SSI Aeration

Bridging the Gap Between Different Regional SOTE Standards

Oxygen Transfer Efficiency Standards

Results can differ substantially between identical equipment due to methodology differences between EU & US standards

ASCE-22

- ASCE-22 is the standard for calculating the Standard Oxygen Transfer Efficiency (SOTE) in the US
- In theory, one would expect all major standards across the world to report results in a similar range of values, however this is NOT the case

EN12255-15

DWA/ATV M-209

- Europe and Germany both have their own standards, EN12255-15 & DWA/ATV M-209, respectively, which are very similar in nature, but both provide more leniency than the ASCE standards in the USA
- This results higher results for companies reporting results in accordance with EN & DWA/ATV versus companies reporting per ASCE
- We will break down the reasons for this in this presentation

Elements Impacting Reported SOTE

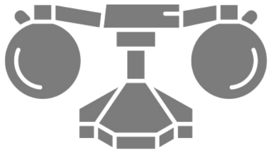
There are four reasons for these differences, 3 related to differences in standards and 1 related to different measurement practices

- In Europe, manufacturers may quote efficiency values determined by their more lenient standards
- This gives the impression that their equipment is more efficient than equipment tested per ASCE
- There are four ways to adjust the output of an efficiency calculation which we will cover in this presentation
- Three of them relate directly to differences between the ASCE and DWA/ATV+EN standards:

1. SATURATION

2. TOLERANCES

3. TDS CORRECTION



4. DWP/HEADLOSS MEASUREMENTS

Related to differences in standards (1–3)

Not related to standards, but also Impacts efficiency curves and calcs (4)

1. DO Saturation Concentration

Saturation refers to the maximum concentration of O2 that can be reached in water through ambient air aeration, and it is dependent on barometric pressure, aeration depth, water temperature, ambient air oxygen concentration & bubble size. Oxygen transfer becomes much more difficult as saturation is approached

(TRANSFER COEFFICIENT) **(SATURATION)**

$$SOTE = \frac{K_L a * C_s * \text{Volume}}{\text{OXYGEN INPUT (mass)}}$$

(STANDARD OXYGEN TRANSFER EFFICIENCY)

As shown by the equation, Cs is in the numerator, thus a higher saturation level results in a higher oxygen transfer efficiency

1. Saturation

In the US, saturation is determined from <u>MEASURED</u> data from calibrated DO sensors, while in Europe it is <u>CALCULATED</u> more favorably without the use of any field data.

- ASCE requires measurement of dissolved oxygen data for saturation determination with calibrated (DO) probes. Though measured in the USA, the 1/3 depth method is a calculation method that offers the closest equivalent to measured saturation, confirmed by SSI's lab measurement results

- European and German standards allow saturation to be calculated from site ambient and physical data instead of measured DO data.
- However, these standards use an old method to calculate saturation, referred to as the mid-depth method
- Although the 1/3 method is the closest approximation of measured oxygen saturation, the EN12255 and DWA/ATV standards continue to allow the use of the mid-depth method.

1. Saturation

The table below shows the advantageous, yet incorrect DO saturation concentration values that can be yielded from using the mid-depth (1/2) method instead of the more accurate 1/3 method for calculating saturation:

DEPTH (m)	1/3 DEPTH METHOD	MID-DEPTH METHOD	MID DEPTH ADV.
1.52	9.53	9.75	**2.34%**
2.13	9.7	10.02	**3.22%**
2.74	9.88	10.28	**4.06%**
3.35	10.06	10.55	**4.87%**
3.96	10.24	10.82	**5.66%**
4.57	10.42	11.09	**6.42%**
5.18	10.6	11.35	**7.15%**
5.79	10.77	11.62	**7.86%**
6.4	10.95	11.89	**8.55%**
7.01	11.13	12.16	**9.21%**
7.62	11.31	12.42	**9.85%**
8.23	11.49	12.69	**10.48%**
8.84	11.67	12.96	**11.08%**

1/3 depth method formula: C*s20 x [1 + (D / (3 + 10.35))]
Mid-depth method formula: C*s20 x [1 + (D / (2 + 10.35))]
C*s20 = Saturation @ surface = 9.09 mg/L

- As mentioned, saturation determination involves real measurements, not calculated under the ASCE standards in the USA, however the 1/3 method is the closest equivalent calculation to true lab measurements
- Nevertheless, the EN & DWA/ATV standards in Europe continue to use the outdated mid-depth method, which results in an advantage
- This advantage grows as a function of depth, as shown by the table
- This false advantage can range anywhere from 2-13%, making results reported in accordance with EN & DWA/ATV much higher Standard Oxygen Transfer Efficiency in comparison to nearly identical products reported per ASCE.
- This is only the first of the differences in standards that impact reported SOTE performance, which can add up to a significant advantage when compounded as you will soon see

2. Tolerances

Tolerances for discrepancies in reported SOTE are permitted under EU standards, but do not exist under US standards


- The EN/DWA-ATV standards allow tolerances for discrepancy in their calculations of SOTE, requiring clients to accept them:

8.3 Specific standard oxygen transfer efficiency

The normal air flow rate Q_A depending on the quality of the metering device can be measured with an accuracy of ± 5 % (see 6.2.5). The specific standard oxygen transfer efficiency (SSOTE) is determined with an accuracy of ± 10 % and in large tanks up to ± 15 %.

- This stipulation results in an allotted discrepancy tolerance of up to 10% in small tanks, and up to 15% in tanks >3000m^3
- Thus, if a manufacturer tests at a 40% SOTE, but their client's specifications require 44%, the manufacturers test is considered to pass

- The ASCE standards allow no such discrepancy tolerances and must be reported as measured
- As a result, EN/DWA-ATV users can often technically fail client requirements, which is then corrected by the tolerance, making their equipment often appear superior to equipment tested per ASCE, which is not the case
- These tolerances are often exploited, and give EN & DWA/ATV up to a 10-15% advantage over ASCE tested products (on top of the 2-13% advantage found by calculating saturation rather than measuring it)

3. TDS Correction

Total Dissolved Solids concentrations in the clean water being tested increase efficiency by reducing bubble size

- ASCE-22 requires all manufacturers to correct their tests to the standard of 1000mg/L of total dissolved salts (TDS)
- Thus, if SSI tests at 0 mg/L of TDS, our reported efficiency is higher
- On the other hand, if we test at 2000 mg/L, our efficiency is corrected down

- Both EN & DWA/ATV standards allow EU manufacturers to use up to 2000 mg/L of TDS in their tests at maximum
- However, they are not required to correct down
- As a result, manufacturers may test at or correct to the maximum, knowing that a higher concentration of TDS will result in a higher SOTE
- Doubling the concentration of TDS to 2000 results in up to a 10% increase to SOTE, further expanding the perceived EN & DWA/ATV advantage.

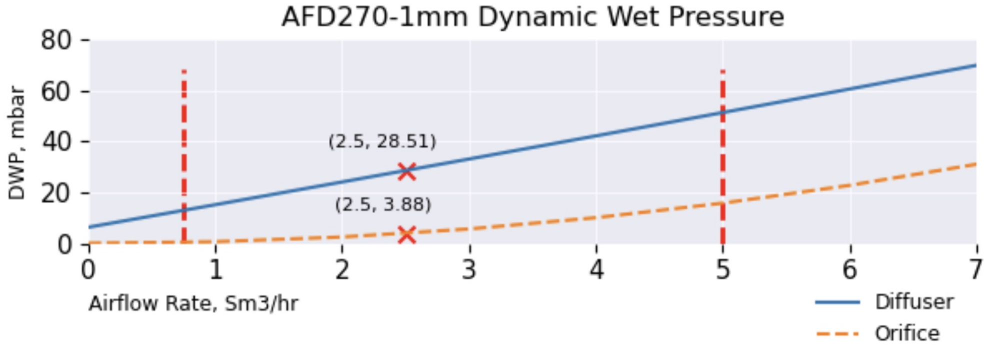
DWP / Diffuser Headloss Measurements

Diffuser headloss/DWP (Dynamic wet pressure) is a component of the Wire to Water measurement of efficiency that can be calculated

- Although this is not regulated by any standards, the method of reporting DWP/headloss can vary by manufacturer. One of the downsides of using the compressed air method is that you remove the safety factor for fouling so it can be less practical.

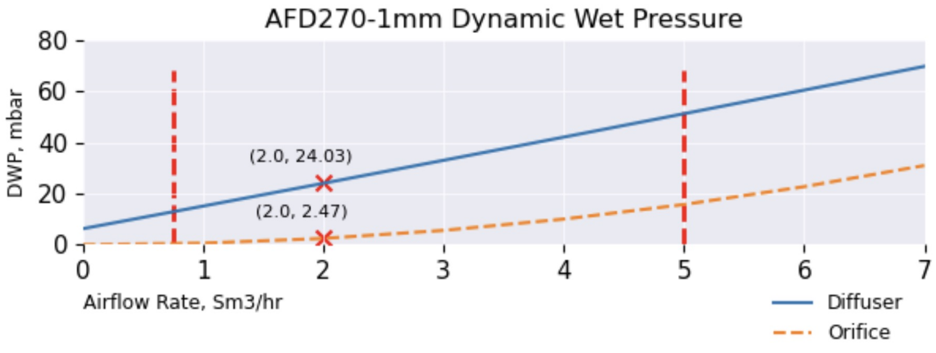
Standard Airflow Rate

- It is common practice for some manufacturers to measure headloss in a shallow aquarium tank, measuring the mostly uncompressed airflow at ambient pressure and temperature
- Near the surface of an aquarium, DWP is ~28.5 mbar with an airflow rate of 2.5m^3/hr:



Compressed Airflow Rate

- Some manufacturers may report DWP/headloss by correcting the airflow rate per diffuser to actual air volumes in the submerged piping system compressed by the static head of water above.
- In the case below the manufacturer corrects the 2.5m^3/hr airflow rate to 2.0 m3/hr actual compressed airflow rate for depth, resulting in a lower DWP of ~24.0 mbar:



DWP / Diffuser Headloss Measurements

By correcting airflow rates to actual or compressed volumes at the diffuser, a manufacturer can demonstrate higher wire to water efficiency.

Technically, the manufacturer's compressed air calculations are correct, but practically it is worse for the client because:

- It puts the onus of adding a safety margin on the buyer in their blower selection and power requirement calculations
- Over time, diffuser heads will foul, leading to increased DWP/headloss & resulting in a system that could lack adequate power
- Often, clients are unaware what headloss values are being reported or that power requirements are being understated
- This can result in a 10-25% reduction in DWP/headloss, giving manufacturers reporting this way another perceived advantage over other products

The Perceived (but false) Advantage

Differences in SOTE standards and DWP measurements can seemingly make some products appear superior, which are not.

	STARTING VALUES	1. SATURATION	2. TOLERANCES	3. TDS CORRECTION
		2-13% EU ADV.	10-15% EU ADV.	10% EU ADV.
Germany / EU	6.6%/m	6.7-7.5%/m	7.4-8.6%/m	8.1-9.4%/m
USA	6.6%/m	6.6%/m	6.6%/m	6.6%/m

THE BOTTOM LINE

When combined, the differences in EU SOTE standards can result in a significant advantage of up to 40% in reported efficiency over manufacturers following ASCE