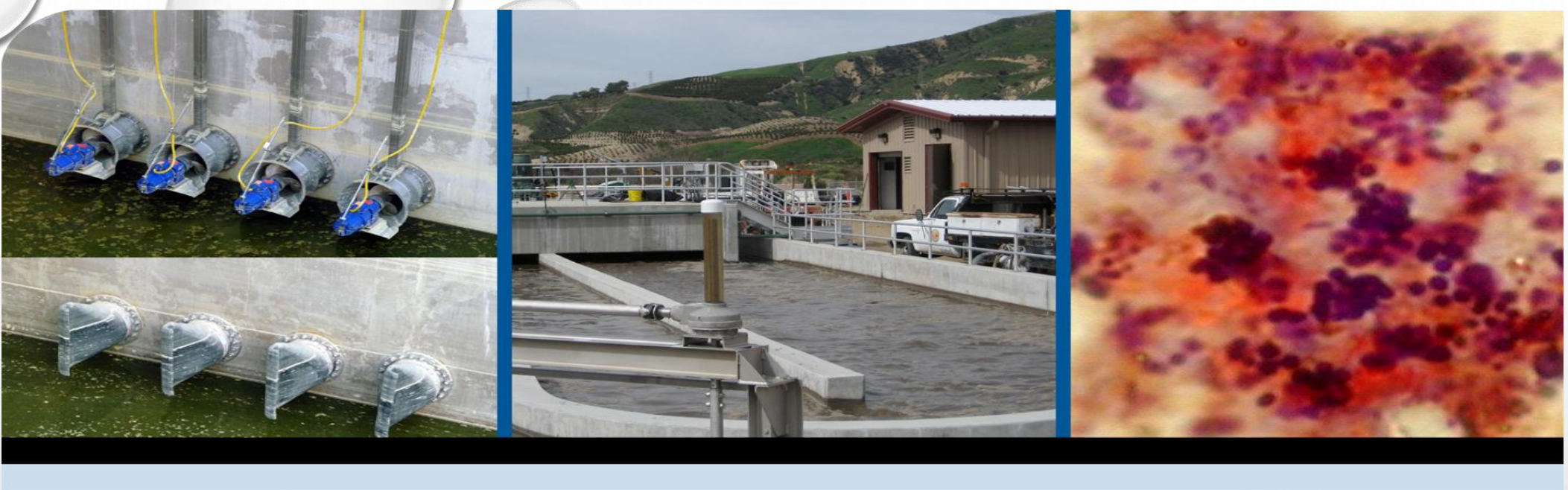




ACTIVATED SLUDGE PROCESS CONTROLS

PROCESS CONTROL IS:

- Any activity
to develop a capable plant (the apparatus)
and take it to the desired level of performance
(control the biology)
- Developing a sludge that settles well
while removing the targeted pollutants
- Managing change
- Understanding & controlling microorganism growth

PROCESS CONTROLS

1. **Dissolved Oxygen** : How much oxygen do we give the microbes?
 - DO Concentration
 - ORP – Oxidation Reduction Potential (Used when $DO < 0.0 \text{ mg/L}$)
2. **Return Sludge** : How many solids are recycled?
 - RAS Flow Rate : How do we set this?
3. **Sludge Mass** - How many microbes are in the tanks?
 - MCRT : Mean Cell Residency Time
 - SRT : Sludge Retention Time

DISSOLVED OXYGEN CONTROL

WHY DO WE CARE ABOUT D.O.?



We Cannot Control The Microbes, But We Can Control Their Environment

WHAT IS DISSOLVED OXYGEN?

DO is the Residual Oxygen After the Demand Has Been Satisfied

Dissolved Oxygen = Oxygen Supplied – Oxygen Demand

Just Like Chlorine Residual = Chlorine Dose – Chlorine Demand

HOW MUCH OXYGEN DO THEY NEED?

BOD Removal:

–About 1.2 pounds of O_2 per pound of BOD

Nitrification:

–About 4.6 pounds of O_2 per pound of Ammonia

Example:

$Q = 5.0 \text{ MGD} \mid \text{BOD} = 200 \text{ mg/L} \mid \text{TKN} = 25 \text{ mg/L}$

$O_2 \text{ for BOD} = 200 \times 5 \times 8.34 \times 1.2 = 10,008 \text{ lbs } O_2$

$O_2 \text{ for } NH_3 = 25 \times 5 \times 8.34 \times 4.6 = 4,796 \text{ lbs } O_2$

Total O_2 Required = 14,804 lbs O_2

Nitrification Requires ~ 48% more O_2 than BOD removal!

WHAT IS THE BEST D.O. CONCENTRATION FOR ACTIVATED SLUDGE?

It Depends.... What do you want the microbes to do?

Aerobic/Oxic: $DO > 0.5\text{mg/L}$

Anoxic: $DO < 0.5\text{mg/L}$, Nitrate (NO_3) Present

Anaerobic: No DO , No NO_3

It's really about oxygen transfer – DO is the result of changing the amount of oxygen transferred into the water

- Airflow

- Aerator Speed

WHAT IS THE BEST D.O. CONCENTRATION FOR ACTIVATED SLUDGE?

- I want them to remove high concentrations of soluble BOD
→ AEROBIC, increase airflow, high DO
- I want them to remove ammonia
→ AEROBIC, adjust airflow, low to high DO¹
- I want them to remove nitrate
→ ANOXIC, stop airflow, low DO²
- I want them to remove ammonia and nitrate at the same time
→ ANOXIC, low DO¹
- I want them to remove phosphorus
→ ANAEROBIC² followed by AEROBIC

¹ Need proper SRT to make this work

² Need soluble food (carbon) to make this work

BY CONTROLLING THE OXYGEN SUPPLIED WE CONTROL THE MICROBE'S RATE

Influent Ammonia ↑

To Increase Nitrification Rate,
Oxygen Dose Should Go ↑

Influent Ammonia ↓

To Decrease Nitrification Rate,
Oxygen Dose Should Go ↓

This assumes that the nitrifying
microbes are present in sufficient
quantity – How do you ensure that?

SRT / MCRT

MYTH: THE DO NEEDS TO BE 2.0 MG/L OR HIGHER

Why?

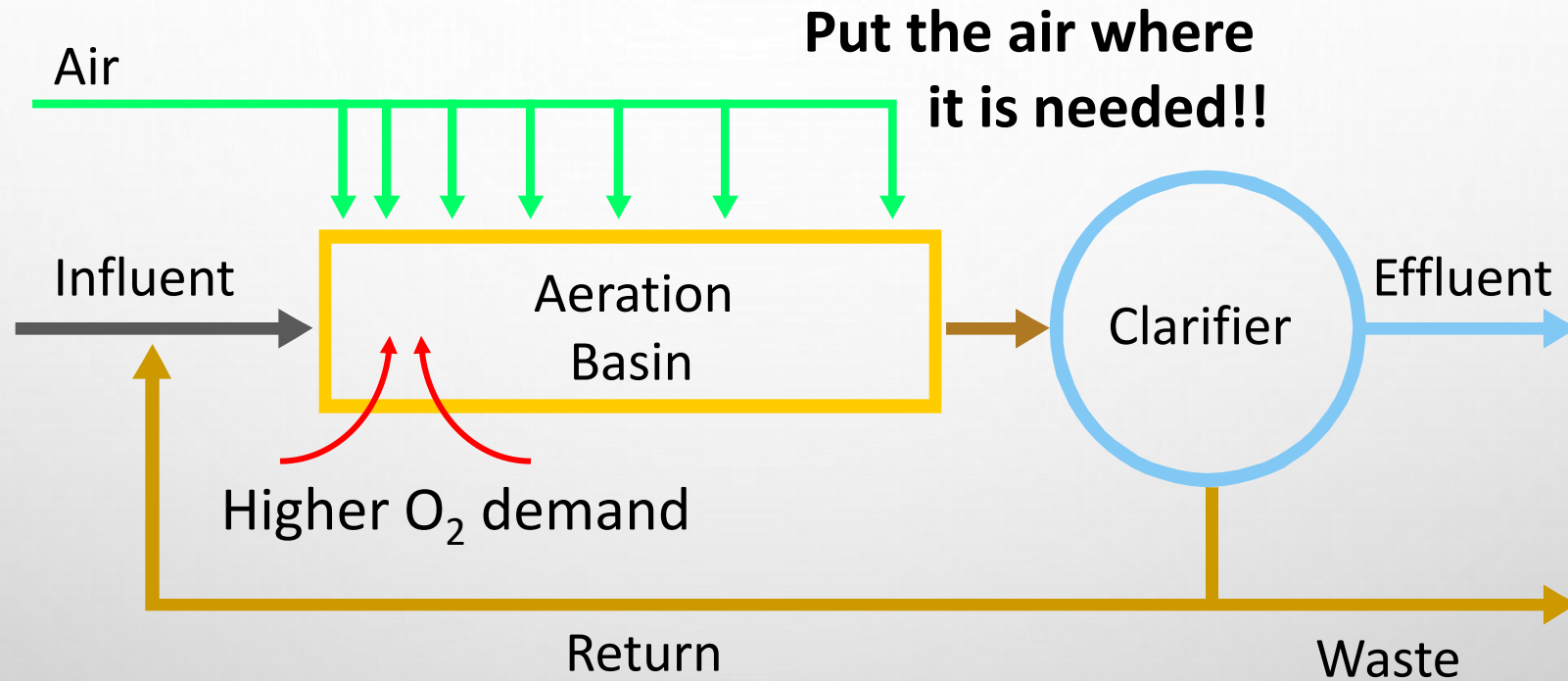
At what point in the tank?

Where did this number come from?

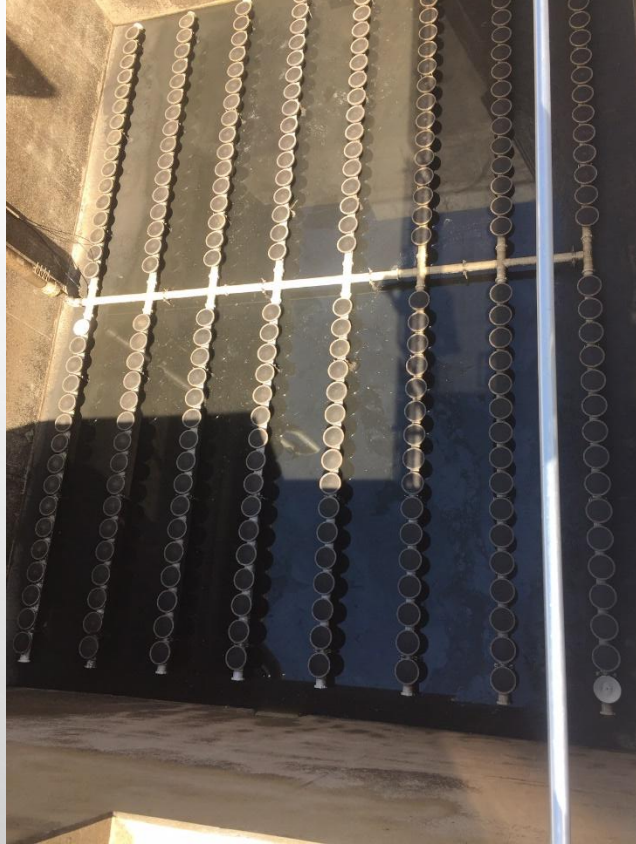
Was it created just to pass a certification exam?

Why not put the right amount of air where it's needed?

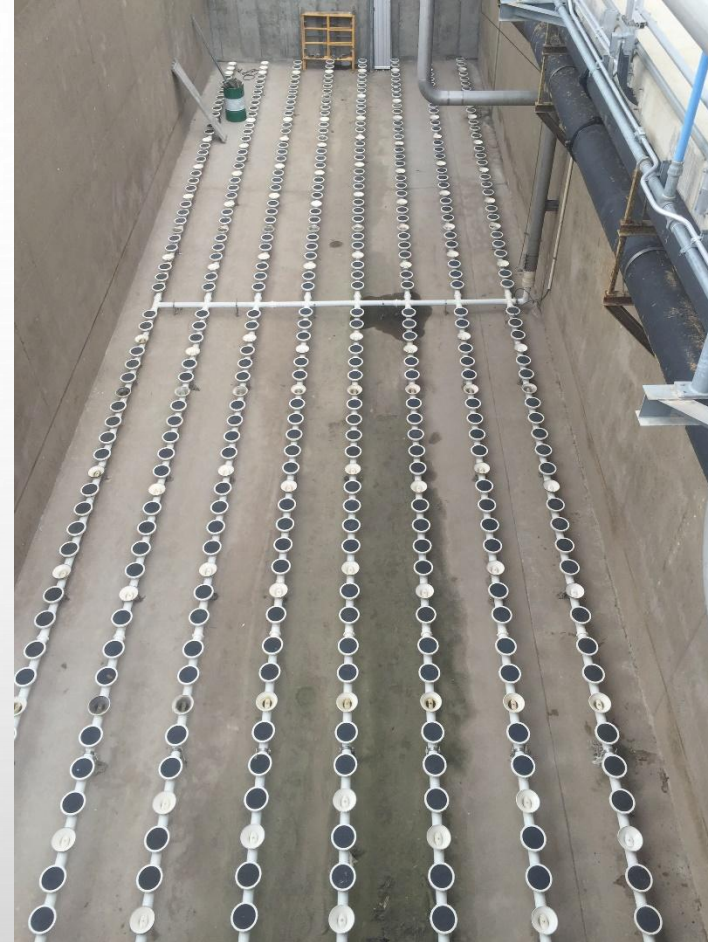
TAPERED AERATION



TAPERED AERATION

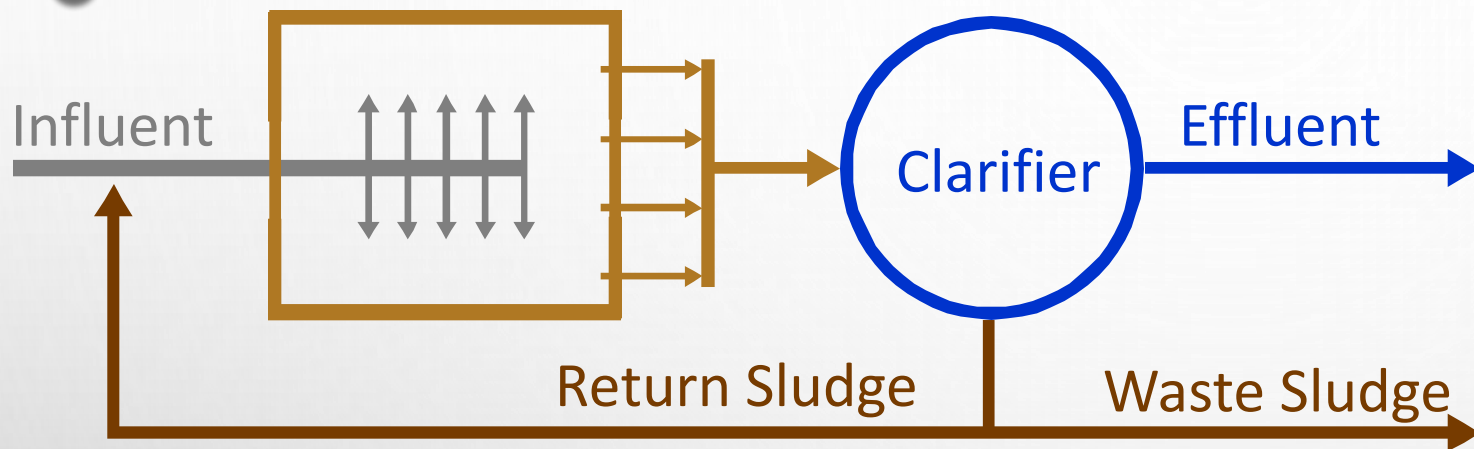


Higher diffuser
density upstream



Lower diffuser density
downstream

ON/OFF AERATION



Complete Mix System

Turn Air ON to Nitrify

Turn Air OFF to Denitrify

Air On



Air Off



LOW DO – BETWEEN 0.1 AND 1.0 MG/L

Complete Mix Systems

Aerate enough to maintain a slight DO residual

Promotes Simultaneous Nitrification & Denitrification

Can save a lot of Aeration Energy!

Low DO



DO SUMMARY

- More about oxygen dose, less about dissolved oxygen residual...
- There is no “Perfect” DO
 - Put the air where the microbes need it to go
 - Depends on type of plant, strategic and tactical objectives
 - If on an exam, probably “Maintain 2.0mg/L” is the right answer but watch it!
- Significant energy savings are possible by upgrading and reducing aeration

HOW DO YOU KNOW IF YOUR PROCESS IS UNDER CONTROL?

- Effluent In Compliance
 - Good Sludge Quality
- Specific Oxygen Uptake Rate (SOUR) is Trending Properly

“ The SOUR test defines what it means to be ‘Activated Sludge’.

‘Activated’ means the microbes are hungry; they have eaten, digested, and converted their food to new cells. ”

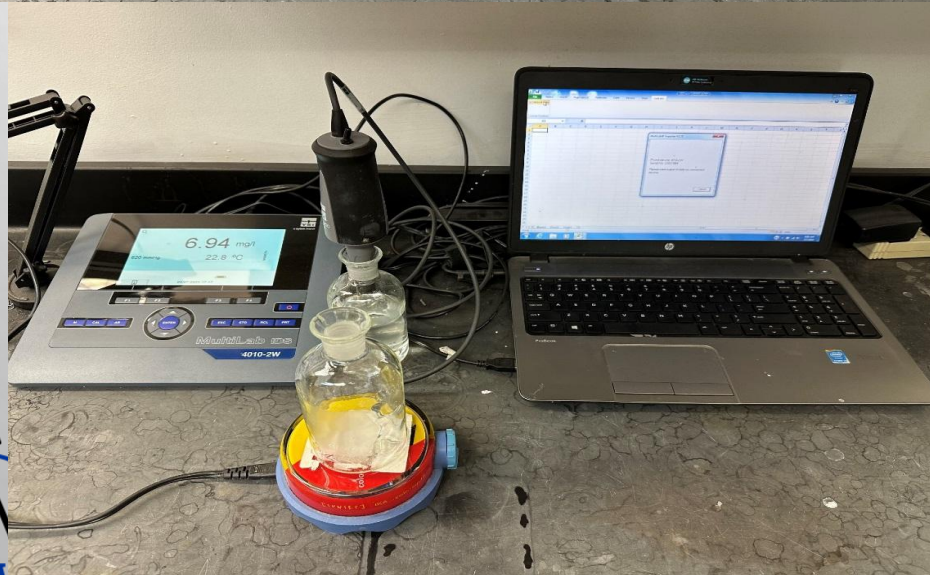
Ron Schuyler, COWAC

OUR TEST EQUIPMENT

Automatic OUR
YSI 4010-2W or 3W



Manual OUR
Hach HQ430 w/ LBOD

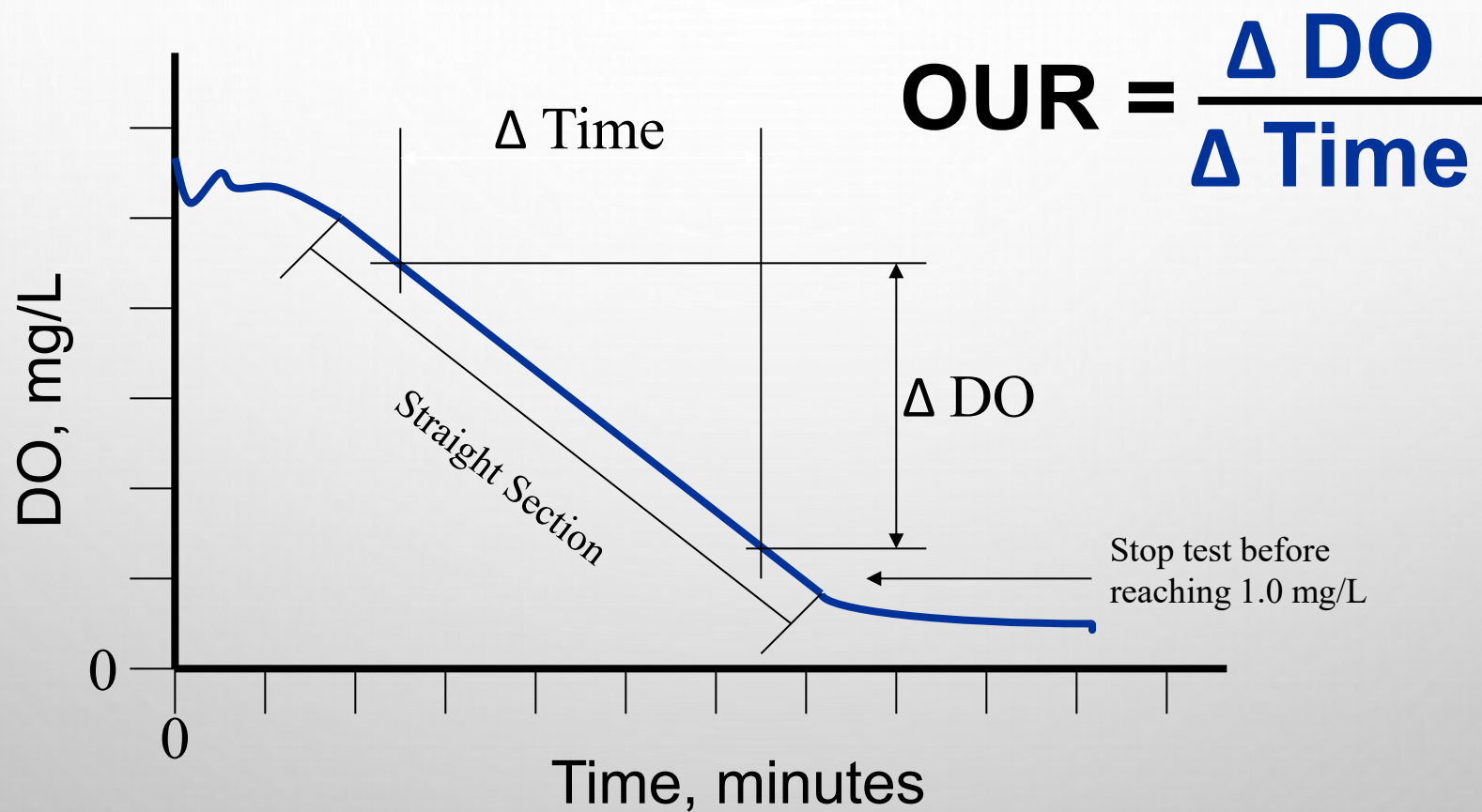


*Koozie or other insulation can be used if temperature is a concern

SOUR PROCEDURE

1. Verify and/or Calibrate DO Probe
2. Collect sample
3. Gently mix sample while transporting
4. Aerate the sample
5. Fill BOD bottle
 - a) Optional: put stir bar inside and place BOD bottle on stir plate
6. Insert DO Probe, start DO probe mixer or start stir plate
7. Wait 30 seconds for DO to stabilize
8. Record data
9. Stop when the DO is less than 1.0mg/L or 15 minutes has passed
10. Calculate OUR and then SOUR

OUR PLOT



WHAT DOES THIS TELL US?

- OUR = rate at which microorganisms consume oxygen
- OUR directly correlates to influent loading strength and microbial growth rate
- Increase in influent strength -> increase in microorganism metabolic activity -> higher OUR
- Increase in microbial growth -> increase in oxygen consumption -> higher OUR

SOUR CALCULATION

$$\text{SOUR} = \frac{\text{OUR (mg/L/min)} * 60 \text{ min/h} * 1000 \text{ mg/g}}{\text{MLVSS (mg/L)}}$$
$$= \text{mg O}_2/\text{h/g MLVSS}$$

SOUR tells us the OUR per unit organism

SPECIFIC OXYGEN UPTAKE RATE (SOUR)

- OUR can change
 - Change in microorganism activity?
 - Change in number of organisms (MLVSS)?
 - Which caused the change in OUR???
- SOUR calculation removes the MLVSS variable
 - SOUR change is due only to microorganism activity
 - Relates to the aerobic metabolic rate of the microorganisms at the sample point



TYPICAL SOUR END OF A-BASIN

Normal Ranges

Pure Oxygen Activated Sludge Range - **20-50** mg/h/g

Conventional Activated Sludge Range - **12-20** mg/h/g

Normal Extended Aeration Range - **6-12** mg/h/g

Aerobic Digestion Range - **<1- 3** mg/h/g

WHAT DOES THIS MEAN TO YOU?

- When SOUR is **high** leaving the basin:
 - There is still metabolic activity happening with the microorganisms meaning higher O_2 consumption
 - Therefore the organisms will continue to consume O_2 at a high rate in the secondary clarifier
 - With continued high O_2 consumption in the clarifier but no more O_2 supplied, denitrification could start in the secondary clarifiers



WHAT DOES THIS MEAN TO YOU?

- When SOUR is **moderate/low** leaving the basin:
 - The organisms aren't consuming high amounts of O_2
 - The organisms aren't as active in the secondary clarifiers
 - The organisms can continue their activities on the remaining O_2 without reverting to denitrification and will denitrify in designated anoxic zones

Normal – darn clear!



WHAT DOES THIS MEAN TO YOU?

- When SOUR is **too low** leaving the basin:
 - There is very little O_2 being consumed by the organisms
 - The organisms are not doing their intended job
 - There's too many organisms for the strength of the influent
 - The organisms are digesting themselves
 - Something toxic in the influent

SOUR SUMMARY

- SOUR is the ONLY way to know if the sludge is “Activated”
- Indicates:
 - Microbe’s response to process changes
 - Clarifier Denitrification Potential
 - Toxicity
- Can be used to inform process control decisions

Full SOUR Procedure



<https://process-opt.com/specific-oxygen-uptake-rate-procedure-for-activated-sludge>