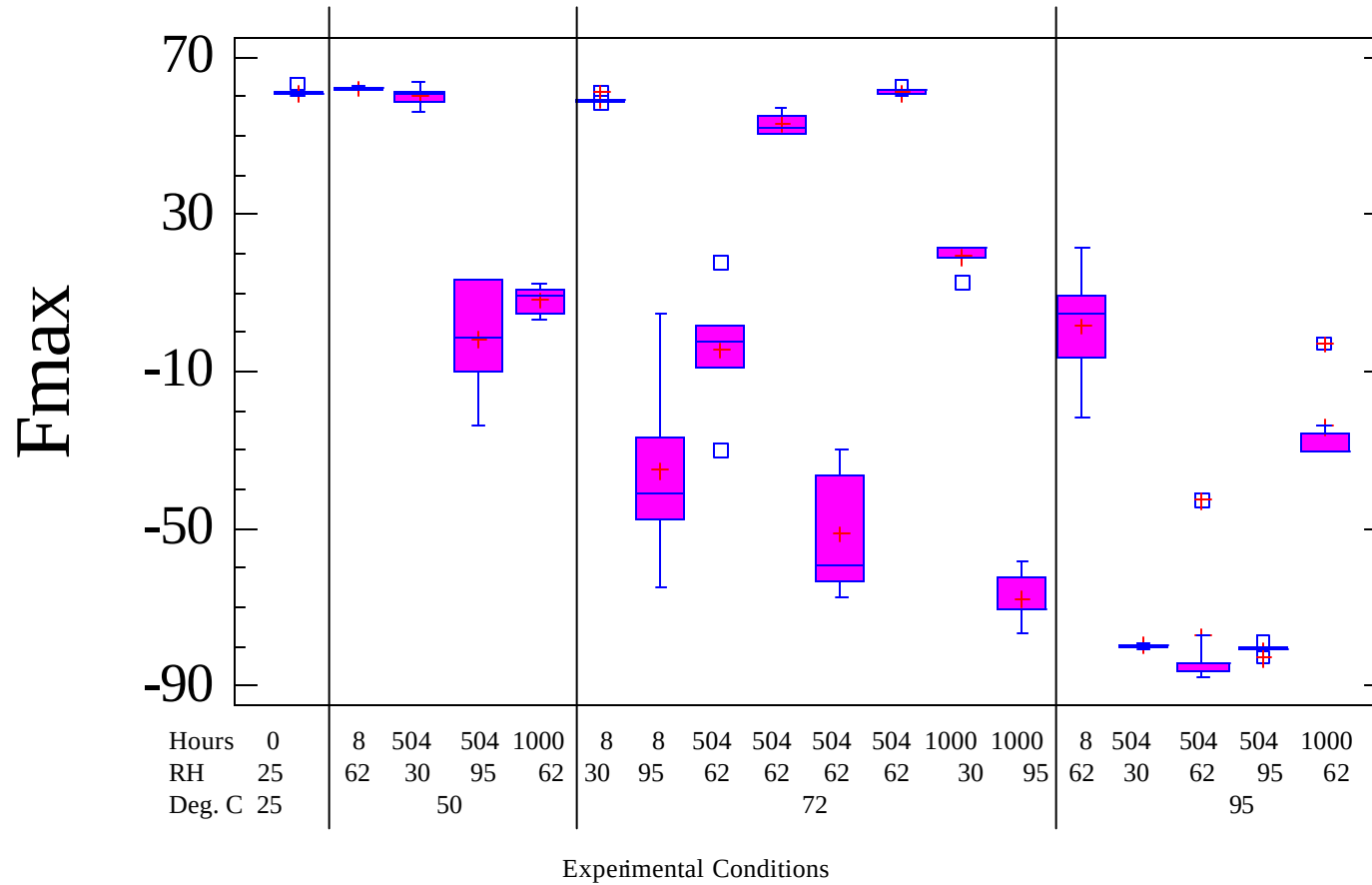
OSP																		
IS																		
RTL																		
BC																		
NG																		
IT																		
Hours	0	8	8	8	8	504	504	504	504	504	504	504	504	504	1000	1000	1000	1000
RH	25	62	30	95	62	30	95	62	62	62	62	30	62	95	62	30	95	62
Deg C	25	50	72	72	95	50	50	72	72	72	72	95	95	95	50	72	72	95

Graphical Format - Uses Reflowed Tin Lead and Fmax

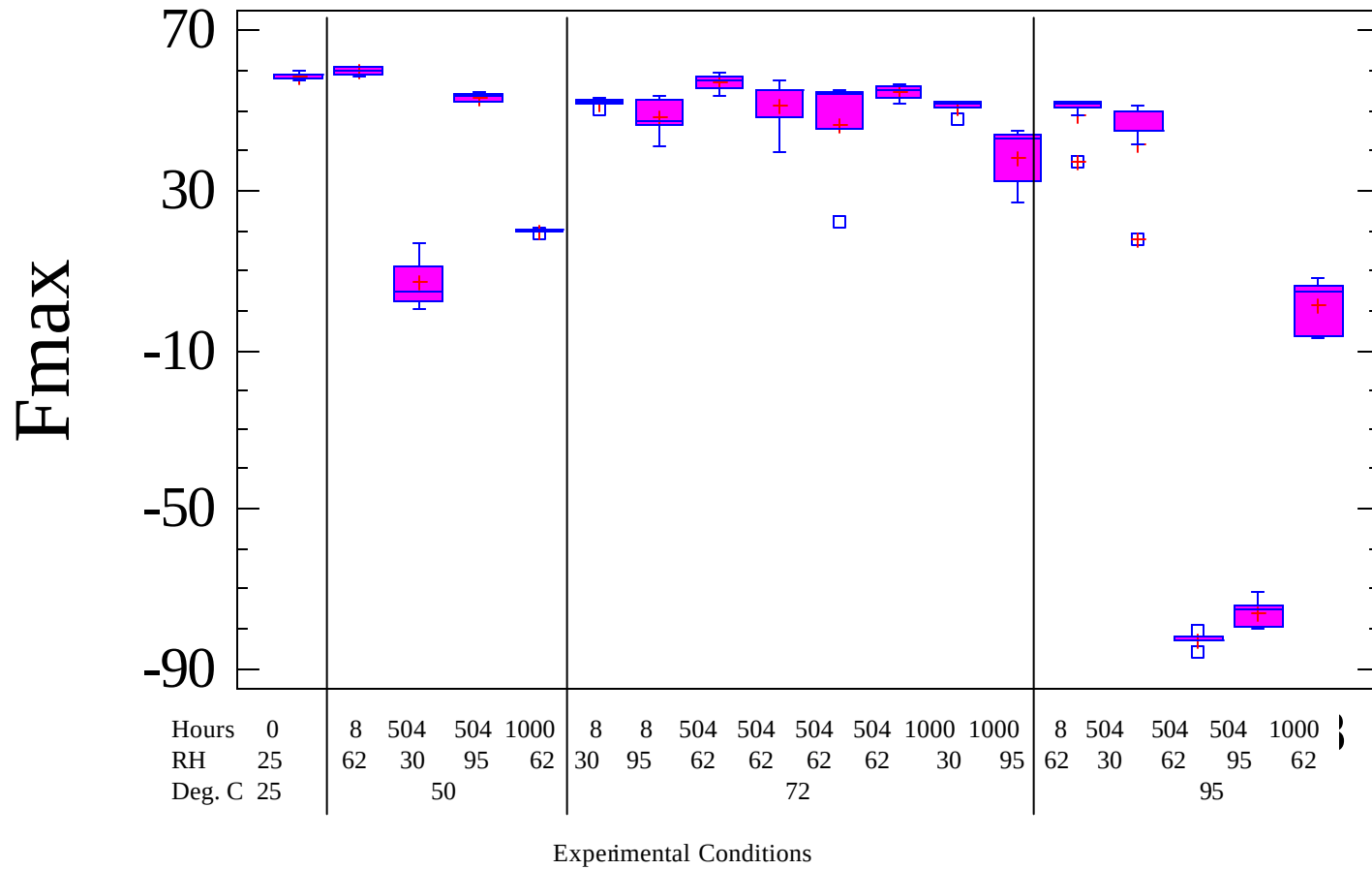


- Box and whisker plot for given parameter
- Data sorted by time
- Within given time slice, sort order is
 - temp
 - humidity
- Repeated for each surface finish

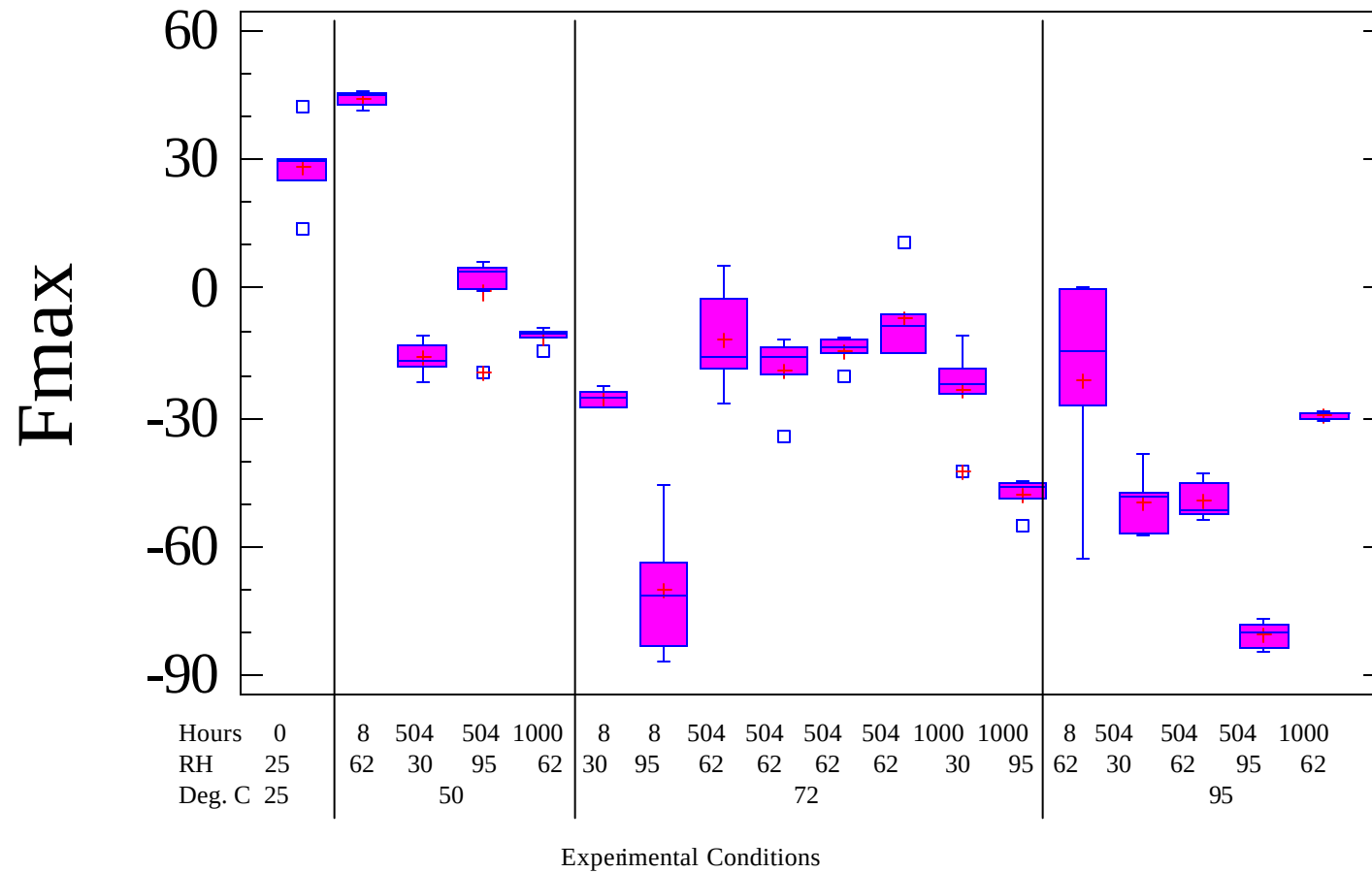
Bare Copper



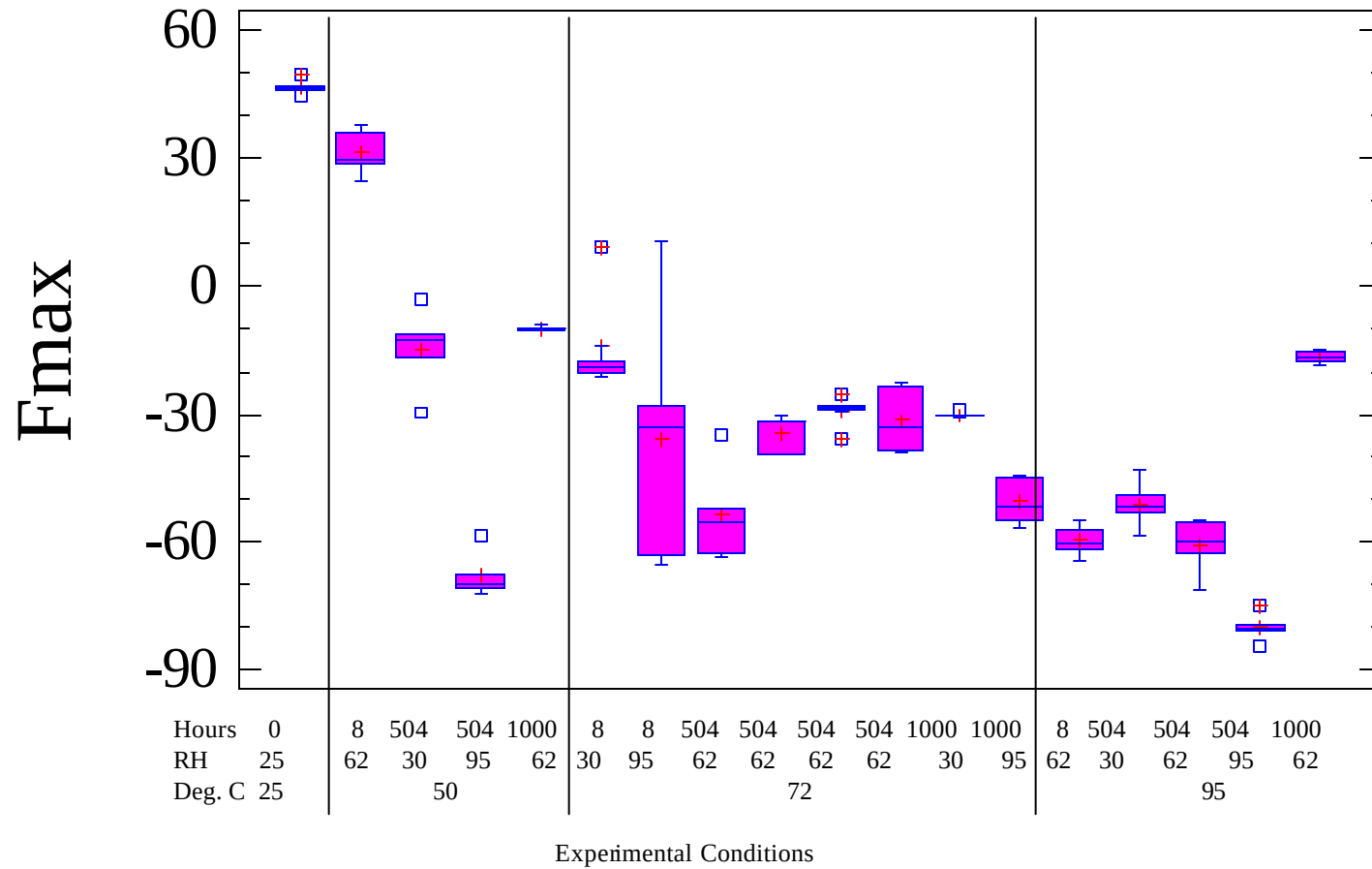
Immersion Silver



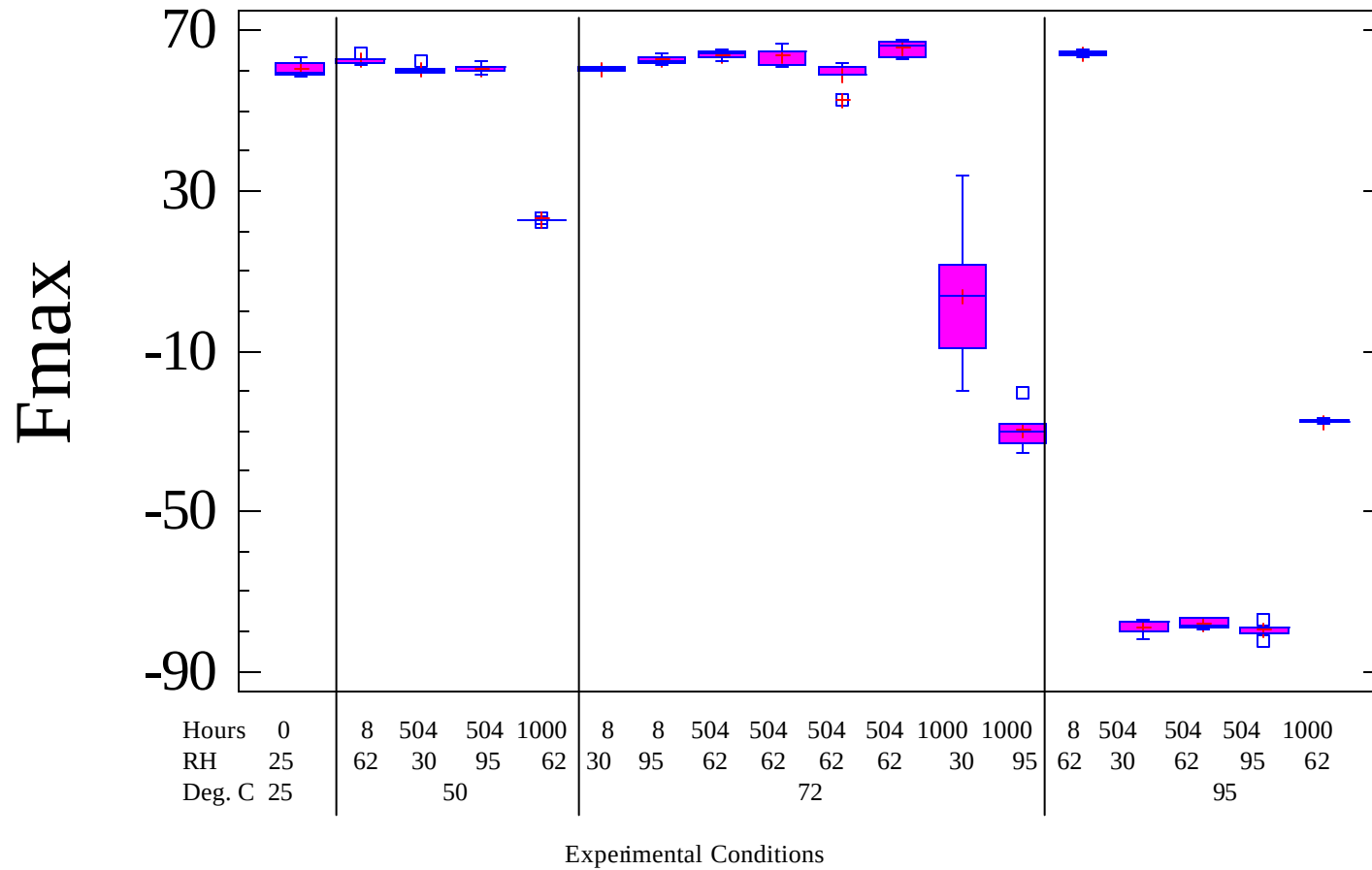
Immersion Tin



Nickel Gold



Organic Solder Protection



Results Summary

- Some clear patterns can be seen in the data
 - Some finishes are more sensitive to the conditioning (IT, NG, BC)
 - Some finishes are more robust to the conditioning (OSP, IS, RTL)
- Many outliers are present in the data
 - Some will materially influence the model
 - Others just add noise
- The data indicates that there are factors affecting solderability which were not controlled in this experiment
 - The model explains only 60-70% of the variation observed
- A conditioning test of 72C, 30-95 RH, 8 hours would differentiate between finishes