Water Testing & Analysis

Avoiding Water Chemistry Problems

Many costly and time consuming water chemistry problems can be prevented by:

- Frequently monitoring the chemical content of water
- Accurately testing the ingredients of the water using quality test reagents and instruments
- Using proper water sampling techniques
- Calculating proper dosages of chemicals needed for adjustment
- Correctly applying chemicals to the pool
- Maintaining recommended chemical levels

Recommended Pool & Spa Water Chemistry Levels

- **Oxidation reduction potential**
  750 mV (Commercial)
  650 mV (Residential)
- 865 mV (Cryptosporidium, Giardia and viral inactivation)
- **Free available chlorine**
  3.0 - 5.0
  Up to 10.0 ppm or as needed to maintain 750 mV ORP
- **Total available chlorine**
  No more than 0.2 ppm higher than FAC
- **Combined available chlorine**
  < 0.3 ppm
- **Total bromine**
  4.0 - 6.0 ppm
  Or as needed to maintain a 750 mV ORP

Recommended Pool & Spa Water Chemistry Levels

- **Cyanuric acid**
  0 ppm (Indoors)
  20 - 30 ppm (Outdoors)
- **Polymeric biguanide (PHMB)**
  30 - 50 ppm
- **Hydrogen peroxide**
  30 - 40 ppm
- **Salinity (Electrolytic cells)**
  2,500 - 6,000 ppm (4,000 ppm ideal)
- **Sulfates**
  < 200 ppm
- **pH**
  7.2 - 7.8

Recommended Pool & Spa Water Chemistry Levels

- **Acid or base demand**
  Neither
- **Total alkalinity**
  80 - 120 ppm
- **Calcium hardness**
  200 - 400 ppm
- **Total dissolved solids (TDS)**
  < 1,500 ppm
- **Saturation index**
  0 (+ or - 0.3 acceptable)
- **Iron**
  0 - 0.2 ppm

Recommended Pool & Spa Water Chemistry Levels

- **Copper**
  0 - 0.3 ppm
- **Manganese**
  1.5 ppm
- **Nitrates**
  < 10 mg/L
  Uncontrolled algae growth likely at 25 mg/L
- **Clarity**
  Crystal clear (< 0.25 NTU)
- **Water temperature**
  104° F (Maximum spas)
  86°- 94° (Therapy pools)
  78°- 82° (Competitive pools)
  83°- 86° (Multi-use pools)

Recommended Pool & Spa Water Chemistry Levels

- **Air temperature**
  2°- 7° F above pool water temperature
- **Relative humidity**
  50 - 60% maximum
  Reduce to 35 - 50% when outside air is below 45°
- **Ventilation**
  0.5 cfm of outside air for each square foot of natatorium area
  15 - 25 cfm for each person in the natatorium
- **Discernible odor**
  None
- **Gas in air 6" over the pool**
  1.0 ppm maximum TWA (Chlorine)
  0.1 ppm maximum TWA (Ozone)

Frequency of Testing

- It is necessary to diagnose water problems before they can be solved
- Constant monitoring, evaluating and adjusting of the water ingredients will lead to consistent water quality
- Large fluctuations in water chemistry may necessitate costly and time consuming rectification
- Water should always be tested and corrections made before patrons are permitted to enter the water
- Well used commercial pools should be tested at least once every one or two hours
- Small pools which are sparsely used may only need to be tested twice or three times per day

Frequency of Testing

- Sanitizer levels and pH should be checked at every test
- Some chemical levels, like calcium hardness or TDS, are slow to change and need only be tested daily or weekly
- Water chemistry changes can occur so rapidly in warm water, heavily used commercial spas that testing, monitoring of pH and ORP, and chemical adjustments must be augmented by the use of automated controllers

Frequency of Testing

- Several factors govern how often water tests should be performed, including:
  - Parameter's tendency to change rapidly
  - Bather load
  - Pool volume
  - Water temperature
  - Turnover time
  - Amount of sunlight shining on the pool
  - Surrounding environment
  - Code requirements
  - Residential or commercial
  - Content of the source water and dilution rate

Daily Swimming Pool Chemical Log

Time	FAC	pH	W°	A°	Bather Load	Chemicals Added
Opening						
Closing						

Daily Swimming Pool Chemical Log

ORP		Iron		Flowrate	
TAC		Copper		Turnover	
CAC		Nitrates		Influent pressure	
CYA		TDS		Effluent pressure	
TA		Clarity			
CH		Water Level		S. Index	

Chemical Adjustment Log

Date	Time of Application	Chemical & Strength	Amount	Method of Introduction	Purpose	Applicator

Test Kits & Testing Instruments

- Test kits, chemical reagents and testing instruments must be available so that detailed water analysis can be conducted by the pool operator and all chemical levels can be maintained within acceptable ranges
- Regardless of the cost or sophistication of the testing equipment, the tests must provide reliable, accurate, repeatable results
- Directions should be easy to follow
- All staff members required to perform water tests should be thoroughly trained in the use of the testing equipment

Test Kits

- Color comparitor
- Colorimeter
- Titration
- Turbidometric
- Electronic
- Dip-and-read strips
- Light meter
- Piston-type volumetric pump (gasses)
- Thermometer
- Dosimeter
- Nephelometer
- Laser particle counter
- Hygrometer

Color Comparitor

- Liquid or tablet reagents are added to a water sample and react with a chemical present in the water to produce a color of a specific intensity or shade

Reagents

- Reagents are chemicals used to measure, detect, or analyze another chemical

Color Comparitor

- The color of the test sample is compared to a printed color chart, or liquid encapsulated color standard
- Accuracy of test results is somewhat subjective and depends heavily on lighting conditions and the pool operator's visual ability to differentiating color graduations
- Commonly used to test for chlorine, bromine, and pH

DPD vs. OTO

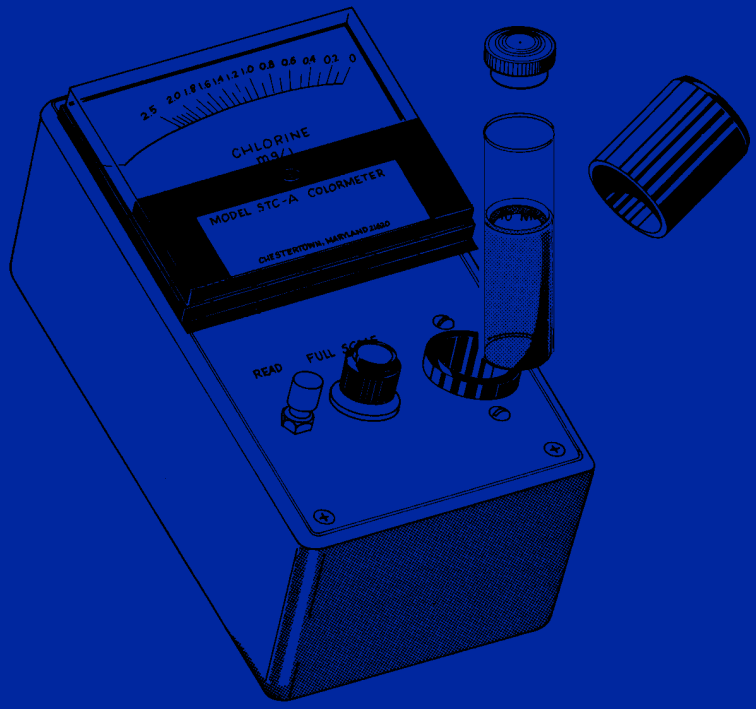
- DPD (diethyl-p-phenylenediamine) is recommended over OTO (orthotolidine) as an indicator reagent
- OTO reagents turn the sample solution yellow. Some pool operators feel that it's easier to distinguish yellow color gradations than the shades of pink produced by DPD reagents.
- OTO is banned by code in many states for use in testing commercial pool waters
- Not capable of accurately distinguishing between free and combined chlorine levels
- Only total available chlorine results can be obtained unless the water sample is first cooled to 1° C (34° F)

DPD vs. OTO

- Color intensity continues to change with OTO -- readings are usually not reliable after a few seconds
- False results may also be obtained because of the interference of dissolved metals, particularly iron or manganese, with the reagent
- OTO is a known carcinogen which can cause urinary tract tumors, and should not be handled without taking appropriate precautions
- OTO testing was dropped from “Standard Methods for the Examination of Water and Wastewater”, because of poor accuracy, imprecision, high error, and toxicity resulting from OTO exposure through absorption, inhalation and ingestion

Colorimeter

- Liquid or tablet reagents are added to a water sample and react with a chemical present in the water
- The sample is placed in a colorimeter chamber or filter photometer and capped to shield outside light



Colorimeter

- Pool operator presses a button on the battery operated meter and a light beam is passed through the test tube containing the sample
- Amount of light which passes through the sample is detected by a photocell
- Photocell responds by sending an electrical current in proportion to the amount of light detected to an analog or digital display on the meter
- Some colorimeters require that the results be converted using calibration graphs requiring some analytic skills

Colorimeter

- Most meters being sold to the pool industry today are calibrated to perform specific tests and use an appropriate light color or wavelength so that results can be direct-read
- Results from a colorimeter are more accurate and reproducible than those obtained using color comparitors because metering instruments:
  - Do not depend on human visual acuity
  - Don’t vary as a result of ambient light levels.
  - Are much more sensitive to tiny variations in color

Titration

- A color change occurs as a measured indicator reagent is added to a test sample
- A titrant is added, depending on the manufacturers directions, either drop by drop or by depressing a plunger on a syringe to dispense the titrant until a second distinct color change occurs when and end-point is reached
- The amount of titrating reagent added to cause the color change is related to the concentration of the chemical in the sample
- Titration is commonly used to test chlorine, bromine, total alkalinity, and calcium hardness levels in pools

Turbidometric

- Test reagent is added to the water sample and forms a suspended non soluble compound or precipitate which clouds the water sample (melamine:cyanuric acid)
- Higher the chemical concentration, the greater the cloudiness of the solution
- Sample is pored into a calibrated test cell until an indicator dot at bottom of the cell is no longer visible
- Some kits raise or lower a test stick down into a test cell instead
- When the indicator dot is obscured, the water level in the cell is compared to the calibration scale on the side of the cell
- Test results can be read visually or by a photometer

Nephelometric

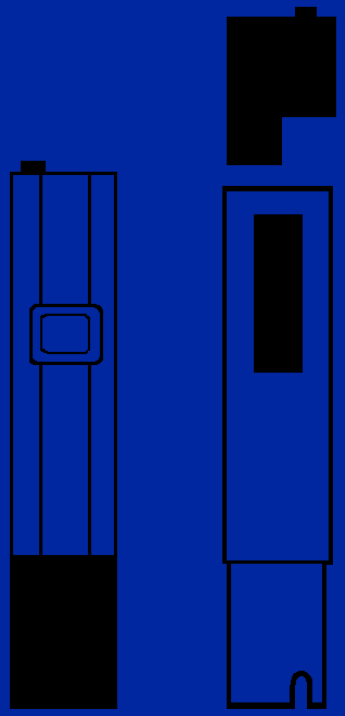
- Nephelometers are used to measure water clarity
- Portable nephelometers are battery operated, and can test in the range of 0 to 1,000 NTUs without the need to perform calculations or interpolate calibration charts, with a resolution of 0.1 NTUs
- Detector compensates for sample color, stray light and light fluctuation
- Meter is switched on, the water sample is placed in the meter, a narrow beam of light is passed through the sample and scattered by the particles
- A light detector and a scatter detector collect the light
- Results in NTUs are digitally displayed within approximately 10 seconds

Laser Particle Counters

- Used to determine filter efficiency and capability of particle size removal
- Cost upwards of $30,000.00 -- out of the price range of most recreational water organizations
- Water samples can be sent to laboratories for laser particle analysis

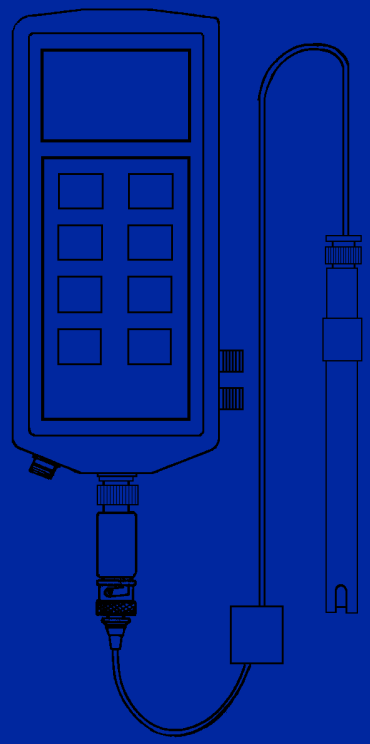
Electrometric (Electronic)

- An electrode or electrical probe is inserted in a test sample, the battery operated meter is turned on, electrical current passes between the electrodes, then the results are displayed on an electronic meter



Electrometric (Electronic)

- Some of the meters have automatic temperature compensation, and automatically turn off after a set period of interruption to extend battery life
- Devices range from simple, low cost hand held pocket meters to professional laboratory instruments



Electrometric (Electronic)

- Inexpensive devices will not have the accuracy of quality laboratory instruments
- Portable electrometric meters are used to measure pH, total dissolved solids, and oxidation reduction potential
- The operator must be careful not to drop the meter on the pool deck, or fully submerge the instrument, unless the meter is designed to be immersed (and most are not)

Electrometric (Electronic)

- The meters must be calibrated frequently
  - As often as daily
  - Some meters use a calibration solution of a known standard in order to avoid drift
  - Others have screwdriver or push button calibration adjustment

Dip-and-Read Strips

- Plastic strips with chemically treated reagent pads
- Strips are dipped in the pool water and removed
- After a 30 second wait for a chemical reaction to take place and color to develop, the reagent pad color is matched to the color patches on the strip container
- Single or multiple test strips are available to test for chlorine, bromine, cyanuric acid, nitrite, nitrates, pH, total alkalinity, calcium hardness, and biguanides
- Shelf life: 10 - 20 months depending on the specific test

Dip-and-Read Strips

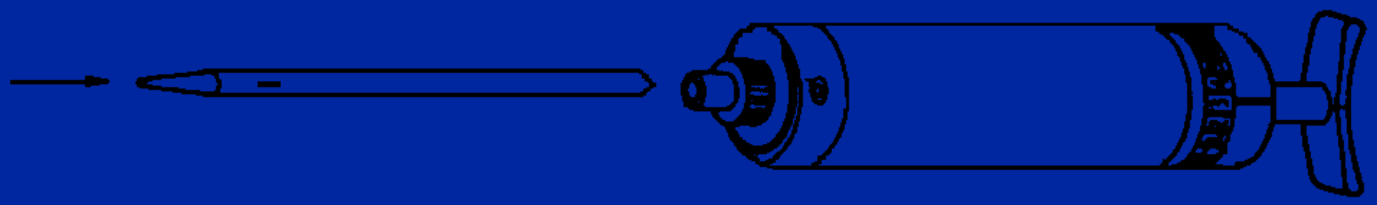
- Technology was originally developed for the medical industry, and has been adapted for use in the swimming pool industry
- Convenient, quick and easy to use
- Best used to:
  - Quickly identify problems or chemicals out of range
  - Determine when further testing needs to be done
- May not be approved by some state health departments for use in testing commercial pool water

Thermometers

- A water thermometer with a direct reading dial on a stainless steel stem probe, with a battery operated analog or digital display is recommended for measuring pool water temperature
- The probe is inserted into the pool for a few seconds in order to obtain a result
- Inexpensive plastic or glass thermometers which are often tied to a pool ladder or rail and left in the pool are:
  - Easily broken
  - Frequently stolen
  - Initiate patron complaints about the temperature

Volumetric Pumps

- Used with gas detector tubes to measure airborne contaminant gasses or vapors in the air over the pool
- To insure that contaminants are within safe levels specified by the EPA or OSHA for work environments
- Pool operators typically test for chlorine, ozone and carbon dioxide 6 inches above the pool water surface



Volumetric Pumps

- Detector tubes are purchased separately for each of the specific gasses needed to be tested, within a measurable concentration range, usually in boxes of 10 or 12 tubes
- If results show overexposure to a regulated chemical in excess of the permissible exposure limit (PEL):
  - Reduce the level of contaminants
  - Adjust work hours, the environment, or work policies and procedures

Volumetric Pumps

- To perform a test:
  - Gas detector tube is selected
  - Ends of the glass tube are carefully snapped off
  - Detector tube is inserted into the pump
  - Pump is stroked and a precisely measured, representative ambient air sample is drawn through the tube and into the pump
    - Some tests require multiple air samples of an indicated length or volume
    - Many of the pumps have stroke counters and end-of-stroke or flow finish indicators to help insure more accurate measurements

Volumetric Pumps

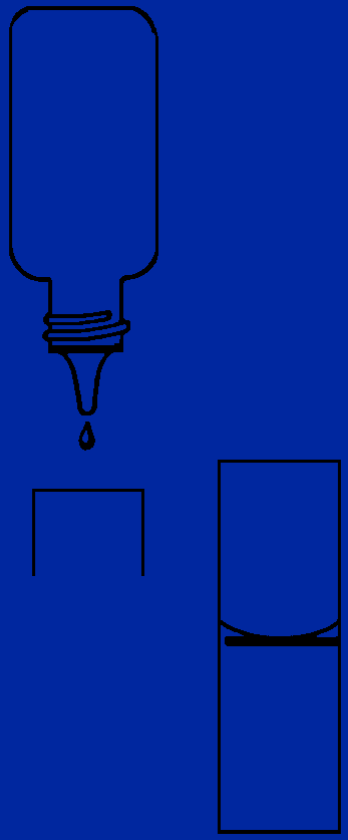
- Chemical vapor drawn into the tube reacts with a reagent and stains the material in the tube
- A chemical reading is obtained by observing the stain and referring to the calibrated scale printed on the indicator tube

Dosimeters

- Before an employee enters a confined space, internal atmosphere of the space must be tested with a direct reading, calibrated instrument (dosimeter), for: oxygen level, flammable gasses and vapors, and toxic air contaminants such as hydrogen sulfide, and carbon monoxide [OSHA "Confined Spaces" Regulation 29 CFR 1910.146]
- Most dosimeters have a sensing cell or probe mounted on the end of a cable or wand which is attached to a sampling hose, pump and monitor
- Dosimeters are battery operated, have digital read-out displays, and visual and audible alarms that sound to warn of dangerous conditions

Proper Testing Methods

- Test results should be consistent and repeatable
- Two different people performing the tests at the same time should get the same results
- Carefully read and follow the test kit manufacturer's directions



Proper Testing Methods

- Obtain a representative sample of water from the pool
  - Gather water samples from at least 12 to 18 inches below the surface of the water
  - Do not take water samples in close proximity to perimeter return inlets
  - Do not take samples directly from the return lines in the pump room
  - If dye tests have indicated the presence of circulation "dead spots", make sure that samples are taken from several areas and from both the shallow and deep ends of the pool

Proper Testing Methods

- Many test reagents are temperature sensitive
  - Allow sample water to cool to room temperature
  - Perform the tests within a reasonable amount of time so the water constituents do not change
- Take the water sample jars, test reagents and instruments to a well lit room away from the pool
- Do not wear sunglasses when interpreting results
- Use fresh reagents
- Never add test reagents directly to the swimming pool in order to do a quick "flash test"
  - It's not very professional
  - Results are worthless

Proper Testing Methods

- Use a clean, plastic water sample jar for sampling
  - Rinse the jar with pool water several times before collecting the water sample
  - While holding the jar up-side-down and in a vertical position, plunge the jar below the water surface
  - When the water level is at your elbow, tilt the jar into an up right position and let the jar fill with water
  - Cap the jar while its still submerged
  - If you are sampling more than one pool, make sure to label the sample jars so you don't accidentally mix up samples

Proper Testing Methods

- Make sure testing equipment and test cells are clean
  - Adding a reagent to a cell which contains traces of reagents from past tests will affect the accuracy of the test
  - Empty and rinse all testing instruments after each use
- Reagents are designed to be used with a specific kit
  - Do not interchange or substitute reagents from one manufacturer with those from another test kit manufacturer
  - Color standards, color intensity and concentration may be different

Proper Testing Methods

- Hold the test cell at eye level
- Fill test cells with the sample water to the indicated line, making sure the bottom of the meniscus curve touches the cell fill line
- Make sure the test kit you are using is capable of giving a reading in the range you are likely to encounter in the pool
  - Purchase wide range test kits.
  - Dilution testing can be complicated and the operator is more likely to make an error

Proper Testing Methods

- Directions may indicate that a sample should be swirled rather than shaken
  - If you shake a sample meant to be swirled, oxygen or carbon dioxide in the air will dissolve in the water producing bubbles which may alter test results
- If test cell caps are lost or destroyed do not use your fingers to cap test cells
  - You'll contaminate the sample
  - Have a supply of extra test cell caps available

Proper Testing Methods: Liquid Reagents

- Always hold the reagent bottle in a vertical position
  - If you hold the bottle like you would hold a pencil, the reagent drop sizes will not be uniform
- Don’t accidentally interchange the reagent caps
  - Put the same cap back on the bottle from which it was removed
- Replace the caps on reagent bottles immediately after performing the test
  - Reagents will react and begin decomposing when exposed to air and their shelf life will be diminished
- If you loose count of the number of drops of reagent you've added to a sample, discard the sample and start over

Proper Testing Methods: Tablet Reagents

- Do not touch the tablets when you remove them from their foil packets
- If the foil packets are torn, or the tablets have gotten wet, discard the reagents

Proper Testing Methods: Dip-and-Read Strips

- Bottle caps should be replaced immediately after use
  - Strips will become reactive with moisture in the air
- Check the timing of the tests
  - Colors change if you wait longer than the time specified
- Many of the tests involve a two step process -- carefully follow directions
  - Total alkalinity, pH, total hardness, and cyanuric acid results are read after 30 seconds
  - The same test strip is re dipped, swished for an additional 30 seconds and then chlorine and bromine results are read immediately

Proper Testing Methods: Instruments

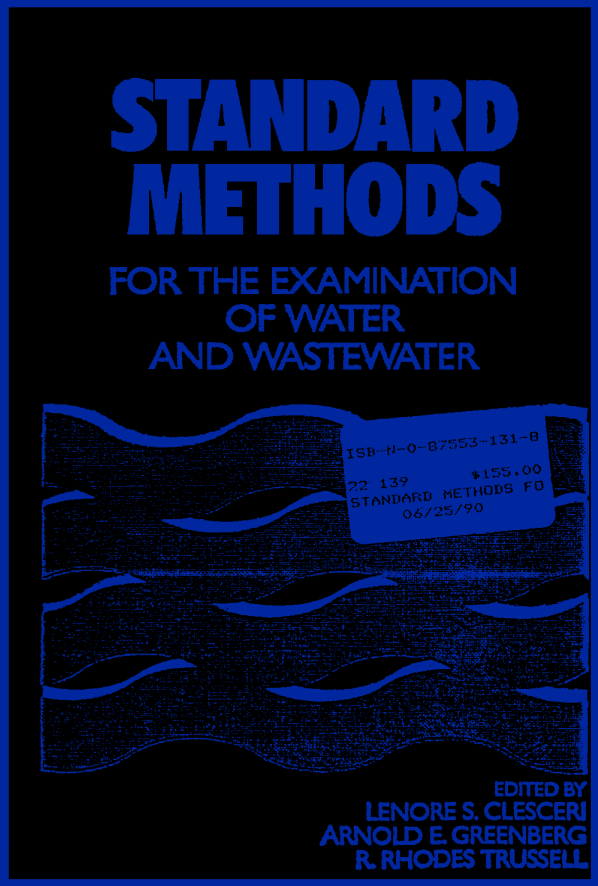
- Make sure all testing instruments are properly calibrated
- Avoid dropping instruments on the pool deck
- Do not expose test instruments to high levels of humidity
- Do not fully submerge testing instruments unless they are sealed and the o-ring or seal is intact

Storage of Reagents

- Reagents are stamped with an expiration date, and should be discarded and replaced if they have expired
  - Most reagents have a short life span of less than one year
  - Some reagents can go bad in an afternoon if improperly stored
- Store reagents in a cool, dark location
  - Do not store reagents on the pool deck in direct sunlight, in the trunk of your car, or in the pump room on top of the heater
  - Heat and ultraviolet light degrade many common reagents
- Do not allow reagents to freeze
  - Reagents may crystallize and become useless
- Don't store reagents in a chemical storage area
  - Pool chemicals, other reagents, and air can be absorbed and contaminate the reagents

For More Information on Water Testing Methods

- Standard Methods for the Examination of Water and Wastewater



For More Information on Water Testing Methods

- Published by a joint committee of the American Public Health Association, American Water Works Association, and Water Pollution Control Federation
- This 1,500 + page book was originally published in 1905, and is in its 19th edition
- Comprehensive text covers everything you ever wanted to know about water testing, testing methods and analysis
- The book can be found in most research libraries or can be purchased for around $155.00