By Tony Palmer and Maureen Ross, P.E.

Using Maintenance Benchmarking Practices to Specify Chlorine Residual Analyzers

We all have been to that meeting where new regulatory standards requiring more stringent guidelines are announced, when it is demanded that the treatment facility be run more efficiently and that it has been decided that automation is inevitable. Of course, there is a limited budget.

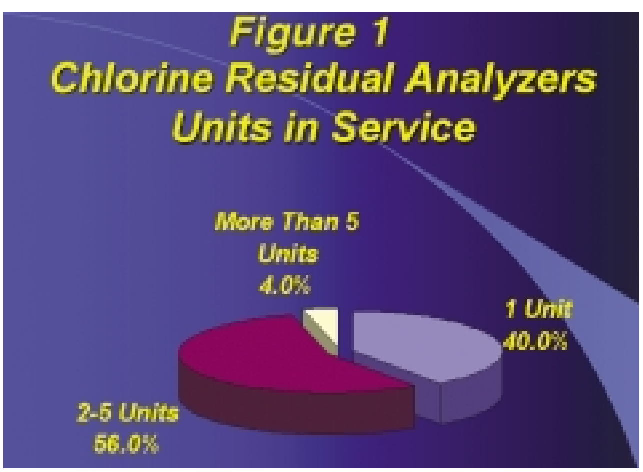
The first question is: "How am I going to meet permit requirements, accomplish improved control and reduce costs all at once?"

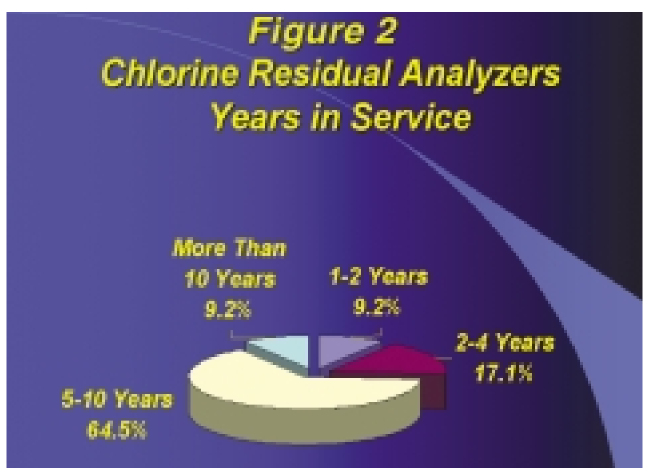
At the heart of addressing these issues is reliable instrumentation. After all, automation is only as good as the data received from the instruments used to monitor and control the plant. If your instruments are feeding your automation system faulty data, then your automation system will lack control resulting in potential permit violations, excessive chemical consumption and increased staff time spent troubleshooting.

Specifying Instruments

One of the most frustrating decisions for an environmental professional is selecting instruments that perform well, are reliable and can be easily maintained. Historically, environmental professionals have had a long-term love-hate relationship with instruments. The idyllic thought of installing instruments that will provide accurate data reliably is very appealing. The reality is that expectations are crushed when some of the instruments selected do not actually perform as promised. This occurred more frequently during the days of low-bid equipment procurement requirements.

So how can an instrument be selected that is accurate and reliable? What resources are available to verify instrumentation accuracy and reliability?





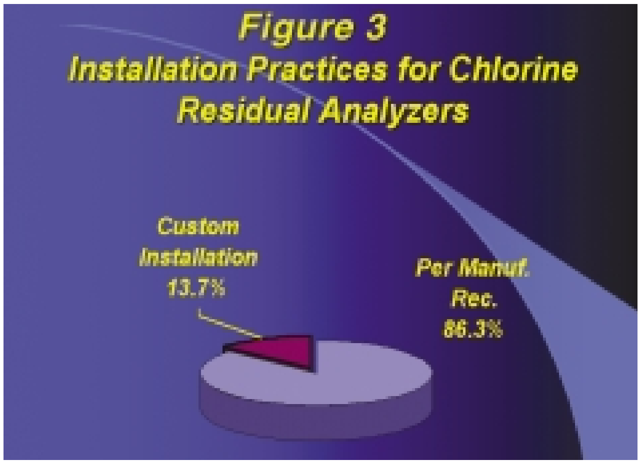


Figure 3 Installation Practices for Chlorine Residual Analyzers

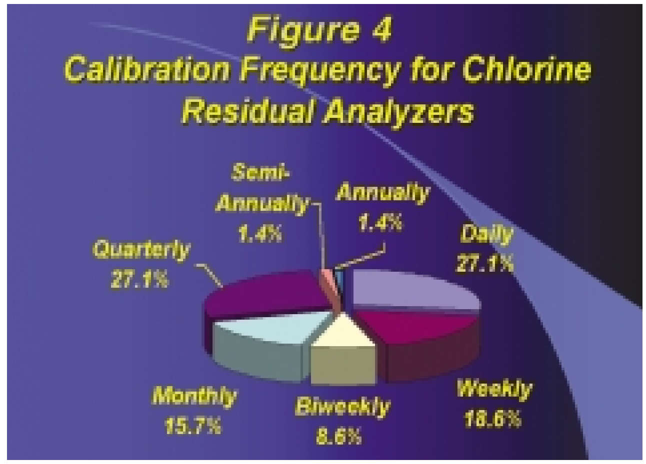


Figure 4 Calibration Frequency for Chlorine Residual Analyzers

These are the questions that were answered by utilities who joined forces to develop a third-party, non-profit, technical and educational organization with the objective to conduct cooperative testing of instrumentation used in the water and wastewater industry. Thus, the Instrumentation Testing Association (ITA) was formed in 1984 as an organization entrusted with this mission.

Available Resources

Resources such as ITA's Performance Evaluation Reports provide comparable data of varying instrument technologies performing in real-time treatment plant processes. Environmental professionals use the evaluation data to make informed decisions for specifying instrumentation for their specific applications. The long-term instrumentation operation, maintenance and performance practices reported by ITA's Maintenance Benchmarking Studies are another tool used to select instrumentation.

Maintenance Benchmarking Practices

ITA's 1999 maintenance benchmarking study, Total and Free Chlorine Residual Analyzers Online, presents reported online chlorine residual analyzer maintenance practices received from 135 surveyed treatment facilities throughout the United States and Canada.

Treatment facilities were asked to report their general information to formulate a plant profile of survey responses. Environmental professionals use reported plant profiles to match facility operation characteristics to their specific applications and needs.

The following summarizes plant profiles for the majority of plants participating in the survey. Ninety percent of the 135 surveyed plants treat wastewater. A majority of the plants (approximately 31 percent) participating in the survey treat an average flow of 1.0 to 10 mgd (3.785 to 37,850 m3/d) and approximately 27 percent treat an average flow of 10 to 50 mgd (37,850 to 189,250 m3/d). Approximately 47 percent have primarily municipal influent flow characteristics and more than 91 percent reported using suspended growth (activated sludge) secondary treatment.

For disinfection practices, 88 percent of the treatment facilities reported using chlorine or sodium hypochlorite as a disinfectant. For advanced treatment, 53 percent reported using nutrient removal by nitrification and/or denitrification as part of their treatment process.

Chlorine Residual Analyzers

ITA's survey requested treatment facilities to report which treatment processes were monitored with chlorine residual analyzers and what technologies were used. An almost even split (66 and 59 percent) reported the use of chlorine residual analyzers for monitoring disinfection and effluent, respectively.

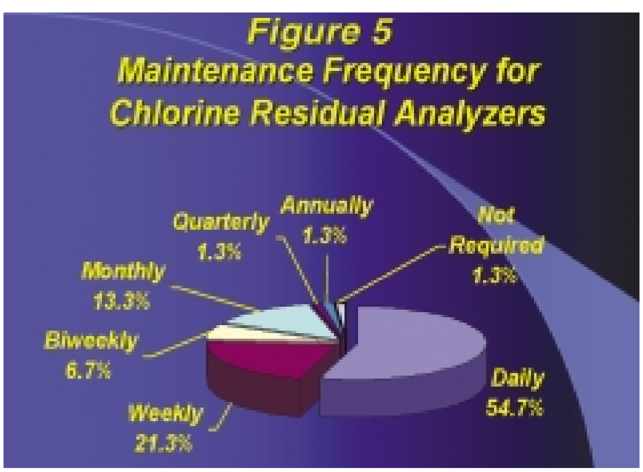


Figure 5 Maintenance Frequency for Chlorine Residual Analyzers

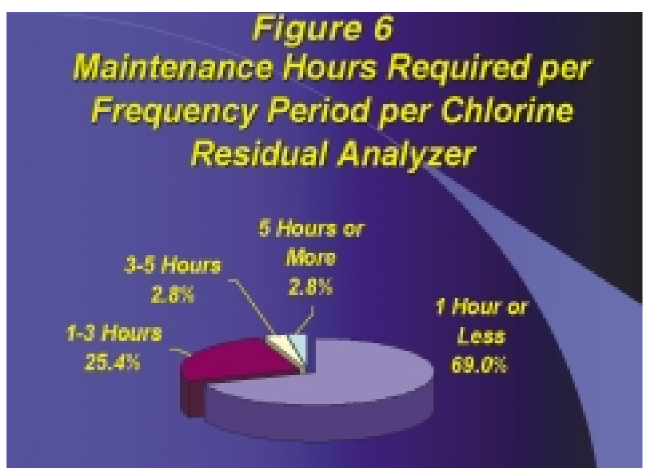
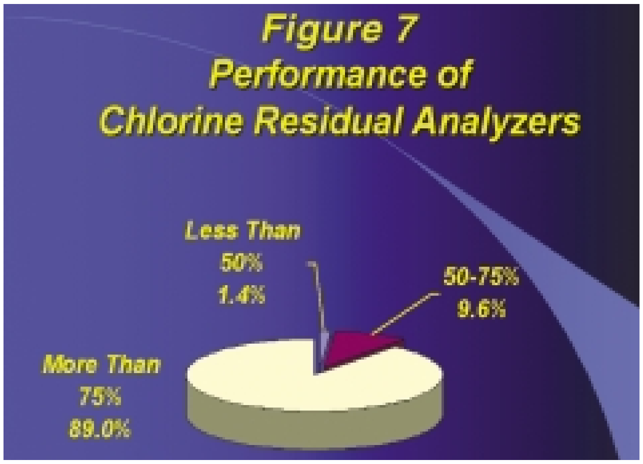
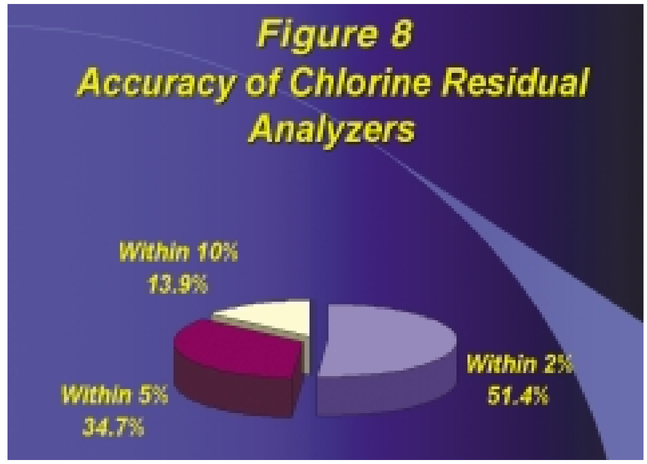


Figure 6 Maintenance Hours Required per Frequency Period per Chlorine Residual Analyzer





Units in Service

A majority of the treatment facilities (56 percent) reported using two to five total and free chlorine residual analyzers for disinfection. Forty percent reported one unit in service and 4 percent reported more than five units in service. (See Figure 1.)

Years in Service

Out of 76 facilities, the majority (64.5 percent) reported using total and free chlorine residual analyzers online for 5 to 10 years. Thirteen (17.1 percent) reported using an analyzer for 2 to 4 years. There was an even split (seven each) for facilities reporting total and free chlorine residual analyzers use for more than 10 years and 1 to 2 years, respectively. (See Figure 2.)

Installation Practices

Out of 73 facilities reporting installation practices, 63 (86.3 percent) installed total and free chlorine residual analyzer per the manufacturer's recommendations and 13.7 percent have custom installations. (See Figure 3.)

Calibration Frequency

A total of 70 survey responses was received for facilities reporting calibration frequency for online total and free chlorine residual analyzers used for disinfection. There was an even split (27.1 percent each) for facilities reporting frequency of performing calibration daily and quarterly, respectively. Thirteen (18.6 percent) reported a weekly calibration frequency and 15.7 percent reported a monthly frequency. Six (8.6 percent) have biweekly frequencies and one facility each have semiannual and annual frequencies. (See Figure 4.)

Maintenance Frequency

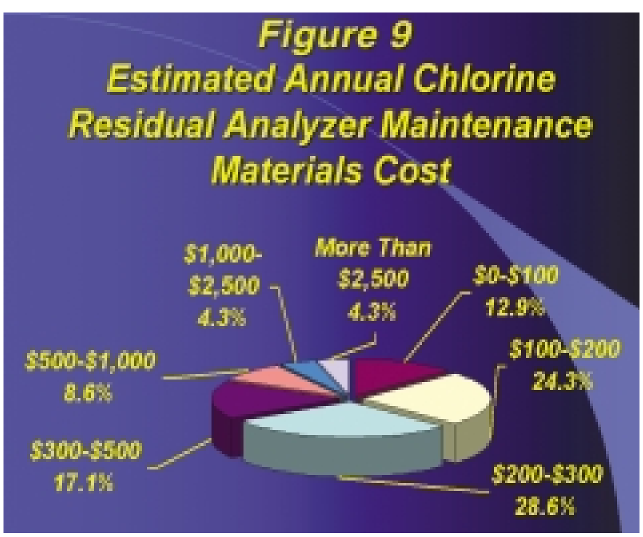
Out of a total of 75 treatment facilities, 54.7 percent reported performing daily maintenance for online total and free chlorine residual analyzers used for disinfection. Sixteen (21.3 percent) have weekly and 13.3 percent have monthly maintenance. Five facilities (6.7 percent) maintain their analyzers biweekly and there was one each for facilities reporting no required maintenance, quarterly maintenance and annual maintenance, respectively. Reported maintenance frequencies are intended to include accuracy verification checks. (See Figure 5.)

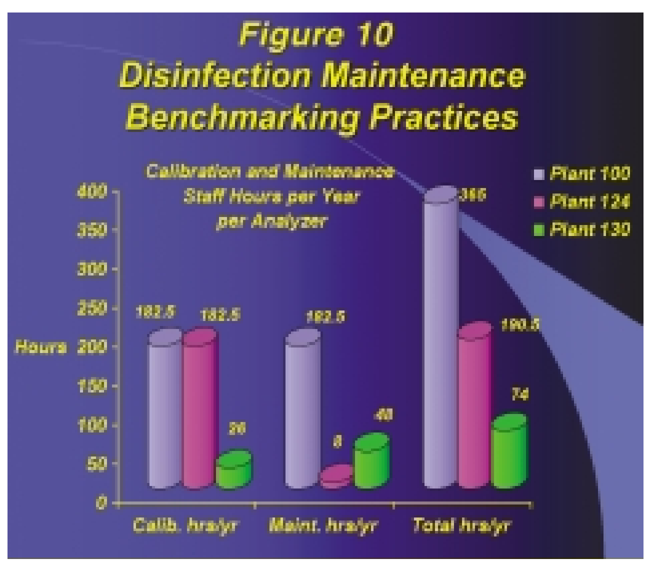
Maintenance Hours

Out of a total of 71 treatment facilities, the majority (69 percent) reported less than 1 hour for maintenance. Eighteen (25.4 percent) reported 1 to 3 hours for maintenance and there were two each (2.8 percent) that reported 3 to 5 hours and 5 hours or more of maintenance, respectively. (See Figure 6.)

Performance

Surveyed facilities were requested to report performance of their online total





and free chlorine residual analyzers, as defined by the percent of time the analyzer is in service. Out of 73 treatment facilities, the majority (89 percent) reported that their online total and free chlorine residual analyzers were in service more than 75 percent of the time. Seven (9.6 percent) reported in-service use at 50 to 75 percent and only one (1.4 percent) has its online total and free chlorine residual analyzer(s) in service less than 50 percent of the time. (See Figure 7.)

Accuracy

Reported accuracy includes the percent error compared to calibration. Accuracy for online total and free chlorine residual analyzers used for disinfection was reported by 72 treatment facilities. More than one-half (51.4 percent) reported accuracy within 2 percent, 25 (34.7 percent) have accuracy within 5 percent, and 10 facilities (13.9 percent) reported an accuracy of within 10 percent. (See Figure 8.)

Maintenance Material Cost

An estimate of annual maintenance material cost was requested for performing maintenance (per instrument) for online total and free chlorine residual analyzers used for disinfection. Cost data is intended to represent costs associated with performing analyzer maintenance, such as chemical cleaning solutions, spare parts and/or cost of replacing sensors/probes.

Twenty (28.6 percent) have $200 to $300 of maintenance costs and 17 (24.3 percent) have costs of $100 to $200. Twelve (17.1 percent) reported $300 to $500 in costs, nine (12.9 percent) reported $0 to $100, and six (8.6 percent) have $500 to $1,000 of maintenance costs. There was an even split, three each (4.3 percent each), of facilities reporting $1,000 to $2,500 and more than $2,500 in costs. (See Figure 9.)

Using Maintenance Benchmarking Data To Make An Informed Decision

Detailed data reported by surveyed treatment facilities are contained in tabular format in ITA's maintenance benchmarking study. A small portion of the survey data is provided in four tables. The following provides examples of how to use detailed information in these tables to make an informed decision.

Disinfection Maintenance Benchmarking Practices

Table 1—Analyzer Technologies

ID	Analyzer Type			Manufacturer	Model	Units in Service			Years in Service				Installation	
Plant ID No.	Total Chlorine Residual	Free Chlorine Residual	Oxidation Reduction Potential (ORP)			1	2-5	More than 5	1-2 years	2-4 years	5-10 years	More than 10 years	Per Manufacturer's Recommendations	Custom Installation
100	X			A	aaa		X				X		X	
107	X			B	bbb		X				X	X	X	
109			X	C	ccc	X			X					X
119			X	C	ccc	X				X			X	
124	X			A	aaa		X			X			X	
125	X			D	ddd	X				X			X	
127		X		E	eee	X				X			X	
130	X			F	fff	X				X			X	

Disinfection Maintenance Benchmarking Practices

Table 2—Calibration Practices

ID		Calibration		Calibration Range	Calibration Frequency						
Plant ID No.	Manufacturer	Required	Not Required	Values and Units	Daily	Weekly	Biweekly	Monthly	Quarterly	Semiannually	Annually
100	A	X		0-2 ppm	X						
107	B	X				X					
109	C	X		0-1000 mV		X					
119	C		X								
124	A	X		0 to 20 ppm	X						
125	D	X		-0.1 - 0.1 ppm			X				
127	E		X								
130	F	X		0 to 5 ppm		X					

Analyzer Technologies

Table 1 displays type, manufacturer and model of installed analyzers reported by the surveyed treatment facilities. In addition, this table identifies the number of units in service, years of service and installation.

The treatment facilities with the plant ID Numbers of 100 and 124 listed in Table 1 will be used for discussion. Each plant reported using a total chlorine residual analyzer from manufacturer "A" and Model "aaa." Both plants have two to five units in service. Plant 100 has used Model "aaa" analyzers for 5 to 10 years while plant 124 has used Model "aaa" for 2 to 4 years. The information contained in this table reveals that for these treatment facilities, this manufac-

Disinfection Maintenance Benchmarking Practices

Table 3—Maintenance Practices

ID		Automatic Cleaning/Maintenance Devices						Maintenance Frequency (includes accuracy verification)								Maintenance Hours Required per Frequency Period per Unit			
Plant ID No.	Manufacturer	None	Flushing	Brushing	Ultrasonic	Other	Other (specified)	Daily	Weekly	Biweekly	Monthly	Quarterly	Semiannually	Annually	Not Required	1 hour or less	1-3 hours	3-5 hours	5 hours or more
100	A	X						X								X			
107	B		X						X								X		
109	C		X						X							X			
119	C		X								X					X			
124	A	X										X					X		
125	D	X						X									X		
127	E	X													X				
130	F	X									X							X	

Disinfection Maintenance Benchmarking Practices

Table 5—Comparative Data

Parameters	Plant 100 Manuf. "A" Model "aaa"	Plant 124 Manuf. "A" Model "aaa"	Plant 130 Manuf. "F" Model "fff"
Application	Total chlorine residual	Total chlorine residual	Total chlorine residual
Installation	Per manuf. rec. 5-10 yrs	Per manuf. rec. 2-4 yrs	Per manuf. rec. 2-4 yrs
Performance (% of the time unit is in service)	50 to 75%	More than 75%	More than 75%
Accuracy (% error compared to calibration)	Within 5%	Within 5%	Within 5%
Calibration Frequency	Daily	Daily	Weekly
Calibration Range (values and units)	0 to2 ppm	0 to 20ppm	0 to 5 ppm
Maintenance Frequency (includes accuracy verification)	Daily	Quarterly	Monthly
Maintenance Hours Required per Frequency per Unit	1 hour or less	1 to 3 hours	3 to 5 hours
Estimated Annual Materials Costs per Unit (i.e., chemical cleaning solutions, spare parts, replacing sensors, etc.)	$300 to $500	$300 to $500	$0 to $100

turer and model are capable of long-term operating conditions if installed per the manufacturer's recommendations. (See Table 1.)

Calibration Practices

Table 2 displays instrument calibration practices and shows calibration frequency that can be translated to maintenance costs. For example, plants 100 and 124 require daily calibration compared to other plants' instruments that require a less frequent calibration, thus requiring less maintenance.

Although typically it is standard practice to calibrate all instrumentation, some treatment facilities reported that calibration is not required (as noted in plants 119 and 127). A lack of instrument calibration can affect instrument performance and automation control. This is the kind of information to take into consideration when looking at these facilities' reported data.

For plants 100 and 124, although the same manufacturer and model are used, calibration ranges vary from 0 to 2 ppm to 0 to 20 ppm, highlighting that this analyzer is capable of varying operating ranges. This could be a benefit if, for example, your disinfection process holds seasonal permits. (See Table 2.)

Maintenance Practices

Table 3 reports instrument maintenance practices, including supplementary automatic cleaning devices, maintenance frequency and the hours required to perform this maintenance. Both plants 100 and 124 do not report supplementary automatic cleaning devices for their analyzers. It interesting to observe that plant 100 performs maintenance on a daily basis for 1 hour or less whereas plant 124 performs quarterly maintenance for 1 to 3 hours. The difference in maintenance frequencies for these analyzers might be that instruments operating at smaller calibration ranges require maintenance to be performed more often. (See Table 3.)

Reported Effectiveness

Table 4 reports analyzer performance as a percent of time the instrument is in service, accuracy as the percent error compared to calibration and estimated annual maintenance material costs. Plant 100 reported its analyzer in service 50 to 75 percent of the time, having an accuracy within 5 percent. However, Plant 124 reported its analyzer performing more than 75 percent of the time at the same accuracy (within 5 percent). In addition, both plants also revealed that estimated annual maintenance material costs were $300 to $500 for each analyzer in service. (See Table 4.)

Summary

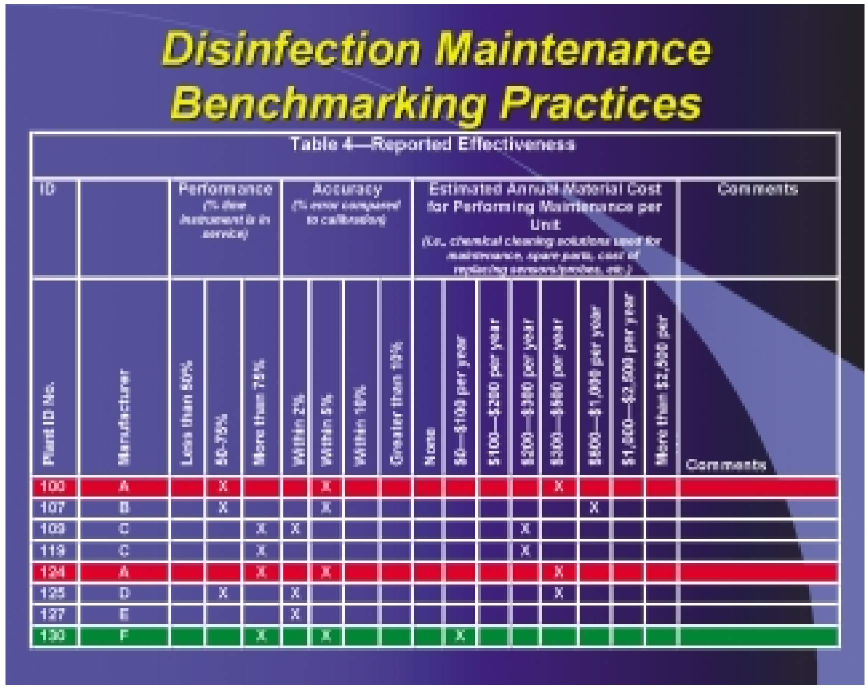
By comparing data from ITA's maintenance studies to your process needs, an assessment can be made to specify the best analyzer for your application.

For example, Table 5 shows comparisons for the data reported in Tables 1 through 4. Out of the data reported in Tables 1 through 4, plant 130 reports an installed analyzer from manufacturer "F" operating over a range of 0 to 5 ppm, with a reported accuracy within 5 percent operating more than 75 percent of the time. In addition to the other analyzers in these tables providing the same accuracy and operating conditions (such as analyzers from plants 100 and 124), the analyzer from plant 130 also provides the following benefits.

- The least amount of maintenance and calibration frequencies,
- The least amount of staff time, and
- The lowest maintenance material cost.

Assuming the analyzer from plant 130 meets your plant profile and application requirements, it would be wise to select this analyzer for its reported optimal performance and reliability capabilities. (See Table 5.)

Finally, Figure 10 shows direct comparisons of staff time required to perform calibration and maintenance for the three plants analyzers being considered for selection. The total staff time required by Plant 100 is 365 hours per year, as compared to 190.5 hours per year for Plant 124 and only 74 hours per year for Plant 130. By just comparing staff time necessary to perform calibration and maintenance, Plant 130's analyzer would be the most cost effective.



Disinfection Maintenance Benchmarking Practices

Table 4—Reported Effectiveness

ID		Performance (% time instrument is in service)			Accuracy (% error compared to calibration)				Estimated Annual Material Cost for Performing Maintenance per Unit (i.e., chemical cleaning solutions used for maintenance, spare parts, cost of replacing sensors/probes, etc.)								Comments
Plant ID No.	Manufacturer	Less than 50%	50–75%	More than 75%	Within 2%	Within 5%	Within 10%	Greater than 10%	None	$0—$100 per year	$100—$200 per year	$200—$300 per year	$300—$500 per year	$500—$1,000 per year	$1,000—$2,500 per year	More than $2,500 per	Comments
100	A		X			X							X				
107	B		X			X								X			
109	C			X	X							X					
119	C			X								X					
124	A			X		X							X				
125	D		X		X								X				
127	E				X												
130	F			X		X				X							

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