Applying Commonly Available Software For Quality Control & Troubleshooting

by P.D. Stransky, CEF*

Chemical analysis of metal finishing process solutions is important, and is done to varying degrees by just about every shop. The information obtained, primarily process solution concentration and chemical additions needed, is of immediate concern to production. This paper expands on the idea of using commonly available software and how we might apply it to a metal finishing operation.

Chemical analysis of metal finishing process solutions is important, and is done to varying degrees by just about every shop. It falls under the category of quality control, or quality assurance and may range from simple titrations in some facilities to sophisticated instrumental analysis in others. The analyst may be a plater in a small shop or a chemist or chemical engineer in a large facility. Motivation for doing it varies. It may be required by the customer or done because common sense tells us it is necessary to keep production running smoothly.

The information obtained, primarily process solution concentration and chemical additions needed, is of immediate concern to production. In addition the ease of record keeping by computer allows for a history to be built up that enables trends to be evaluated relating to both quality and plant operations issues. An earlier "how to" paper[1] described how to use commonly available software to make analysis and addition calculations easier as well as the record keeping that goes along with it.

This paper expands on the idea of using commonly available software and how we might apply it to a metal finishing operation. In addition to spreadsheets a simple (low tech) example of an "expert system" making use of Microsoft Excel or Microsoft Access is shown.

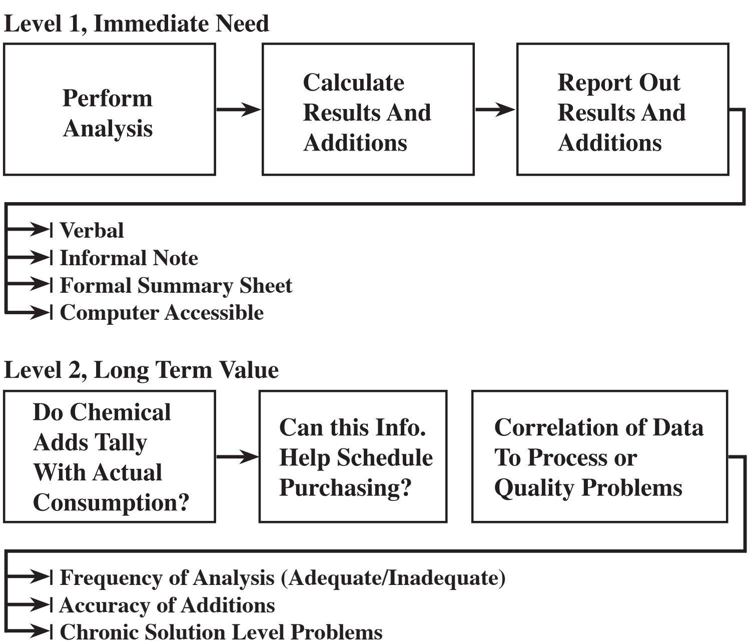

Fig. 1—Flowcharts indicating short and long-term use of analysis information.

Nuts & Bolts: What This Paper Means to You

Chemical analysis of metal finishing process solutions is important, and is done to varying degrees by just about every shop. Even in these days of quality management, log books and paper scraps still serve as records. This paper shows just what can be done with computers, both in terms of recordkeeping and troubleshooting.

Background

Basically we want to acquire information, in this case process solution analytical results, and process it in a relatively easy way making use of common software that most likely is in-house in the office (Microsoft Excel, Lotus, etc.). The immediate need for results is to get them to the "appropriate person." How this is done will obviously depend on the size of the facility. Figure 1 is a simple flow chart and as is indicated, reporting may be an informal verbal report, note, or a summary sheet that includes results for all solutions analyzed that day. If there is a local area network (LAN) it is possible for the "appropriate person" to access the information remotely. Too frequently test results are after the fact, so anything that speeds up the process is helpful.

As Fig. 1 indicates, there is also a second level of longer term interest when historical results are available in spreadsheet form, it becomes very easy to make comparisons or run correlations.

A few examples are given here, since we have a record of all chemical additions that are easily totaled for some time period (week, month, quarter) a comparison can be made to chemical inventory. This may be of use to schedule purchasing. It may also give a feel for how accurately additions are being made, and if they are being made at all on some occasions. Perhaps of more importance is in troubleshooting *i.e.*, the ability to see if process or finished part quality is related to process solution variability.

*Corresponding Author:
Mr. Paul D. Stransky, CEF
Putnam, CT 06260
E-mail: pstransky@snet.net

Table 1
Thirty Weeks of Data for a Hardcoat Anodizing Bath

Anodize Type III
Range 15 - 22 % Vol. H2SO4 **494 Gal. Working Volume**
Range 25- 37 % Wt. H2SO4
Range 274 - 405 g/L

	TOTAL ACID				FREE ACID				
Enter Date	Enter mL NaOH	Oz/Gal	% Vol	% Wt.	Enter mL NaOH	Oz/Gal	Alum. g/L	Addn. Gal	Enter Initials
20-Oct-00	21.55	28.19	11.42	19.18	19.10	24.98	4.41	52.26	
02-Nov-00	24.70	32.31	13.09	21.99	22.00	28.78	4.86	44.01	
09-Nov-00	34.60	45.26	18.34	30.80	32.10	41.99	4.50	18.09	
16-Nov-00	34.30	44.86	18.18	30.53	31.83	41.63	4.45	18.88	
22-Nov-00	37.50	49.05	19.88	33.38	34.10	44.60	6.12	10.50	
30-Nov-00	36.90	48.27	19.56	32.85	33.30	43.56	6.48	12.07	
07-Dec-00	38.55	50.42	20.43	34.32	35.00	45.78	6.39	7.75	
14-Dec-00	37.90	49.57	20.09	33.74	34.60	45.26	5.94	9.45	
21-Dec-00	39.90	52.19	21.15	35.52	36.05	47.15	6.93	4.21	
28-Dec-00	40.10	52.45	21.25	35.70	35.95	47.02	7.47	3.69	
04-Jan-01	40.05	52.39	21.23	35.65	36.60	47.87	6.21	3.82	
12-Jan-01	39.18	51.25	20.77	34.88	35.57	46.53	6.50	6.10	
18-Jan-01	38.93	50.92	20.63	34.66	34.85	45.58	7.34	6.75	
25-Jan-01	41.53	54.32	22.01	36.97	36.80	48.13	8.51	0.00	
01-Feb-01	39.00	51.01	20.67	34.72	35.10	45.91	7.02	6.57	
08-Feb-01	39.35	51.47	20.86	35.03	35.10	45.91	7.65	5.65	
15-Feb-01	38.05	49.77	20.17	33.87	34.15	44.67	7.02	9.06	
22-Feb-01	39.20	51.27	20.78	34.90	34.90	45.65	7.74	6.05	
01-Mar-01	40.60	53.10	21.52	36.14	36.30	47.48	7.74	2.38	
08-Mar-01	39.60	51.80	20.99	35.25	33.57	43.91	10.85	5.00	
15-Mar-01	36.50	47.74	19.35	32.49	32.40	42.38	7.38	13.12	
22-Mar-01	38.70	50.62	20.51	34.45	34.10	44.60	8.28	7.36	
29-Mar-01	38.80	50.75	20.56	34.54	35.60	46.56	5.76	7.09	
05-Apr-01	37.25	48.72	19.74	33.16	33.30	43.56	7.11	11.15	
12-Apr-01	39.80	52.06	21.09	35.43	36.00	47.09	6.84	4.48	
19-Apr-01	38.80	50.75	20.56	34.54	34.85	45.58	7.11	7.09	
25-Apr-01	38.30	50.10	20.30	34.09	34.20	44.73	7.38	8.40	
02-May-01	38.00	49.70	20.14	33.83	33.70	44.08	7.74	9.19	
10-May-01	38.70	50.62	20.51	34.45	34.85	45.58	6.93	7.36	
17-May-01	45.70	59.78	24.22	40.68	40.30	52.71	9.72	0.00	
					Total Gal. Sulfuric Acid Added			307.52	

Example 1: Anodizing

Table 1 contains results for a Type III (hard coat) anodizing bath (in Microsoft Excel) for 30 weeks. In this case the analyst only makes four entries: "date," "total acid titration," and free acid titration" and "initials." All calculations are done automatically. A more detailed explanation for the embedded math in each column is given in the Appendix. Total acid concentration is shown three ways, because three customers audit records annually. One customer wants to see it as vol%, another as wt% and another in oz/gal. Free acid is only calculated in oz/gal and aluminum in g/L. Additions of sulfuric acid (66°Bé) are calculated in gallons from the vol% results.

Figure 2 is a plot of vol% sulfuric acid over the 30 week period. The specification range is 15 to 22 vol% . The plot was made fairly easily from the spreadsheet using the Excel "chart" function. This was a new bath startup, so it can be seen that once the bath was up to strength, it was kept within limits up to week 29. The higher value on week 30 most likely was a level issue, *i.e.*, the solution level was low when the sample was taken.

Figure 3 is a plot of dissolved aluminum over the 30 weeks. The bath was made up by adding the equivalent of 4 g/L aluminum, and was not to exceed 12 g/L. The week 21 analysis showed the aluminum at 10.9 g/L, so a portion of the bath was replaced to lower it. Again, very reasonable control was exhibited. This is a good indication that, in this case, a weekly analysis was sufficient .

Example 2: Chromate Conversion Coating (Clear)

Table 2 and Fig. 4 are a spreadsheet and accompanying plot for a clear chromate conversion coating bath. The desired concentration range was 0.1 to 0.3 oz/gal, a quick look at either the table or plot shows that with the exception of week 1, it was always out of specification, being too concentrated. Consistently high values tend to indicate level problems. In this case the tank was in a far corner of the facility, there was no DI water right at the tank and it was a hassle for the busy operator to maintain its level correctly. Assuming that sometime in the week between testing the bath was topped off, a more frequent analysis schedule may have shown more data points within specification.

Example 3: Chromate Conversion Coating (Gold)

Table 3 and Fig. 5 are a spreadsheet and plot for a gold chromate conversion coating bath. The concentration for this bath is expressed in terms of mL of sodium thiosulfate (0.1N). The specified range was 5.3 to 7.3 mL. This bath was controlled quite well in that there were only two out of 31 weeks out of range. This was a very large tank with its own DI water line for make up and level control.

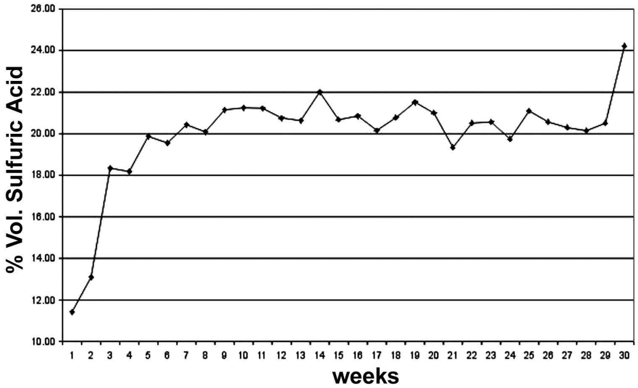

Fig. 2—Volume % sulfuric acid vs. time.

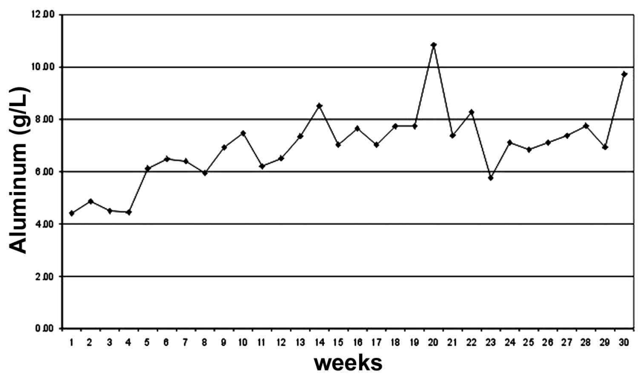

Fig. 3—Dissolved aluminum vs. time.

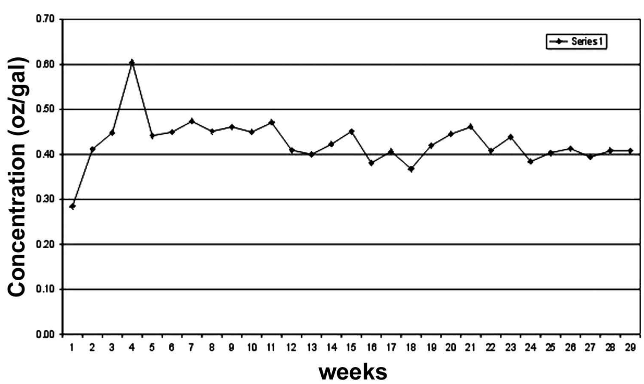

Fig. 4—Chromate concentration vs. time.

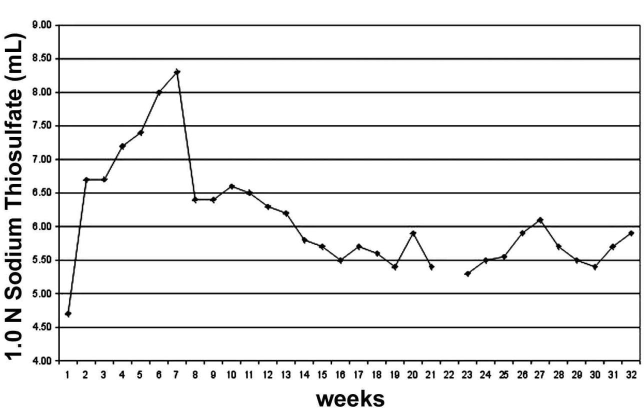

Fig. 5—Titration range vs. time.

Troubleshooting is another area where common software such as Microsoft Excel, and database management software such as Microsoft Access, Filemaker Pro, Star Office Suite or Wordperfect suite can help. There is considerable troubleshooting information available in print (books, *P&SF*, other trade journals, plating chemical data sheets, etc.) for metal finishing process solutions. Frequently however, there are periodic problems that crop up from time to time in a given facility. One hears on the shop floor, "Oh, yeah. This happened before." followed by several different opinions on how the problem was solved. So-called "expert systems" are a way to handle these problems. Recently, there have been a few papers on the subject[2,3] that deal with it in a very sophisticated way, more like artificial intelligence than simply a way of having some convenient answers on hand at the click of a mouse to particular problems.

Table 2
Twenty-nine Weeks of Data For a Clear Chromate Conversion Coating Bath

Chromate Conversion Coating (Clear)
Range 0.1 - 0.3 oz/gal **90 Gal. Working Volume**
pH Range 1.8 - 2.9

Enter Date	Enter mL STS*	Conc. oz/gal	Needed oz/gal	Addn. Lbs	Enter pH	Enter Initials
24-Oct-00	8.90	0.28	0.00	0.00	2.50	
09-Nov-00	12.85	0.41	0.00	0.00	2.50	
16-Nov-00	14.00	0.45	0.00	0.00	2.18	
22-Nov-00	18.90	0.60	0.00	0.00	2.17	
30-Nov-00	13.80	0.44	0.00	0.00	1.94	
07-Dec-00	14.05	0.45	0.00	0.00	2.44	
14-Dec-00	14.80	0.47	0.00	0.00	1.93	
21-Dec-00	14.10	0.45	0.00	0.00	2.38	
28-Dec-00	14.40	0.46	0.00	0.00	2.20	
04-Jan-01	14.05	0.45	0.00	0.00	2.16	
12-Jan-01	14.70	0.47	0.00	0.00	2.16	
18-Jan-01	12.80	0.41	0.00	0.00	2.02	
25-Jan-01	12.50	0.40	0.00	0.00	1.76	
01-Feb-01	13.20	0.42	0.00	0.00	1.76	
08-Feb-01	14.10	0.45	0.00	0.00	2.07	
15-Feb-01	11.90	0.38	0.00	0.00	2.20	
22-Feb-01	12.70	0.41	0.00	0.00	1.51	
01-Mar-01	11.50	0.37	0.00	0.00	2.32	
08-Mar-01	13.10	0.42	0.00	0.00		
15-Mar-01	13.90	0.44	0.00	0.00		
22-Mar-01	14.40	0.46	0.00	0.00	2.19	
29-Mar-01	12.75	0.41	0.00	0.00	2.96	
05-Apr-01	13.70	0.44	0.00	0.00	2.29	
12-Apr-01	12.00	0.38	0.00	0.00	1.14	
19-Apr-01	12.60	0.40	0.00	0.00	2.53	
25-Apr-01	12.90	0.41	0.00	0.00	2.53	
02-May-01	12.30	0.39	0.00	0.00	2.32	
10-May-01	12.75	0.41	0.00	0.00	2.43	
17-May-01	12.75	0.41	0.00	0.00	1.53	

** sodium thiosulfate*

Access is a component of Microsoft Office. Basically, it is a way of retrieving information from a database such as Excel, or from tables containing information made up in the Access program. Access can be used to do very sophisticated work. However, it can also be used in a very simple way for troubleshooting. Figure 6 is a diagram of the initial Access window. A standard Microsoft Windows tool bar is displayed across the top of the screen. Below it, on the left is an object box which contains "radio buttons" for tables, queries, reports and other things that we won't be using. To the right of that is the area where various instructions show up for each choice.

In this simple approach we work with queries which are going to be questions that represent a problem such as "poor adhesion", "thin coatings" or other problems unique to a particular facility. Tables con-

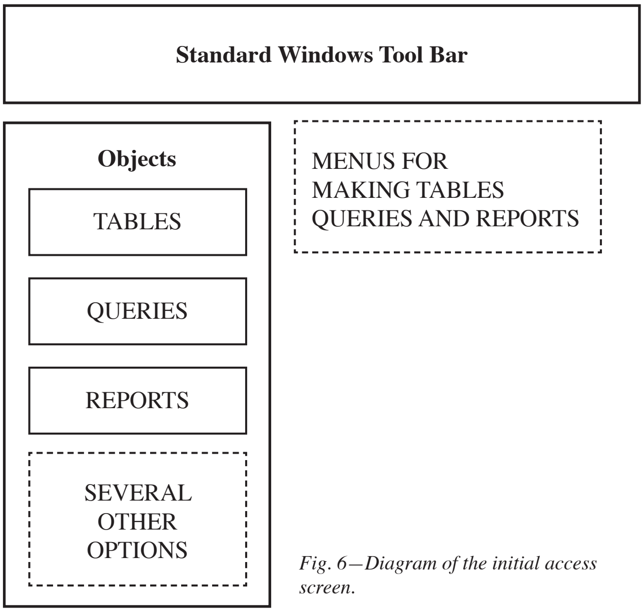

Fig. 6—Diagram of the initial access screen.

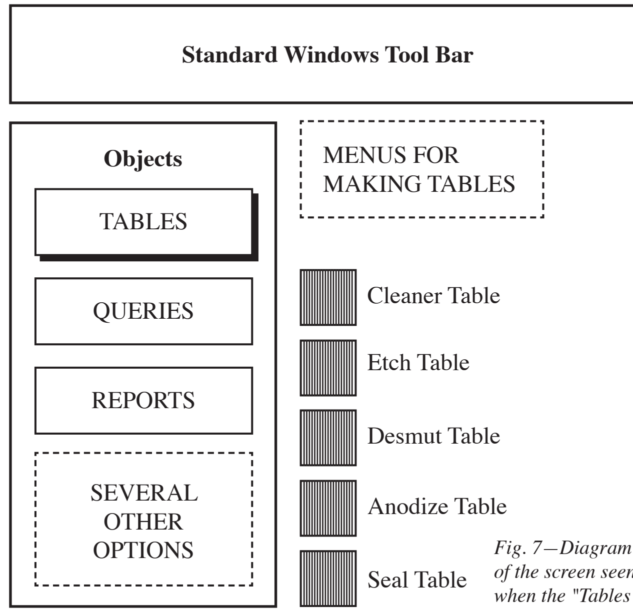

Fig. 7—Diagram of the screen seen when the "Tables" button is selected.

tain the information needed to solve a particular problem. This may be from theory, or experience. Reports are dressed-up query results that are created automatically.

The construction sequence is as follows:

1. Think of the particular problems you want to address for a process. The examples used here are some anodizing problems, thin coatings, burning, soft coatings and pitting.
2. Create the table or tables first by following program directions and enter all the possible causes of each problem. In this case a table was constructed for each step in the anodizing process, cleaning, etching, desmuting, anodizing and sealing. Once the tables are constructed they can be accessed by clicking on the “Tables” button. They will then appear as seen in Fig. 7. Each individual table can be seen by clicking on the button next to the title. For example if the “Anodize Table” button was clicked the table in Fig. 8 would be shown.
3. Next, create the queries following program directions. In this process each query is assigned the particular information in your table. When the queries have been constructed, clicking on the “Queries” button in Fig.6 will bring up a list of the queries, as shown in Fig. 9. Clicking on an individual query, such as “Thin Coating,” will bring up all of the possibilities for that problem that have been entered into the table, as seen in Fig. 10.
4. The same process is followed for reports except that they are constructed automatically from information that answers each query. When the “Report” button (Fig. 6) is clicked, the list of reports available is shown. It is exactly the same as the list of queries. A report can be printed out in a nicer format if needed, although the information is exactly the same as that in Fig. 10.

Access Table: ANODIZE TANK

Problem	Cause	Reason	Action
Thin Coating	Volts / Amps	Rectifier Meters Wrong	Test with DVM Or Ammeter
Thin Coating	ASF Too Low	Connections Bad (High Resistance)	Clean, Check Racks
Thin Coating	Solution	Film Dissolving , Acid High	Analyze - Adjust (Dilute)
Thin Coating	Solution	acid Low (High Resistance)	Analyze - Adjust (Add)
Thin Coating	Solution	Film Dissolving, Temperature High	Measure - Adjust
Thin Coating	Solution	ASF Low, Temperature Low	Adjust Temperature
Thin Coating	Operations	Area Too large for rectifier	Reduce Number Of parts
Thin Coating	Operations	Run Time Too Short	Increase Time
Burning	Heat	Current Density High	Reduce
Burning	Solution	Solution Temperature	Measure - Adjust
Burning	Solution	Additive Needed	Analyze - Adjust
Soft Coatings	ASF Too Low	Connections Bad (High Resistance)	Clean, Check Racks
Soft Coatings	Solution	Temperature High	Measure - Adjust
Soft Coatings	Seal	Can be a Factor	Refer to Seal Tank Table
Pitting	Pretreat-ment	Can be caused by Cleaner/ Etch	Refer to Cleaner & Etch Tables
Pitting	Solution	Contamination (Chlorides,Nitrates)	Analyze

Fig. 8—Example of the table displayed by clicking the "Anodize Table" button shown in Fig. 7.

References

1. P.D. Stransky, “Use of Commonly Available Software in the Metal Finishing Lab”, *Plating and Surface Finishing*, to be published.
2. A.W. Brace, *Plating and Surface Finishing*, **87**, 88 (January 2000).
3. Ibid., *Plating and Surface Finishing*, **87**, 81 (February 2000).

About the Author

Paul D. Stransky, CEF has a BA in chemistry from Southern Connecticut State College, and an MS in polymer science/materials science from the University of Connecticut. He has worked in the metal finishing industry over 40 years. During that time he worked for Sylvania, spent 10 years at the finishing group at Olin Corporation’s Metals Research Laboratory as a development engineer and 20 years at Rogers

Corporation as a development engineer. Since retiring from Rogers he has been working as a consultant, as well as teaching chemistry as an Adjunct Professor.

Appendix

Explanation of Calculations for Results and Additions

Process – Sulfuric Acid Anodizing, Type III (Hard Coat)

	TOTAL ACID				FREE ACID			
A	B	C	D	E	F	G	H	I
Enter Date	Enter mL NaOH	Oz/Gal	% Vol	% Wt.	Enter mL NaOH	Oz/ Gal	Alum. g/L	Addn.* Gal

Results calculation formula for oz/gal sulfuric acid (Column C)
The formula is (B × 1.303), where B = mL 1N sodium hydroxide used to titrate a 5 mL sample and 1.303 is a factor.

Results calculation formula for vol% sulfuric acid (Column D)
The formula is (C / 1.84 / 128 × 100), where C is the value calculated in column C, 1.84 is the specific gravity of sulfuric acid, 128 = fluid oz/gal and 100 converts to percent.

Results calculation formula for wt% sulfuric acid (Column E)
The formula is (B × 9.81 / 11.02), where B = mL 1N sodium hydroxide used to titrate a 5 mL sample. 9.81 and 11.02 are factors.

Results calculation formula for oz/gal free sulfuric acid (Column G)
The formula is (F × 1.303), where F = mL 1N sodium hydroxide used to titrate a 5 mL sample after potassium fluoride has removed the aluminum, and 1.303 is a factor.

Results calculation formula for g/L aluminum (Column H)
The formula is ((B – F) × 0.24) × 7.5, where B and F are the calculated values in those columns, 0.24 is a factor, and 7.5 converts the results to g/L from oz/gal.

Addition of gallons of sulfuric Acid to be added to the tank (Column I)
The formula is [IF D>22,0,(22-D)/100×494], where D = the value from column D. The first part of the formula is telling the computer to print a 0 if D is a value higher than 22, which is the top end of the range (22%). 100 is to convert back to a number from %. 494 is the number of gallons in the tank.

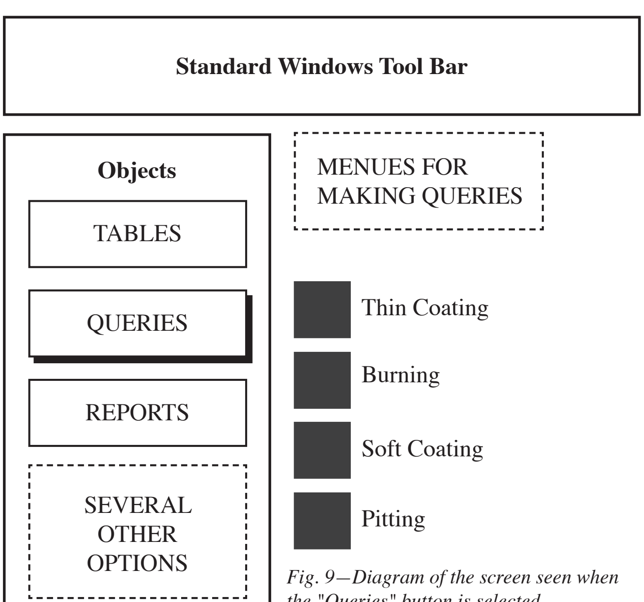

Fig. 9—Diagram of the screen seen when the "Queries" button is selected.

Table 3
Thirty-one Weeks of Data for a Gold Chromate Conversion Coating Bath

Chromate Conversion Coating (Gold)
Working Volume 2093 Gal
Range 5.3 - 7.3 mL Titration
pH Range 1.3 - 1.8

Enter Date	Enter mL STS*	Needed oz/gal	Addn. Lbs	Enter pH	Enter Initials
21-Sep-00	4.70	1.60	2.09	2.08	
22-Sep-00	6.70	0.00	0.00	1.86	
29-Sep-00	6.70	0.00	0.00	1.79	
02-Nov-00	7.20	0.00	0.00	1.79	
09-Nov-00	7.40	0.00	0.00	2.15	
16-Nov-00	8.00	0.00	0.00	1.87	
22-Nov-00	8.30	0.00	0.00	1.91	
30-Nov-00	6.40	0.00	0.00	1.91	
07-Dec-00	6.40	0.00	0.00	2.11	
14-Dec-00	6.60	0.00	0.00	1.89	
21-Dec-00	6.50	0.00	0.00	2.03	
28-Dec-00	6.30	0.00	0.00	1.95	
04-Jan-01	6.20	0.10	2.09	1.95	
12-Jan-01	5.80	0.50	10.47	2.10	
18-Jan-01	5.70	0.60	12.56	2.11	
25-Jan-01	5.50	0.80	16.74	1.90	
01-Feb-01	5.70	0.60	12.56		
08-Feb-01	5.60	0.70	14.65	2.32	
15-Feb-01	5.40	0.90	18.84	2.32	
22-Feb-01	5.90	0.40	8.37	2.00	
28-Feb-01	5.40	0.90	18.84	2.00	
08-Mar-01		Line Down			
15-Mar-01	5.30	1.00	20.93	2.47	
22-Mar-01	5.50	0.80	16.74	2.22	
29-Mar-01	5.55	0.75	15.70	3.05	
05-Apr-01	5.90	0.40	8.37	3.05	
12-Apr-01	6.10	0.20	4.19	2.05	
19-Apr-01	5.70	0.60	12.56	3.19	
25-Apr-01	5.50	0.80	16.74	2.42	
02-May-01	5.40	0.90	18.84	2.39	
10-May-01	5.70	0.60	12.56	3.39	
17-May-01	5.90	0.40	8.37	1.86	
Total Lbs. Chromate Added			252.21		

** sodium thiosulfate*

Access Query: “Thin Coating”

Problem	Cause	Reason	Action
Thin Coating	Volts / Amps	Rectifier Meters Wrong	Test with DVM Or Ammeter
Thin Coating	ASF Too Low	Connections Bad (High Resistance)	Clean, Check Racks
Thin Coating	Solution	Film Dissolving , Acid High	Analyze - Adjust (Dilute)
Thin Coating	Solution	acid Low (High Resistance)	Analyze - Adjust (Add)
Thin Coating	Solution	Film Dissolving, Temperature High	Measure - Adjust
Thin Coating	Solution	ASF Low, Temperature Low	Adjust Temperature
Thin Coating	Operations	Area Too large for rectifier	Reduce Number Of parts
Thin Coating	Operations	Run Time Too Short	Increase Time

Fig. 10—Diagram displaying the stored information on thin coatings when the "Thin coating" button in Fig. 9 is selected.