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**Chloramination Analyzer Life Cycle Cost Comparison**

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## **Chloramination Analyzer Life Cycle Cost Comparison**

### **Summary**

This document provides a comparison between chloramination monitoring using the ChemScan UV-2150/S Process Analyzer equipment furnished by Applied Spectrometry Associates, Inc and using equipment furnished by Hach, principally the APA-6000.

The comparison includes a discussion of equipment costs and O&M costs for each system, over a 5 and a 10 year period. The analysis includes either single or dual sample line operation.

The comparison shows that, even though the initial cost of the ChemScan system appears to be much higher, factors such as longer life expectancy, fewer hidden costs for additional equipment, less frequent repairs and much lower overall operating and maintenance cost result in a much lower total cost of ownership for the ChemScan system.

The total cost to own and operate a ChemScan UV-2150/S for one sample line is less than half of the equivalent Hach system over either a 5 or 10 year period. The life cycle cost for a dual sample line ChemScan system is about one third of the equivalent Hach system over the 5 or 10 year period.

# **Chloramination Analyzer Life Cycle Cost Comparison**

## **Introduction**

Numerous utilities have requested an analysis showing cost comparisons between the ChemScan UV-2150/S and the Hach APA-6000 for analysis of chloramination chemistry parameters in water disinfection and distribution monitoring applications. This document is intended to provide data for a complete life cycle cost comparison between these two products.

## **Life Cycle Cost Factors**

The usual factors for a life cycle analysis include the equipment costs plus the total operating cost of the equipment over the useful life of the equipment. For this analysis, both a five year and a ten year period will be used, owing to differences in the expected life of each system. It is assumed, for the sake of simplicity, that the rate of inflation and the discount or interest rates are identical. All figures are stated as a present value, based on recent list prices for equipment and supplies. Hach prices are based on the "2003 Products for Analysis" catalog. Current prices may differ. ChemScan prices are based on their FY 2005 internal price list. If O&M work is performed by owner personnel, it is assumed that the marginal rate for labor and benefits is \$35/hour. Time for tasks is based on field observations during side by side tests and reports from current owners of the equipment. Any group of tasks performed by owner personnel are assumed to require a minimum 1 hour period. No attempt has been made to make allowances for travel time to remote sites, so users of this report are cautioned to make appropriate allowances if the intended use of the equipment is for distribution monitoring.

## **Equipment Costs**

The owner may not see the full equipment cost when attempting to perform a cost comparison based only on vendor quotations because some of the costs may be included in the budget for installation by a third party contractor or intentionally not quoted as part of the initial price by the vendor. Investigation of the full costs borne by owners after the initial sale will often verify that an apparent low cost system may have substantial additional costs for equipment and accessories and that a system with a higher initial price may have very few of these additional hidden costs. A true "apples to apples" equipment cost comparison between products requires that consideration be given to the following major factors:

1. **Analytical Capability.** The suite of parameters recommended to adequately monitor and control chloramination processes include free ammonia, total ammonia, monochloramine and total chlorine. Additional parameters such as nitrate or nitrite may be recommended for distribution monitoring. The basic analytical capabilities of each product may differ and, if the two products are to be fairly compared, additional analytical equipment may be required so that the overall analysis capabilities of each system are equal. The ChemScan UV-

2150/S is capable of providing all four parameters required for full chloramination chemistry analysis. List price is \$25,000 for a one sample line, four output system. (Other ChemScan products can perform the full chloramination analysis suite plus additional analysis parameters.) For this analysis, the Hach APA-6000, at a list price of \$9,850 provides an analysis of total ammonia, free ammonia and monochloramine but is not capable of providing total chlorine analysis and must therefore be supplemented with an additional analyzer to provide this capability. The Hach CL-17 is the most frequent selection and has been used in the analysis, at a list price of \$2,862 each. This price includes Aquatrend network capability, but does not include power cord (\$26) and verification kit (\$122). The CL-17 is dedicated to one sample line, so two analyzers are needed if dual sample lines are to be monitored. (This comparison ignores the issue of whether or not the **quality** of analysis is identical. The Hach APA-6000 system does not perform a separate analysis of each parameter and relies on calculations to estimate some results.)

2. Peripheral Equipment. The ChemScan analyzer is sold complete with all necessary operator interface displays and data transmitters for output signals and alarms. Standard output formats are analog or MODBUS. The ChemScan analyzer can be factory configured for either one or two sample line operation. There is an additional charge of \$500 for the second sample line and \$250 for each additional output signal, so the total additional charge for a second sample point with either analog or MODBUS outputs is \$1,500. Other output formats are available at additional cost. The Hach APA-6000 is basically a stand alone product that has one or two sample line capability as standard. The "Aquatrend" display is a separate catalog item. The \$9,850 price quoted above includes an allowance for an Aquatrend display mounted on the front of the analyzer, but only includes allowance for two output signals. An additional Signal Output Module (SOM8) is required for additional analog outputs and has a list price of \$1,018 with power cord. MODBUS I/O and software has a list price of \$1,570 if this format is required. Analog outputs were assumed for this analysis. It was also assumed that one SOM8 module was required and could provide output signals for either the one or two sample line configurations for the APA-6000 and either one or two additional CL-17 analyzers.
3. Sample Conditioning. The ChemScan UV-2150/S does not require any external sample conditioning, although pressure reduction may be required if inlet pressure exceeds 60 psi. This was assumed not to be necessary for normal applications. The Hach APA-6000 may require extensive sample conditioning prior to analysis in order to reduce maintenance cycles. The sample feed mechanism is especially sensitive to particulates in the sample and the detection system is very sensitive to micro-bubbles in the sample. An air flush sample conditioning kit, list price \$126, and a micro filter system, list price \$2,100 are frequently required. One filter is assumed to be required for

each sample line. Some installations have also used bubble arrestors and sample heaters in an effort to improve reliability, but these items are not included in the analysis. Sample filters and other conditioning equipment will not be included in bids or quotations by Hach unless specifically required in bid documents by the owner, so these costs will not normally be seen as part of a cost comparison based on equipment quotes from vendors.

4. **Operating Environment and Installation.** Both manufacturers recommend that the analyzers be limited to indoor installation and require a pressurized sample from a bypass line, with sample flow from the analyzer discharged by gravity to a drain line or floor drain. 115 V operating power for either analyzer system is comparable and not a differentiating factor. Either analyzer system can be wall mounted to Unistrut. The ChemScan Analyzer can be furnished with an optional floor standing mounting rack at a list price of \$1,000. Indoor wall mount was assumed for the analysis, with all power at 115V, AC. No additional costs were assigned to either system related to this category.
5. **Service Life.** There is a substantial difference in the service life of these analyzers. The ChemScan analyzer has a service life in excess of 10 years. The Hach analyzers have a service life of less than 5 years. This has a substantial impact on how a life cycle cost comparison is performed. If the period of time selected for the comparison is five years or less, it must be assumed that the ChemScan system has a "residual value" equal to its remaining unused service life. If "straight line" depreciation is used and a five year period is considered, this residual value of the ChemScan equipment is equal to half of the original equipment acquisition costs for the analyzer plus all accessory items. If, on the other hand, a 10 year period is used for analysis, it is assumed that ChemScan will last the full period but at least one complete set of Hach equipment and accessories will be required to reach the end of the ten year period. It is assumed that a second set of equipment is purchased at the end of the 5<sup>th</sup> year. Since it was assumed that the inflation rate and the discount rate were identical, current year costs were assumed for the present value of this purchase.

<b>Equipment Cost Summary</b>	<b>ChemScan</b>	<b>Hach</b>
<b>One Sample Line System</b>		
UV-2150/S	\$25,000	
APA-6000		\$9,850
Aquatrend Display		Included
APA-6000 Power Cord		23
Air Flush Sample Conditioning Kit		126
Micro Filter System		2,100
CL-17		2,862
CL-17 Power Cord		26
CL-17 Verification Kit		148
Signal Output Module		995
Power Cord		23
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Subtotal	\$25,000	\$15,257
Residual Value after 5 years	\$12,500	\$ 0
Total Equipment Cost for 5 year period	\$12,500	\$15,257
Total Equipment Cost for 10 year period	\$25,000	\$30,514
<b>Two Sample Line System</b>	<b>ChemScan</b>	<b>Hach</b>
UV-2150/S (1)	\$26,500	
APA-6000 (1)		\$9,850
Aquatrend Display (1)		Included
APA-6000 Power Cord (1)		23
Air Flush Sample Conditioning Kit (2)		252
Micro Filter System (2)		4,200
CL-17(2)		5,724
CL-17 Power Cord (2)		52
CL-17 Verification Kit		148
Signal Output Module		995
Power Cord		23
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Subtotal	\$26,500	\$21,267
Residual Value after 5 years	\$13,250	\$ 0
Total Equipment Cost for 5 year period	\$13,250	\$21,267
Total Equipment Cost for 10 year period	\$26,500	\$42,534

## **Operating and Maintenance Costs**

The cost to operate and maintain an analytical system over its useful life can often exceed the initial cost of the system and can differ substantially between systems. Owners may not be aware of the full operating cost of an analyzer because out-of-pocket expenses for maintenance and consumables are budgeted separately from the capital costs for the analyzers. Purchase of reagents, standards and supplies may be part of a larger order for instrument and laboratory supplies. The labor costs for operation and maintenance are usually dispersed throughout the organization and are rarely summed as a specific line item. This is especially true if the maintenance of the analyzers is one responsibility among many other responsibilities being performed by the staff. It should also be noted that some vendors have a “business model” that minimizes the initial cost of the equipment and maximizes the sustaining cost to operate and maintain the equipment, usually because the vendor expects to receive a captive stream of revenue associated with the sale of proprietary services, consumables and parts. Other “business models” are based on the supply of high quality equipment that will minimize the cost of operation and maintenance. These vendors must charge more for the higher quality equipment initially provided because they do not expect a captive stream of after-sale revenue.

Operating and maintenance costs can be divided into the following major categories:

1. **Commissioning (Start-up) Costs.** These costs include services related to on-site check of the equipment after installation prior to initial operation, field configuration of the equipment to operate as intended (activation of analysis parameters, sample lines, etc), functional check of equipment and integration with peripheral items and accessories, installation of initial reagents and consumables, adjustment and calibration of the equipment for analysis of the parameters, verification and adjustment of outputs and alarms and training of owner personnel for operation and maintenance. ChemScan generally performs these functions using factory based specialists traveling from Waukesha, WI. An allowance for time and travel, amounting to \$2,500 is included in the purchase price of the equipment, regardless of whether one or two sample lines are configured. Hach generally relies on their local distributor or regional representative to perform this work, so most travel expenses are avoided. A typical allowance of \$250 per instrument covers the time of the local representative. Unlike ChemScan, the purchase price of a Hach analyzer may not necessarily include an allowance for commissioning, which may need to be ordered as a separate item if not performed by contractor or owner personnel. This analysis includes an allowance for commissioning each of the Hach APA-6000 and CL-17 analyzers. A second set of

commissioning costs are required for the second set of Hach equipment under the 10 year evaluation.

2. Consumable Items. Consumables include reagents and standards plus any other wear items that are regularly replaced during routine service by the owner. This does not include any spare or repair parts, which are included in a separate category. An evaluation of consumables requires more than a simple tabulation of a purchase price for the consumable items. The evaluation must also consider usage rate (a variable based on the cycle time of the analyzer), vendor policy concerning shelf life for chemicals (which may prohibit full utilization of the quantity purchased) plus any owner supplied labor for sample preparation that may be required.

a. The consumables for the ChemScan UV-2150/S include reagents, zero standard and cleaning solution.

i. ChemScan Reagents. Reagents may be purchased as premixed solutions from third party vendors, but most owners prefer to purchase the component commodity chemicals directly from a laboratory supply distributor (such as Fisher or Aldrich) and mix the specific reagents in bulk quantity. This is the most economical arrangement if a large number of analyzers are being operated. Some labor is required for reagent mixing, but the long shelf life of the ChemScan reagents means that the supply of reagents in the analyzer can be “topped off” rather than fully replaced. All reagents can be mixed in 1 hour or less, which can be limited to once each quarter (4 times per year) Reagents are identified by the color code on the 1 liter reagent bottle located in the analyzer. The analysis assumes 120 analysis cycles per day. More cycles per day are possible but this analysis uses the higher cost per day associated with small quantity volumes to balance the lower cycle time:

1. Yellow Stripe: Each 1 liter bottle consists of 15 grams of sodium hydroxide, 10 grams of tripolyphosphate, and 100 ml of bleach in 900 ml of DI water. Use is 0.1 ml of mixed reagent for each analysis cycle for a total of 12 ml per day. A 1000 ml container will last 83 days. Cost of the components in small quantity is \$1.92 per liter or \$0.023 per day. Large quantity purchase of the component chemicals will not significantly reduce the cost per day.

2. Green Stripe: Each 1 liter bottle contains 10% Sulfuric acid, normally purchased already dilute. Use is 0.3 ml of dilute acid for each analysis cycle for a total of 36 ml per day. A 1000 ml container will last 28 days. Cost of premixed acid is \$14.51 per liter or \$0.518 per day. Large quantity purchase can reduce the cost per day to \$0.17.
  3. Grey Stripe: Each 1 liter bottle contains 100 grams of potassium iodide and 20 grams of tripolyphosphate in 1000 ml of DI water. Use is 0.15 ml of mixed reagent for each analysis cycle for a total of 18 ml per day. A 1000 ml container will last 55 days. Cost of components in small quantity is \$42.25 per liter or \$0.768 per day. Large quantity purchase of the components can reduce the cost per day to \$0.18.
- ii. Zero Standard. ChemScan uses DI water as the zero standard. The DI water is stored in a container below the analyzer. Use depends on the frequency of zeroing. A minimum of 30 liters per month is typical. It was assumed that most owners will produce their own DI water in a central laboratory. Cost per liter is therefore insubstantial in the quantities required by ChemScan. Labor cost to replenish is tabulated under operating labor.
  - iii. Cleaning Solution. ChemScan uses dilute muriatic acid for cleaning, 1 liter of acid in 9 liters of DI water. The cleaning solution is stored in a container below the analyzer. Because cleaning is on demand based on internal set points, actual use is unpredictable, but average use of cleaning solution is estimated at 10 liters per quarter. Cost of components is \$5.00 per liter or \$0.055 per day.
  - iv. Other Items. No other consumable items are required for ChemScan.
- b. The consumables for the Hach APA-6000 include reagents, standards, and operating supplies. Hach has a 30 day shelf life limit on all reagents and standards, so all chemical consumables must be replaced at the end of each month, whether fully used or not. This analysis assumes 1 liter per month for each chemical, which are supplied in premixed 1 liter bottles. Prices are from 2003 and may differ from current pricing:
- i. Reagent 1, Indicator \$34.85/liter
  - ii. Reagent 2, Buffer \$14.20/liter

- iii. Reagent 3, Reactant \$19.95/liter
      - iv. Standard 1, low ammonia \$15.75/liter
      - v. Standard 2, high ammonia \$15.60/liter
      - vi. Air Flush Sample Conditioning Kit (replacement filter cartridge is necessary at 1/month/filter) \$126.00 each
    - c. The consumables for each Hach CL-17 include reagents, calibration kits and maintenance kits. 30 day shelf life applies to the reagents, which are premixed in 473 ml bottles. Use is 1 bottle per month for total chlorine analysis.
      - i. Reagent 1, Indicator Solution \$12.50/bottle
      - ii. Reagent 2, Buffer Solution \$12.50/bottle
      - iii. Calibration Kit \$122.55/quarter
      - iv. Maintenance Kit, for annual maintenance of the reagent tubing, caps and fittings plus quarterly replacement of pump module tubing. \$98.80/year
3. Operating Labor. Operating labor includes all time required to perform regular routine tasks such as reagent preparation and servicing of consumables for the analyzer and also including related scheduled maintenance replacements and adjustments.
- a. ChemScan operating labor includes periodic reagent mixing and replenishment of consumables at the analyzer.
    - i. Reagent mixing can be limited to 1 hour per quarter for all reagents, 4 hours per year total.
    - ii. Consumable replenishment and adjustment could be as frequent as once each two or three weeks, due mainly to the need to top off the zero standard if a 20 liter container is used. If a larger zero container is used, visits can be limited to once each month. We have used two visits per month for this analysis, although less frequent visits are possible and easily achieved. The operator may download maintenance logs, re-prime the reagent injectors, perform a manual test zero, enter slope and offset adjustments and/or collect comparison samples during the visit within the allotted one hour time per visit.
    - iii. No routine parts replacements are required for ChemScan.
  - b. Hach APA-6000 routine operating labor includes replacement of reagents and servicing of the sample filters.
    - i. Reagents and standards must be replaced once each month. Calibration checks may also be performed during the visit.
    - ii. The filter requires a replacement element and other cleaning once each month.

- c. Hach CL-17 routine operating labor includes replacement of reagents and servicing of the reagent delivery system.
    - i. Reagents must be replaced once each month. A monthly manual calibration is necessary. More frequent calibration may be required for some applications.
    - ii. Reagent tubes, caps and fittings are replaced annually. Pump module tubing is replaced quarterly.
  - d. One hour of routine operation labor each month was allocated for a Hach system consisting of one APA-6000, one filter and one CL-17. If a second sample line is operated, an additional hour of labor was allocated for the second filter and CL-17.
4. Maintenance and Repairs. There are substantial differences between the analyzers for this category of cost.
- a. The ChemScan UV-2150/S analyzer has very few moving parts or wear items. These parts are limited to reagent injectors, manifold valves and an internal diaphragm pump. Replacement parts average less than \$500.00 per year for the UV-2150/S. Pre-stocking of parts is not recommended, as all parts are available for overnight shipment. No special skills are required for installation of most replacements, which avoids the need for routine service by factory personnel. Most repairs can be performed in 2 hours or less by owner personnel. For this analysis we have allocated one ChemScan repair every other year by owner personnel at 2 hours per repair (averaged to one hour per year). The original ChemScan equipment and any replacement parts are warranted for 12 months from initial operation, not to exceed 18 month from shipment. Extended warranties are available at additional cost.
  - b. ChemScan recommends but does not require a periodic service visit after the initial warranty period to check analyzer functions, verify software settings, check major subassemblies and adjust solid state optics. One visit every other year is sufficient. This service may be performed by factory personnel or by authorized third parties that have been factory certified. Most major chloramination markets have third party maintenance available at an average cost of \$600 per visit. One local maintenance visit every other year was used for this analysis (average \$300 per year).
  - c. The Hach APA-6000 requires frequent servicing of the sample feed and flow injection control mechanism, which wears very rapidly. When wear occurs, the ratio between reagent and sample is altered and inaccurate measurements are made by the analyzer. Many owners report that a rebuild of the sample feed system is required once every four to six weeks. Starting in 2005, Hach requires that a mandatory service contract be

purchased with the APA-6000 system. This service contract has reportedly been quoted at \$2400 per year in some markets where there is a substantial installed base of analyzers. The contract prepays one visit each quarter, but does not include the cost of replacement kits, at \$150 per replacement. If the rebuild rate is only once every six weeks, only four replacements per year are performed by the Hach representative under the service contract, leaving at least 4 rebuilds per year to be performed by owner personnel. One analyzer system would require either two service contracts from Hach or allocation of owner personnel time for additional rebuilds. Each rebuild requires 4 hours. We estimate a minimum of 4 rebuilds per year by owner personnel. Estimated material costs related to these rebuilds are \$150 each or \$1200 per year, not including labor.

### Operating and Maintenance Cost Summary

One Sample Line System	ChemScan	Hach
Commissioning	\$2,500	\$ 500
Consumables		
ChemScan		
Reagents	478/year	
Cleaning	20/year	
APA-6000		
Reagents		828/year
Standards		376/year
Filter Kits		1,512/year
CL-17		
Reagents		300/year
Calibration Kits		490/year
Maintenance Kit		99/year
Operating Labor		
ChemScan		
Reagent Mixing (4 hrs)	140/year	
Consumable Service (24 hrs)	840/year	
APA-6000		
Reagent Changes		420/year
Filter Maintenance		Included
CL-17		
Reagent Changes		Included
Repairs and Maintenance		
ChemScan		
Spare/Repair Parts	500/year	
Repair Labor (1 hr)	35/year	
Service Visit	300/year	
APA-6000		
Rebuild Kits		1,200/year
Service Contract		2,400/year
Repair Labor (16 hrs)		560/year
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Subtotal, Annual Costs	\$2,313/year	\$8,185/year
5 year costs, annual	\$11,565	\$40,925
5 year commissioning	2,500	500
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5 year total O&M	\$14,065	\$41,425

10 year costs, annual	\$23,130	\$81,850/year
10 year commissioning	2,500	1,000
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10 year total O&M	\$25,630	\$82,850
Two Sample Line System	ChemScan	Hach
Commissioning	\$2,500	\$ 750
Consumables		
ChemScan		
Reagents	478/year	
Cleaning	20/year	
APA-6000		
Reagents		828/year
Standards		376/year
Filter Kits (2)		3,024/year
CL-17 (2)		
Reagents		600/year
Calibration Kits		980/year
Maintenance Kit		198/year
Operating Labor		
ChemScan		
Reagent Mixing (4 hrs)	140/year	
Consumable Service (24 hrs)	840/year	
APA-6000		
Reagent Changes		420/year
Filter Maintenance		Included
CL-17 (2)		
Reagent Changes		420/year
Repairs and Maintenance		
ChemScan		
Spare/Repair Parts	500/year	
Repair Labor (1 hr)	35/year	
Service Visit	300/year	
APA-6000		
Rebuild Kits		1,200/year
Service Contract		2,400/year
Repair Labor (16 hrs)		560/year
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Subtotal, Annual Costs	\$2,313/year	\$11,006/year

5 year costs, annual	\$11,565	\$55,030
5 year commissioning	2,500	750
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5 year total O&M	\$14,065	\$55,780
10 year costs, annual	\$23,130	\$110,006
10 year commissioning	2,500	1,500
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10 year total O&M	\$25,630	\$111,506

### Summary, Life Cycle Costs

	ChemScan	Hach
One Sample Line System		
5 year Equipment	\$ 12,500	\$ 15,527
5 year O&M	14,065	41,425
5 year Total Cost	<u>\$ 26,565</u>	<u>\$ 56,952</u>
10 year Equipment	\$ 25,000	\$ 30,514
10 year O&M	25,630	82,850
10 year Total Cost	<u>\$50,630</u>	<u>\$113,364</u>
Two Sample Line System		
5 year Equipment	\$ 13,250	\$ 21,267
5 year O&M	14,065	55,780
5 year Total Cost	<u>\$ 27,315</u>	<u>\$ 77,047</u>
10 year Equipment	\$ 26,500	\$ 42,534
10 year O&M	25,630	111,506
10 year Total Cost	<u>\$ 52,130</u>	<u>\$154,040</u>