Bench Myths 2

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Introduction

The first Bench Myths paper in 2014[1] asked some basic questions and started to explore some answers. Instead of asking more questions, this paper will expand on one topic explored in that research: annealing. It will continue the research by digging a little deeper into the variables of work surface, fluxes, the addition of soldering, and examining whether or not the choice of work surface and flux has a demonstrable effect on the workpiece.

Experiment

The number of soldering surfaces and fluxes available these days is impressive. If you take a look at a tool and supply website or catalog, you will find many options. A quick search for "soldering block" on the Rio Grande website delivers ten different types of soldering media, nine when you search Stuller, and nine when you search Gesswein®. After accounting for redundancy, there are about a dozen different options available between these three vendors. A search for "flux" gives you eight different hard soldering options from Rio Grande, five from Stuller, and five from Gesswein. There are no fewer than thirteen options after accounting for redundancy across these vendors. While these numbers aren't huge independent of one another, when you look at potential combinations, that number grows to 156. That is a lot of options for a fundamental process!

It's reasonable to ask, with so many options available, how much difference might this choice really make? Is it worth trying something new or perhaps revisiting options you haven't explored in a while? This research is intended to offer some perspective on these questions.

For this experiment, I narrowed down the options into some commonly used broad categories: saving solution, liquid and paste fluxes, and charcoal and non-charcoal soldering surfaces. I elected to use hard charcoal and Solderite™ brand soldering surfaces, a traditional boric acid saving solution, Superior #6 as the paste flux, and My-T-Flux for the liquid flux. Saving solution was mixed with two parts denatured alcohol to one part boric acid. Superior # 6 has a temperature range of 900–1600°F (485–870°C), and My-T-Flux a temperature range of 1100–1700°F (593–927°C).

There were two primary criteria in these selections. First, frankly, I like them all and use them regularly in my own shop. I have chosen to use them over the course of many years at the bench, and the process has been fairly organic, taking into account factors like convenience, safety and, most important, the results in the work. This is the pragmatic way many bench jewelers arrive at their preferences for soldering set-up, so it seemed a reasonable basis for comparison and experimentation. More significant for this project, however, is the fact that they represented the broad categories I wanted to represent in the research.

I tested the following combinations: paste flux only on the entire sample, liquid flux only on the entire sample, saving solution on the entire sample with paste flux only at the solder joint, saving solution on the entire sample with liquid flux only at the solder joint, and no flux on the sample with paste flux only at the solder joint, all on hard charcoal. An identical second set of samples was tested on a Solderite™ pad.

***Table 1** Sample preparation and soldering surface*

Sample Number	Soldering Surface	Sample Preparation	Sample Number	Soldering Surface	Sample Preparation
1–3 31–33	Hard charcoal	Paste flux	16–18 46–48	Solderite™	Paste flux
4–6 34–36	Hard charcoal	Liquid flux	19–21 49–51	Solderite	Liquid flux
7–9 37–39	Hard charcoal	Saving solution, paste flux at the solder joint	22–24 52–54	Solderite	Saving solution, paste flux at the solder joint
10–12 40–42	Hard charcoal	Saving solution, liquid flux at the solder joint	25–27 55–57	Solderite	Saving solution, liquid flux at the solder joint
13–15 43–45	Hard charcoal	No flux or saving solution, paste flux at the solder joint	28–30 58–60	Solderite	No flux or saving solution, paste flux at the solder joint

Samples for all experiments were .925 silver, 10 mm X 10 mm X 20 gauge. Each sample weighed 0.8–1.0 grams, and samples were randomized across the experiments. The goal was to have a small, jewelry-scale sample to mimic a real-world application of annealing and soldering processes. Since .925 silver is notorious for oxidation, it was the ideal choice for testing to create a "worst-case scenario."

Each sample was annealed once and hard soldered once. I used a Smith Handi-Heet® torch with a #2 tip. I considered using a more conventional dual fuel system for these experiments, but elected to use an atmospheric oxygen option to try to maintain consistency by eliminating the variables introduced by adjusting a gas/oxygen flame. For annealing processes, I judged temperature by color or by flux surface, depending on the sample preparation. All samples were pickled for three minutes in a citric acid pickle after annealing, which was typically around 155°F (68°C) when checked throughout the experiment.

I used Hoover and Strong's hard silver solder for the soldering operations, which has a melting point of 1370°F (743°C) and a flow point of 1490°F (810°C). The soldering step was laid out at the same position on each sample, 2 mm from the upper right corner. I used a 1.3 mm ball bur to create a small divot, following a common process used to locate small findings. Solder pallions were cut to a consistent size using shears and placed in the divots. Each piece was heated until solder flowed, following my established best practice. The heating process started opposite the solder location to begin to warm up the silver without affecting the flux too much, was followed by a more generalized heating step using the flux surface as an indicator of increasing temperature, and then finally moving on to work at the mock "seam" to flow the solder. A solder pick was used as needed to move pallions that had shifted back into position. Samples were then pickled again for three minutes.

Samples 1-30 (which will also be referred to collectively as Sample Group 1) were labeled and placed directly on the soldering surface called for in the experiment. All observations were strictly visual. Samples 31–60 (which will be referred to collectively as Sample Group 2) were intended for collecting more information about actual temperatures during the different experiments. After labelling this group, I laser welded bare thermocouple wire to samples 31-60 and used an Omega™ HH11A thermometer to record temperatures. This was the same process used in the original "Bench Myths" research of 2014 to record annealing temperatures in the course of that annealing experiment. The thermocouple was positioned out of my view in front of a smart phone on a tripod, and each experiment was captured on video. Annealing temperatures and solder flow were announced as they were observed and the videos reviewed to determine at what temperature each process was observed.

Observations

Sample Group 1

Surfaces were observed after the initial annealing and pickling steps to judge the level of discoloration and oxidation, and to determine if there were any discernible differences between sample preparations. The results are shown in Table 2, with the cleanest surface in the first position. There was no significant difference in all 12 samples annealed with saving solution, though there was some level of variability across the group. The samples heated without flux on the Solderite™ block showed the most discoloration and oxidation.

Table 2 *Ranking of Sample Group 1 after the annealing step*

Ranking	Sample Number	Soldering Surface and Sample Preparation
1	7–9, 10–12, 22–24, 25–27	Saving solution, regardless of soldering surface
2	16–18	Paste flux, Solderite™
3	1–3	Paste flux, charcoal
4	4–6	Liquid flux, charcoal
5	19–21	Liquid flux, Solderite
6	13–15	No flux or saving solution, charcoal
7	28–30	No flux or saving solution, Solderite

Sample Group 1 was then soldered and pickled, and the surfaces judged. Observations (without ranking) are shown in Table 3.

Table 3 *Observations of Sample Group 1 after soldering (without ranking)*

Sample Number	Soldering Surface and Sample Preparation	Observations
1–3	Paste flux, charcoal	Surfaces silver where there was flux coverage, other areas white from pickle, generally clean
4–6	Liquid flux, charcoal	More discoloration in flux, flux not completely removed by pickle
7–9	Saving solution, paste flux at the solder joint, charcoal	Very consistently clean surfaces
10–12	Saving solution, liquid flux at the solder joint, charcoal	Very consistent clean surfaces, some discoloration around solder joint
13–15	No flux or saving solution, paste flux at the solder joint, charcoal	Clean at solder joint, obvious oxidation on the rest of the sample
16–18	Paste flux, Solderite™	Surfaces silver where there was flux coverage, other areas white from pickle, clean
19–21	Liquid flux, Solderite	Most discoloration in the flux of any of the samples, flux not completely removed by the pickle
22–24	Saving solution, paste flux at the solder joint, Solderite	Samples very consistently clean
25–27	Saving solution, liquid flux at the solder joint, Solderite	Samples very consistently clean, some discoloration around solder joint
28–30	No flux or saving solution, paste flux at the solder joint, Solderite	Clean at solder joint, obvious discoloration on the rest of the sample

Before determining a final ranking, all of Sample Group 1 was subjected to a final forced oxidizing step. All samples were gently heated to force discoloration in any oxidized area, with the goal of making any areas of oxidation more obvious. Samples were not pickled, again, to preserve the discoloration. Final ranking of samples is shown in Table 4.

Table 4 *Ranking of Sample Group 1 after forced oxidizing*

Ranking	Sample Number	Soldering Surface and Sample Preparation
1	1–3	Paste flux, charcoal
2	19–21	Liquid flux, Solderite™
3	13–15	No flux or saving solution, paste flux at the solder joint, charcoal
4	4–6	Liquid flux, charcoal
5	7–9	Saving solution, paste flux at the solder joint, charcoal
6	28–30	No flux or saving solution, paste flux at the solder joint, Solderite
7	25–27	Saving solution, liquid flux at the solder joint, Solderite
8	16–18	Paste flux, Solderite
9	22–24	Saving solution, paste flux at the solder joint, Solderite
10	10–12	Saving solution, liquid flux at the solder joint, charcoal

Sample Group 2

The goal of Sample Group 2 was to determine what temperatures were achieved in these different approaches to begin to determine relationships between fluxes, soldering surfaces and actual working temperatures. Tables 5–14 and Figures 1–10 show results in both table and graph formats.

***Table 5** Temperatures observed in samples 31–33 during annealing and soldering*

Sample number	Annealing Temperature Observed °F / °C	Soldering Temperature Observed °F / °C	High Temperature Observed °F / °C
31	1171 / 633	1416 / 769	1416 / 769
32	1184 / 640	1397 / 758	1433 / 778
33	1062 / 572	1431 / 777	1462 / 794

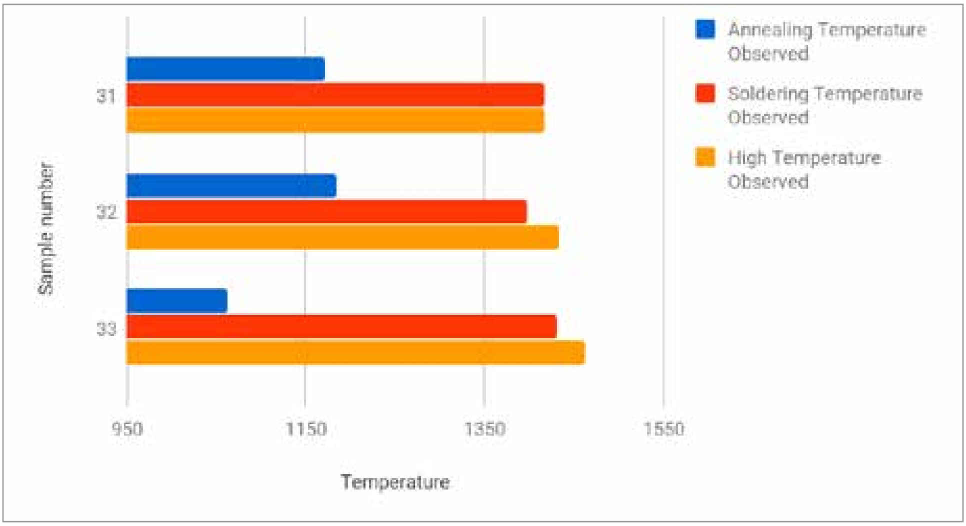

***Figure 1** Observed temperatures (°F) in samples 31–33 during annealing and soldering*

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Table 6 *Temperatures observed in samples 34–36 during annealing and soldering*

Sample number	Annealing Temperature Observed °F / °C	Soldering Temperature Observed °F / °C	High Temperature Observed °F / °C
34	1324 / 718	1468 / 798	1518 / 826
35	1350 / 732	1423 / 773	1450 / 788
36	1295 / 702	1443 / 784	1461 / 794

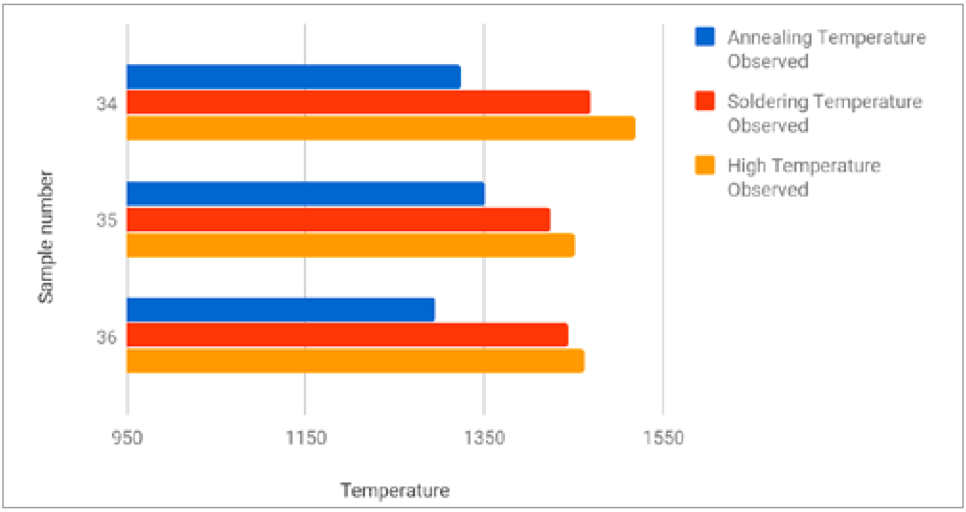

Figure 2 *Observed temperatures (°F) in samples 34–36 during annealing and soldering*

***Table 7** Temperatures observed in samples 37–39 during annealing and soldering*

Sample number	Annealing Temperature Observed °F / °C	Soldering Temperature Observed °F / °C	High Temperature Observed °F / °C
37	1070 / 577	1403 / 762	1403 / 762
38	1275 / 691	1506 / 819	1540 / 838
39	1305 / 707	1518 / 826	1546 / 841

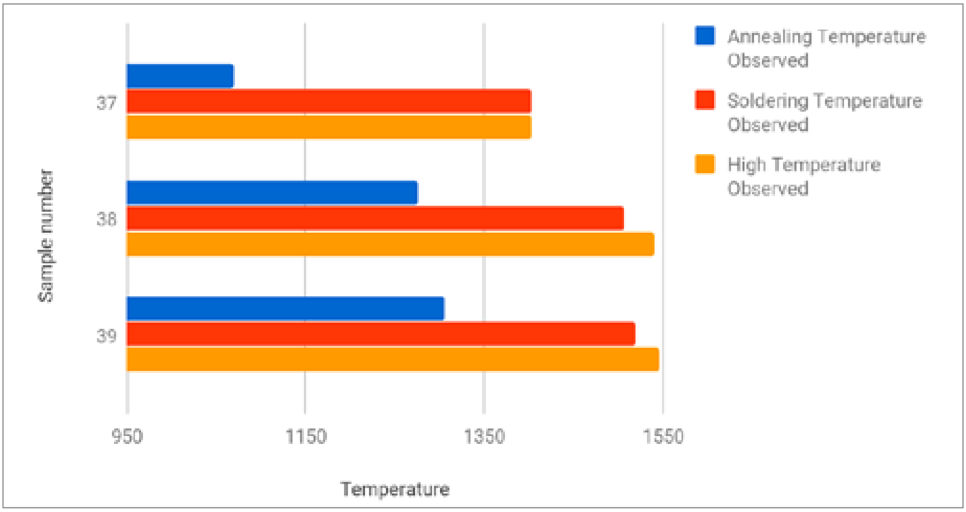

***Figure 3** Observed temperatures (°F) in samples 37–39 during annealing and soldering*

Table 8 *Temperatures observed in samples 40–42 during annealing and soldering*

Sample number	Annealing Temperature Observed °F / °C	Soldering Temperature Observed °F / °C	High Temperature Observed °F / °C
40	1357 / 736	1370 / 743	1393 / 756
41	1302 / 706	1430 / 777	1430 / 777
42	1265 / 685	1453 / 789	1460 / 793

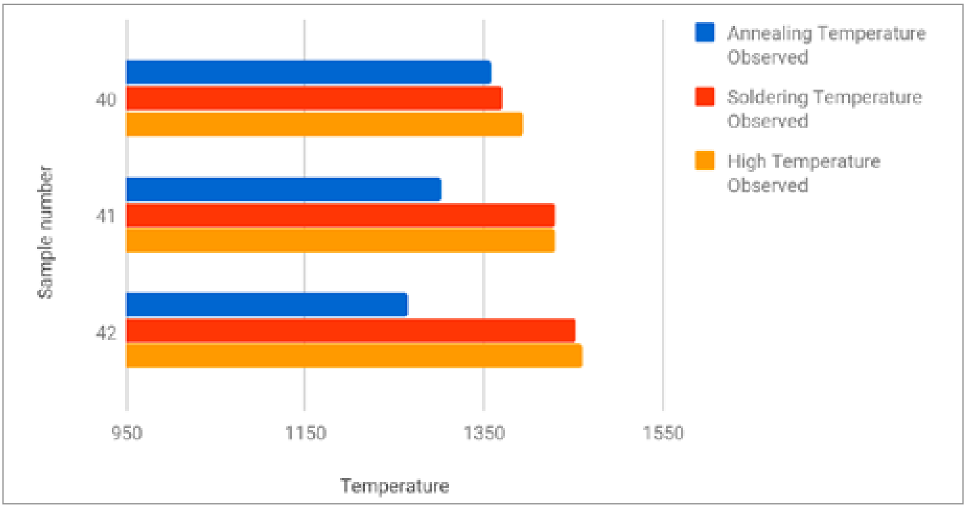

Figure 4 *Observed temperatures (°F) in samples 40–42 during annealing and soldering*

Table 9 Temperatures observed in samples 43–45 during annealing and soldering

Sample number	Annealing Temperature Observed °F / °C	Soldering Temperature Observed °F / °C	High Temperature Observed °F / °C
43	988 / 531	1490 / 810	1511 / 822
44	1058 / 570	1481 / 805	1524 / 829
45	1213 / 656	1420 / 771	1425 / 774

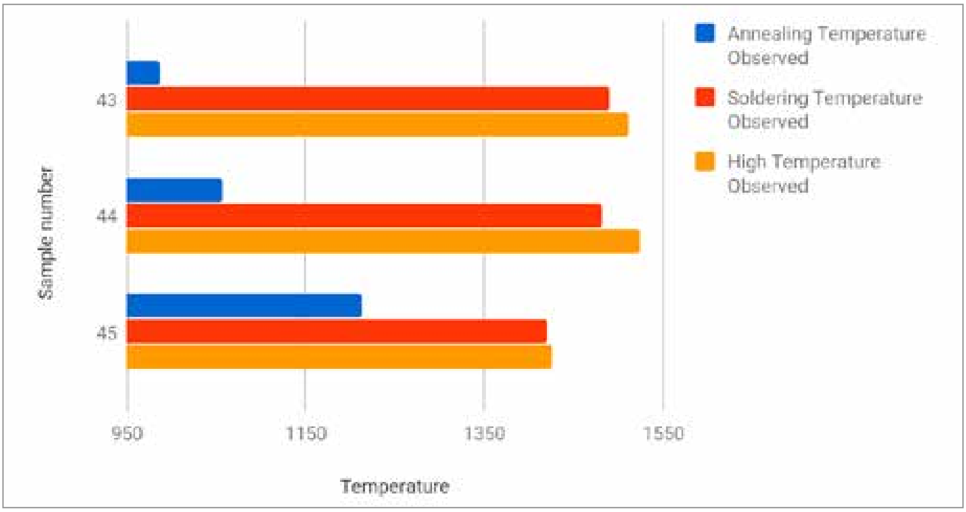

***Figure 5** Observed temperatures (°F) in samples 43–45 during annealing and soldering*

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Table 10 *Temperatures observed in samples 46–48 during annealing and soldering*

Sample number	Annealing Temperature Observed °F / °C	Soldering Temperature Observed °F / °C	High Temperature Observed °F / °C
46	1026 / 552	1270 / 688	1270 / 688
47	1198 / 648	1411 / 766	1430 / 777
48	1070 / 577	1461 / 794	1498 / 814

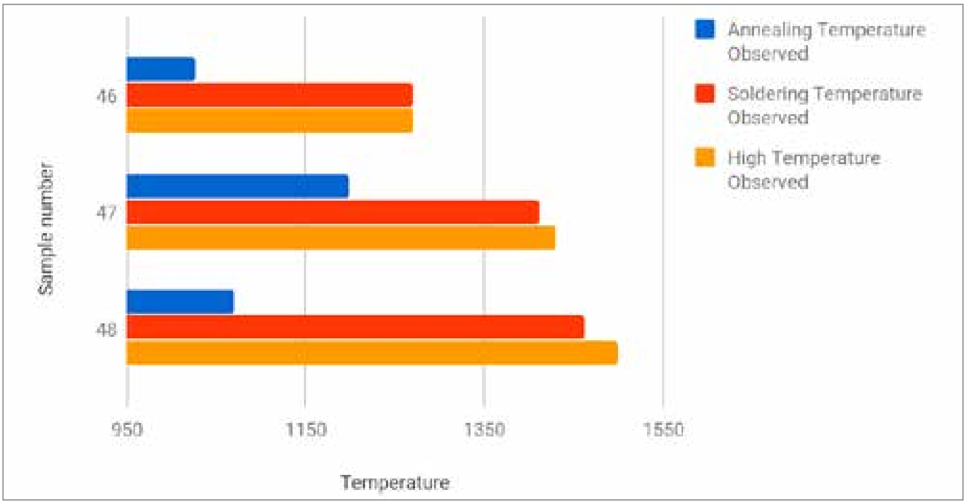

Figure 6 *Observed temperatures (°F) in samples 46–48 during annealing and soldering*

Table 11 *Temperatures observed in samples 49–51 during annealing and soldering*

Sample number	Annealing Temperature Observed °F / °C	Soldering Temperature Observed °F / °C	High Temperature Observed °F / °C
49	1294 / 701	1430 / 777	1430 / 777
50	1052 / 567	1425 / 774	1472 / 800
51	1301 / 705	1389 / 754	1425 / 774

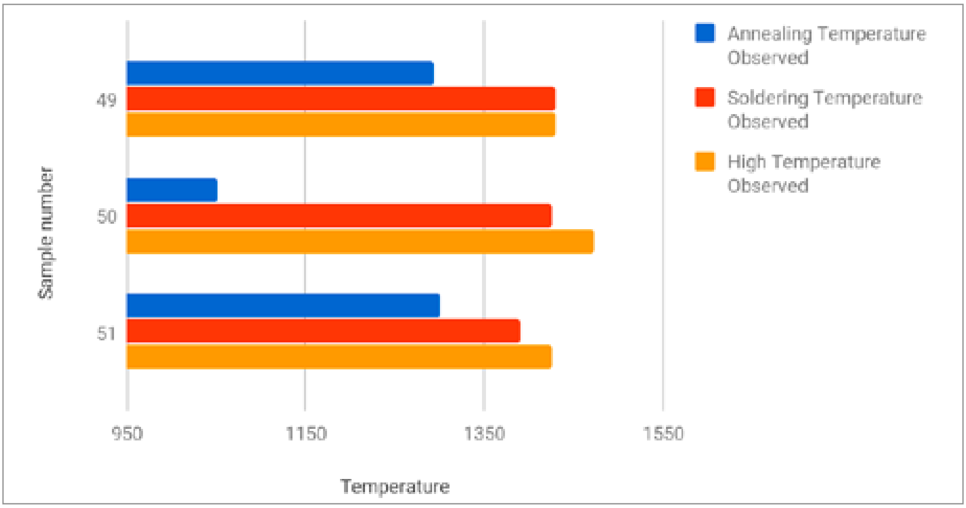

Figure 7 *Observed temperatures (°F) in samples 49–51 during annealing and soldering*

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Table 12 *Temperatures observed in samples 52–54 during annealing and soldering*

Sample number	Annealing Temperature Observed °F / °C	Soldering Temperature Observed °F / °C	High Temperature Observed °F / °C
52	972 / 522	1439 / 782	1439 / 782
53	1025 / 552	1437 / 781	1437 / 781
54	1306 / 708	1391 / 755	1391 / 755

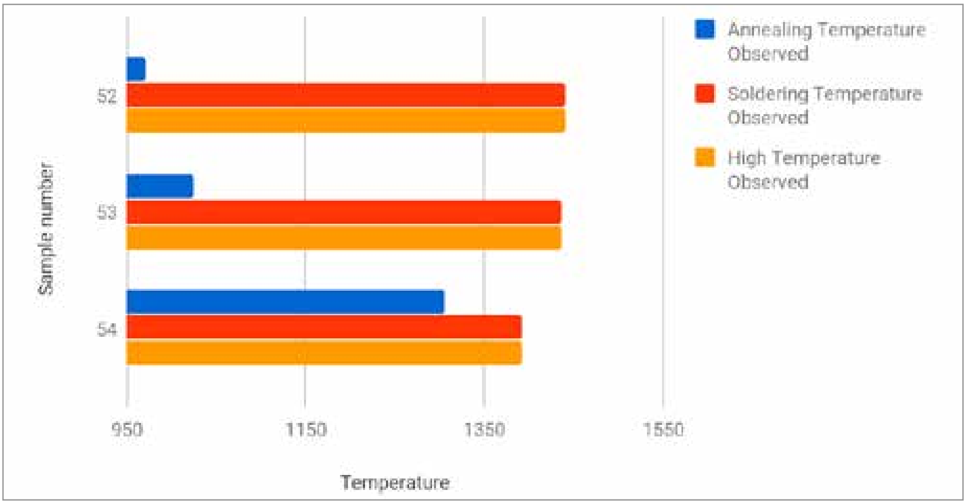

Figure 8 *Observed temperatures (°F) in samples 52–54 during annealing and soldering*

Table 13 Temperatures observed in samples 55–57 during annealing and soldering

Sample number	Annealing Temperature Observed °F / °C	Soldering Temperature Observed °F / °C	High Temperature Observed °F / °C
55	1064 / 573	1428 / 776	1462 / 794
56	1238 / 670	1425 / 774	1433 / 778
57	980 / 527	1422 / 772	1422 / 772

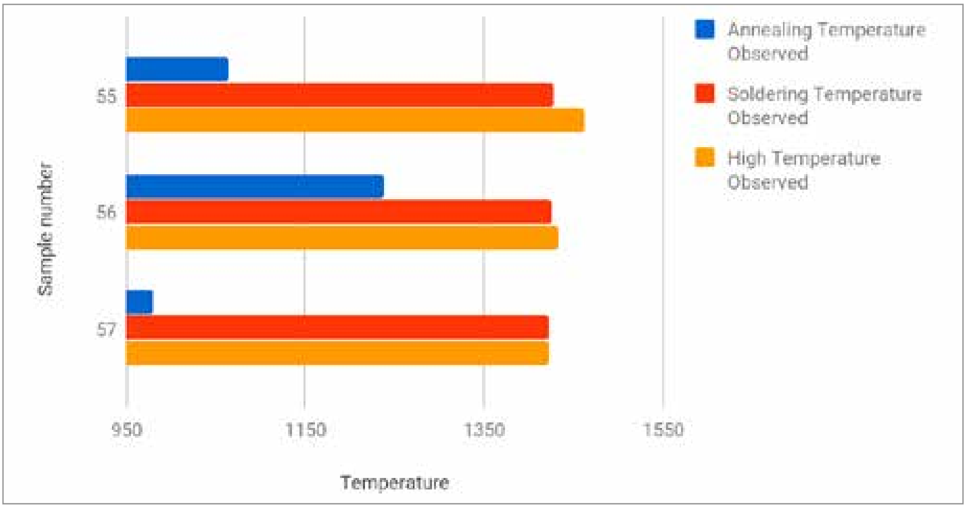

Figure 9 *Observed temperatures (°F) in samples 55–57 during annealing and soldering*

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Table 14 ***Temperatures observed in samples 58–60 during annealing and soldering***

Sample number	Annealing Temperature Observed °F / °C	Soldering Temperature Observed °F / °C	High Temperature Observed °F / °C
58	1080 / 582	1439 / 782	1467 / 797
59	1219 / 659	1099 / 593	1262 / 683
60	1194 / 646	1463 / 795	1463 / 795

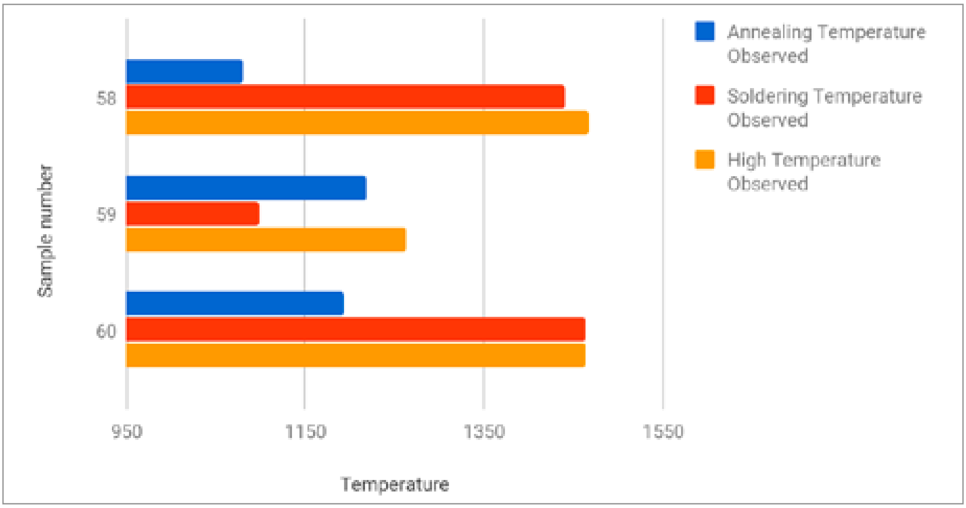

Figure 10 *Observed temperatures (°F) in samples 58–60 during annealing and soldering*

Figures 11-13 show us the aggregated data from all of Sample Group 2.

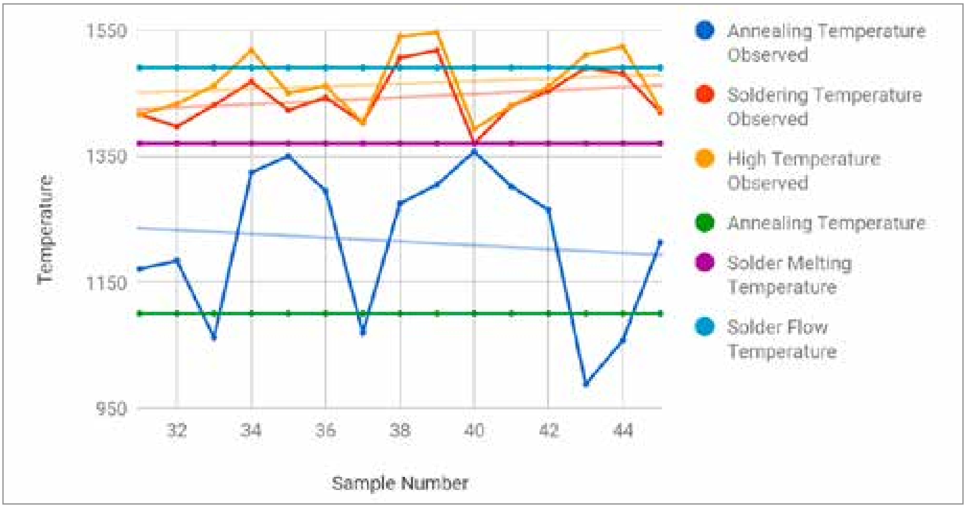

Figure 11 *Aggregate of observed temperatures in °F, samples 31–45*

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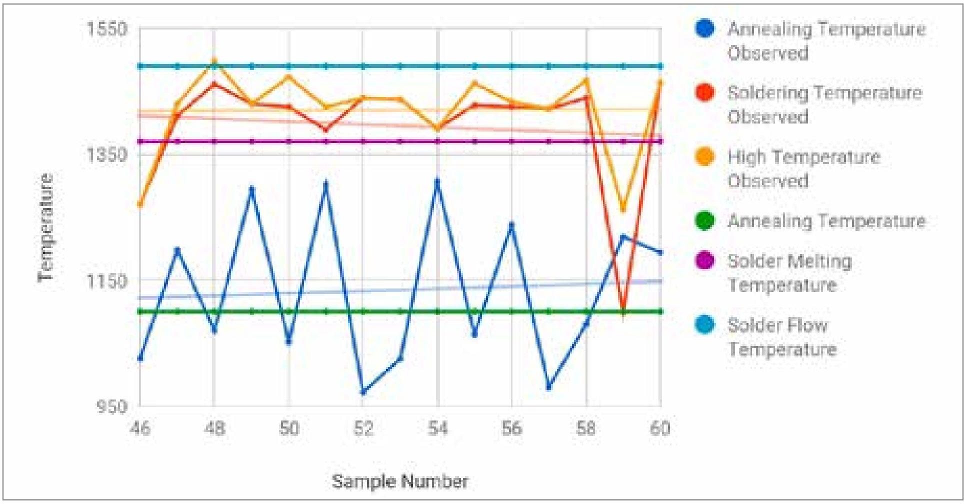

Figure 12 *Aggregate of observed temperatures (°F) in samples 46–60*

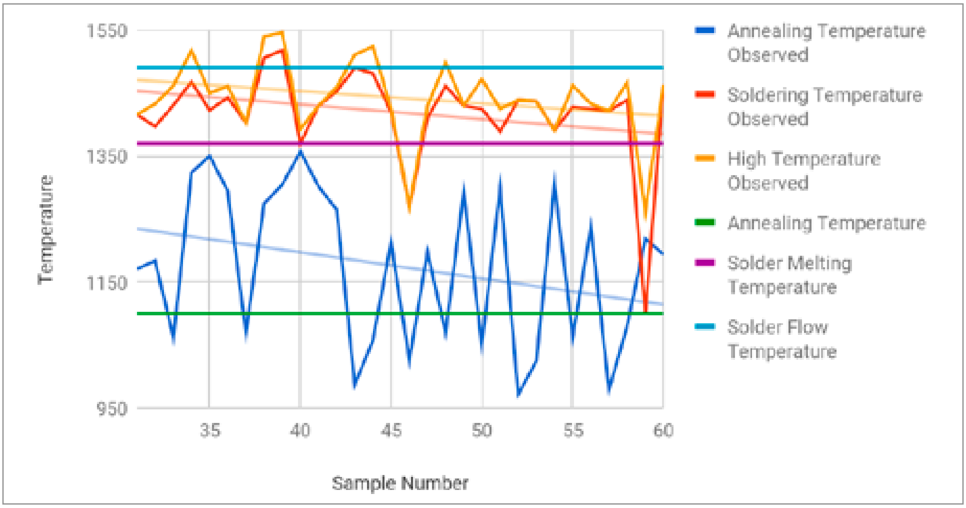

Figure 13 *Aggregate of observed temperatures (°F) in Sample Group 2*

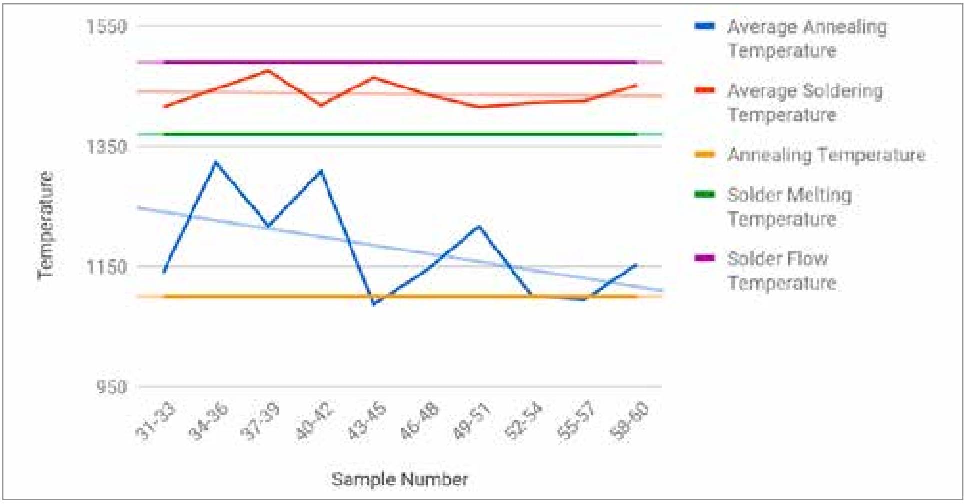

Figure 14 Aggregate of average observed temperatures (°F) in Sample Group 2

Comparisons and Conclusions

So what does an analysis of all of this data tell us? Figure 15 shows the temperature data from Sample Group 2 applied to the Ranking results from Group 1. Table 15 shows us temperature data applied to our original rankings, and notes the flux and soldering surface. What we see is that while there is some variability in the average soldering temperatures, the greatest variability lies in annealing. As the temperature trend line increases, the amount of oxidation on the samples also increases.

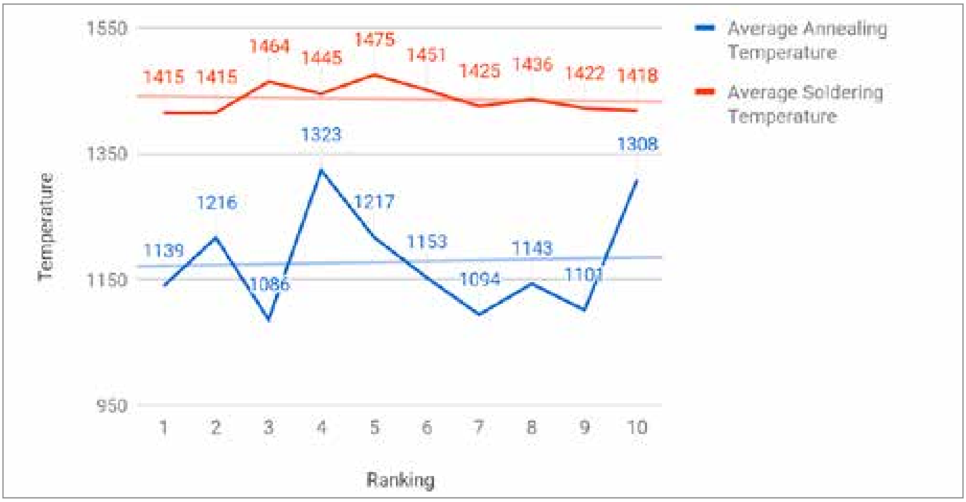

***Figure 15** Temperature data (°F) from Sample Group 2 applied to the ranking results from Sample Group 1*

***Table 15** Temperature data applied to original rankings with flux and soldering surface information*

Ranking	Average Annealing Temperature °F / °C	Average Soldering Temperature °F / °C	Soldering Surface	Annealing Preparation	Soldering Preparation
1	1139 / 615	1415 / 768	Charcoal	Paste flux	Paste flux
2	1216 / 658	1415 / 768	Solderite™	Liquid flux	Liquid flux
3	1086 / 586	1464 / 796	Charcoal	No flux or saving solution	Paste flux
4	1323 / 717	1445 / 785	Charcoal	Liquid flux	Liquid flux
5	1217 / 658	1475 / 802	Charcoal	Saving solution	Saving solution with paste flux at the joint only
6	1153 / 623	1451 / 788	Solderite	No flux or saving solution	Paste flux at the joint only
7	1094 / 590	1425 / 774	Solderite	Saving solution	Liquid flux at the joint only
8	1143 / 617	1436 / 780	Solderite	Paste flux	Paste flux
9	1101 / 594	1422 / 772	Solderite	Saving solution	Paste flux at the joint only
10	1308 / 709	1418 / 770	Charcoal	Saving solution	Liquid flux at the joint only

The connection between soldering surfaces and the amount of oxidation on the surfaces isn't quite as clear if looking only at general trends, though the general trend in the data indicates that the samples annealed and soldered on charcoal were generally less oxidized. The samples ranked 7, 8, and 9 are particularly important in drawing a conclusion, however. All have nearly ideal average temperatures, yet they are some of the most oxidized. What we must note is that they were all annealed and soldered on Solderite™. When you look further at the fact that two of the lesser oxidized samples (rankings 4 and 5) had higher average annealing temperatures but were heated on charcoal, the role of the soldering surface as a critical contributor to the whole picture becomes clearer. Charcoal's ability to provide a reducing environment appears to have very demonstrable effects on soldering and annealing outcomes.

While the use of a flux was not always associated with a less oxidized result, the top two results used a flux on all surfaces for both annealing and soldering.

An additional important observation is that the top two rankings are associated with the approaches I tend to use in my own studio practice. This is not to say that they are, therefore, the best practices. Rather, I think it underscores the very real implications practice and experience have on any set of variables.

References

1. Ann Cahoon, "Bench Myths," *The Santa Fe Symposium on Jewelry Manufacturing Technology* 2014, ed. E. Bell and J. Haldeman (Albuquerque: Met-Chem Research, Inc., 2014): 51-88.