

Turbidity Definition - What is it?

Turbidity is the “optical property that causes light to be scattered and absorbed rather than transmitted in straight lines through the sample.”

Standard Methods for Examination of Water and Wastewater

Turbidity is the clarity of the sample.

Turbidity Applications

MUNICIPAL

- Water Treatment Plants
- Wastewater Treatment Plants

INDUSTRIAL

- Metals and Mining
- Chemical Processing
- Pulp and Paper
- Power
- Food and Beverage
- Pharmaceuticals
- Refining

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Why Measure Turbidity in Drinking Water?

Plant Goal: Provide a Source of Safe and Reliable Drinking Water to Their Community.

- Harmful Microorganisms Are Removed by a Combination of Filtration and Disinfection
- Turbidity Measures the Adequacy of the Filtration Process

Why Measure Turbidity?

- Monitor and Improve Plant Efficiency
- Detect Filter Breakthrough
- Meet Regulatory and Governmental Requirements

Turbidity - Two Approved Methods

Two Design Methods For Reporting Turbidity:

- United States Environmental Protection Agency (USEPA 180.1)
- International Standards (ISO 7027)

Turbidity Measuring Method Must Meet EPA or ISO Requirements for Water Testing

Comparison of USEPA 180.1 and ISO 7027 Method

| Item | EPA 180.1 | ISO 7027 |
|-----------------|-------------------------------------|-------------------------------------|
| Light Source | Tungsten Lamp | LED or Other Filtered Source |
| Wavelength | 400-600 nm | 860 ± 30 nm |
| Characteristics | Long Warm Up Time | Low Stray Light |
| | More sensitive to Smaller Particles | Less Sensitive to Smaller Particles |
| | Color Interferences | Low Color Interferences |

Units of Measure - Turbidity

- Different Units
 - NTU: Nephelometric Turbidity Units
 - FTU: Formazin Turbidity Units
 - FNU: Formazin Nephelometric Units
 - These Units, NTU, FTU, and FNU are Equivalent
- Formazin is the Polymer Suspension Used to Calibrate Turbidity Sensors
- Turbidity is Determined in a Nephelometric Instrument, and Measures the Light that is Scattered at 90° from the Light Source

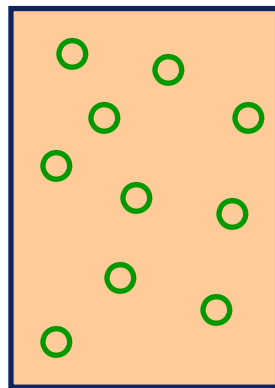
Total Suspended Solids - Definition and Units

- Definition:
 - A Measure of the Total Mass of Particles in a Sample
- Determination of TSS:
 - Filtering a Volume of Sample and Weighing the Mass of the Dried Residue Retained on the Filter
- The TSS Value is Calculated From the Turbidity Measurement
- Turbidity and TSS Relationship Must be Determined by the User
- Available Units: ppm, mg/L or no units displayed

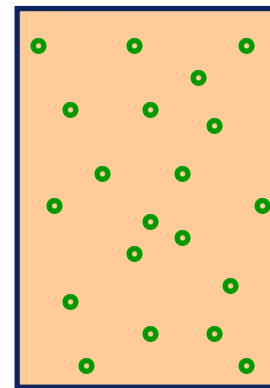
Turbidity versus Total Suspended Solids

- **Turbidity is not the same as total suspended solids (TSS)**
- Both Turbidity and TSS Are Defined by the Method Used to Measure Them
- TSS is a Gravimetric Measurement; it Depends on the Total Mass of Filterable Material in the Sample
- Turbidity is an Optical Measurement; it Depends on the Number of Particles in the Sample and Their Shape and Size

For 100 mg of solid particles in 1 L
TSS is 100 mg/L.
Turbidity has a certain value



→
Cut each particle in half



TSS is still 100 mg/L.

Turbidity is different: since there are more particles and smaller in size.

Effects on Turbidity

Turbidity Depends on:

- Number of Particles Per Volume
- Size of Particles
- Wavelength of Light Used for Measurement
- Color of Particles
- Shape of Particles
- Refractive Index of Particles
- Presence of Air Bubbles

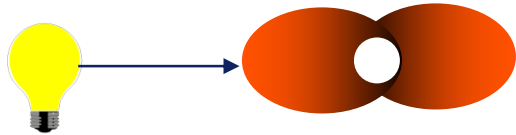
Development of Turbidimeter



First Turbidimeter: The Quality of Wine of Beer Was Determined by Holding the Glass up to a Light Source and Look for Small Particles.

Pattern of Particle Scattering

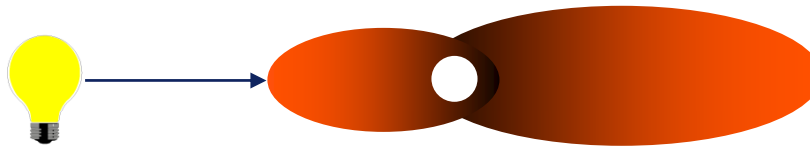
Small Particles



Size: Smaller Than $1/10$ the Wavelength of Light

Description: Symmetric

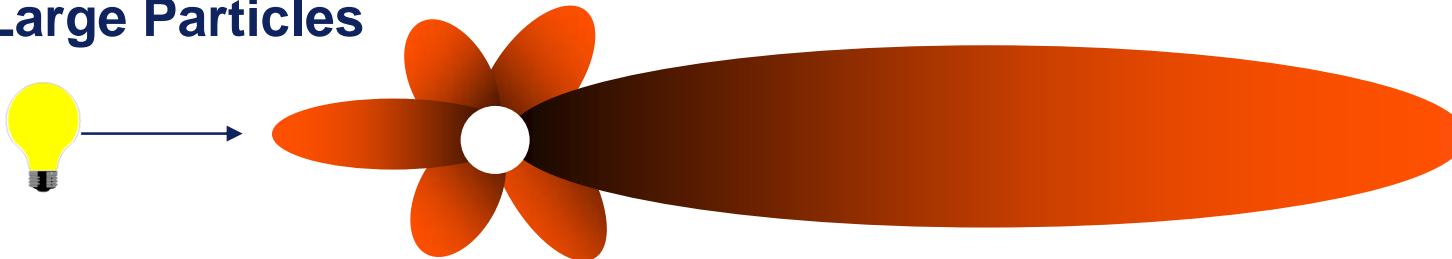
Medium Particles



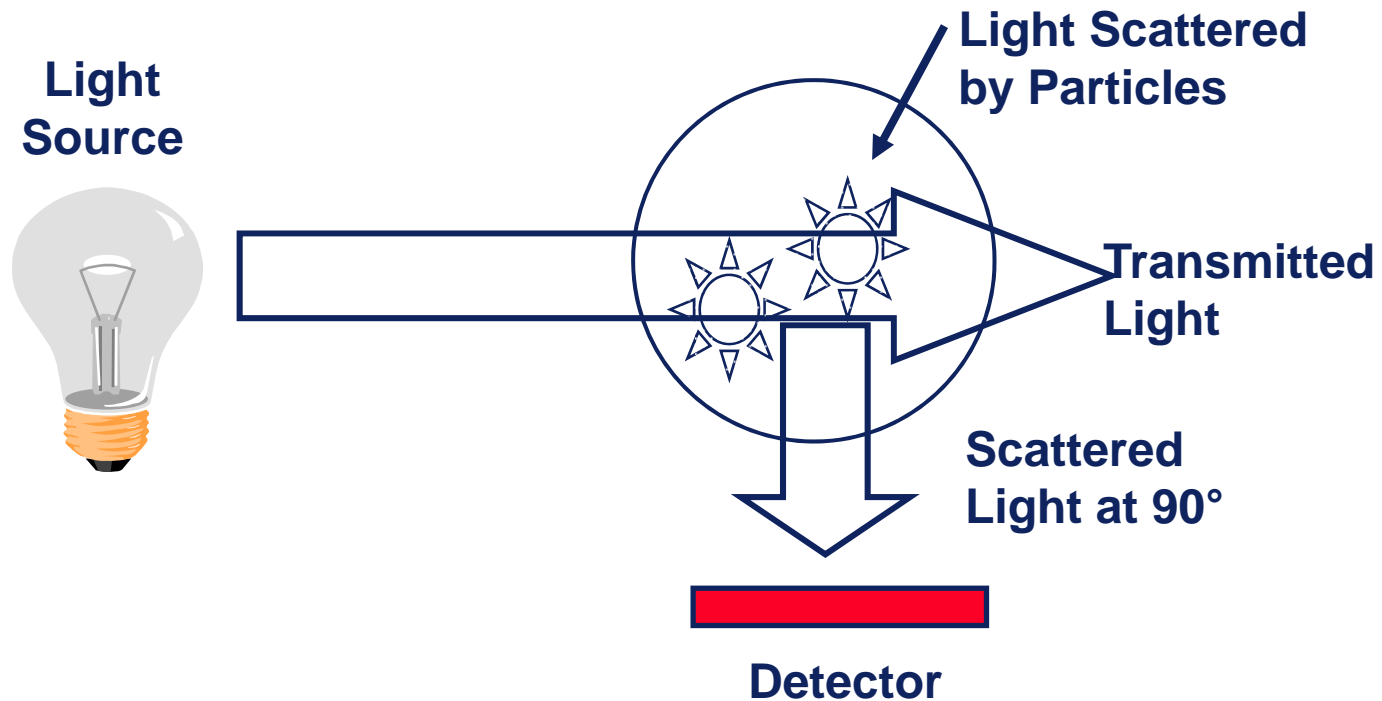
Size: Approximately $1/4$ the Wavelength of Light

Description: Scattering Concentrated in Forward Direction

Large Particles

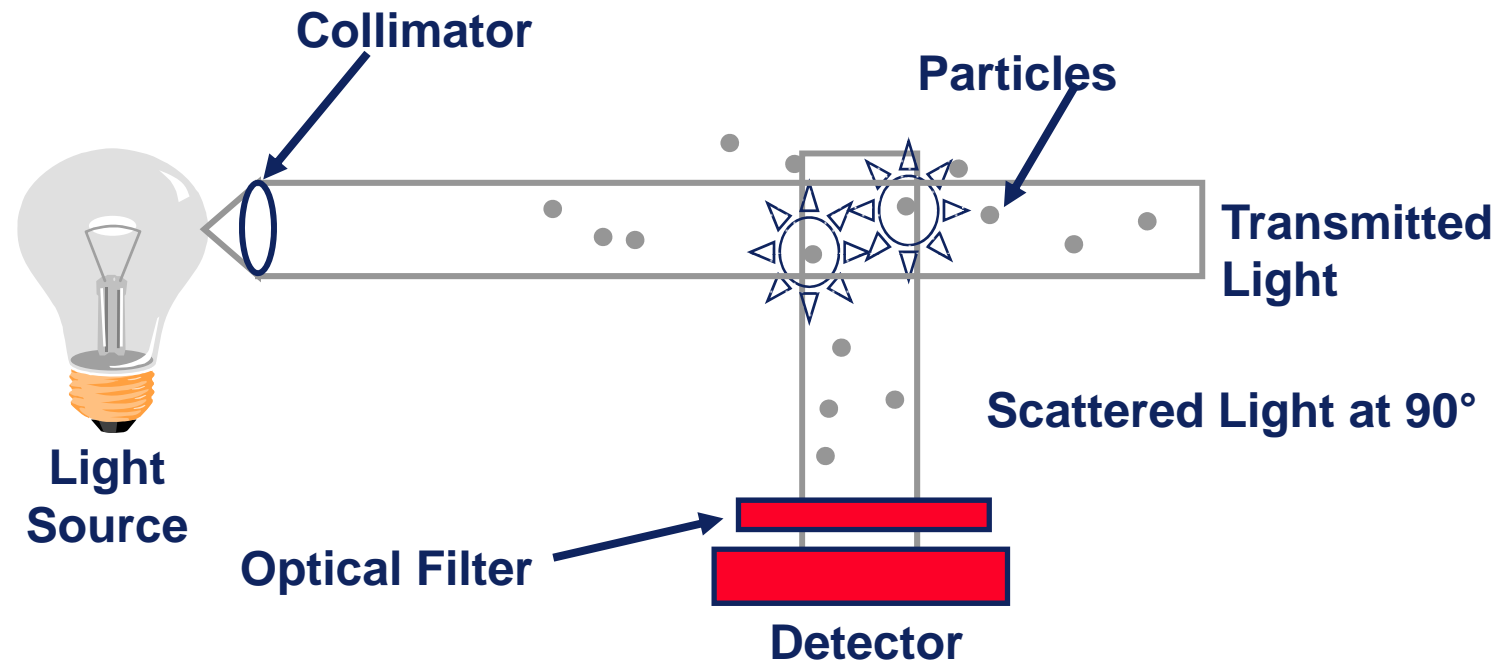


Basic Nephelometer



Turbidity is the measure of the amount of light scattered by particles in a sample. A beam of light passes through a sample containing suspended particles. The particles interact with the light and scatter the light. A detector at 90° measures the intensity of the scattered light.

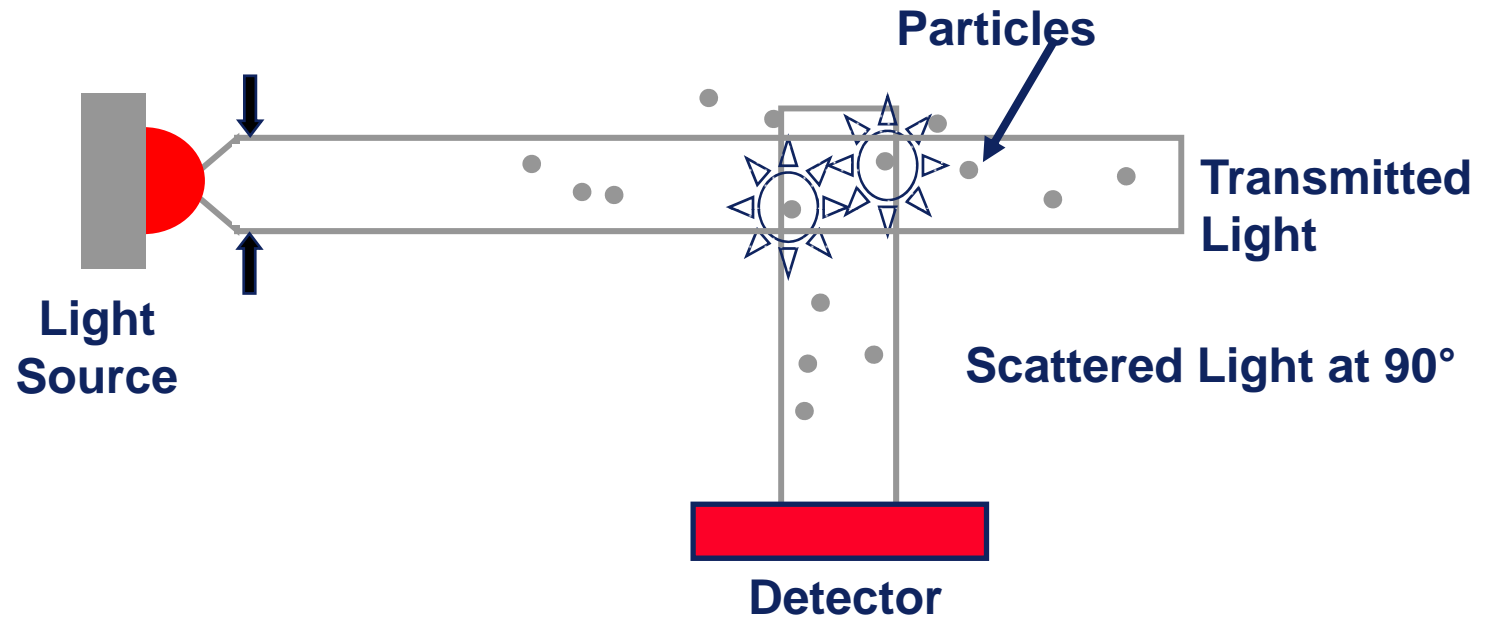
Turbidity Sensor - EPA 180.1 Method



EPA Method 180.1 requires:

1. Tungsten Lamp Light Source with Filament Temperature Between 2200 - 2700 K
3. Detector Response Between 400 and 600 nm
4. Scattered Light be Measured at $90^\circ \pm 30^\circ$
5. Total Path Length Through Sample Less Than 10 cm

Turbidity Sensor - ISO 7027 Method



ISO Method 7027 requires:

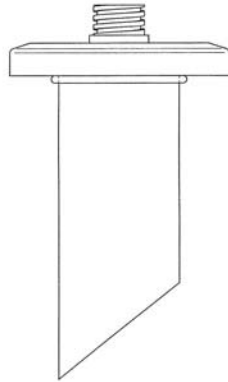
1. The Wavelength of the light to be $860 \text{ nm} \pm 30 \text{ nm}$
2. The Measuring angle to be $90 \pm 2.5^\circ$
3. Light Source Using a Laser, LED, or Tungsten Filament Lamp with Filter

Turbidity Measuring System

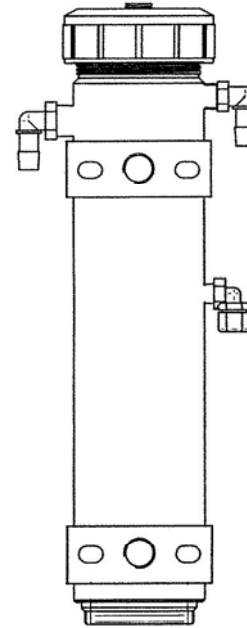


- Complete System
- Single or Dual Sensor Input
- Debubbler/Measuring Chamber
- USEPA Method 180.1 or ISO Method ISO 7027
- 0 - XXX NTU Range
- Resolution X.XXX NTU
- Ideal for ??? Level Turbidity
- Analyzer
- Suitable for Wastewater / Discharge / Industrial / Process Water Applications

Online Turbidimeter



Turbidity Sensor



Debubbler/Measurement Chamber



Calibration Methods

Three Turbidity Calibration Methods:

1. User Prepared Solution
2. Commercially Available Standard Solution
3. Comparison with a Referee Turbidity Instrument

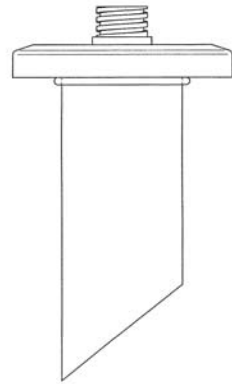
Note: The USEPA Does Not Recommend Calibrating an On-line Turbidity meter by Comparison with a Bench Meter

Dry Calibration Standard Available for Checking the Performance

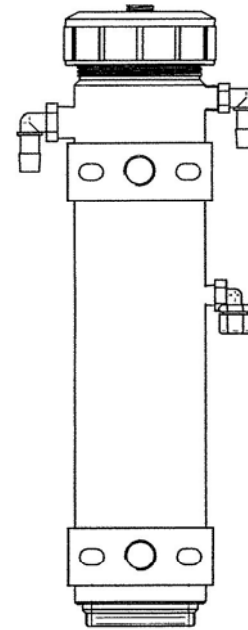
Total Suspended Solids Calibration Method:

Enter an Equation into the Analyzer to Convert Turbidity to a TSS Reading

Installation

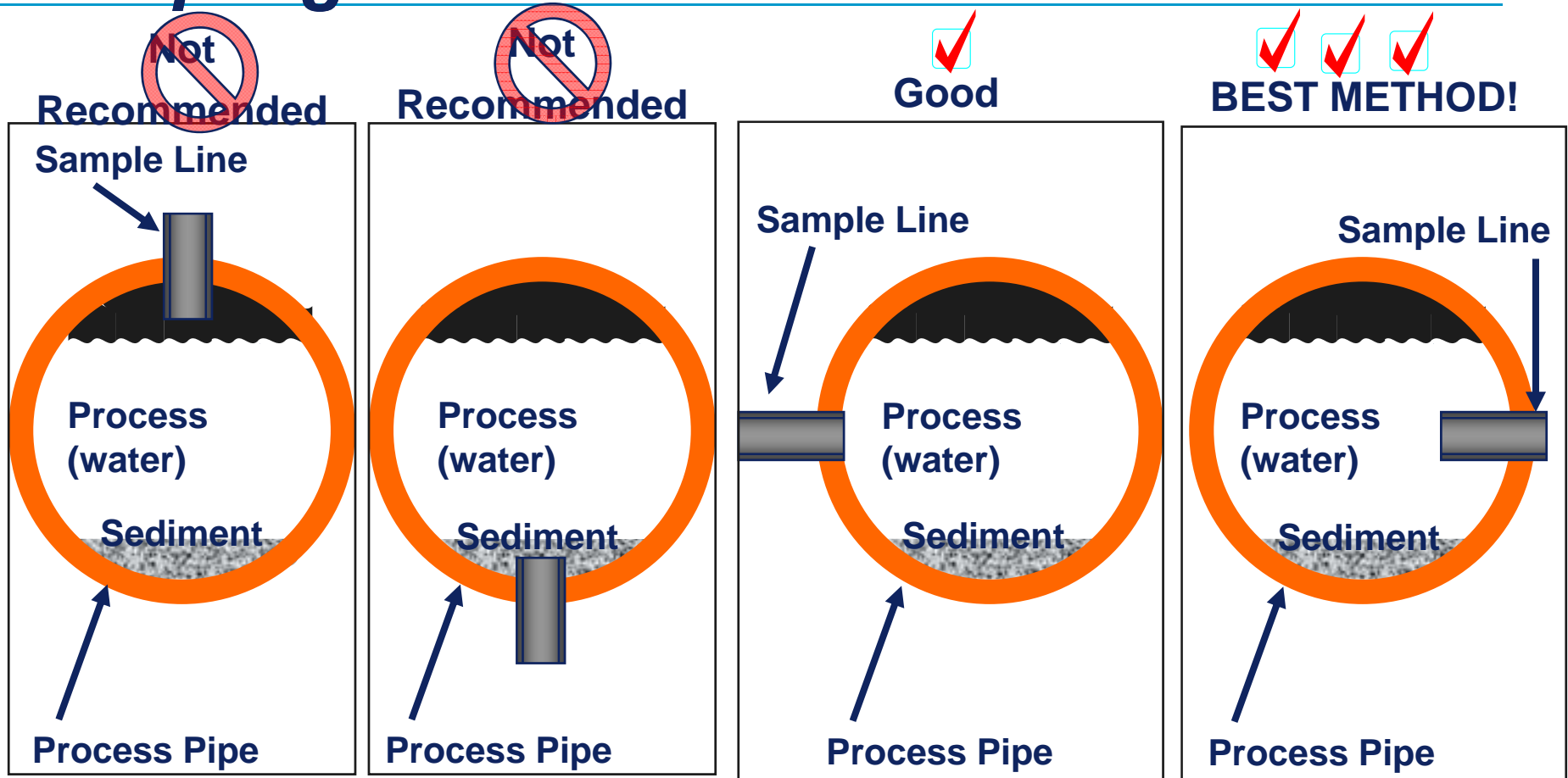


Turbidity Sensor



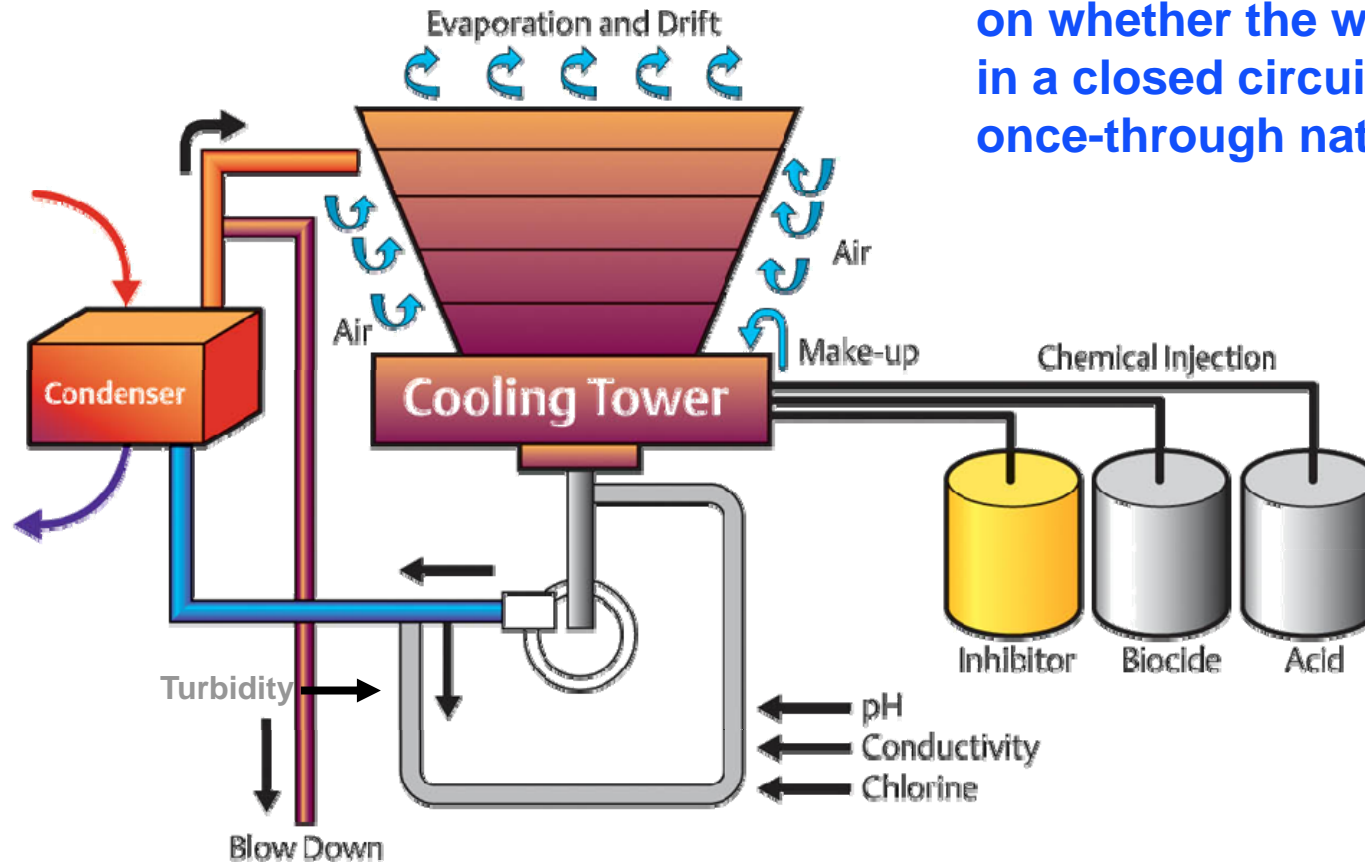
Debubbler/Measurement Chamber

Sampling Methods



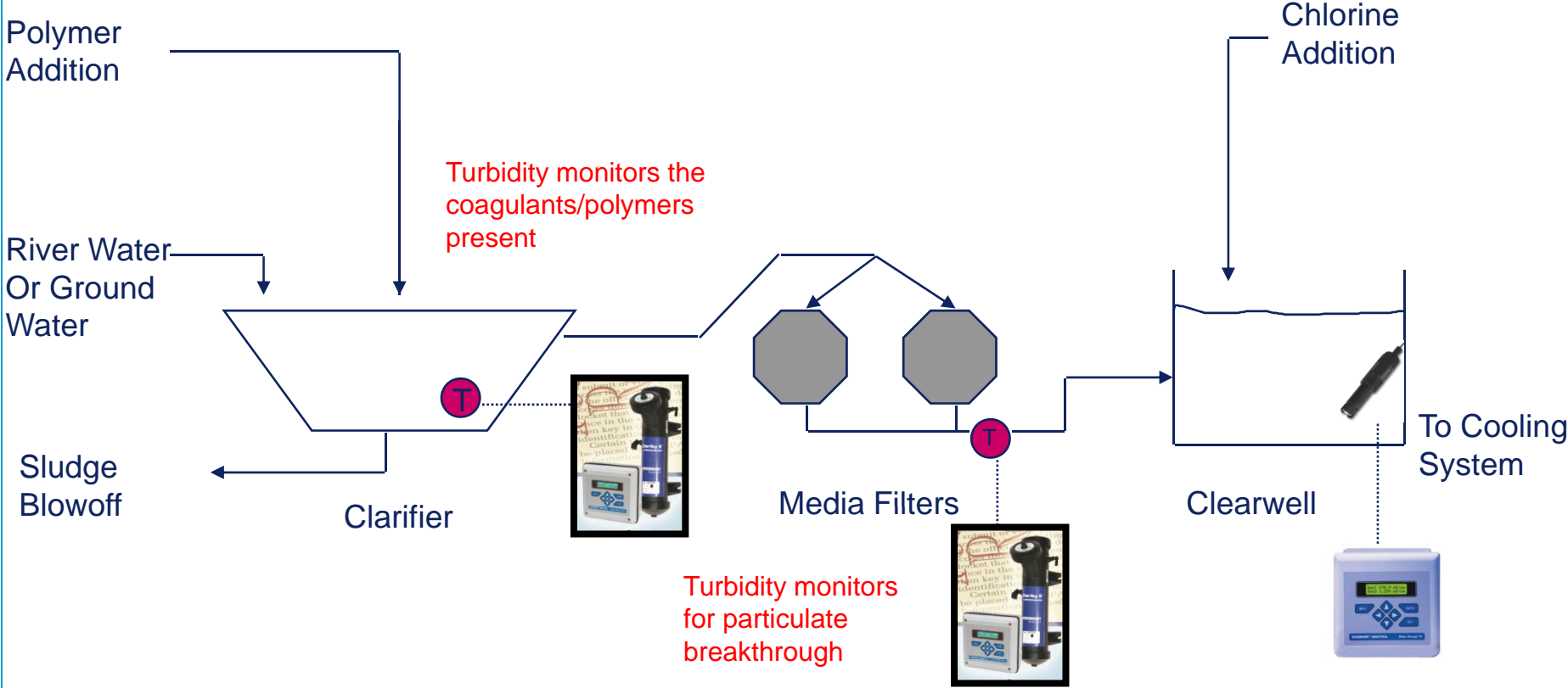
Cooling Water Systems

Typical Cooling Tower Control System

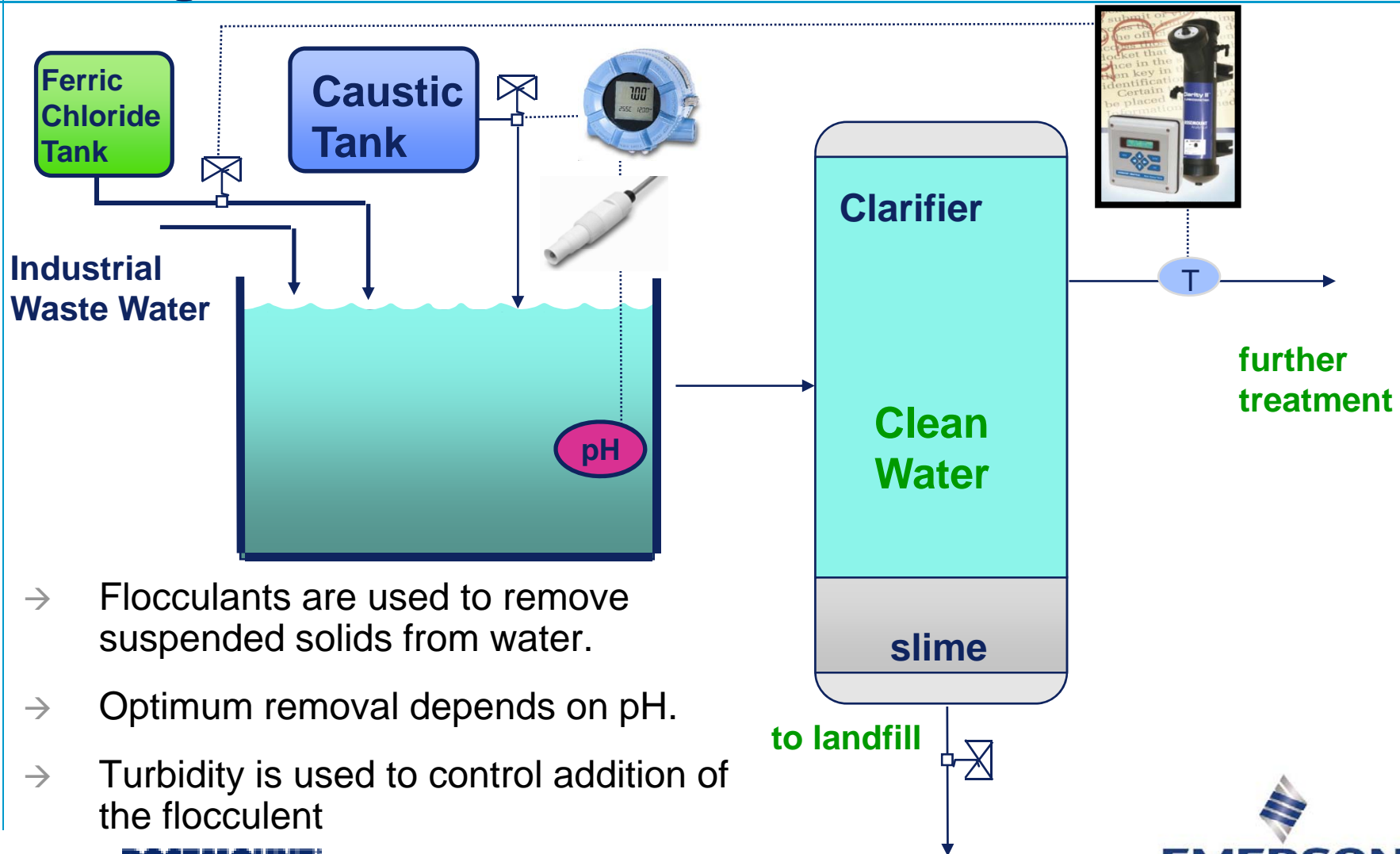


Quantity of analyzers depends on whether the water used is in a closed circuit or from a once-through natural source

Raw Make-up Water System



Coagulation and Flocculation



- Flocculants are used to remove suspended solids from water.
- Optimum removal depends on pH.
- Turbidity is used to control addition of the flocculent

Following the Water in Steam Power Generation

Overview

Efficiency reductions and equipment failures due to corrosion and deposition cost the power industry billions of dollars every year.

Good water chemistry can help to mitigate some of these effects and is best achieved with online liquid analysis and control.

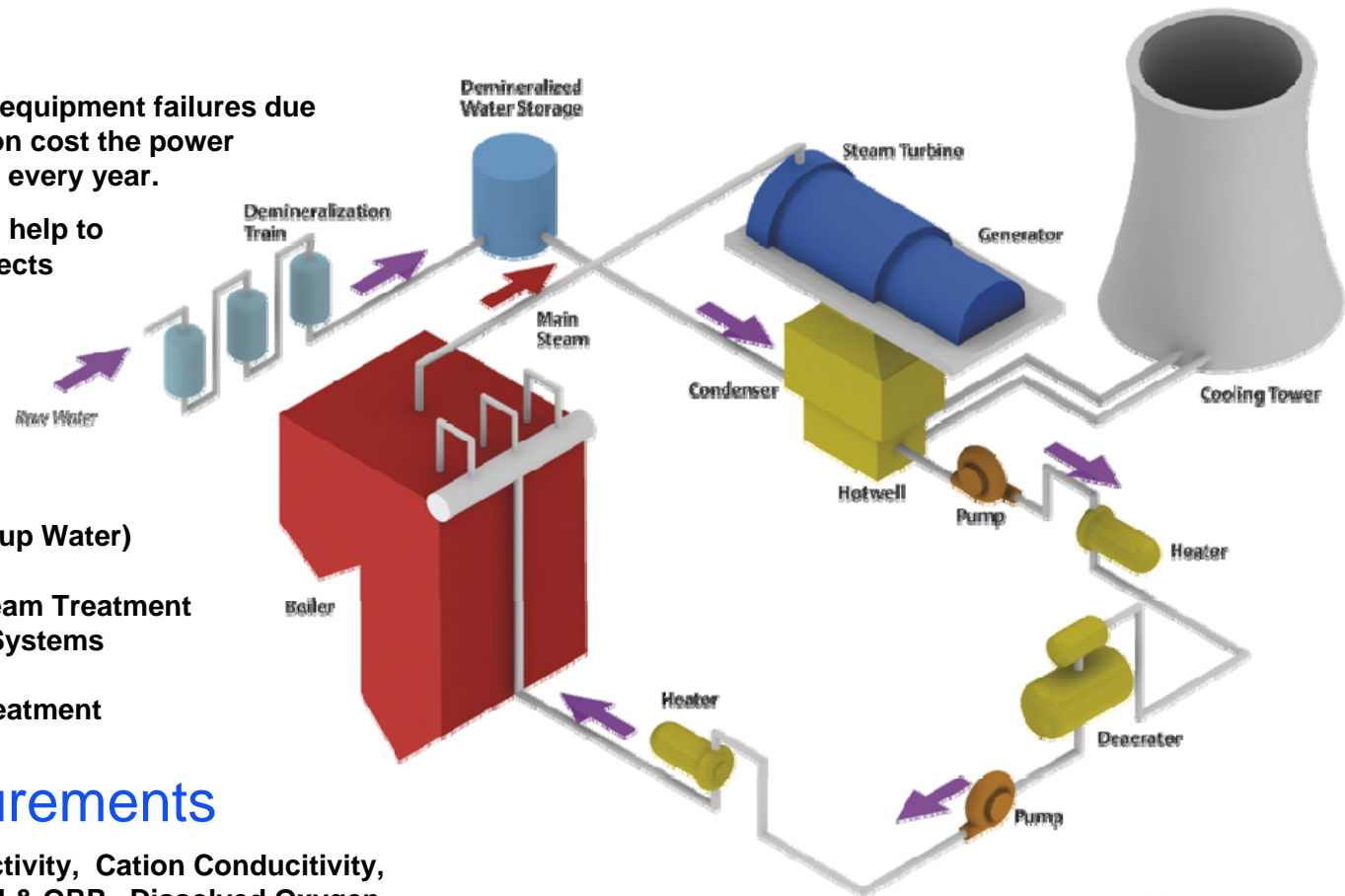
Applications

- Demineralization (Make-up Water)
- Condensate Returns
- Boiler Water & Steam Treatment
- Cooling Water Systems
- Scrubbers
- Waste Treatment

Measurements

- Conductivity, Cation Conductivity,
- pH & ORP, Dissolved Oxygen,
- Chlorine, Ozone, Turbidity,
- Silica, Sodium, Phosphate,
- Hydrazine

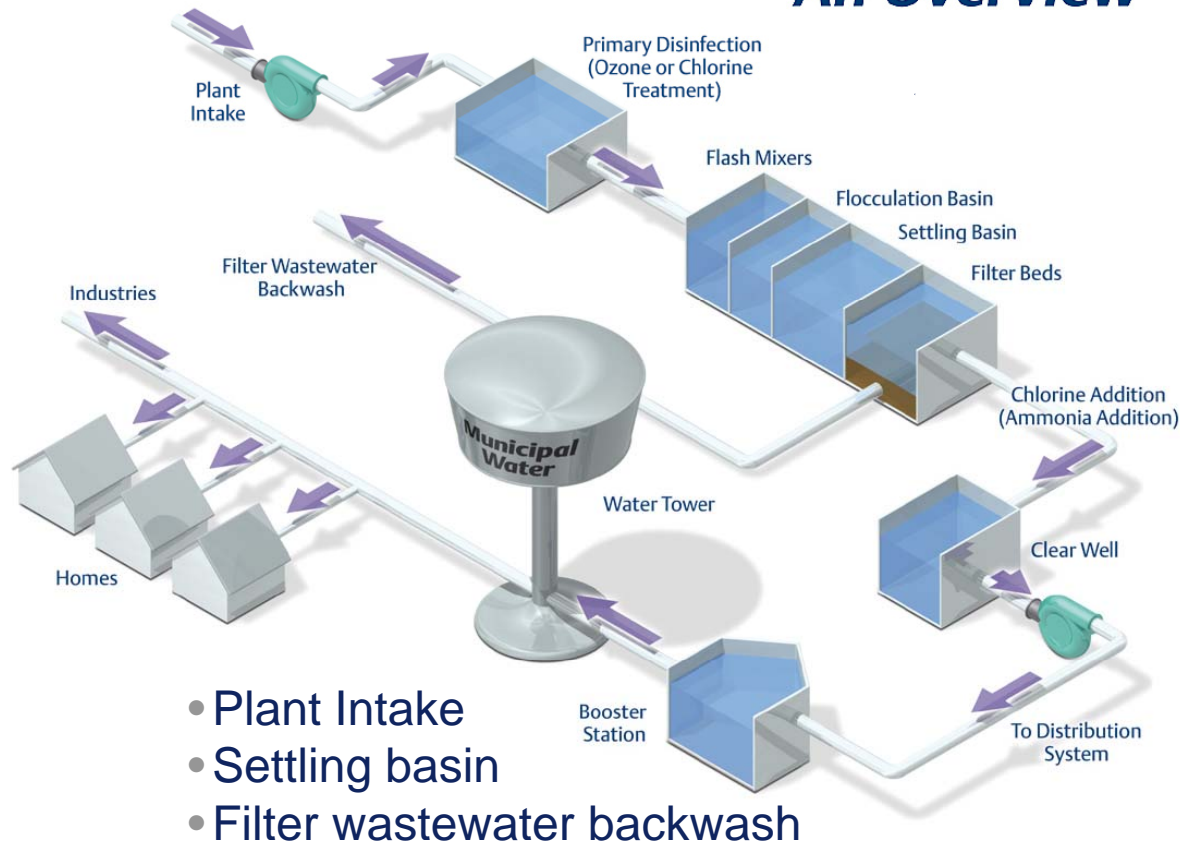
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Turbidity - Drinking Water Applications

Drinking Water Treatment An Overview



- Plant Intake
- Settling basin
- Filter wastewater backwash

Drinking Water Regulations - USEPA

Two USEPA Rules to Monitor Turbidity for Drinking Water Treatment Plants

1. Plants Serving >10,000 People

Combined Filter Effluent (CFE) Water Turbidity:

≤ 0.3 NTU 95% of Measurements Taken Each Month

Never Exceed 1 NTU

Individual Filter Effluent (IFE) Water Turbidity:

≤ 0.5 NTU

Never Exceed 1.0 NTU

Readings: Continuous and Recorded Every 15 Minutes

Water Source: Surface or Ground Water

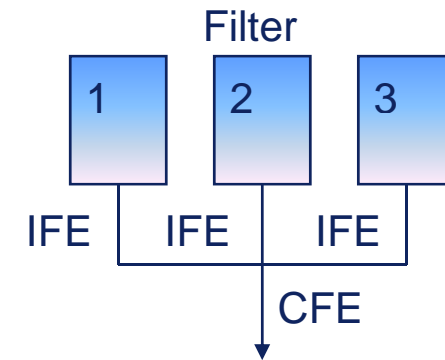
Filtration: Conventional and Direct

Rule: Interim Enhanced Surface Water Treatment Rule (IESWTR)

Compliance: Jan 1, 2002

Report Violations to the State

Keep Records for Three Years



Drinking Water Regulations - USEPA

Second Rule

2. Plants Serving <10,000 people

Turbidity Requirements for the Small Plants (<10,000 people) Will be the Same as Those for the Big Plants (>10,000 people)

Rule: Long Term 1 Enhanced Surface Water Treatment Rule (LT1ESWTR)

Compliance: Jan 14, 2005

Drinking Water Regulations - International

Regulations for Turbidity Requirements for Drinking Water Treatment Plants Outside the USA

These Plants Have Either ...

- Adopted the USEPA Standards,
- Developed Their Own Regulations, or
- Follow the World Health Organization (WHO) Recommendations of 1 NTU

Questions?

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