SolVantage® Vapor Solv

Solvent Testing:

Trichloroethylene

vs.

SolVantage® Vapor Solv

Data courtesy of

ELECTRO SPEC

SolVantage® Vapor Solv Testing

Purpose of Testing

- Vapor Solv is a environmentally responsible TCE replacement
- Testing effectiveness at a lower temperature (-94° F)
- Determine if it works just as well as our current vacuum degreaser system (Trichloroethylene)
  - Parts analyzed at multiple stages of process
  - Parts will be checked using Final Inspection criteria

SolVantage® Vapor Solv Testing

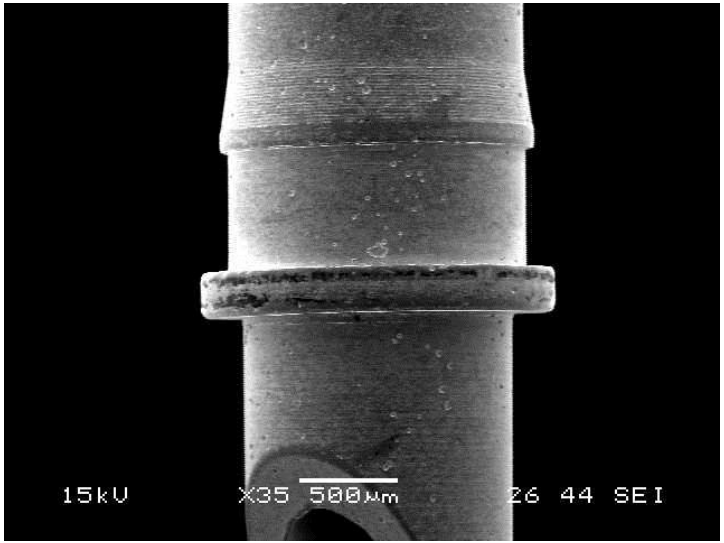
Initial Setup

- Three different substrates were chosen
  - Copper
  - Brass
  - Stainless Steel
- Scanning Electron Microscope (SEM) images of the raw parts were obtained
- Parts were soaked in cutting oil for 24 hours
- SEM images were obtained of the soiled parts
- Energy Dispersive Analysis X-Ray (EDAX) analysis of soiled and degreased parts

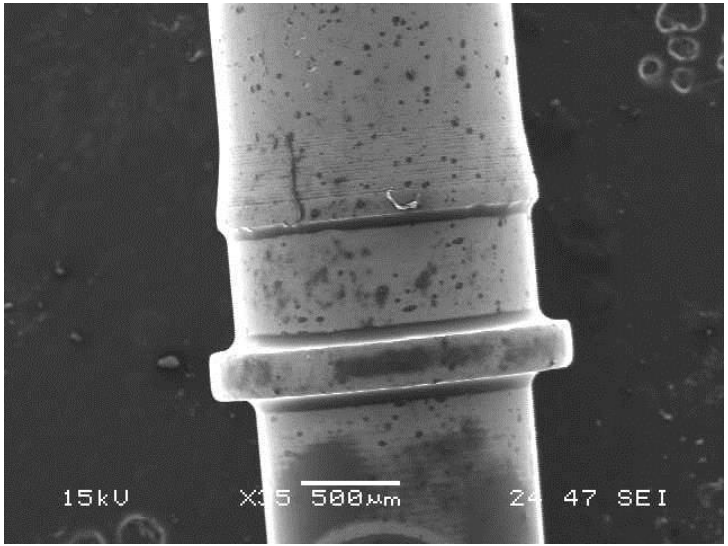
SolVantage® Vapor Solv Testing

SEM Images (Brass Parts)

Raw Brass Part



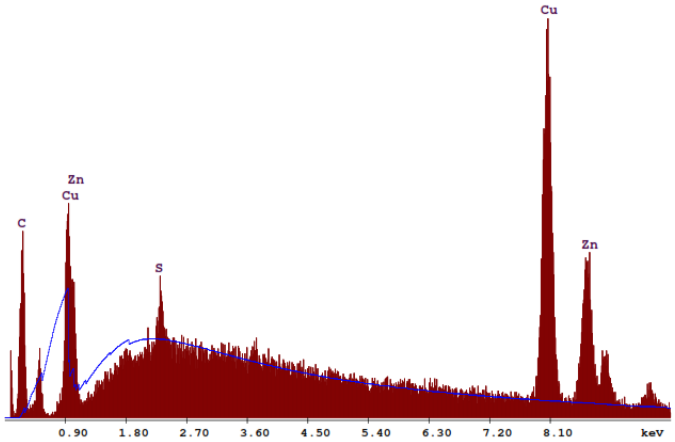
Soiled Brass Part



SolVantage® Vapor Solv Testing

- Purpose
- Setup
- Raw Parts
- Degreasing Process
- Degreased Parts
- Plating Process
- Plated Parts
- Conclusions

EDAX Analysis of Soiled Brass Part



EDAX ZAF Quantification (Standardless)
Element Normalized
SEC Table : Default

Element	Wt %	At %	K-Ratio	Z	A	F
C K	15.06	48.54	0.0273	1.1917	0.1518	1.0002
S K	0.38	0.45	0.0028	1.1083	0.6778	1.0000
CuK	54.95	33.47	0.5246	0.9531	1.0016	1.0000
ZnK	29.61	17.53	0.2828	0.9530	1.0023	1.0000
Total	100.00	100.00				

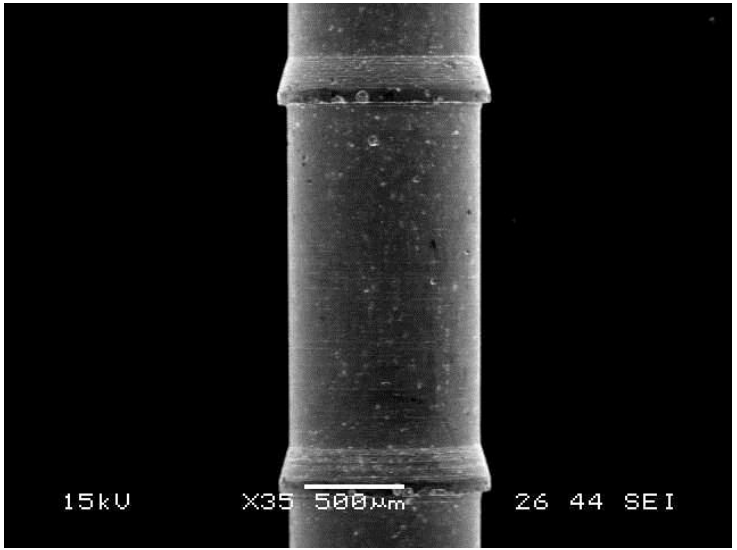
Element	Net Inte.	Bkgd Inte.	Inte. Error	P/B
C K	36.28	6.78	2.75	5.35
S K	8.16	75.92	21.92	0.11
CuK	165.90	17.38	1.21	9.55
ZnK	65.20	14.80	2.11	4.41

SolVantage® Vapor Solv Testing

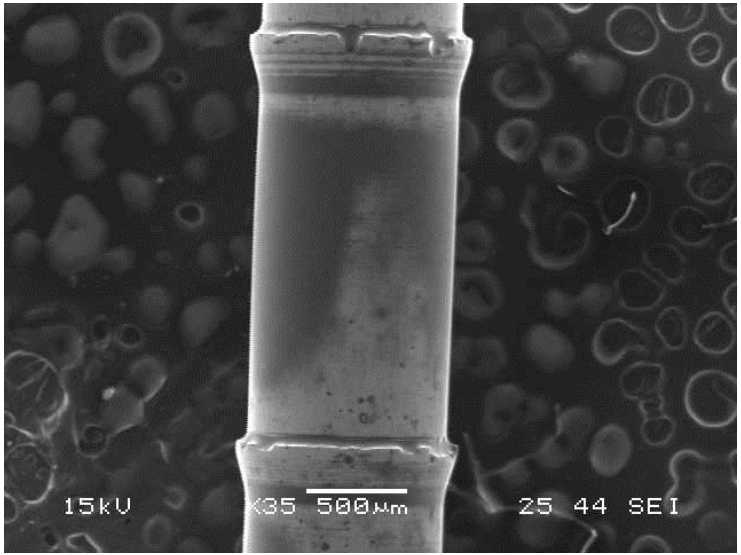
- Purpose
- Setup
- Raw Parts
- Degreasing Process
- Degreased Parts
- Plating Process
- Plated Parts
- Conclusions

SEM Images (Copper Parts)

Raw Copper Part



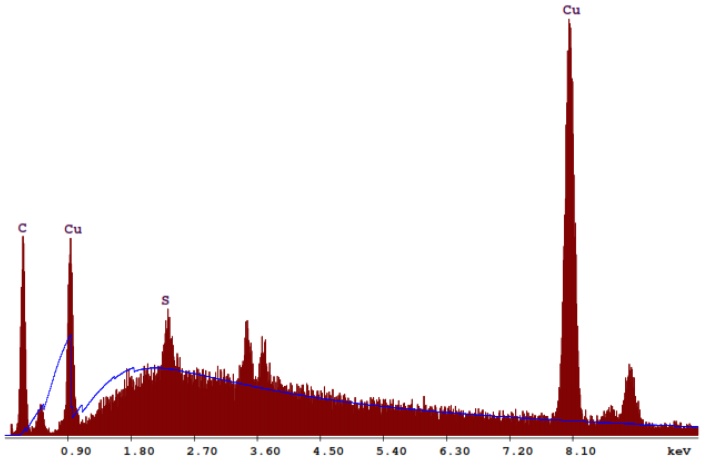
Soiled Copper Part



SolVantage® Vapor Solv Testing

- Purpose
- Setup
- Raw Parts
- Degreasing Process
- Degreased Parts
- Plating Process
- Plated Parts
- Conclusions

EDAX Analysis of Soiled Copper Part



EDAX ZAF Quantification (Standardless)
Element Normalized
SEC Table : Default

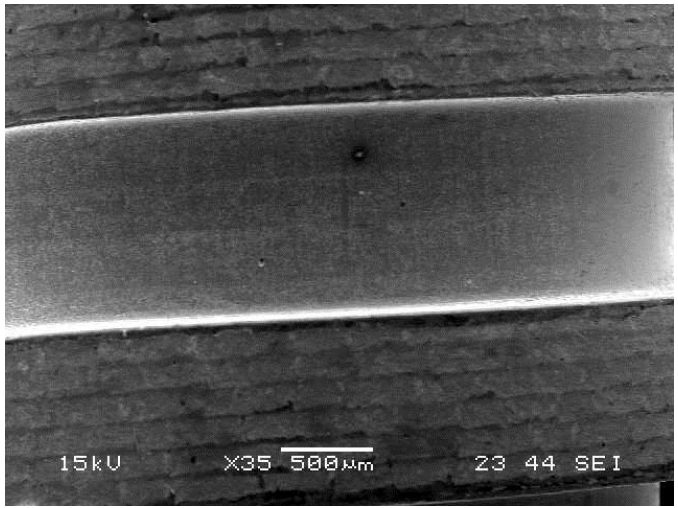
Element	Wt %	At %	K-Ratio	Z	A	F
C K	19.78	56.31	0.0382	1.1773	0.1639	1.0002
S K	0.97	1.03	0.0075	1.0939	0.7039	1.0000
CuK	79.25	42.66	0.7462	0.9392	1.0025	1.0000
Total	100.00	100.00				

Element	Net Inte.	Bkgd Inte.	Inte. Error	P/B
C K	43.14	5.12	2.40	8.43
S K	18.32	69.72	9.70	0.26
CuK	200.32	16.02	1.08	12.50

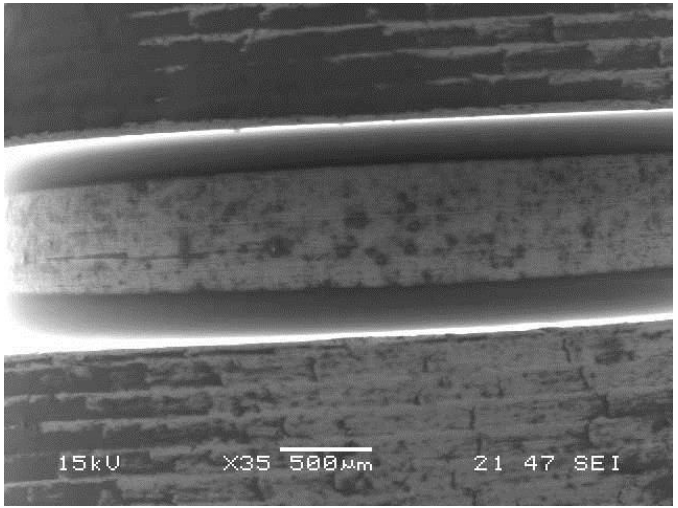
SolVantage® Vapor Solv Testing

SEM Images (Stainless Steel Parts)

Raw Stainless Steel Part

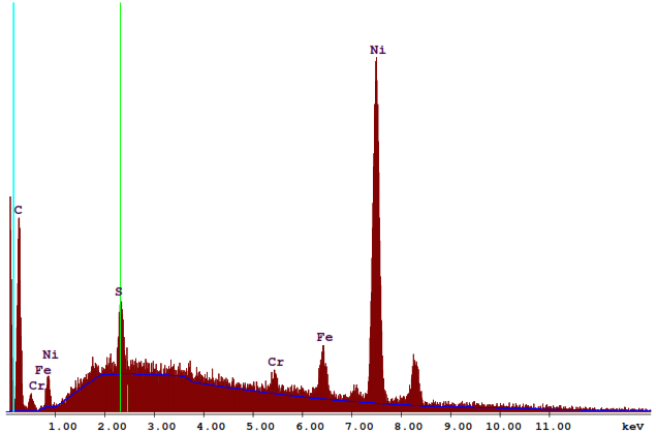


Soiled Stainless Steel Part



SolVantage® Vapor Solv Testing

EDAX Analysis of Soiled Stainless Steel Part



EDAX ZAF Quantification (Standardless)
Element Normalized
SEC Table : Default

Element	Wt %	At %	K-Ratio	Z	A	F
C K	27.68	64.53	0.0598	1.1213	0.1926	1.0002
S K	1.95	1.70	0.0153	1.0398	0.7583	1.0003
CrK	1.54	0.83	0.0155	0.9239	0.9945	1.0923
FeK	5.02	2.52	0.0555	0.9230	0.9997	1.1966
NiK	63.81	30.43	0.5961	0.9354	0.9988	1.0000
Total	100.00	100.00				

Element	Net Inte.	Bkgd Inte.	Inte. Error	P/B
C K	62.80	0.60	1.80	104.67
S K	35.00	45.24	4.53	0.77
CrK	12.28	23.02	8.79	0.53
FeK	29.50	16.18	3.77	1.82
NiK	196.52	10.72	1.06	18.33

SolVantage® Vapor Solv Testing

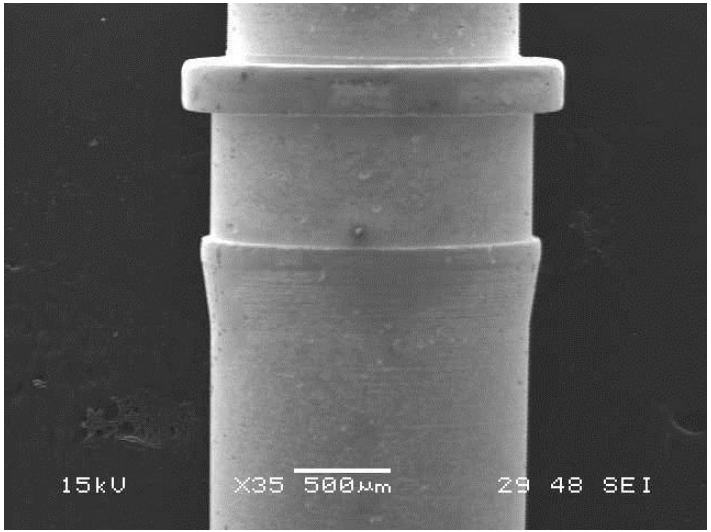
Degreasing Process

- Parts were evenly divided
- One set of brass, copper, and stainless steel parts were processed through our standard degreasing process.
  - 130°F
  - 24 Minutes
- The other set were degreased using the Vapor Solv solvent in the lab under the hood on a hot plate
  - 100°F
  - 24 Minutes
- SEM images were obtained after processing

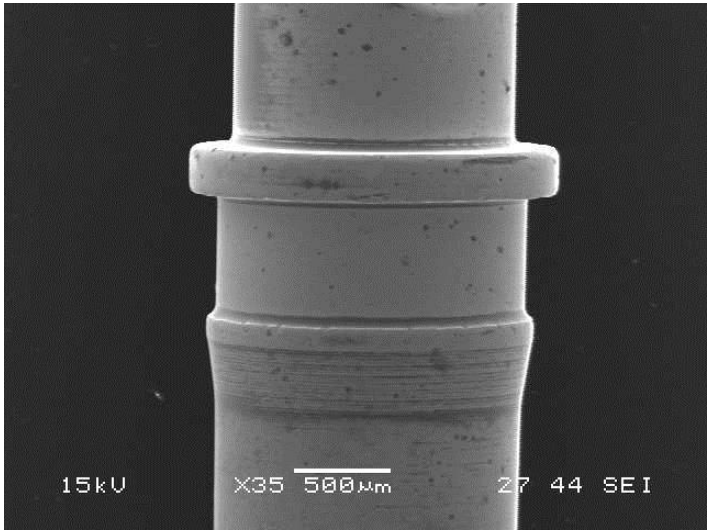
SolVantage® Vapor Solv Testing

SEM Images (Brass Parts)

Brass Part ESI Vapor



Brass Part Vapor Solv

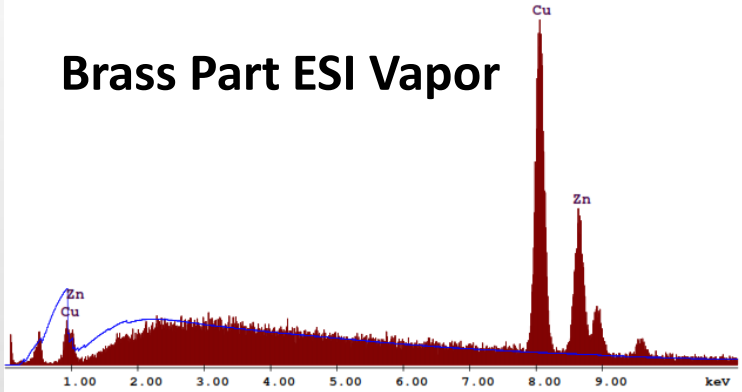


SolVantage® Vapor Solv Testing

- Purpose
- Setup
- Raw Parts
- Degreasing Process
- Degreased Parts
- Plating Process
- Plated Parts
- Conclusions

EDAX Analysis of Degreased Brass Parts

Brass Part ESI Vapor

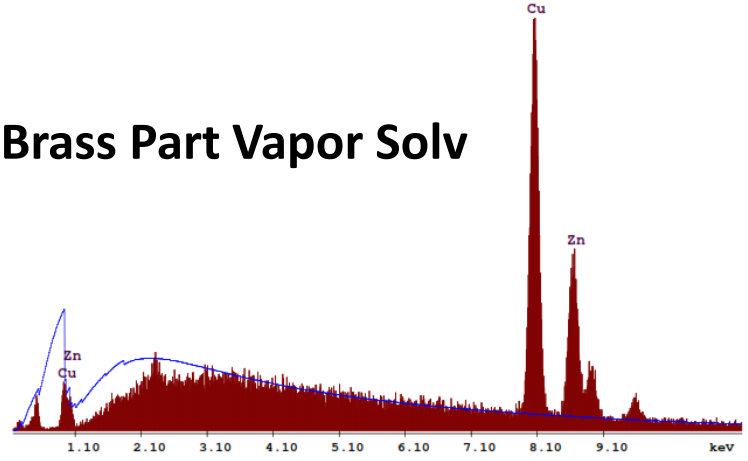


EDAX ZAF Quantification (Standardless)
Element Normalized
SEC Table : Default

Element	Wt %	At %	K-Ratio	Z	A	F
CuK	64.71	65.36	0.6466	0.9997	0.9995	1.0000
ZnK	35.29	34.64	0.3533	1.0005	1.0007	1.0000
Total	100.00	100.00				

Element	Net Inte.	Bkgd Inte.	Inte. Error	P/B
CuK	237.48	19.86	0.99	11.96
ZnK	94.58	16.98	1.70	5.57

Brass Part Vapor Solv



EDAX ZAF Quantification (Standardless)
Element Normalized
SEC Table : Default

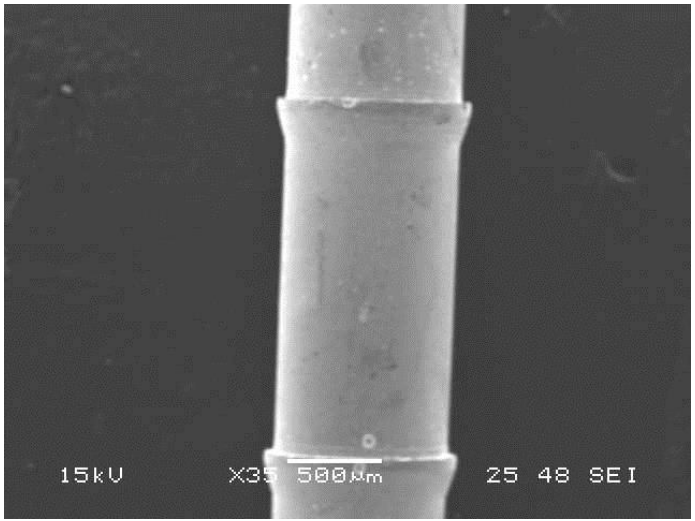
Element	Wt %	At %	K-Ratio	Z	A	F
CuK	64.31	64.95	0.6425	0.9997	0.9995	1.0000
ZnK	35.69	35.05	0.3574	1.0005	1.0007	1.0000
Total	100.00	100.00				

Element	Net Inte.	Bkgd Inte.	Inte. Error	P/B
CuK	227.13	21.64	1.02	10.50
ZnK	92.08	18.46	1.74	4.99

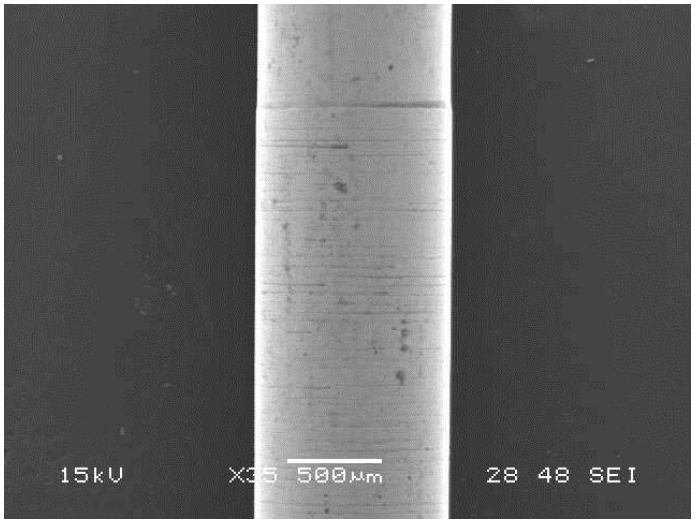
SolVantage® Vapor Solv Testing

SEM Images (Copper Parts)

Copper Part ESI Vapor



Copper Part Vapor Solv

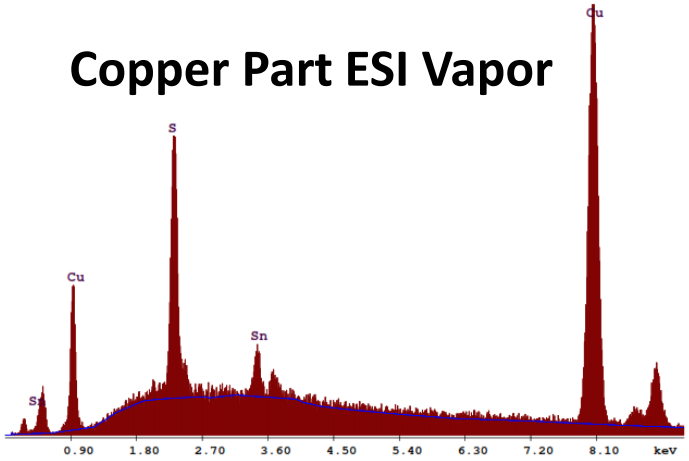


SolVantage® Vapor Solv Testing

- Purpose
- Setup
- Raw Parts
- Degreasing Process
- Degreased Parts
- Plating Process
- Plated Parts
- Conclusions

EDAX Analysis of Degreased Copper Parts

Copper Part ESI Vapor

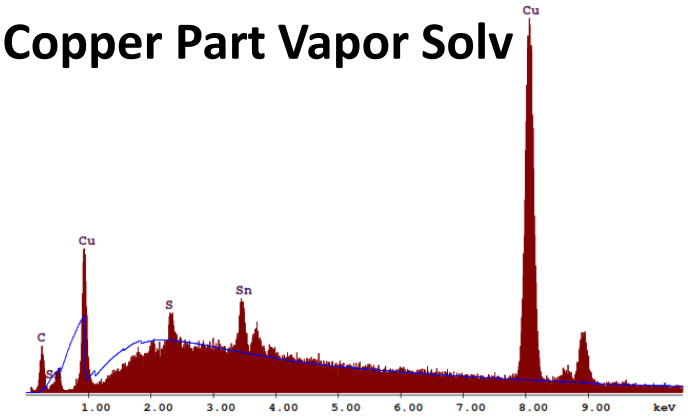


EDAX ZAF Quantification (Standardless)
Element Normalized
SEC Table : Default

Element	Wt %	At %	K-Ratio	Z	A	F
S K	6.06	11.51	0.0461	1.1516	0.6603	1.0006
SnL	3.47	1.78	0.0292	0.8783	0.9579	1.0000
CuK	90.47	86.71	0.8967	0.9934	0.9977	1.0000
Total	100.00	100.00				

Element	Net Inte.	Bkgd Inte.	Inte. Error	P/B
S K	189.16	72.40	1.37	2.61
SnL	34.86	80.64	5.68	0.43
CuK	402.34	22.72	0.74	17.71

Copper Part Vapor Solv



EDAX ZAF Quantification (Standardless)
Element Normalized
SEC Table : Default

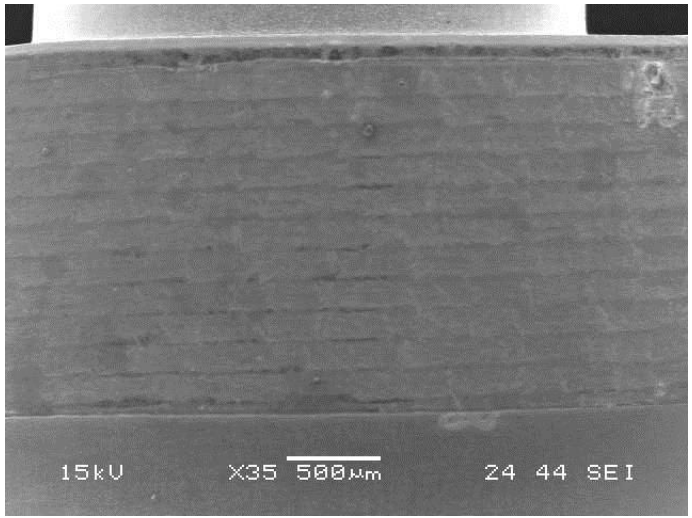
Element	Wt %	At %	K-Ratio	Z	A	F
C K	8.71	33.95	0.0162	1.2178	0.1528	1.0002
S K	0.31	0.45	0.0023	1.1340	0.6714	1.0007
SnL	4.14	1.63	0.0351	0.8652	0.9803	1.0000
CuK	86.84	63.97	0.8481	0.9774	0.9991	1.0000
Total	100.00	100.00				

Element	Net Inte.	Bkgd Inte.	Inte. Error	P/B
C K	28.93	8.36	3.30	3.46
S K	9.06	106.18	23.23	0.09
SnL	39.60	87.00	5.22	0.46
CuK	359.42	26.64	0.80	13.49

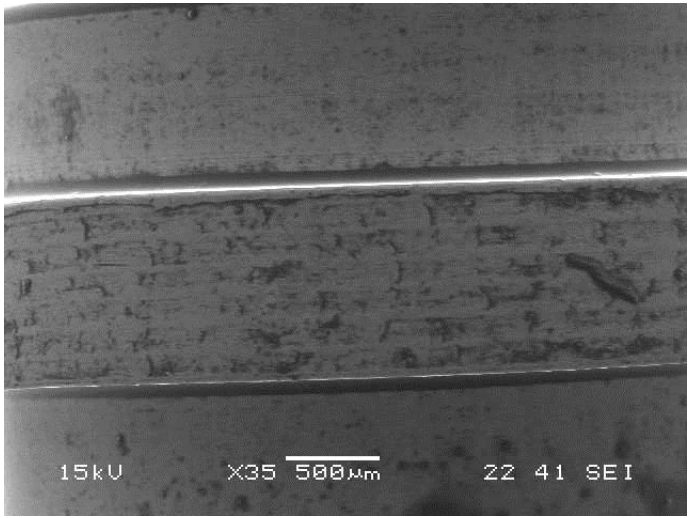
SolVantage® Vapor Solv Testing

SEM Images (Stainless Steel Parts)

Stainless Steel Part ESI Vapor



Stainless Steel Part Vapor Solv

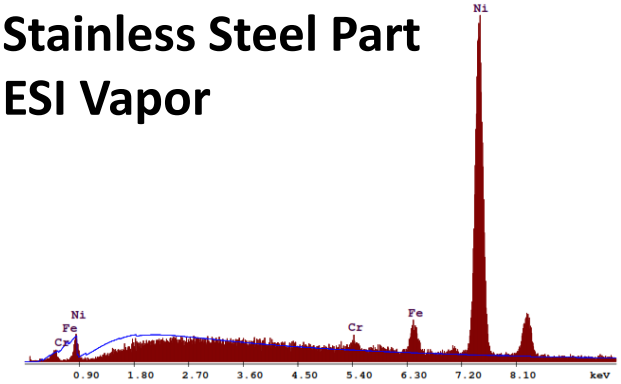


SolVantage® Vapor Solv Testing

- Purpose
- Setup
- Raw Parts
- Degreasing Process
- Degreased Parts
- Plating Process
- Plated Parts
- Conclusions

EDAX Analysis of Degreased Stainless Steel Parts

Stainless Steel Part ESI Vapor

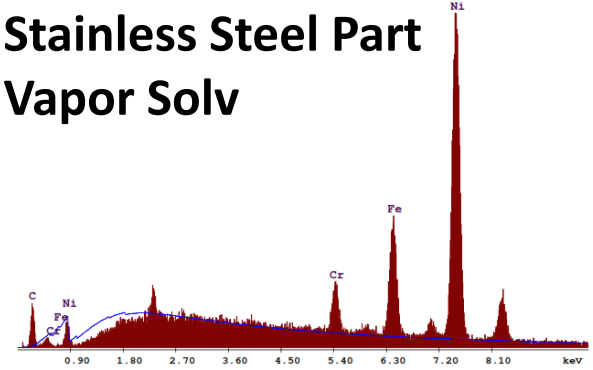


EDAX ZAF Quantification (Standardless)
Element Normalized
SEC Table : Default

Element	Wt %	At %	K-Ratio	Z	A	F
CrK	1.08	1.22	0.0116	0.9847	0.9840	1.1066
FeK	3.99	4.18	0.0488	0.9853	0.9938	1.2481
NiK	94.92	94.60	0.9462	1.0007	0.9961	1.0000
Total	100.00	100.00				

Element	Net Inte.	Bkgd Inte.	Inte. Error	P/B
CrK	10.68	28.54	10.90	0.37
FeK	30.06	21.78	4.04	1.38
NiK	361.26	16.30	0.78	22.16

Stainless Steel Part Vapor Solv



EDAX ZAF Quantification (Standardless)
Element Normalized
SEC Table : Default

Element	Wt %	At %	K-Ratio	Z	A	F
C K	7.71	28.72	0.0152	1.1713	0.1687	1.0003
CrK	3.86	3.32	0.0406	0.9690	0.9884	1.0969
FeK	13.57	10.88	0.1515	0.9691	0.9934	1.1601
NiK	74.86	57.08	0.7274	0.9836	0.9879	1.0000
Total	100.00	100.00				

Element	Net Inte.	Bkgd Inte.	Inte. Error	P/B
C K	17.64	3.78	4.02	4.67
CrK	35.46	27.08	3.78	1.31
FeK	88.86	20.40	1.81	4.36
NiK	264.34	15.42	0.92	17.14

SolVantage® Vapor Solv Testing

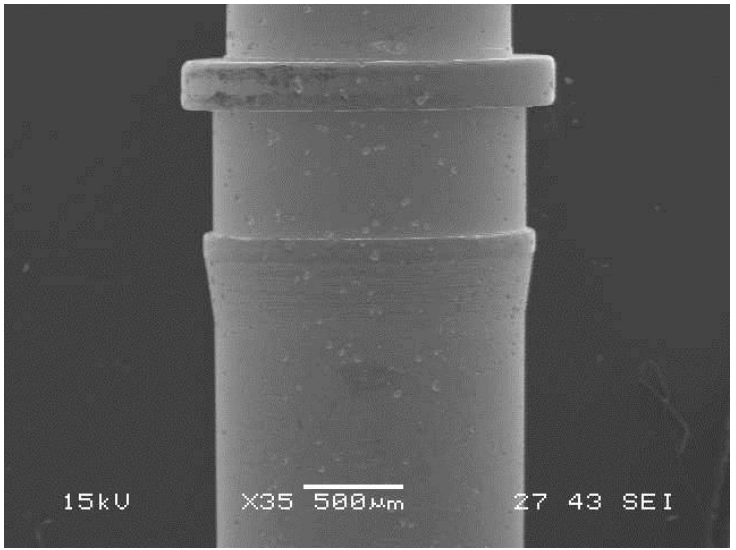
Plating Process

- Separated lots of parts were plated on the Small Manual Line
  - Brass Parts were plated with Nickel
  - Copper Parts were plated with Nickel
  - Stainless Steel Parts were plated with a Woods Strike and then Nickel
- SEM images were obtained after plating

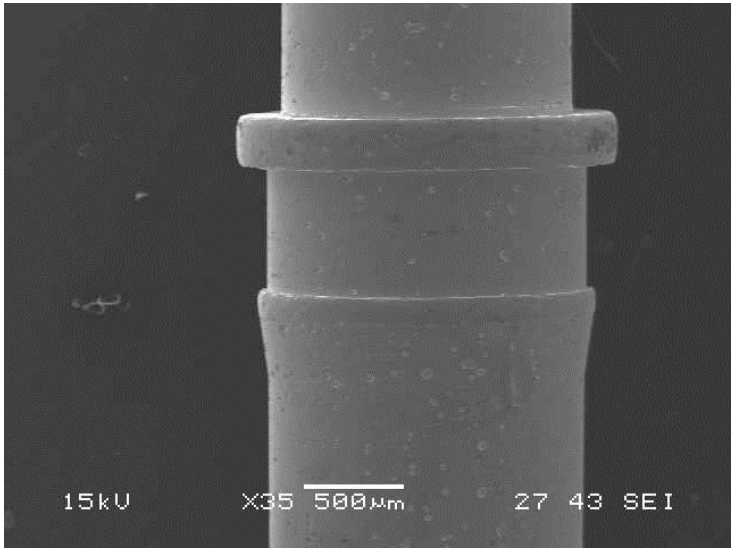
SolVantage® Vapor Solv Testing

SEM Images (Brass Parts)

Plated Lot A



Plated Lot B

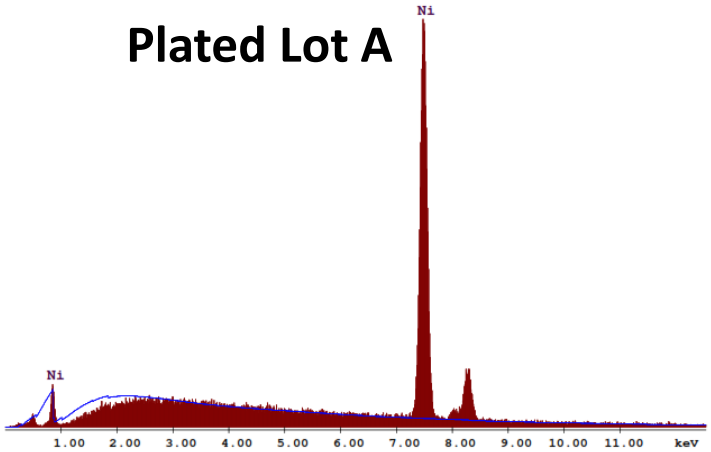


SolVantage® Vapor Solv Testing

- Purpose
- Setup
- Raw Parts
- Degreasing Process
- Degreased Parts
- Plating Process
- Plated Parts
- Conclusions

EDAX Analysis of Plated Brass Parts

Plated Lot A

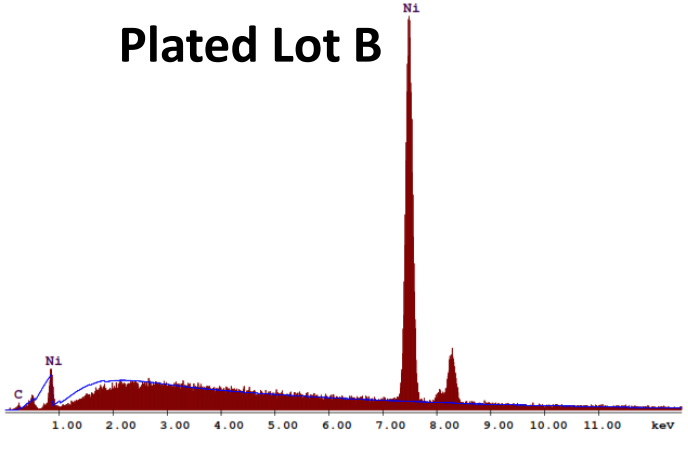


EDAX ZAF Quantification (Standardless)
Element Normalized
SEC Table : Default

Element	Wt %	At %	K-Ratio	Z	A	F
NiK	100.00	100.00	1.0000	1.0000	1.0000	1.0000
Total	100.00	100.00				

Element	Net Inte.	Bkgd Inte.	Inte. Error	P/B
NiK	508.26	24.82	0.66	20.48

Plated Lot B



EDAX ZAF Quantification (Standardless)
Element Normalized
SEC Table : Default

Element	Wt %	At %	K-Ratio	Z	A	F
C K	0.23	1.12	0.0004	1.1864	0.1515	1.0004
NiK	99.77	98.88	0.9971	0.9994	1.0000	1.0000
Total	100.00	100.00				

Element	Net Inte.	Bkgd Inte.	Inte. Error	P/B
C K	0.59	4.60	74.44	0.13
NiK	448.06	22.54	0.70	19.88

SolVantage® Vapor Solv Testing

Final Inspection Brass Parts

Plated Lot A

- Average Nickel Thickness: 59.64 microinches
- Tape Test: Pass
- Crush Test: Pass
- Bake Test (350°F 1 hour): Pass
- Visual @ 10X: Frosty Finish & Dull
- Inspected by Tina Gardener

Plated Lot B

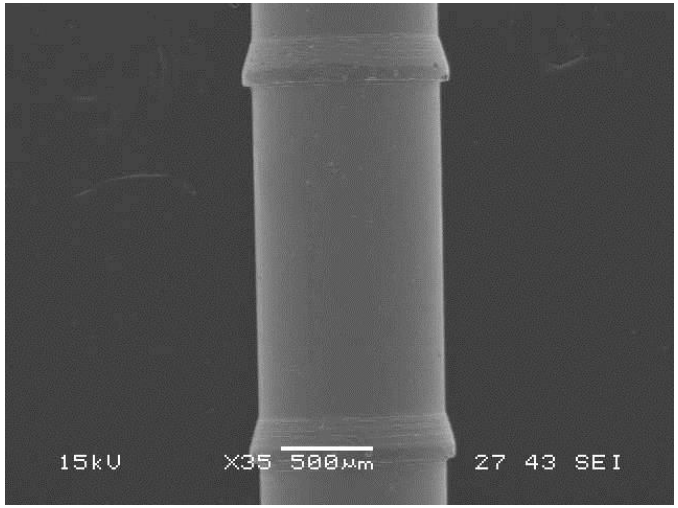
- Average Nickel Thickness: 86.58 microinches
- Tape Test: Pass
- Crush Test: Pass
- Bake Test (350°F 1 hour): Pass
- Visual @ 10X: Voids ID & OD, Nice & Shiny
- Inspected by Tina Gardener

SolVantage® Vapor Solv Testing

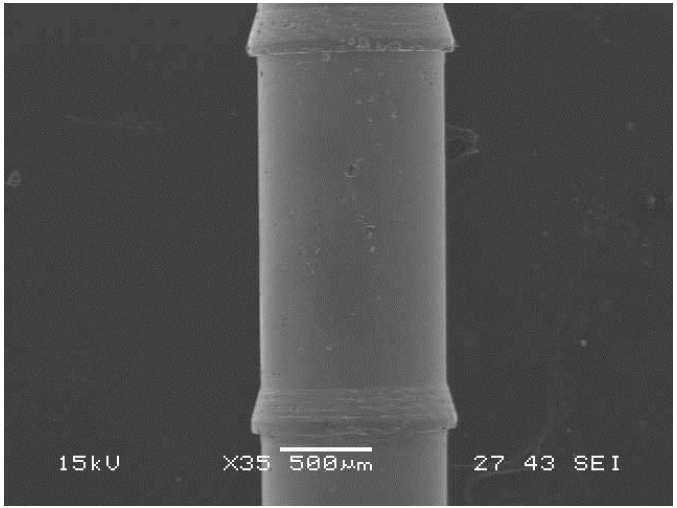
- Purpose
- Setup
- Raw Parts
- Degreasing Process
- Degreased Parts
- Plating Process
- Plated Parts
- Conclusions

SEM Images (Copper Parts)

Plated Lot A



Plated Lot B

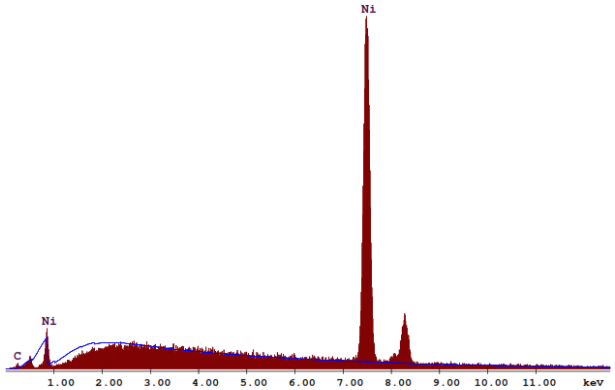


SolVantage® Vapor Solv Testing

- Purpose
- Setup
- Raw Parts
- Degreasing Process
- Degreased Parts
- Plating Process
- Plated Parts
- Conclusions

EDAX Analysis of Copper Parts

Plated Lot A

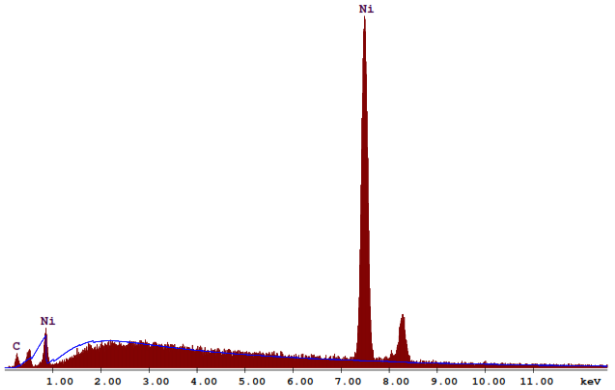


EDAX ZAF Quantification (Standardless)
Element Normalized
SEC Table : Default

Element	Wt %	At %	K-Ratio	Z	A	F
C K	0.29	1.42	0.0005	1.1863	0.1515	1.0004
NiK	99.71	98.58	0.9964	0.9993	1.0000	1.0000
Total	100.00	100.00				

Element	Net Inte.	Bkgd Inte.	Inte. Error	P/B
C K	0.71	4.10	59.20	0.17
NiK	421.96	18.88	0.72	22.35

Plated Lot B



EDAX ZAF Quantification (Standardless)
Element Normalized
SEC Table : Default

Element	Wt %	At %	K-Ratio	Z	A	F
C K	2.31	10.37	0.0042	1.1811	0.1542	1.0004
NiK	97.69	89.63	0.9716	0.9942	1.0003	1.0000
Total	100.00	100.00				

Element	Net Inte.	Bkgd Inte.	Inte. Error	P/B
C K	6.01	4.36	9.03	1.38
NiK	435.06	19.46	0.71	22.36

SolVantage® Vapor Solv Testing

Final Inspection Copper Parts

Plated Lot A

- Average Nickel Thickness: 197.52 microinches
- Tape Test: Pass
- Crush Test: Pass
- Bake Test (350°F 1 hour): Pass
- Visual @ 10X: Nice & Shiny, Voids in ID of Tines
- Inspected by Tina Gardener

Plated Lot B

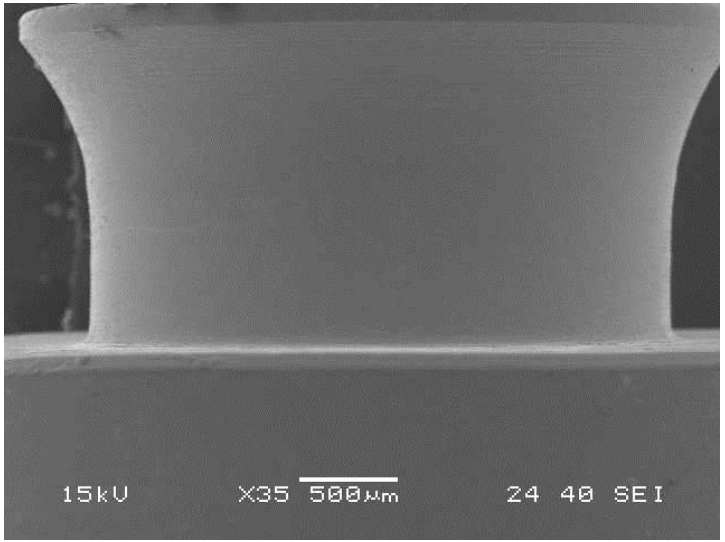
- Average Nickel Thickness: 189.32 microinches
- Tape Test: Pass
- Crush Test: Pass
- Bake Test (350°F 1 hour): Pass
- Visual @ 10X: Nice & Shiny, No Voids, Little dull on ends
- Inspected by Tina Gardener

SolVantage® Vapor Solv Testing

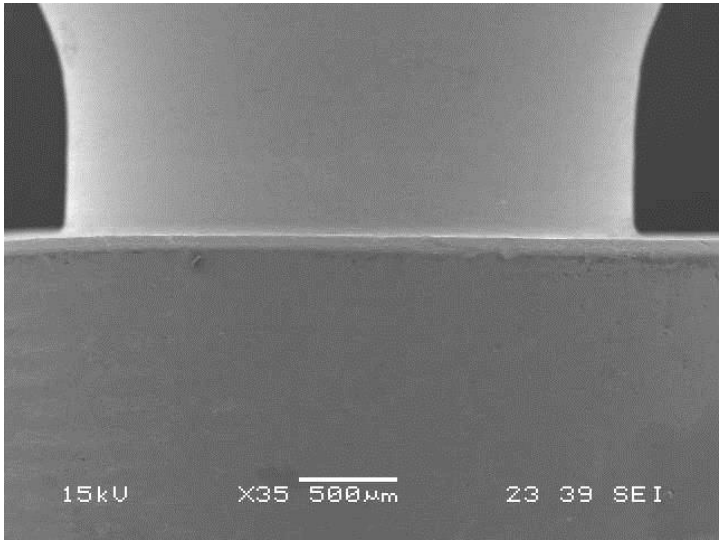
- Purpose
- Setup
- Raw Parts
- Degreasing Process
- Degreased Parts
- Plating Process
- Plated Parts
- Conclusions

SEM Images (Stainless Steel Parts)

Plated Lot A



Plated Lot B

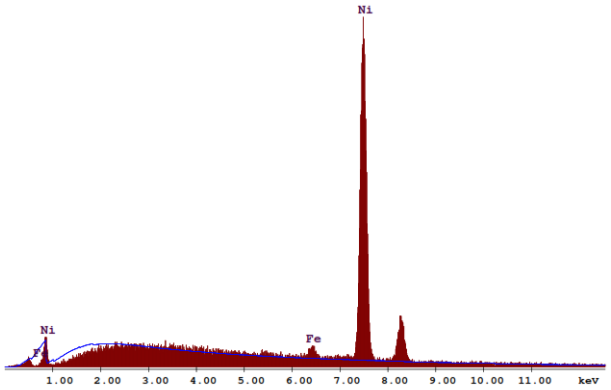


SolVantage® Vapor Solv Testing

- Purpose
- Setup
- Raw Parts
- Degreasing Process
- Degreased Parts
- Plating Process
- Plated Parts
- Conclusions

EDAX Analysis of Stainless Steel Parts

Plated Lot A

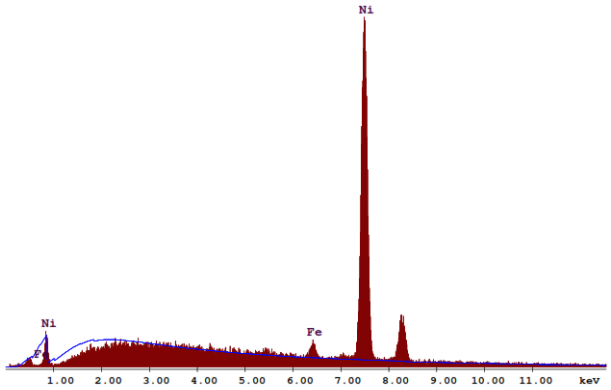


EDAX ZAF Quantification (Standardless)
Element Normalized
SEC Table : Default

Element	Wt %	At %	K-Ratio	Z	A	F
FeK	1.88	1.97	0.0235	0.9848	0.9949	1.2784
NiK	98.12	98.03	0.9800	1.0003	0.9985	1.0000
Total	100.00	100.00				

Element	Net Inte.	Bkgd Inte.	Inte. Error	P/B
FeK	14.58	21.60	7.37	0.67
NiK	376.46	16.70	0.76	22.54

Plated Lot B



EDAX ZAF Quantification (Standardless)
Element Normalized
SEC Table : Default

Element	Wt %	At %	K-Ratio	Z	A	F
FeK	1.95	2.05	0.0245	0.9848	0.9949	1.2777
NiK	98.05	97.95	0.9792	1.0003	0.9984	1.0000
Total	100.00	100.00				

Element	Net Inte.	Bkgd Inte.	Inte. Error	P/B
FeK	17.50	26.10	6.75	0.67
NiK	433.98	19.64	0.71	22.10

SolVantage® Vapor Solv Testing

Final Inspection Stainless Steel Parts

Plated Lot A

- Average Nickel Thickness: 139.66 microinches
- Tape Test: Pass
- Crush Test: Failed, Peeling
- Bake Test (350°F 1 hour): Pass
- Visual @ 10X: Blisters, Peeling, Frosty, Scaley ID
- Inspected by Tina Gardener

Plated Lot B

- Average Nickel Thickness: 137.76 microinches
- Tape Test: Pass
- Crush Test: Failed, Peeling
- Bake Test (350°F 1 hour): Pass
- Visual @ 10X: Peeling OD & ID, Frosty
- Inspected by Tina Gardener

SolVantage® Vapor Solv Testing

Conclusions

- Some soils left on part visually after Vapor Solv treatment, but EDAX showed very similar analyses
- No large difference in plated parts from an EDAX of Final Inspection stand point
- Due to these successes we should scale up our experiment to our small degreasing unit and do more loads

SolVantage® Vapor Solv Testing

Scaled Up Experimentation

- BHC provided ESI with 20 gallons of Vapor Solv.
- Solvent was placed in a Baron-Blakeslee manual degreasing unit that had been wired up by ESI's maintenance.
- Production parts were used and plated as normal.
- These parts were followed to see what issues might have arisen.

SolVantage® Vapor Solv Testing

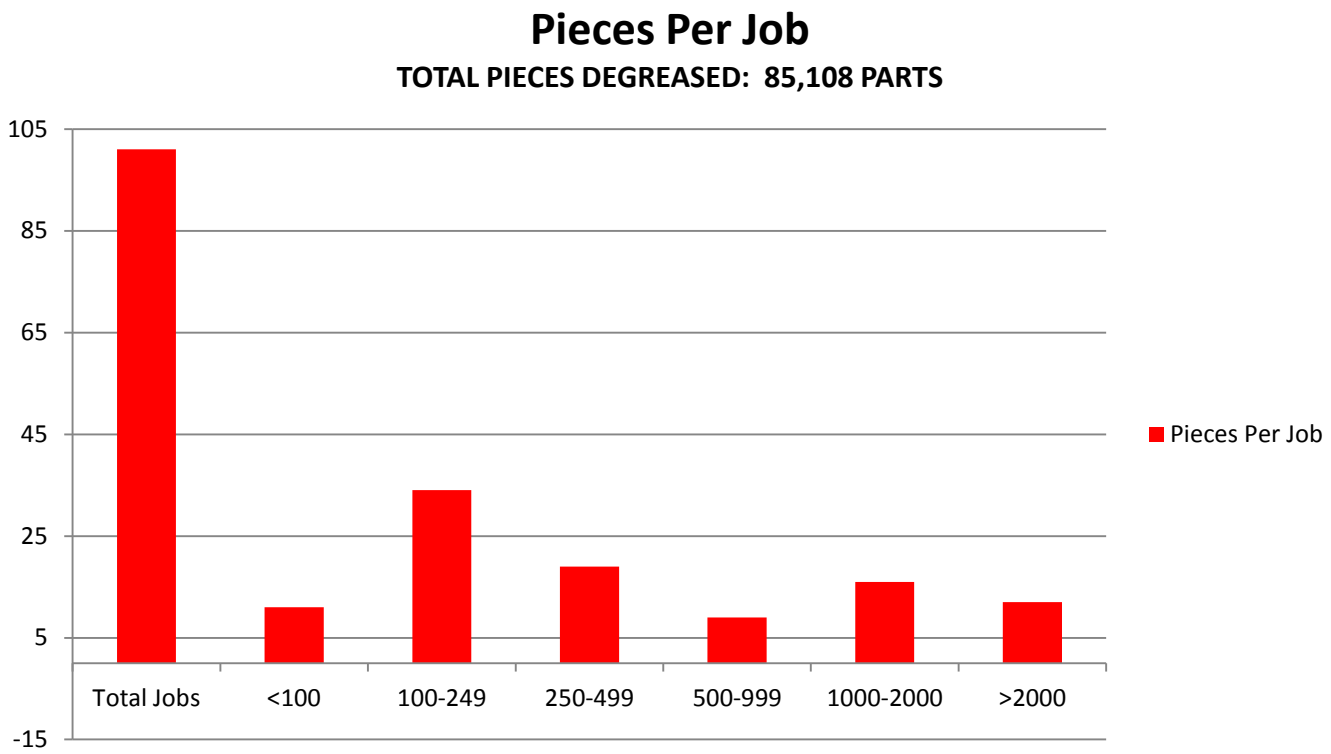
Information Collected

- Customer Name
- Part Number
- Quantity
- Date
- Material
- Plating required
- Number of reworks & the reason
- Any RMA's associated

SolVantage® Vapor Solv Testing

- Purpose
- Setup
- Raw Parts
- Degreasing Process
- Degreased Parts
- Plating Process
- Plated Parts
- Conclusions

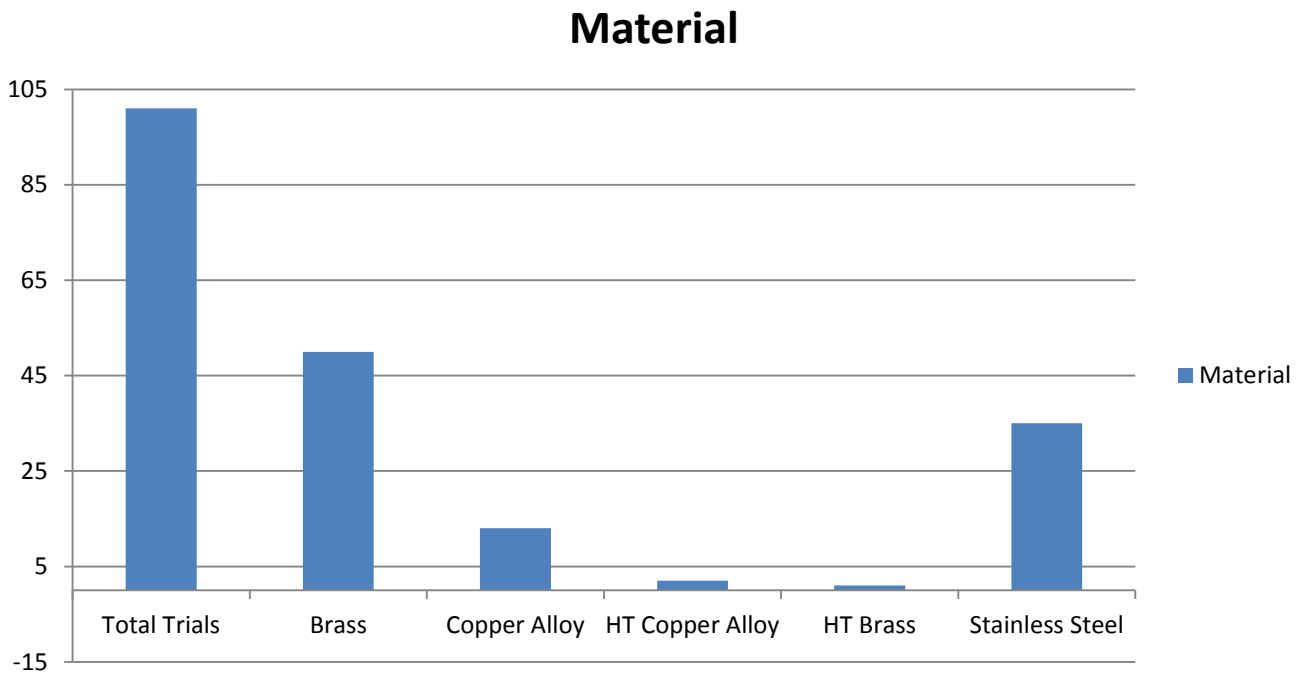
Number of Pieces per Load



SolVantage® Vapor Solv Testing

- Purpose
- Setup
- Raw Parts
- Degreasing Process
- Degreased Parts
- Plating Process
- Plated Parts
- Conclusions

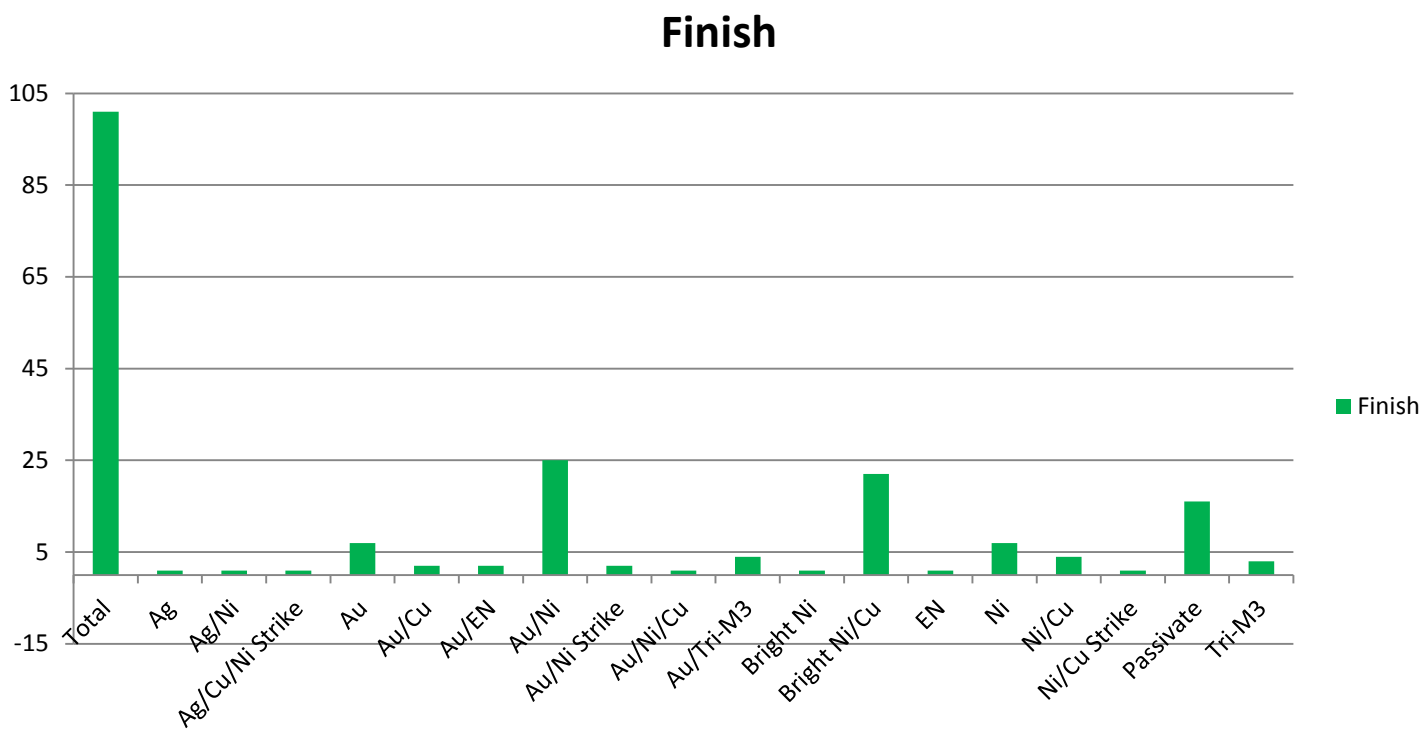
Types of Material Processed



SolVantage® Vapor Solv Testing

- Purpose
- Setup
- Raw Parts
- Degreasing Process
- Degreased Parts
- Plating Process
- Plated Parts
- Conclusions

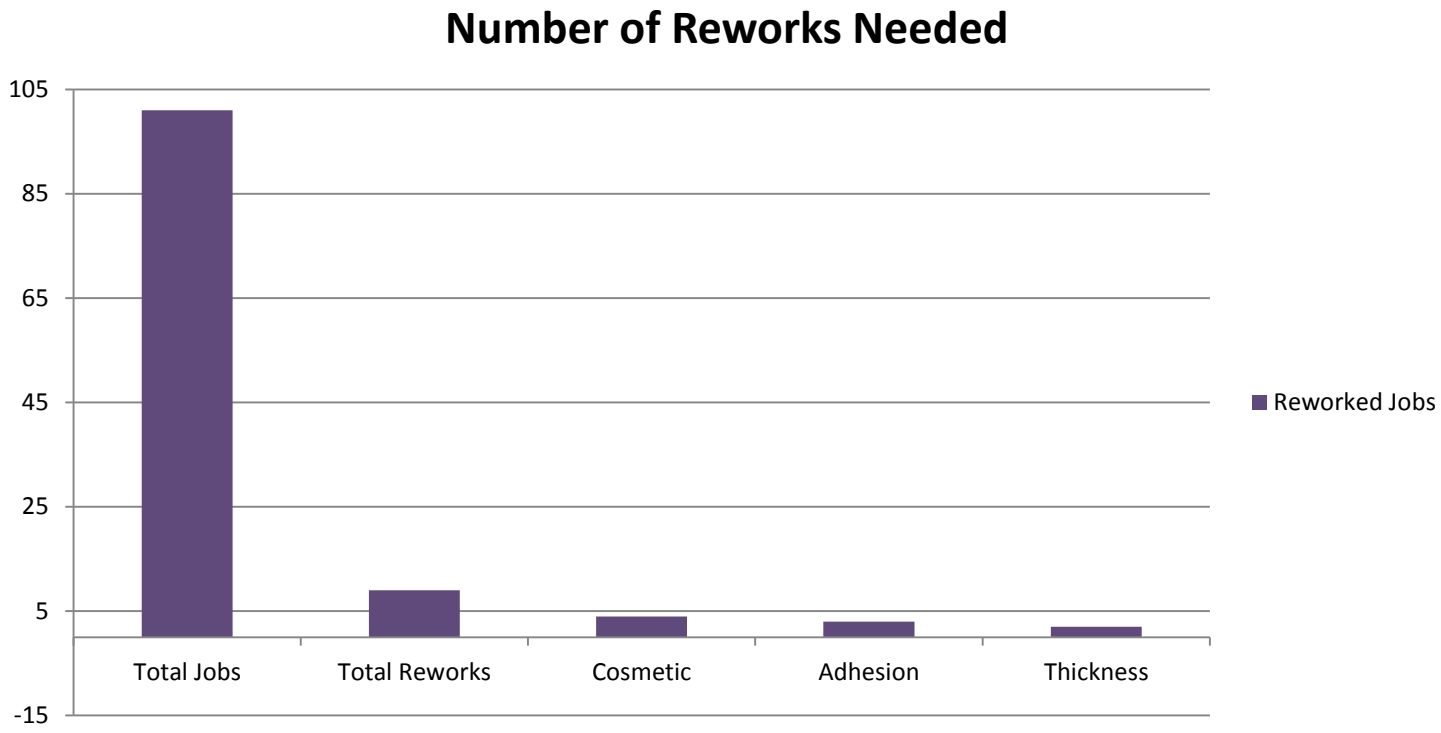
The Plated Finishes of Parts Tested



SolVantage® Vapor Solv Testing

- Purpose
- Setup
- Raw Parts
- Degreasing Process
- Degreased Parts
- Plating Process
- Plated Parts
- Conclusions

Tracking of Reworked Product



SolVantage® Vapor Solv Testing

Conclusions

- Based upon the data collected and the plating results of the wide variety of customer parts processed through the specific ESI plating processes, ESI is converting the Tiyoda Vacuum Degreaser from TCE to Vapor Solv.
- Conversion of the degreaser will require gasketing replacement at a cost of @$5000.