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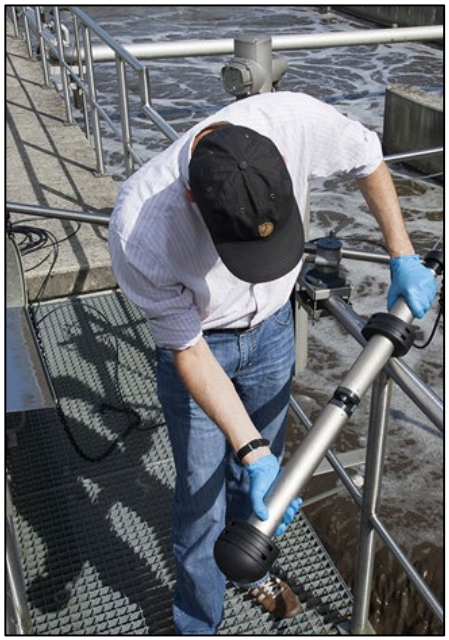
July, 2020

Webinar
Photometry & Automated Chemistry Analyzers

XAVIER TAN -&- BENJAMIN CHIANG

WTW Webinar Series

June 25
How to monitor BOD with OxiTop (Part #1)



July 7
Online Wastewater Monitoring of COD/BOD With Spectral Sensors

July 9
How to monitor BOD with OxiTop (Part #2)

July 14
Photometry basics & Automated Chemistry Analyzers

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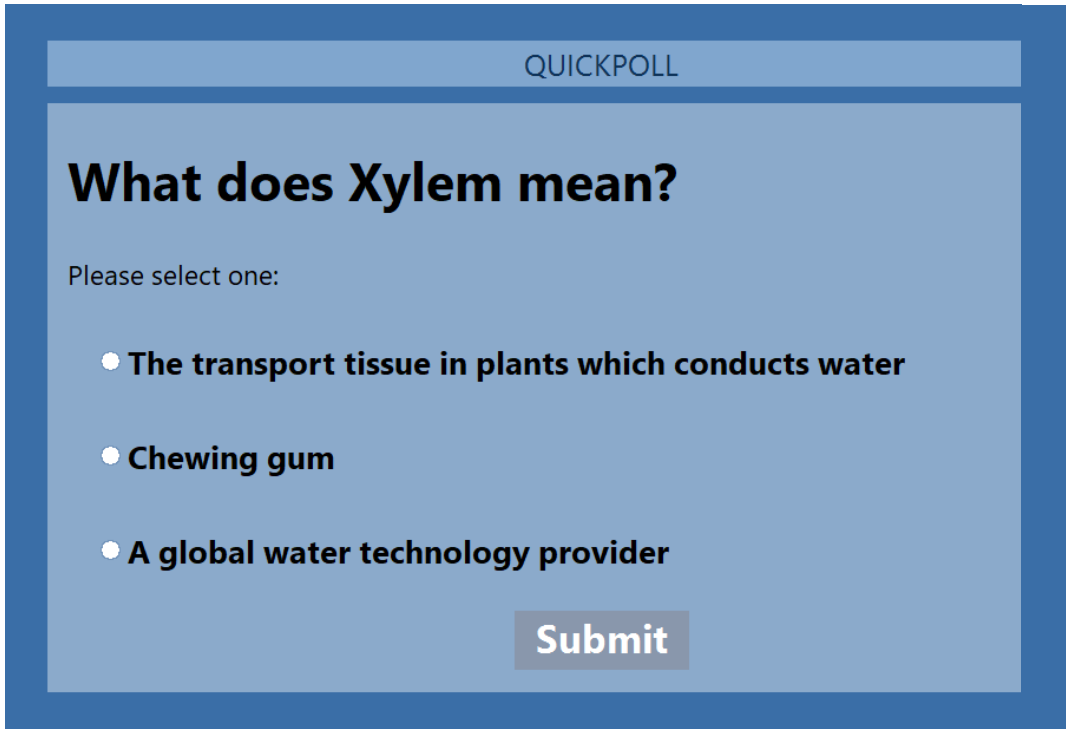
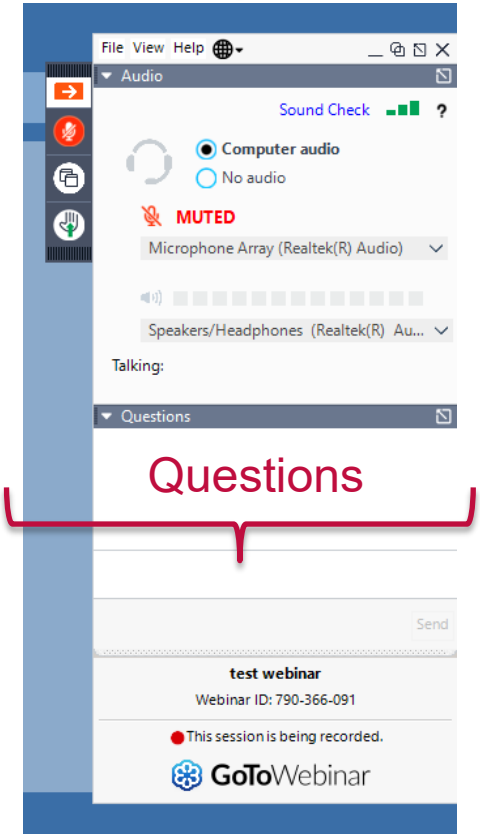
GoToWebinar

Poll Question



Control Panel



Questions

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Month XX, 20XX

WTW Photometry

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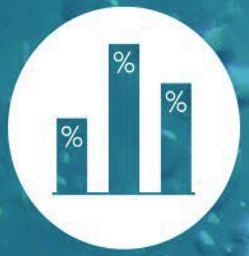
Xavier Tan

- Lab and Process Product Manager for water and wastewater, South East Asia
- 8 years laboratory and online process instrumentation
- 1 year with Xylem
- Product manager for WTW, STM & MJK instrumentation



Poll Question #1

Which part of the industry are you from?

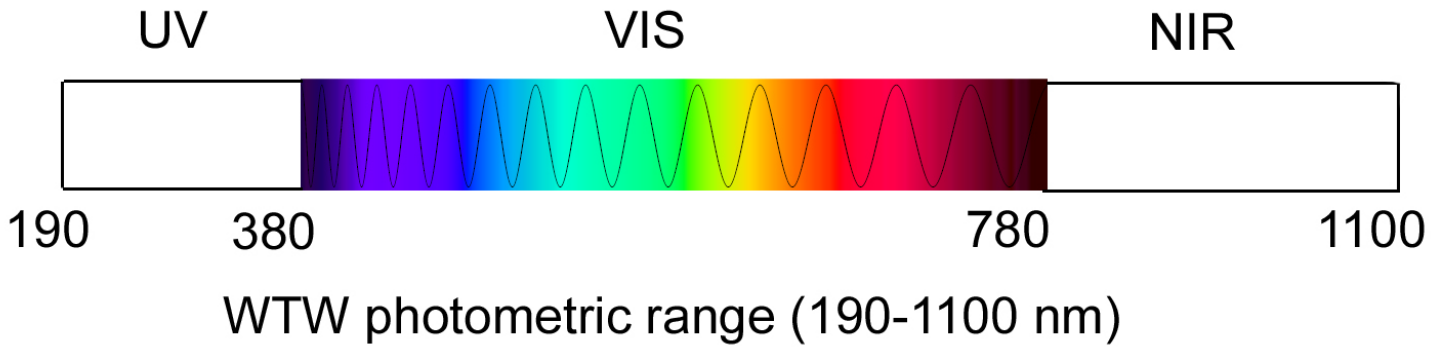
Overview

- Introduction to Photometry
  - Light & Optics
  - Measurements
- Xylem Analytical Lab & Field Photometric Solutions
  - WTW Lab & Field Photometers
  - OI Automated Chemistry Analyzer
- Q & A

Introduction to Photometry

Phos (Greek) for light => Photometry is a measurement method to analyse (aqueous) solutions by means of a light source.

Light (physical) is a spectra of electromagnetic waves, divided into different ranges: Visible light (white light) ranges from approx. 380 – 780 nm



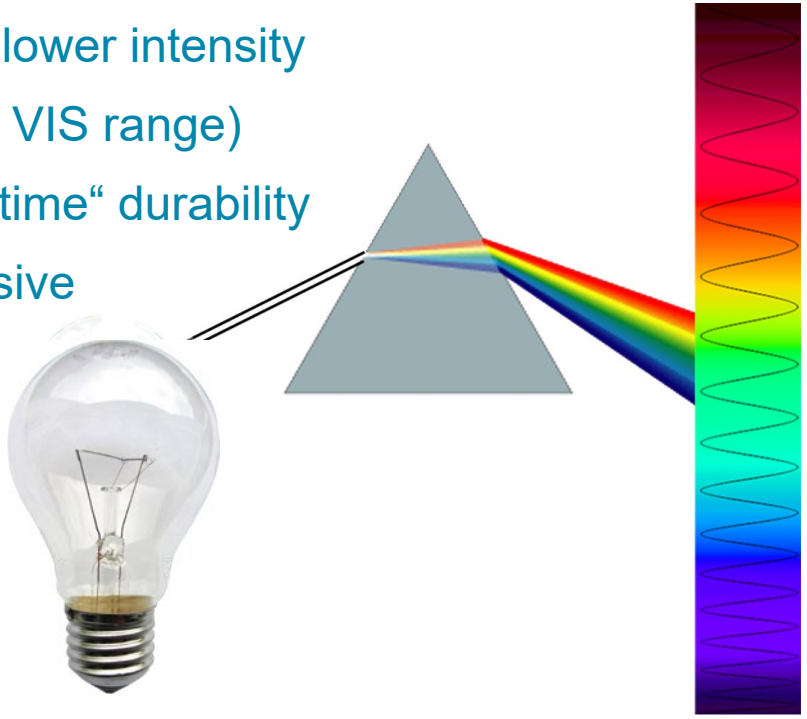
Photometric / Colorimetric Analysis:
Determination of substances by their specific colour reaction / absorbance to their chemical properties at a specific wavelength.

Introduction – Light and Optics

Specific Wavelengths are obtained by

Different light sources

- LEDs (λ_x) = lowest power consumption, lower intensity
- Tungsten (White light halogene lamp for VIS range)
- Xenon (UV-VIS) => Flash lamp with „lifetime“ durability
- Deuterium (UV) => special lamp, expensive

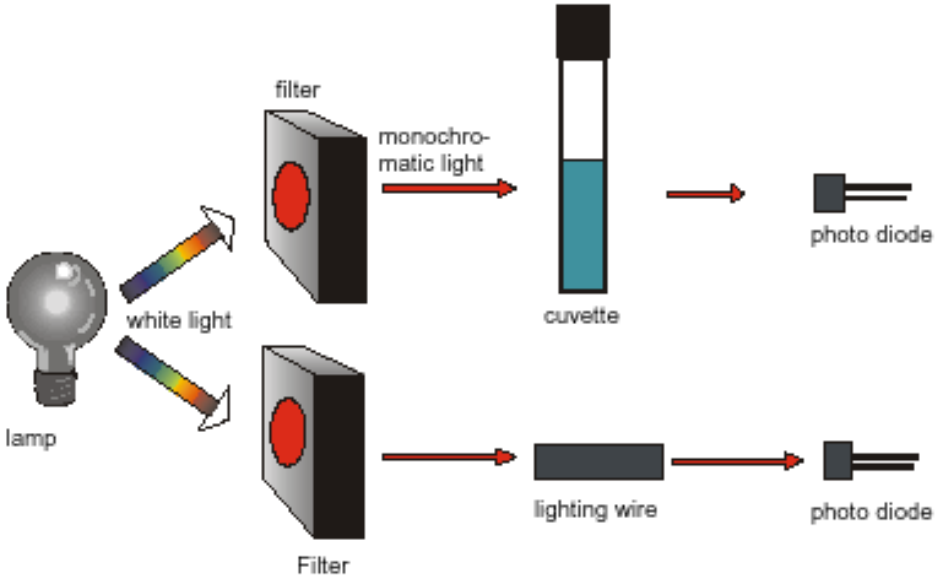


and different optical techniques

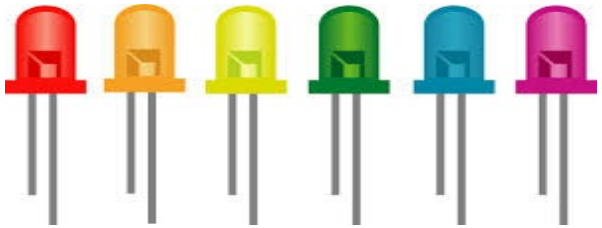
- Monochromator
- Polychromator
- Filter
- others

Optics: Filter and LED Photometer

Filter photometer with reference beam: photoLab® S6/S12 Series

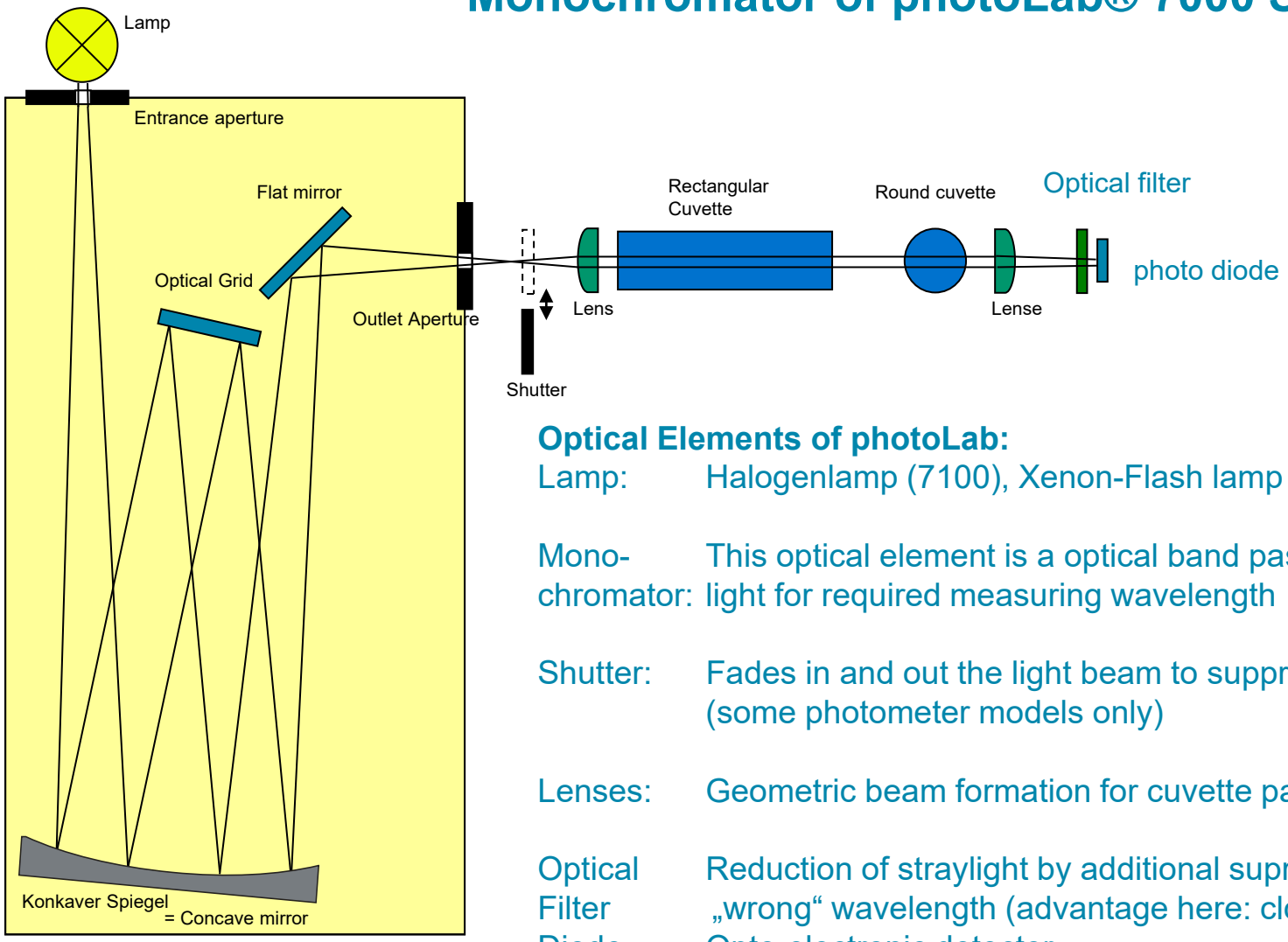


LED_{λ} + optical Filter – single beam: photoFlex ® Series



Optics - Spectrophotometer

Monochromator of photoLab® 7000 Series



Optical Elements of photoLab:

Lamp:	Halogenlamp (7100), Xenon-Flash lamp (7600)
Mono-chromator:	This optical element is a optical band pass to uncouple light for required measuring wavelength
Shutter:	Fades in and out the light beam to suppress ambient light (some photometer models only)
Lenses:	Geometric beam formation for cuvette passing light beam
Optical Filter	Reduction of straylight by additional supression of light of „wrong“ wavelength (advantage here: close to diode)
Diode	Opto-electronic detector

Measurement modes

What type of measurement is performed in (UV-)VIS?

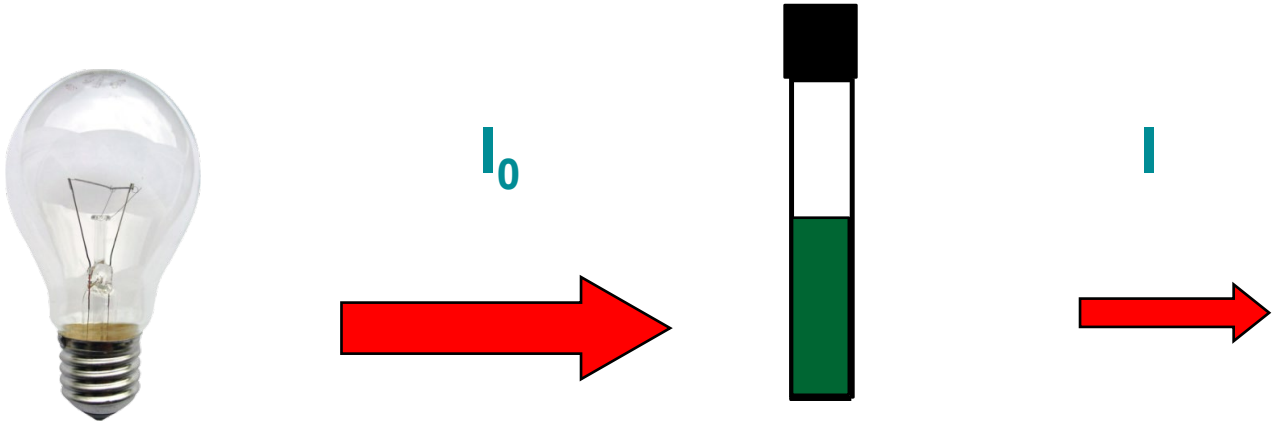
=> 3 Measurement modes of Photometric Analysis

1.) **Transmission T (%)** : light intensity before and after cuvette

2.) **Absorbance**: Abs_{λ} = - log (T) or „Extinction of light intensity“

3.) **Concentration**:
quantitative analysis of defined substance at a defined wavelength based on a calibration curve

Transmission measurement



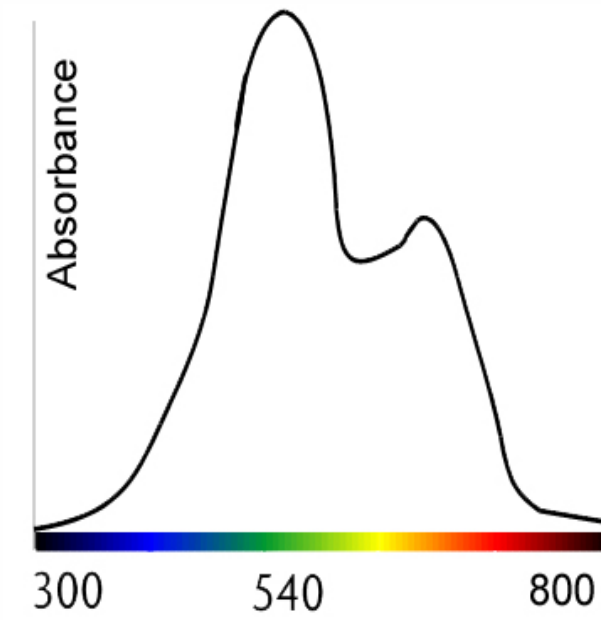
Transmission is the ratio of passed light **I** / initial light I_o: $T\,\% = \frac{I}{I_o} \times 100$

Transmission measurement can be also used in photometers to measure **turbidity at 180°** (angle of light): => correction factor or turbidity measurement in the unit FAU

Absorbance / Concentration Measurement

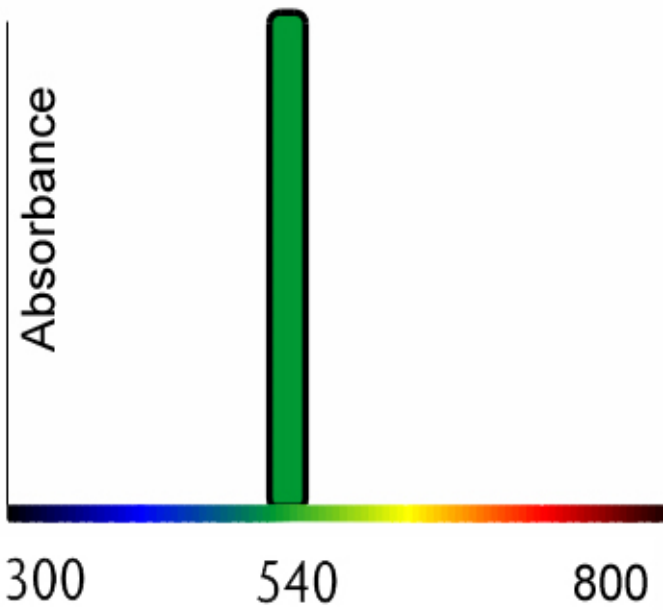
Absorbance = „Extinction of light“:
Each substance has a specific spectra with an absorbance peak

=> Spectra is the preliminary task to define the wavelength for concentration measurement



Concentration measurement:

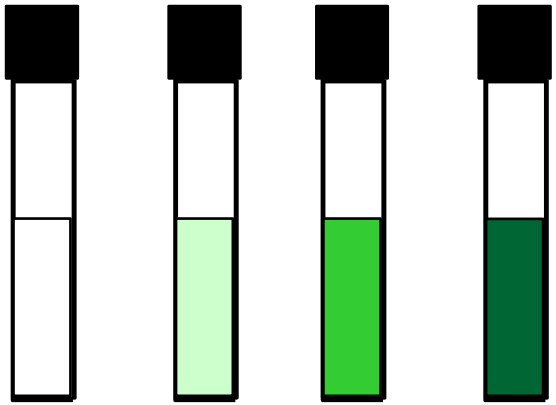
The specific wavelength at absorbance peak will be obtained by matching LED, optical filter or monochromator



Relation %T / Abs / Conc.

Transmission measurement:
The transmission of a sample varies **exponentially** with thickness and concentration

Absorbance measurement:
Absorbance of a sample is **proportional** to thickness of the sample and concentration



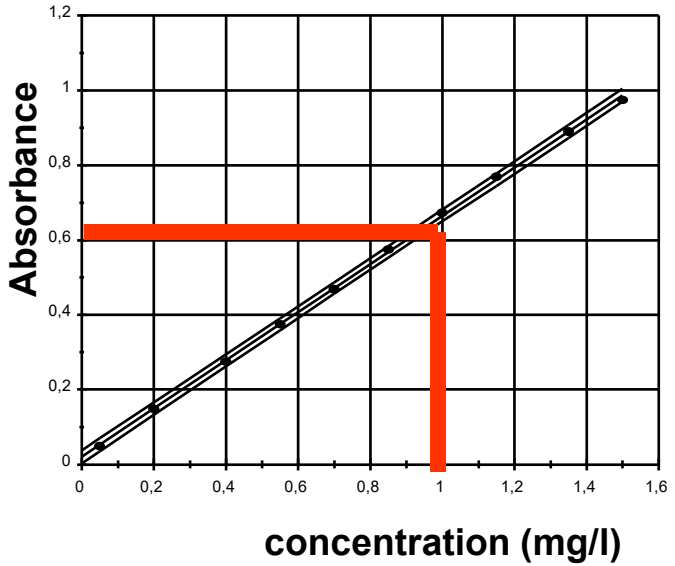
Transmission (T%)	100	10	1	0,1	=> Logarithmic correlation
Absorbance A = -lg (T)	0	1	2	3	=> linear correlation
Concentration (mg/l)	0	4	8	12	

Concentration Measurement

Linearity for absorbance => concentration measurement based on

calibration curve

for each parameter (sustance):
known concentrations at a defined λ
(at defined pathlength = cuvette size)



Unknown concentration can be „read“ in the curve!

Method data / Programs: programmed calibration curves in the meters
=> automatic calculation of concentration by absorbance value

Method data / Program for each parameter

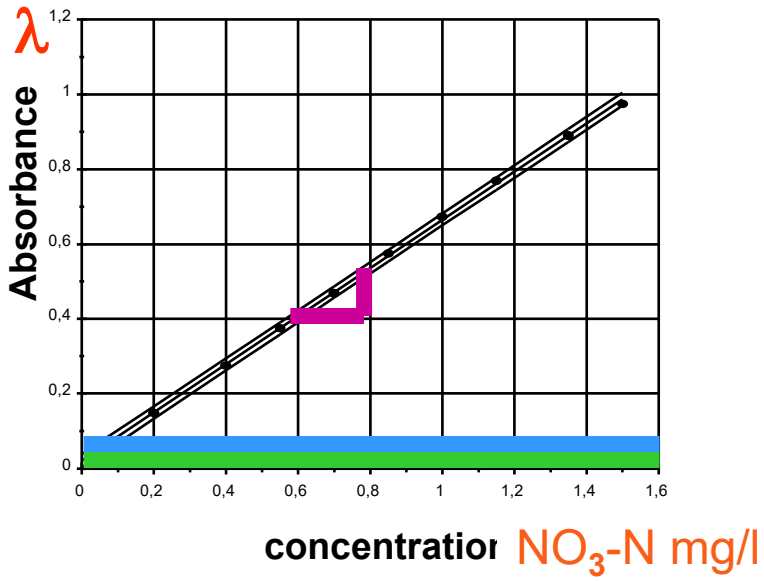
Method data contain all necessary information for the concentration measurement:

λ = usually absorbance peak of substance

Reagent blank Eo = coloration of reagent

Factor for calculation: slope of the kurve

Citation & unit (e.g. NO_3-N mg/l)



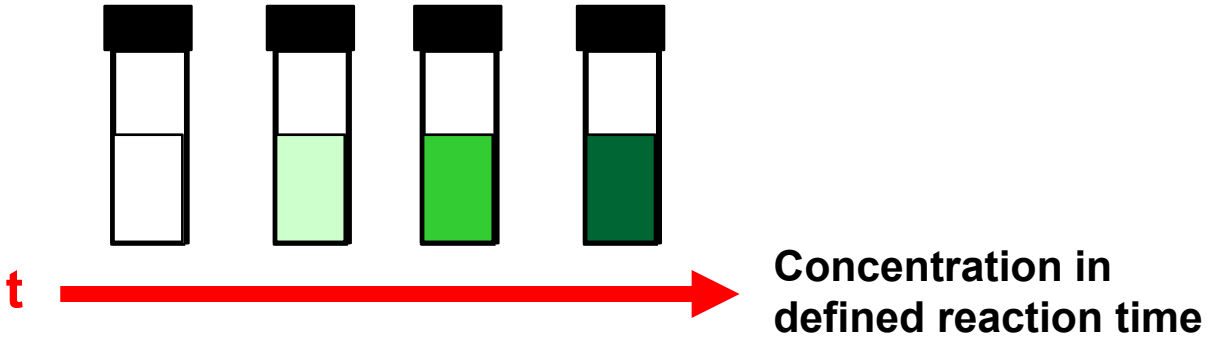
Caclulation factor to change citation & unit (e.g. NO_3; mmol/l)

Sample blank (e.g. coloration of the sample) is **not** included!
„Eo“ would be increased: individually for sample, no defined factor!

Pre-Requisites

- Coloured solution contains dissolved dye
  absorption of light leads to a coloration in **complementary color**
  Intensity is in relation to concentration

- The chemical reaction of parameter with reagent leads to **building or disappearance** (e.g. COD 4-40 mg/l) of dye in defined reaction time



Reaction must be selective for the substance – no reaction with other **disturbing** substances: see package leaflets

The developped dye must be stable for time of measurement => e.g. reading within 10 minutes after reaction time!

WTW Photometer

Portable Photometers

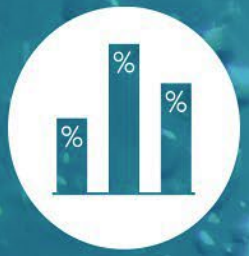
- pHotoFlex STD
- pHotoFlex pH
- pHotoFlex Turb

Benchtop Photometers

- photoLab S6
- photoLab S12

Spectrophotometer

- photoLab 7100
- photoLab 7600 UV-VIS



Poll Question #2

What do you normally test using Lab and Field Photometers?

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pHotoFlex® Series
Multiparameter Portable Colorimeter

Water frame work directive – the portable Lab 2 Go!

What PhotoFlex is commonly used for

Disinfectants (e.g. Chlorine, Ozone)

- Fast degradation

Environmental Test

- Nutrients (e.g. NH_4, NO_3, PO_4)

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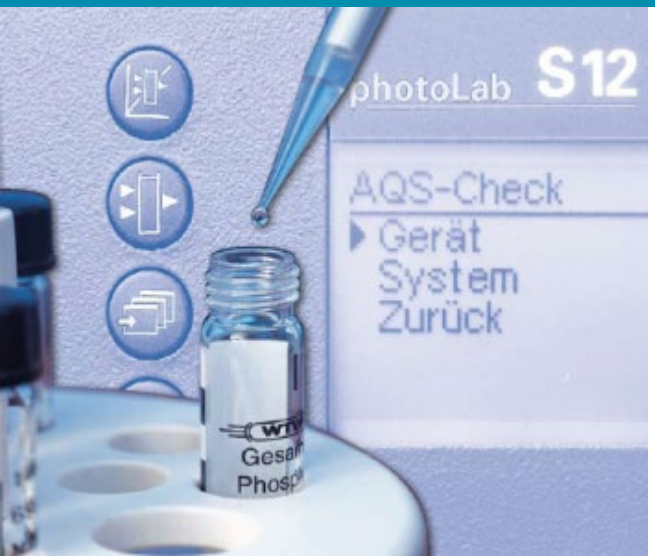
photoLab S6 / S12

Routine measurement at it's best



photoLab® S6/S12 – Just Measure!

Open lid, place cell, read result!

photoLab® - S6/S12

The best choice for routine tasks!

- Fastest measurement < 2 s to result
- Highest precision
  due to filter technology with ref.beam
- Most robust - no disalignment possible
  („mechanics free“)

photoLab Series offers:

- barcode for **round cells and reagent** test
  in rectangular cells 10, 20, 50 mm
- Automatic recognition for all cells

What is S6/S12 commonly used for

- **Routine tests**
  - **Dosing Applications**
  - **Regulatory Compliance**
- **Repetitive tests**
- **Large Number of tests**

e.g. Chemical Oxygen Demand, Nutrients, e.t.c.

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Proven and Pioneering

photoLab® 7000 Series

photoLab® 7000 Series
Routine and Spectral Analysis

All in One – One for All

- Routine analysis
  with programmed method data
- Special and multistep procedures
- Comprehensive programming options
- Spectral and Kinetics Analysis

From Water to Wine

From R&D to Production

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Extended PC Software

photoLab® color **+ photoLab Data *spectral***

- ✓ Color measurement from CIE to Gardner
- ✓ Data management offering link to LIMS (GLP Complaint)

Application: mostly Quality control

Markets:

Food&Beverage: Juice, Sugar, Oil

Resin, varnish…

photoLab® color:

Color measurement instead of color perception

- CIE color measurement: XYZ, x,y,z, CIE-L* a* b*, CIE-L* u* v*,
- Hazen (Pt-Co)
- Yellowness-Index
- ADMI color number
- ASTM
- Gardner
- Sugar color ICUMSA
- Beer color according to EBC and ASBC
- Iodine color number

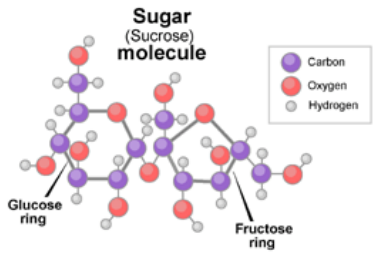
What is Photolab 7000 commonly used for

- **Where PhotoFlex or S6/S12 cannot fulfill.**

- **3rd Party Testing Lab**
  - **E.g. Meet ISO 17025 standards**

- **Teaching/Research**
  - **E.g. Kinetics**

- **Special Applications**
  - **E.g. Sugars, Chlorophyll, Special color scales, e.t.c**



Takeaways

Think about how do you run your photometric tests?

- Field – Portability
  - ✓ PhotoFlex
- Lab Routine – Ease of measurement from test to test
  - ✓ Photolab S6/S12
  - ➢ **Automated, stay tuned for next part of this presentation**
- Lab Special analysis/Research – Comprehensive functions
  - ✓ Photolab 7000

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July, 2020

Instruments for Chemical Analysis

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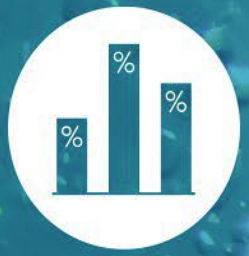
Benjamin Chiang

- Lab and Process Business Development Manager
- 15 Years in process filtration and process instrumentation business
- 4 years with Xylem
- SEA Product manager for OIA analytical
- BDM for YSI, ISS & Aanderaa. MY,BN,PH

Agenda

1. OIA Introduction & Portfolio
2. What is Automated Chemistry analyzer (ACA)
3. Different ACA techniques and methods.
4. Advantages of automation
5. The FS3700
6. Application examples
7. Summary and closing



Poll Question #3

What is your greatest concern when performing a sample analysis?

Poll Question #4

How many samples of the same test (Eg. TKN, Cyanide) do you need to do per day?

OI Analytical Laboratory and Online Products

Total Organic Carbon (TOC) Analyzers (Lab & Online)

- Detects and measures the concentration of organic matter and compounds in water samples.

Gas Chromatography (GC) Products

- Selective GC detectors (PID, ELCD, FID, XSD, & PFPD) for GC instrumentation manufacturers, Purge & Trap (P&T) sample concentrators,

Automated Chemistry Analyzers

- Continuous laboratory flow analyzers for water, soil, and plant samples.

Cyanide Analyzer

- Measures available cyanide in precious metal leaching solutions by U.S. EPA Method

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FS3700 - Automating chemical analysis with OI Analytical

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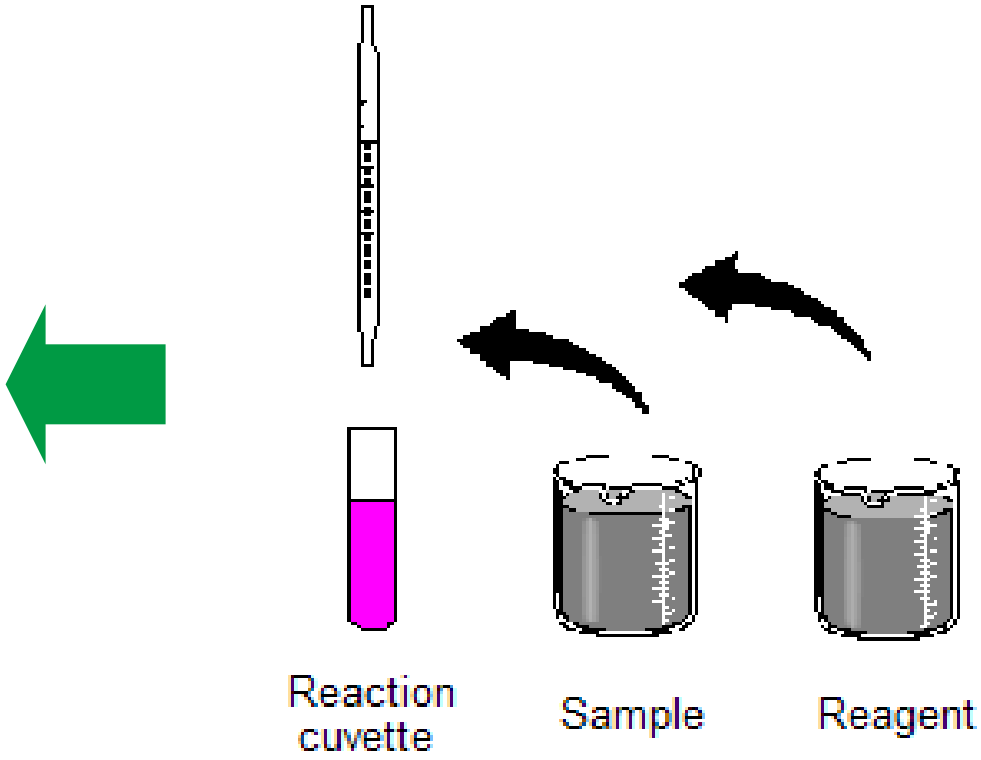
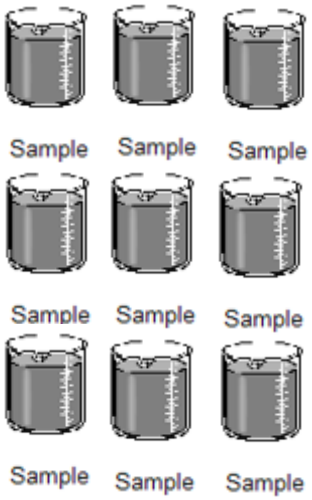
Manual Method Process

Detector

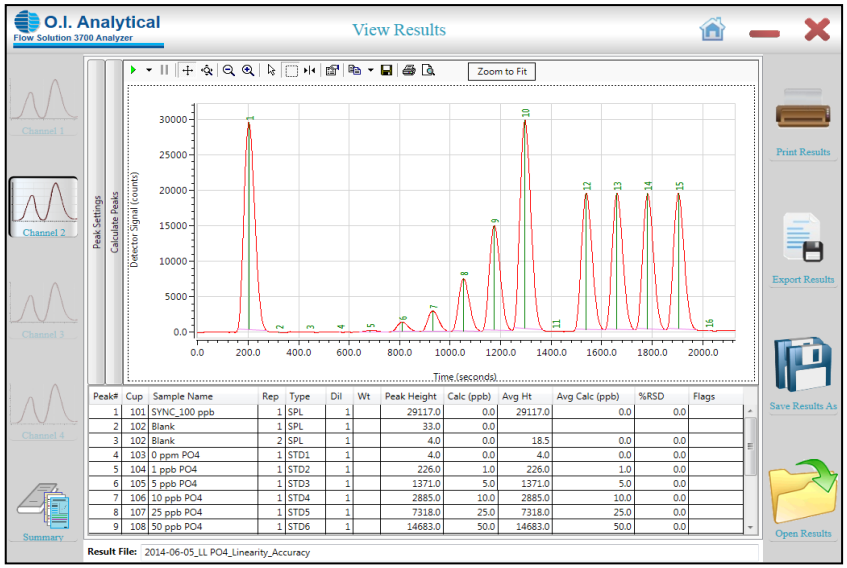


OIA Automated Process

Up to 360
Samples in 1 run



Up to 2 types of chemical
analysis in 1 run



Peak#	Cup	Sample Name	Rep	Type	Dil	Wt	Peak Height	Calc (ppb)	Avg Ht	Avg Calc (ppb)	%RSD	Flags
1	101	SYNC_100 ppb	1	SPL	1		29117.0	0.0	29117.0	0.0	0.0	
2	102	Blank	1	SPL	1		33.0	0.0				
3	102	Blank	2	SPL	1		4.0	0.0	18.5	0.0	0.0	
4	103	0 ppm PO4	1	STD1	1		4.0	0.0	4.0	0.0	0.0	
5	104	1 ppb PO4	1	STD2	1		226.0	1.0	226.0	1.0	0.0	
6	105	5 ppb PO4	1	STD3	1		1371.0	5.0	1371.0	5.0	0.0	
7	106	10 ppb PO4	1	STD4	1		2885.0	10.0	2885.0	10.0	0.0	
8	107	25 ppb PO4	1	STD5	1		7318.0	25.0	7318.0	25.0	0.0	
9	108	50 ppb PO4	1	STD6	1		14683.0	50.0	14683.0	50.0	0.0	

Reagent

Who Should Automate?

Anyone looking to improve laboratory efficiency

- Environmental
- Municipal Waste / Drinking water
- Agricultural
- Food and beverage
- Pharmaceutical
- Mining
- Petrochemical / Chemical
- Academic research
- Etc.

Advantages of Automating your testings

Increases productivity.
Decreases labor cost.
Increases day to day reproducibility.
Reduces reagent use
Reduces the cost for waste disposal
Analysis costs are reduced.
All other relevant cost will be reduced

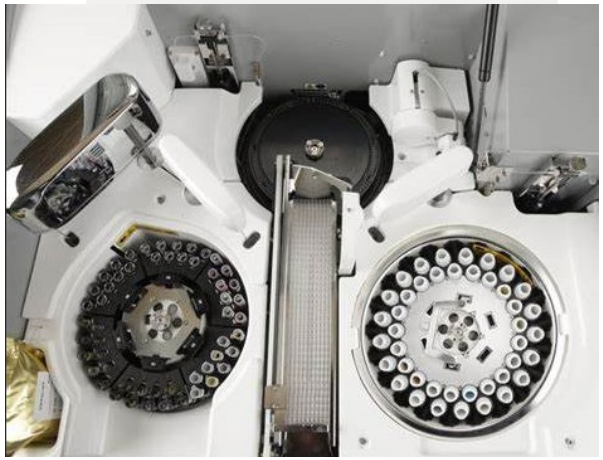
Laboratory costs that can be reduced by automation

	Laboratory Cost reduction by…
Direct labor	**20 – 28 %**
Indirect Labor	**7 – 12 %**
Operational Supplies	**10 – 20 %**

Two important automated chemistry technologies

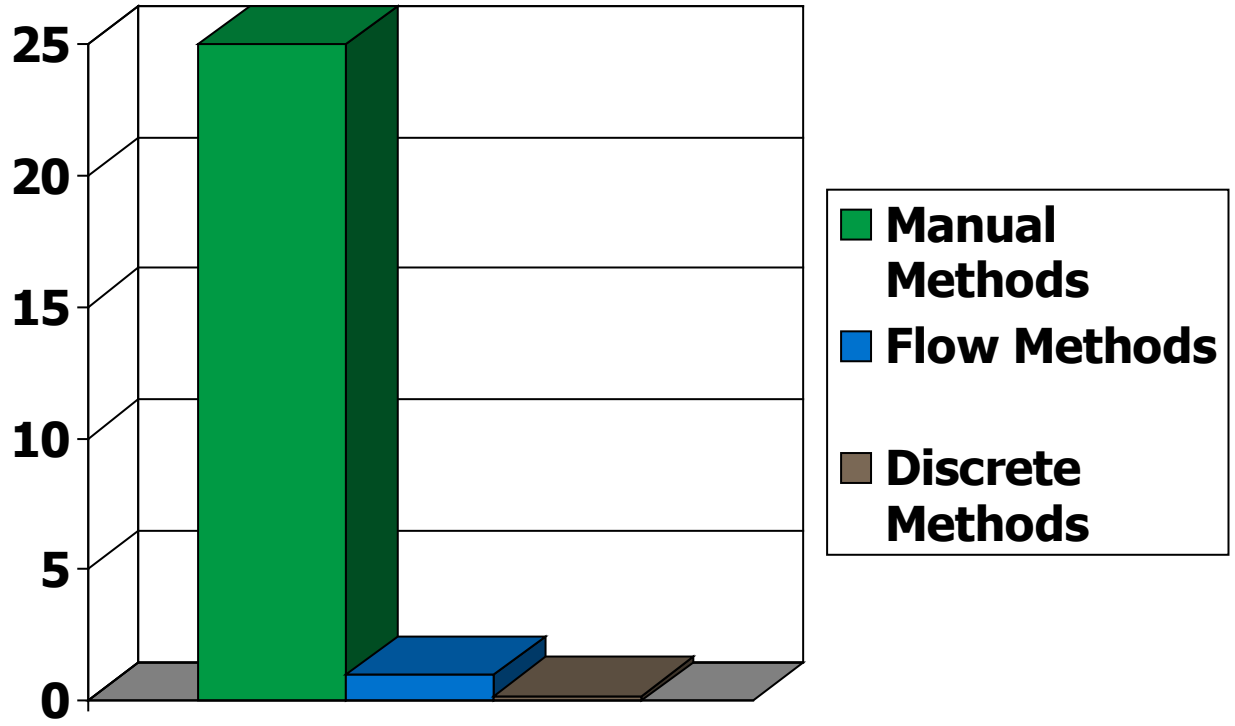
Automated Wet Chemistry

- Continuous Flow
  - SFA
  - FIA
- Robotic
  - Discrete

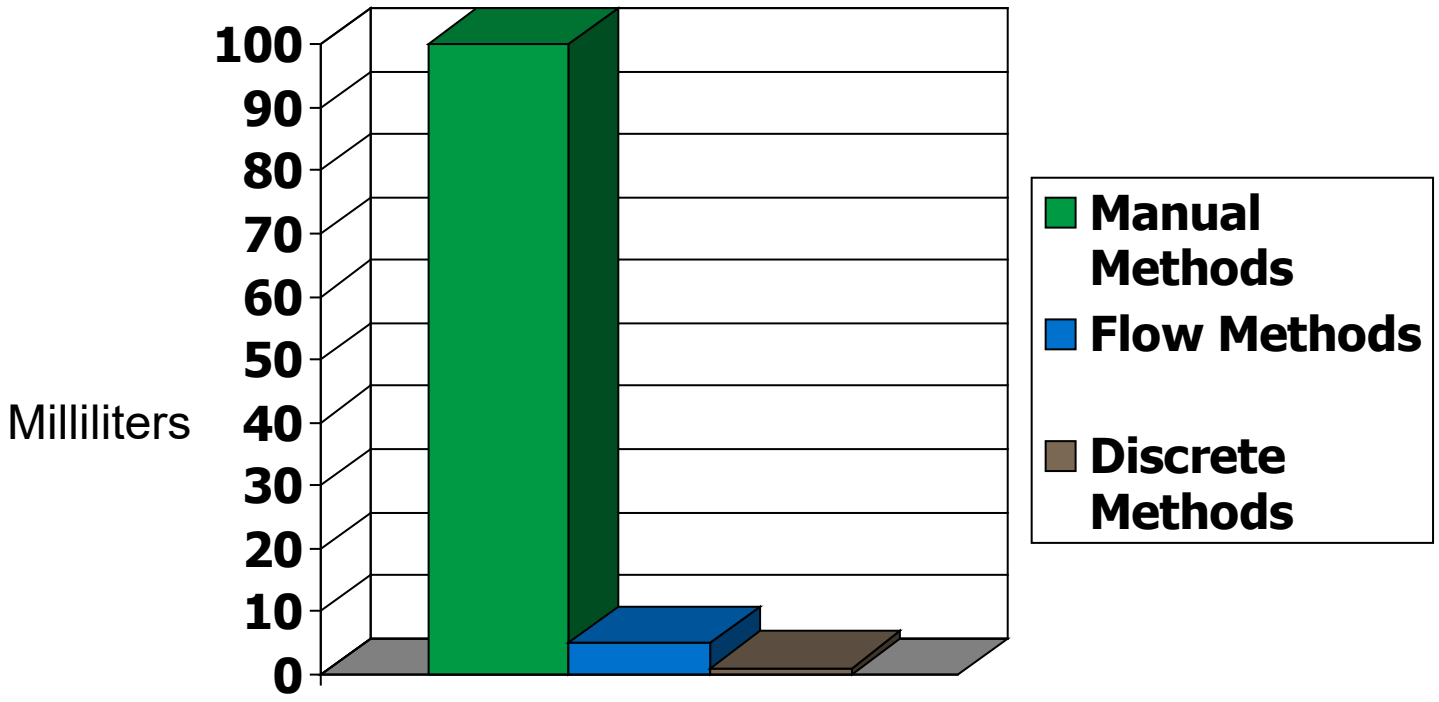


Reagent usage is decreased by automation

Milliliters



Waste generation is decreased by automation



FS 3700 Automated Chemistry Analyzer Methods

Analyte	Technique	Method	Operating Range	MDL[1]	Throughput	Channel[2] Part #	Cartridge Part #
Ammonia	SFA, Gas Diffusion	USEPA 350.1	0.01-20.0 ppm 10.0-20,000 ppb	0.001 ppm 1.0 ppb	40 samples per hour	330109	330094
Ammonia, Nitrogen (Phenate)	FIA	USEPA 350.1	0.01-20 ppm	0.002 ppm	51 samples per hour	330353	330354
Chloride	SFA	Standard Methods 4500-Cl-E	1.0-200 ppm	0.12 ppm	60 samples per hour	330360	330361
Cyanide Available (1677)	FIA	OIA-1677-09	0.002-5.00 ppm 2.0-5,000 ppb	0.0005 ppm 0.5 ppb	30 samples per hour	330107	330092
Cyanide Available (D6888) (Sulfide abatement)	FIA	ASTM D6888-09	0.005-0.5 ppm 5.0-500 ppb	0.002 ppm 2.0 ppb	30 samples per hour	330106	330091
Cyanide Free (D7237)	FIA	ASTM D7237-10	2.0-500 ppb	0.5 ppb	30 samples per hour	330355	330356
Cyanide Free	Photometric Detection	ISO 14403	2.0-500 ppb	0.4 ppb	30 samples per hour	330371	330372
Cyanide Post-Distillation	FIA, Photometric Detection	USEPA 335.4	5.0-500 ppb	0.5 ppb	30 samples per hour	330351	330352
Cyanide Total	SFA, UV Digestion	ASTM D7511-09	0.003-0.5 ppm 3.0-500 ppb	0.0001 ppm 1.0 ppb	30 samples per hour	330076	330090
Cyanide Total	Photometric Detection	ISO 14403	2.0-500 ppb	0.4 ppb	30 samples per hour	330366	330367
Hexavalent Chromium	FIA	USEPA 600/4-79-020	0.01-10 mg/L	0.0011 mg/L	48 samples per hour	331543	331544

Analyte	Technique	Method	Operating Range	MDL[1]	Throughput	Channel[2] Part #	Cartridge Part #
MBAS	Continuous Flow	ISO 16265	0.025-2.0 mg/L as LAS	0.008 mg/L as LAS	24 samples per hour	330357	330358
Nitrate/Nitrite	FIA	USEPA 353.2	0.01-10.0 ppm 10.0-10,000 ppb	0.001 ppm 1.0 ppb	60 samples per hour	330108	330093
	SFA		0.005-10.0 ppm	0.001 ppm	40 samples per hour	331377	331376
Nitrate/Nitrite in Milk	FIA w/ In-line Dialysis	ISO 14673-3	**Nitrate** 0.5 mg/L - 5.0 mg/L **Nitrite** 0.025 µg/L - 0.400 µg/L	**Nitrate** 0.016 mg/L **Nitrite** 0.0016 mg/L	30 samples per hour	331534	331535
Phenol In-line distillation	SFA	USEPA 420.2	1.0-500 ppb	0.5 ppb	22 samples per hour	330363	330364
Phenol Post-Distillation	FIA	USEPA 420.4	0.01-2.00 ppm 10.0-2,000 ppb	0.002 ppm 2.0 ppb	90 samples per hour	330110	330083
Phosphorus All Forms	FIA	USEPA 365.1	0.01-5.0 ppm 10.0-5,000 ppb	0.001 ppm 1.0 ppb	60 samples per hour	330111	330096
Phosphorus All Forms - Low Level	FIA	USEPA 365.1	0.001-0.1 ppm 1.0-100 ppb	0.0003 ppm 0.3 ppb	45 samples per hour	330112	330095
Sulfate	FIA Photometric	USEPA 375.2	1.0 mg/L - 25 mg/L	0.1 mg/L	40 samples per hour	331385	331386
TKN Total Kjeldahl Nitrogen	SFA, Gas Diffusion	USEPA 351.2	0.01-20.0 ppm 10.0-20,000 ppb	0.001 ppm 1.0 ppb	40 samples per hour	330109	330094

[1] Method Detection Limit (MDL) determined in accordance with 40 CFR Part 136 Appendix B

[2] Channels include the cartridge, detector, and valve (if required).

Automated Chemistry Sample Types

We have Large Applications Library in these sectors. **ASK US!**

- Beverages
- Boiler feedwater
- Brackish waters
- Drinking water
- Feeds
- Fertilizers
- Foodstuffs
- Groundwater
- Wastewaters
- Industrial waste
- Mining process and wastewaters
- Plating baths
- Seawater
- Soil and plant extracts and digestion
- Surface waters
- Tobacco
- Wine
- Ultrapure water

(CFA) Continuous flow analyzers move liquid continuously through tubing.

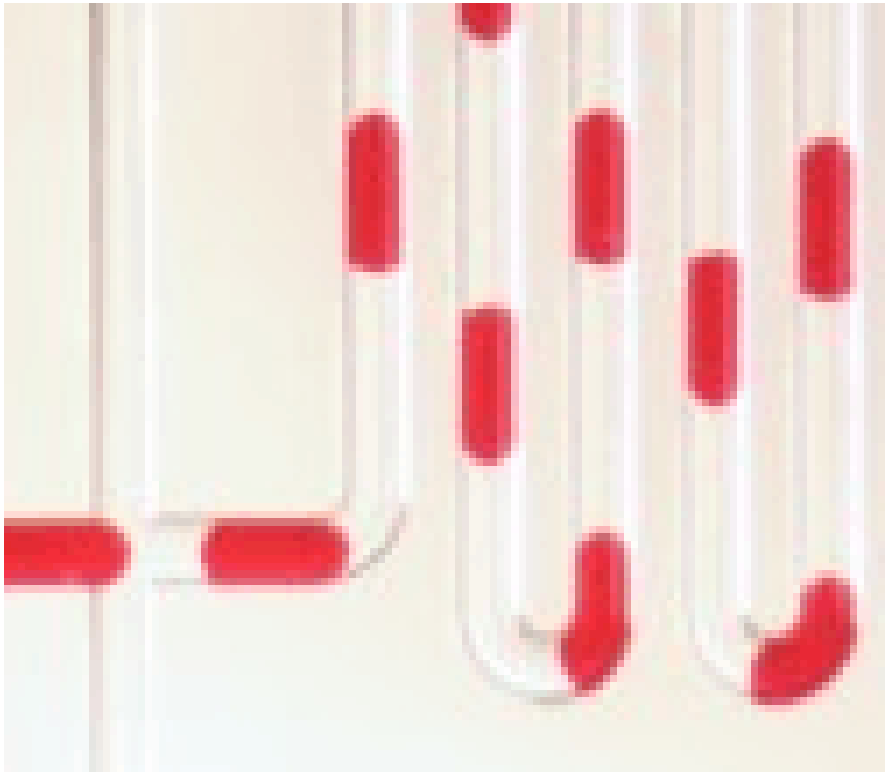
<u>Within the tubes</u>

Flow

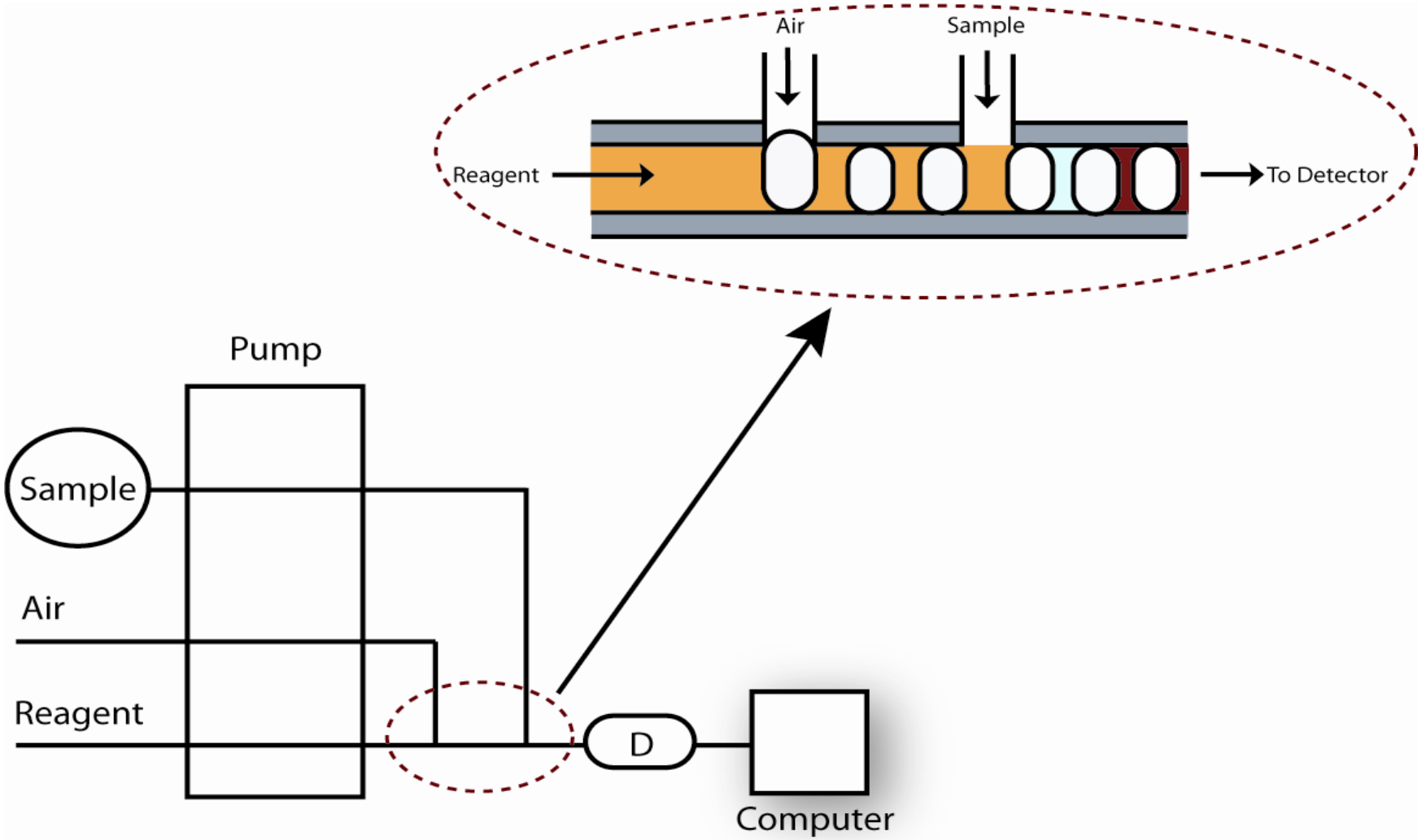
Mix

React

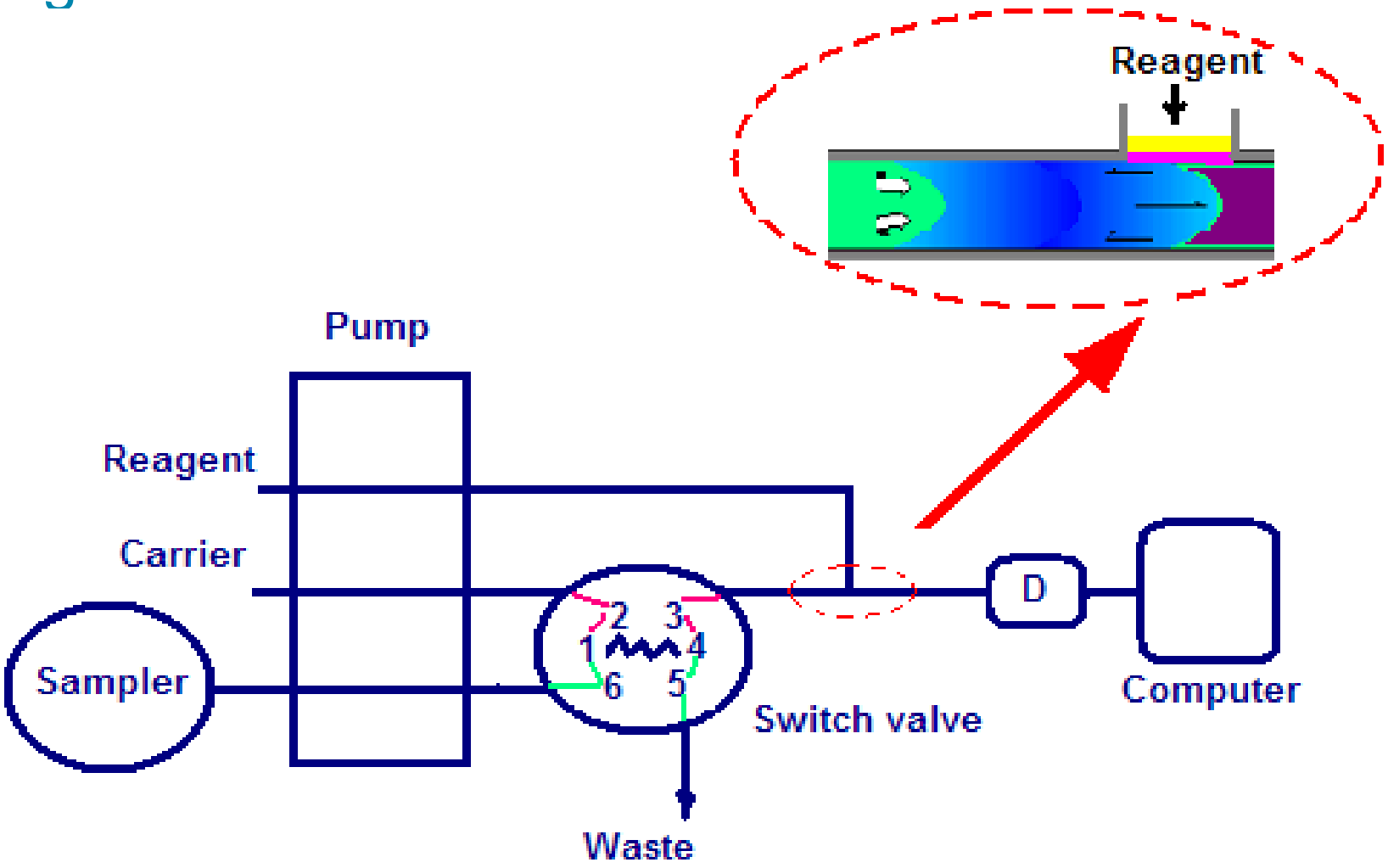
Detect



(SFA) Segmented Flow Analysis minimizes dispersion with air bubbles.

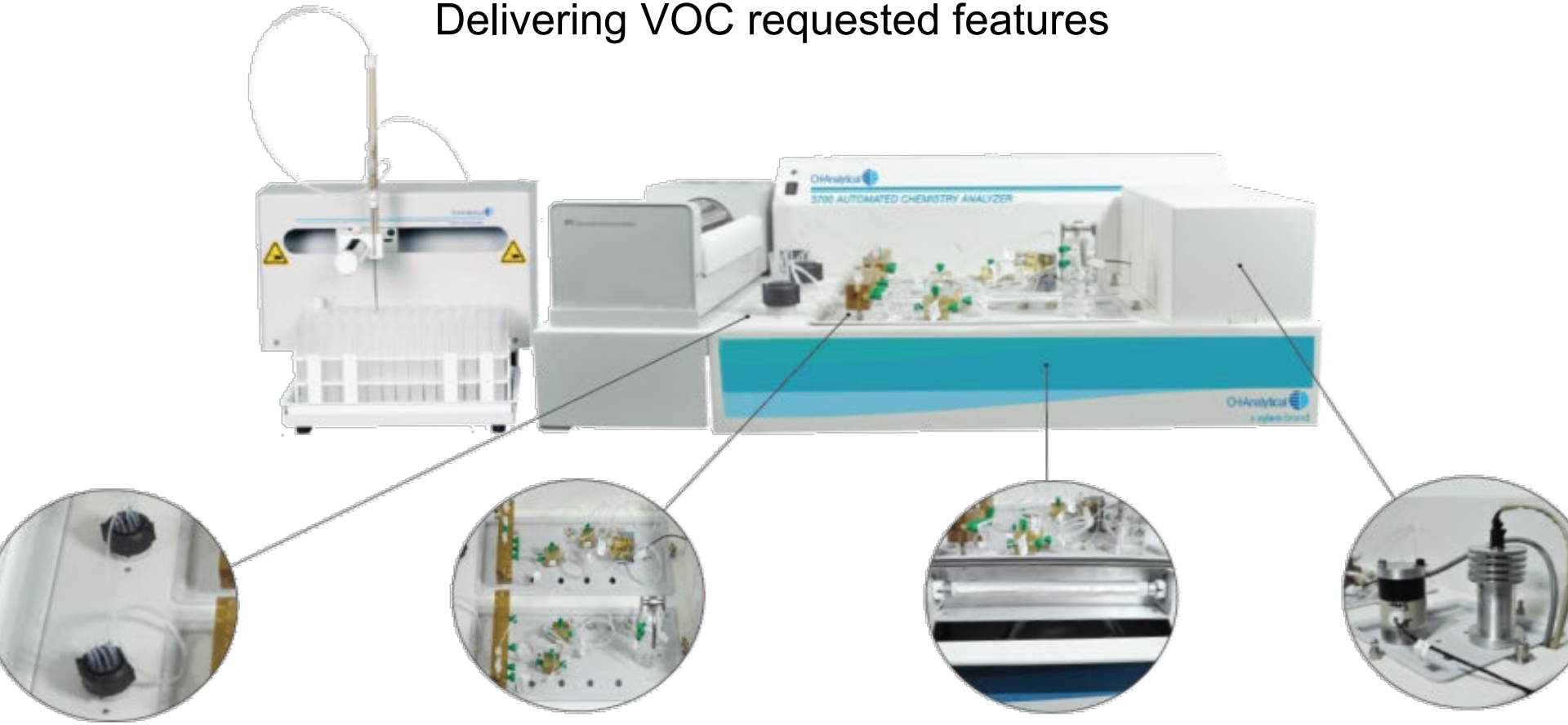


(FIA) Flow injection analysis injects into an unsegmented stream.



First Look – FS3700

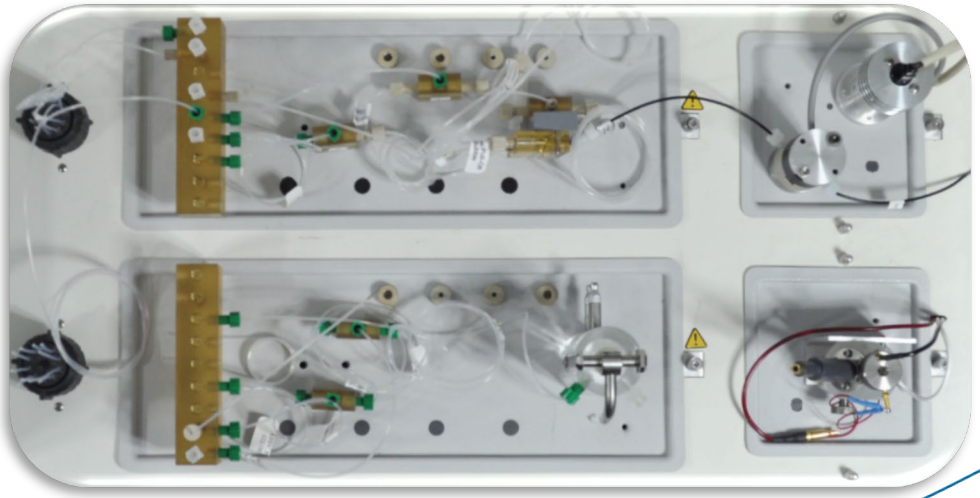
Delivering VOC requested features



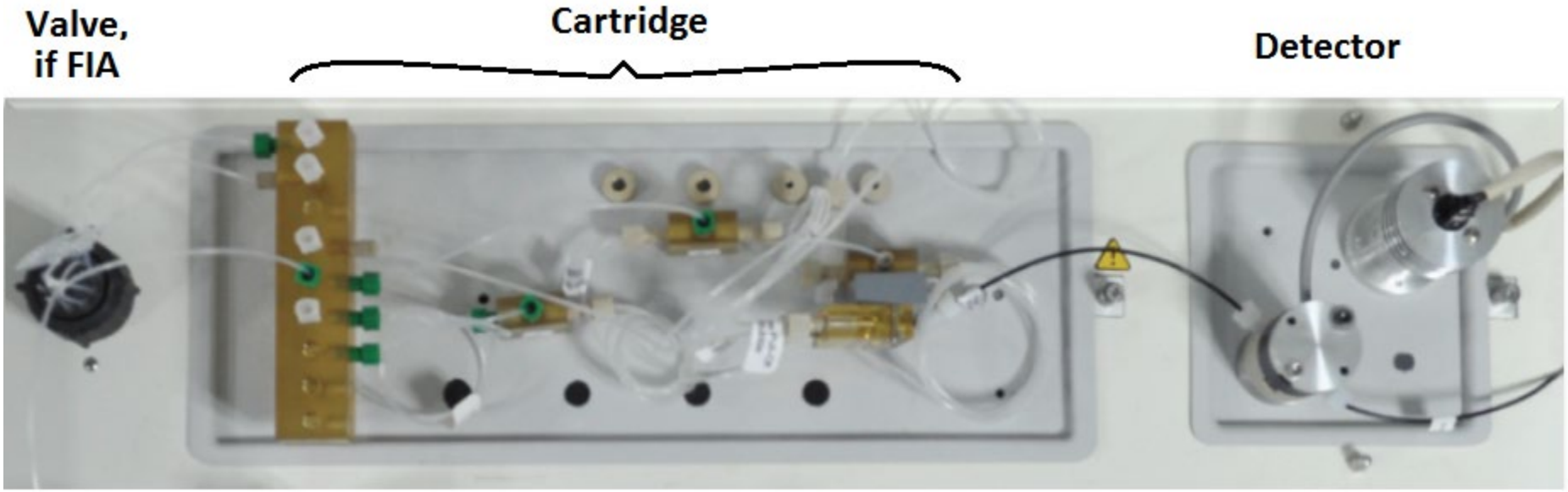
- Linear Logical Layout – Flows from left to right
- Modular hardware – add and modify on the fly
- Up to date software – no software issues
- Rapid and fast deployment – Easy to setup

Chemistries available (Top sellers)

- Available cyanide (EPA OIA-1677)
- Available cyanide (ASTM D6888)
- Total cyanide (ASTM D7511)
- Ammonia/TKN by gas diffusion
- Nitrate/Nitrite
- Phosphate, all forms
- Phosphate, all forms (low level)
- Phenol, Post-distillation



What's in a channel?



- Everything needed to perform analysis is included in a channel.
- Cartridges include gas diffusion manifolds, heaters or UV lamps (as needed) all tubing, pump tubing and the chemistry kit.

Everything is included?

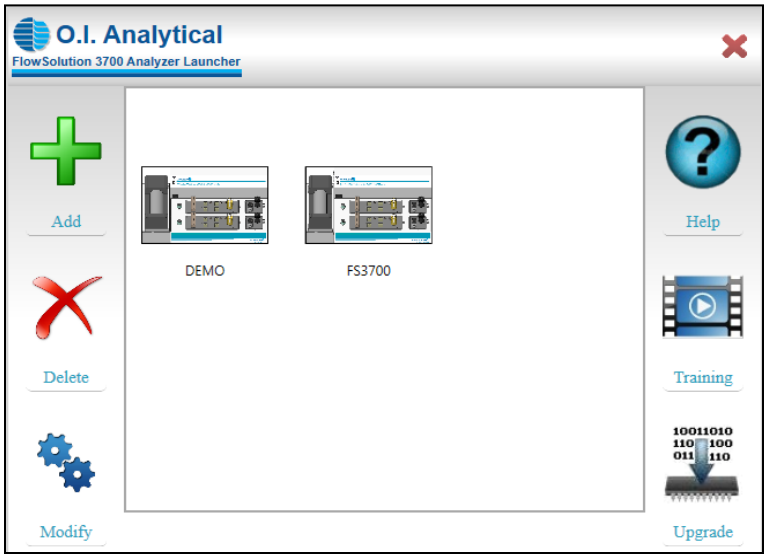
Yes. The nesting structure of FS 3700 channels.

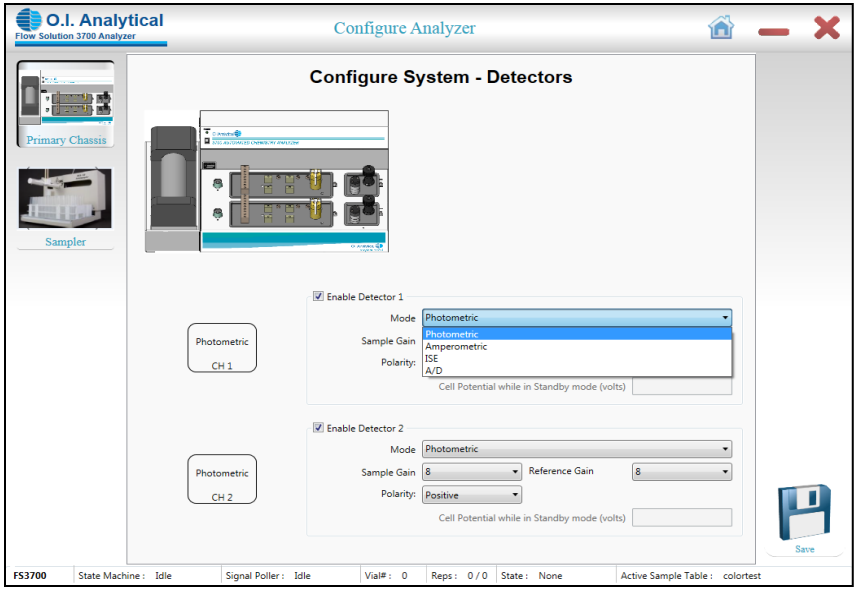
CHANNEL – Total Cyanide, ASTM D7511 330076

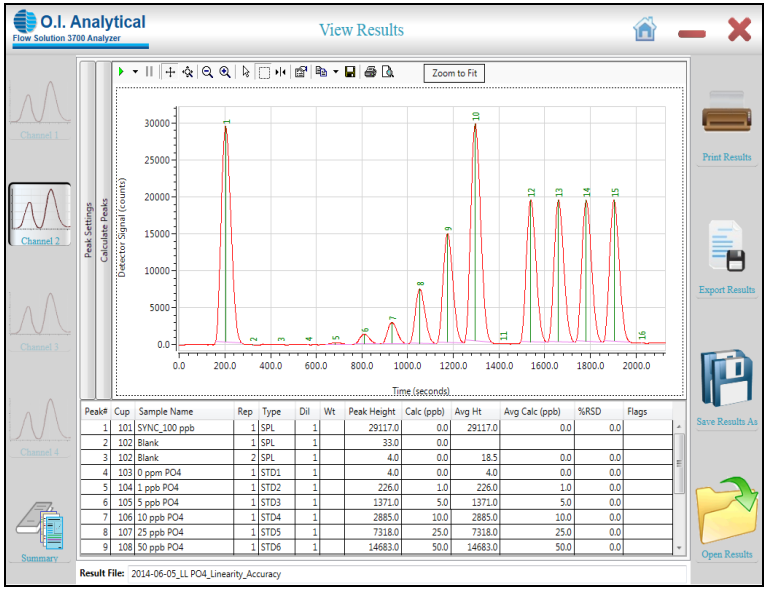
FIA VALVE ASSY 330086	CARTRIDGE 330090	ASSY – AMP DETECTOR 330077
Valve 330184	CARTRIDGE 330090CT: UV Assy 330055; Gas Diff. Manif. 329040	Tested Cell 330001
Tubing Kit 330121	Chemistry Kit 330090K	Amp Cable 330001
Valve Tray TBD	Tubing Kit 330090TK	Detect. Tray 329387

UV Ballast 330055 & Detector Cover 329515 are included at channel level.

FlowView – user friendly interface







O·I·Analytical
a xylem brand

Flow Solution 3700

Some of the applications recently used…

- Monterrey Bay Analytical Services. Environmental application. FS3700 Purchase with Ammonia/TKN and Phosphorus (All Forms).
- Gerhardt Block Digestor (for TKN or TP digestions)
- KJELDATHERM Digest System KBL40S 230V coupled with the FS3700

KJELDATHERM®

Flow Solution S3700

Another application recently used…

- Unique application for the FS3700 is Nitrite/Nitrate in Milk Products
- ISO Method 14673 (Flow Injection) ISO Method 14673-2 (Segmented)

- Determination of NO2/NO3 contents of mill and milk products by FIA. Applicable to hard, semi-hard, soft cheeses, whey powder, milk powder and milk based infant foods.

- Tillamook in Boardman, OR (Cheese)
- Dairy America in Tulare, CA

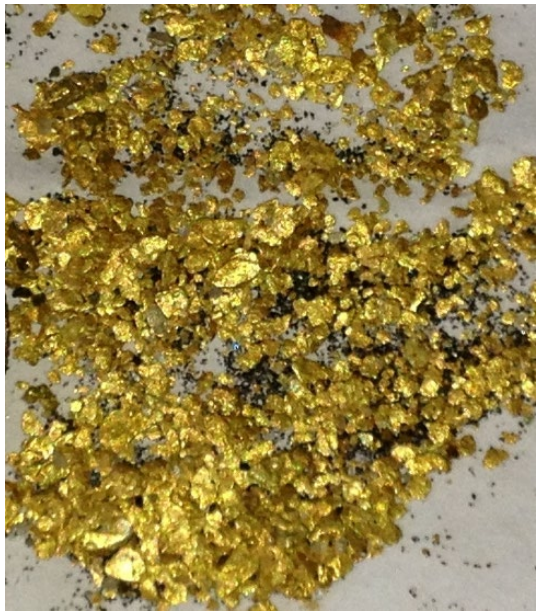
Flow Solution S3700

Another application recently used…

- Unique application for the FS3700 is Cyanide Analysis in Gold Mining
- USEPA Methods OIA-1677, OIA-1678 & Total CN Method ASTM D7511-09

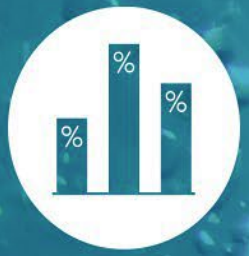
- Determination of cyanide levels in tailings ponds of Gold mines
- Determination of cyanide levels released into the environment

- Mines in USA, Africa(Ghana) and Australia.



Summary on Flow Solution 3700

- The FS 3700 introduces **flexible and innovative technology** to automated your chemistry smoothly.
- Icon-driven software that is as **easy to use** like a smartphone
- **Modular**, plug-n-play components allows **easy customization** on the system for your chemistries and improve your laboratory workflow.
- **Simple** to setup, operate and **inexpensive** to maintain.
- **High sample throughput**, while handling complex matrices that other analyzers can't process.
- **Minimal Operator involvement**. Once set, move to other jobs…
- FS3700 handles a **wide variety of chemistries** such as Total and Free Cyanide, NO2/NO3, Ammonia/TKN, TP and low-level Ortho-P.



Poll Question #5

Would you like someone from Xylem to contact you about photometry or automated chemical analyzer solutions?

xylem
Let's Solve Water

Questions?

Contact us:

Xavier Tan (Photometry)
Xavier.Tan@xyleminc.com

Benjamin Chiang (Auto Chemical Analyzers)
Benjamin.Chiang@xyleminc.com

www.xylem-analytics.asia