Aeration System Optimization Can Offer the Greatest Long-term Savings

Rich Atoulikian, PMP, P.E.

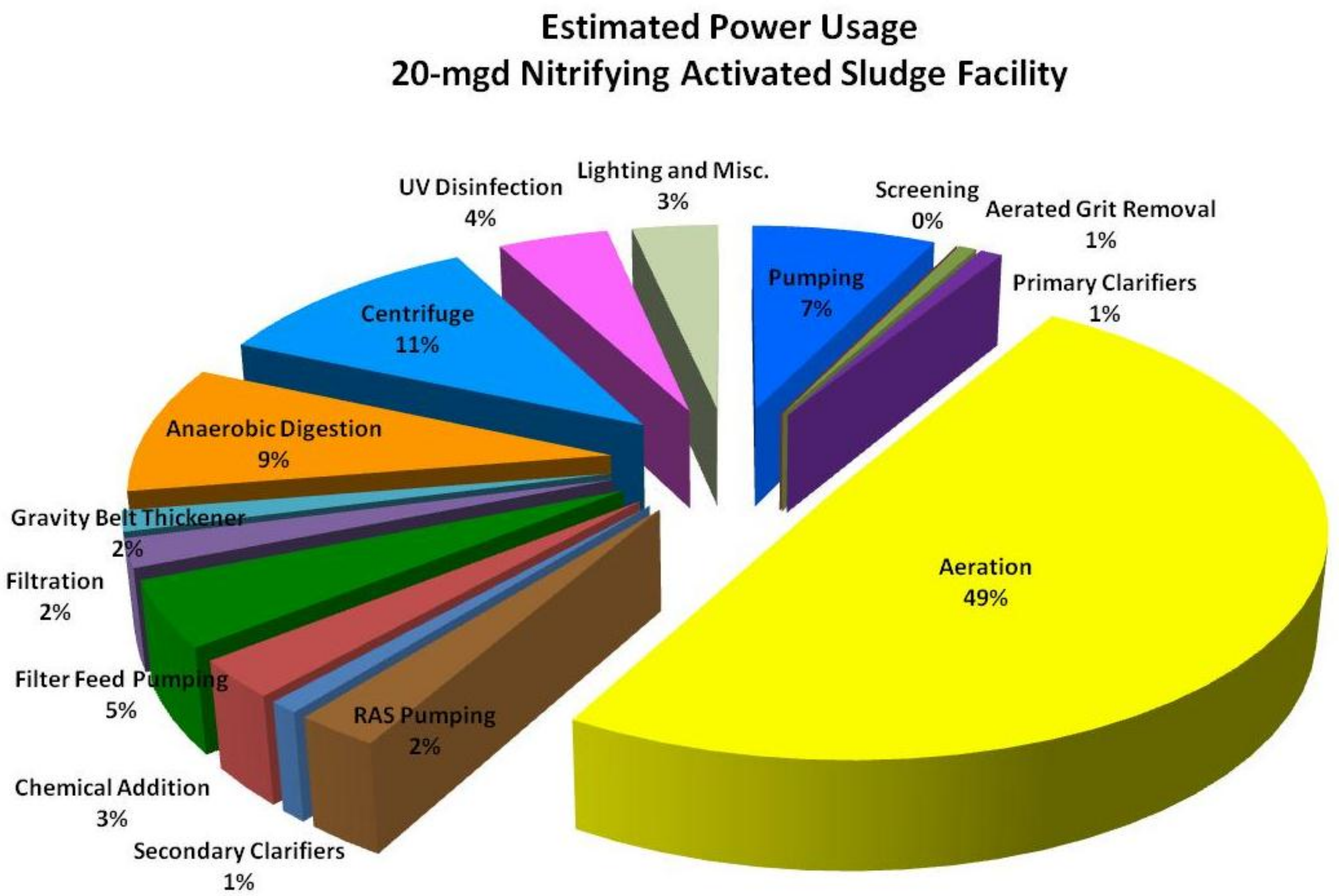
OWEA 2012 | June 2012

HDR

Outline

- Aeration Blower Types
- Efficiency Comparison
- Turbo Blowers
- Blower Sizing Consideration

Wastewater Treatment Plant Power Usage by Unit Process



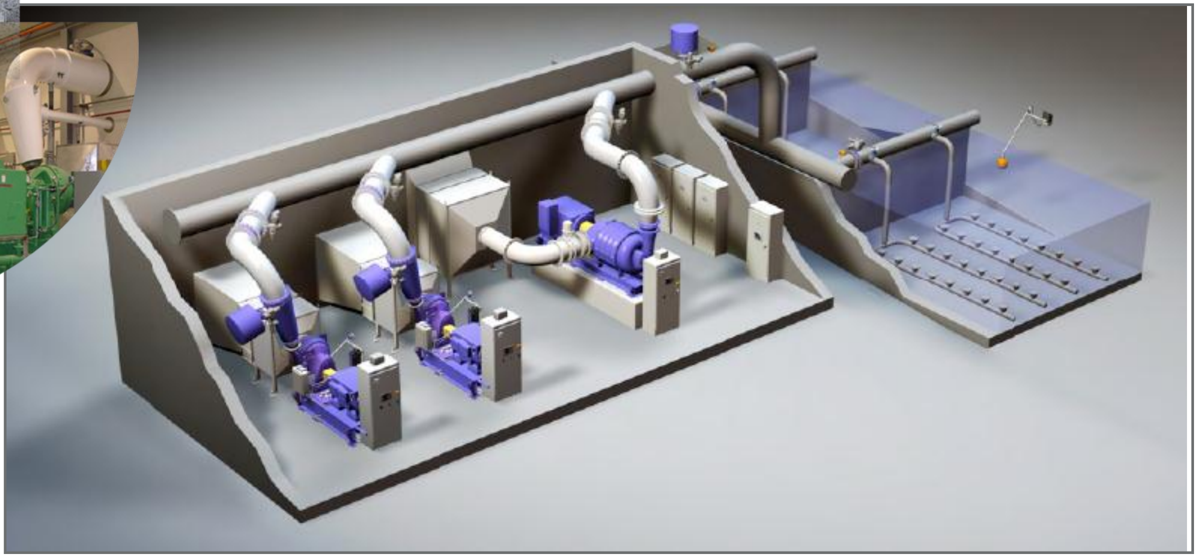
Actual Percentages Depends on:

- **Overall Process**
- **Process Design Parameters**
- **Effluent Criteria**

Source: "Energy Conservation in Wastewater Treatment Facilities" – Manual of Practice – No. 32, Water Environment Federation – Copyright 2009

Aeration System Components For Activated Sludge Plants

Blowers provide the motive power to deliver air to the diffusers



Aeration Blower Types

- Positive Displacement
  - Rotary Lobe
    - Constant, or variable speed drive
- Centrifugal
  - Multi-Stage
    - Inlet throttling
    - Variable speed drive
  - Single-Stage Centrifugal
    - Direct Drive
    - Single-point guide vane control
    - Two-point guide vane control

Existing Blower Technologies
Positive Displacement Blowers

- Lower flow, higher pressure
  - <3000 cfm, 10 psi
- Low turn-down, can't throttle inlet
- Low efficiency
- Noisy

Existing Blower Technologies
Multi-stage Centrifugal

- Each Stage Increases Discharge Pressure
- Higher flow >3000 cfm
- Low efficiency, low turn-down
  - ~ 30% turn-down
- Industry standard for many years
- Usually inlet butterfly and/or VFD Control

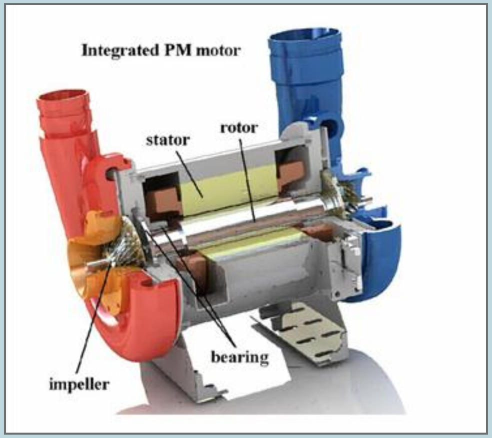
HDR

Existing Blower Technologies
Single-stage Centrifugal

- Guide Vane Control
- Higher turn-down than multi-stage
  - ~ 50%
- More efficient than multi-stage
  - >70%
- Sound attenuation required

Existing Blower Technologies
Single-stage "Turbo" Blower

- Higher turn-down – 45%
- More efficient than multi-stage
  - >80%
- Sound attenuation required



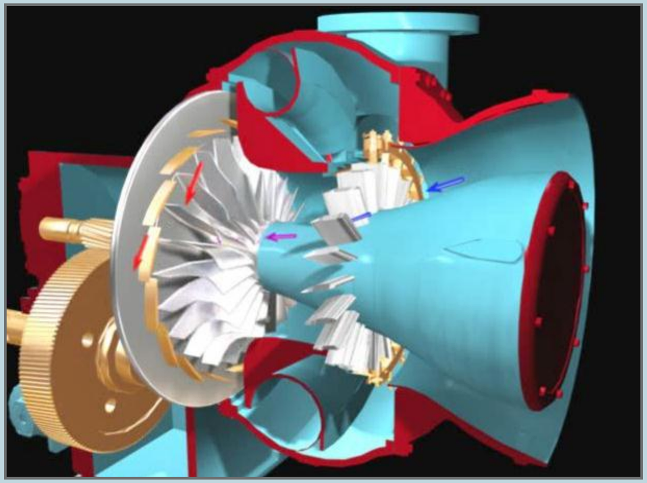
- Two Types
  1. Constant Speed, Variable Vane?
     Vs
  2. Variable Speed?

HDR

Existing Blower Technologies
Single-Stage Turbo Blowers

Variable Vane/Constant Speed Control

- Integrally Geared Single-Stage Blowers
- Guide Vane Control
  - Inlet/Outlet Vanes Independent
  - Inlet Vary Head
  - Outlet Vary Volume
- Higher Speed
- More Expensive
- More Common In Large WWTPs

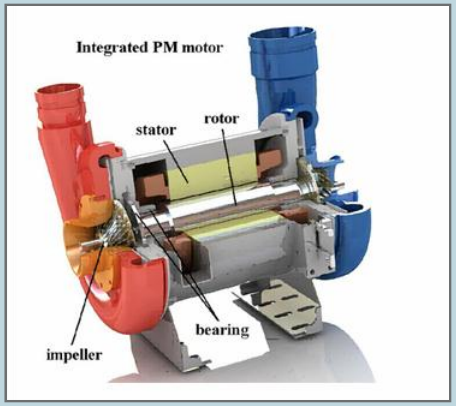


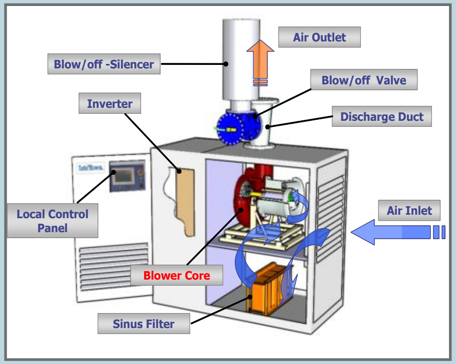
HDR

Existing Blower Technologies
Single-Stage Turbo Blowers

Variable Speed Control

- Variable Frequency Driven
- Many Manufacturers
  - Neuros (Korea)
  - K-Turbo (Korea)
  - HST (Finland)
  - Atlas-Copco
  - HSI
  - HV Turbo





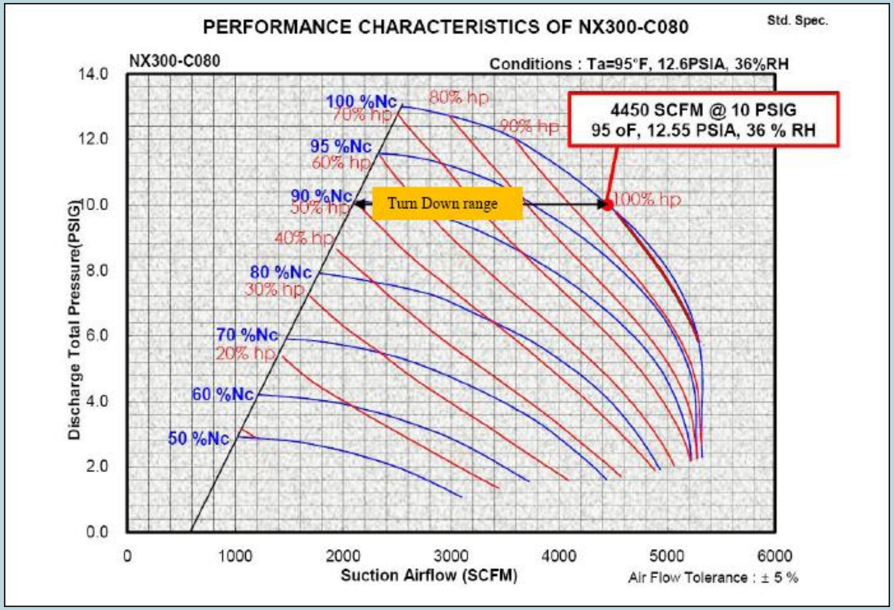
Turbo Blower Background / History

- On Market for Approximately 15 Years
  - Only Recently Embraced by North America Engineering Community
- Utilize Very High Speed Motor > 30,000 RPM
  - Impeller Design Based on Jet Engine Turbine
- Few Installations in the U.S.
  - However, Thousands In Europe and Asia
- Motor and VFD Are Custom Engineered

HDR

Turbo Blower Energy Related Benefits

- High Efficiency > 70% wire to air
  - Some states offer energy saving rebates
- High turndown > 50%
  - Much easier to meet low flows efficiently
  - Avoid surge conditions
- Lower horsepower under most operating conditions



HDR

Turbo – Blower, More Benefits

- Small Footprint
- Historically Very Low Maintenance
- Cost Competitive

Turbo - Blower Impeller Comparison

HV-Turbo

KTurbo

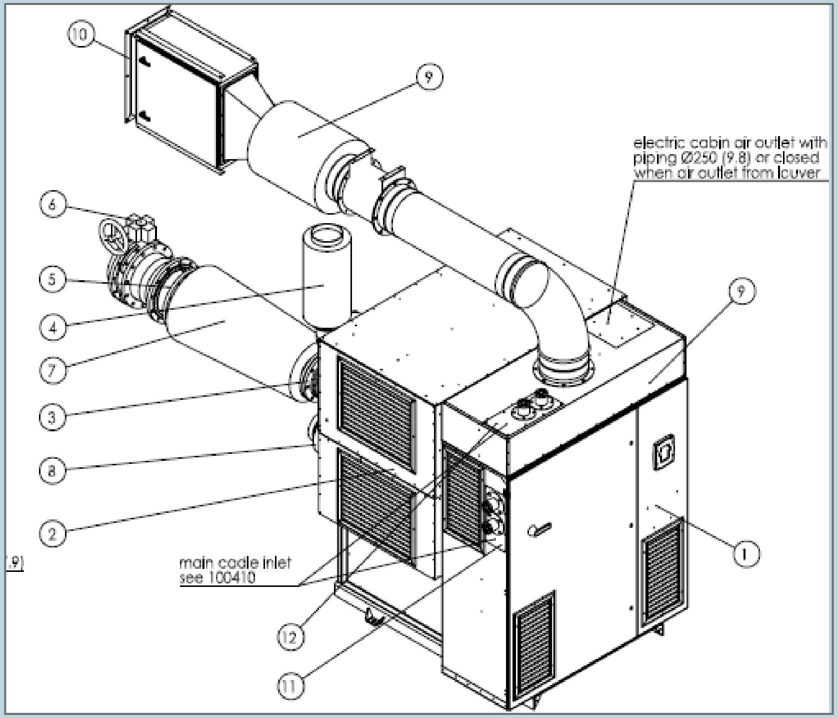
Neuros

ABS-HST

Atlas Copco

Turbo – Blower System Components

- Drive Unit
- Bearings
- Inlet Filters
- Blow-off Valve
- Vibration
- Auxiliary Cooling



Bearings

- Air Bearing
  - Two Parts – Corrugated Bump Foil and Inner High Temperature Allow Core
  - At 2,000 RPM – Thin Air Film Created
  - Upon Power Failure – Touchdown Pad
- Electromagnetic Bearings
  - Power (i.e. 500-600 Watts) Used to Hold Turbine in Suspension
  - Upon Power Failure – Turbine Rests on Touchdown Bearings

Inlet Filters

- 10 Micron Industrial Air Filter on Inlet Cabinet
  - Change Every 6 Months
- Bag Filter In Separate Housing On Inlet
  - Change Yearly

Neuros Inlet Filter

ABS Bag Filter

HDR

Blowoff Valve

- Blowers Must Startup Under Zero Discharge Pressure
  - Typically Takes 20 sec
- Requires Silencer

Neuros Blowoff

ABS Blowoff

HDR

Auxiliary Cooling

Water Cooling Unit

Specification Development

- Equipment Varies Greatly From Each Manufacturer
- Requires Performance Based Spec
  - Wire to Air Power Evaluation
  - Must Include All Auxiliary Items
  - Power Guarantee
- Pre-purchase?

SECTION 11081
HIGH SPEED TURBO AERATION BLOWER

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. High speed turbo blowers including:
a. Integral drive unit.
b. Variable frequency controller.
c. Valves for blow-off, backflow prevention, and isolation.
d. Inlet filter and silencer.
e. Discharge silencer.
f. Blow-off silencer.
g. Flexible connectors.
h. Pressure and temperature monitoring devices.
i. Local control panel (LCP).
2. Custom software for control.

B. Equipment numbers:
1. 310-BLR-01, 310-BLR-02, 310-BLR-03

C. Related Sections include but are not necessarily limited to:
1. Division 0 - Bidding Requirements, Contract Forms, and Conditions of the Contract.
2. Division 1 - General Requirements.
3. Section 11005 - Equipment: Basic Requirements.
4. Section 11088 – Aeration Equipment: Fine Bubble Type

1.2 SYSTEM DESCRIPTION

A. Three new turbo blowers shall be installed to replace the existing blowers. The new blowers shall provide process air for existing Bioreactor No. 1 and new Bioreactors No. 2, and No. 3. Provide blower, driver, and accessories through single manufacturer. Contractor shall provide and install all external piping, pipe supports, wiring, instrumentation, conduit and appurtenances not provided by the blower manufacturer for a complete functional blower system.

B. Acceptable blower manufacturers shall include the following with no equal:
1. ABS HST Turbo-Compressor
2. APG-Neuros, Inc

1.3 SUBMITTALS

A. General:
1. See Section 01340 for requirements for the mechanics and administration of the submittal process.
2. All products required for submittal under this section shall be furnished in one complete package.
3. All submittal dimensions, calculations and other information shall be in USA English units of measure.

B. Product Data:
1. Acknowledgement that products submitted meet requirements of standards referenced.
2. Manufacturer's installation instructions.
3. Blower characteristics, specifications, and performance.
a. Descriptive brochures and blower data.

1.4 POWER GUARANTEE

A. The BLOWER MANUFACTURER shall submit with the Shop Drawings the guaranteed wire-to-air ("wire") KW for the blower unit. The wire KW shall include all losses associated with the blower unit at all specified operating points. The guaranteed wire KW's of the blower unit shall not exceed the following

Guaranteed Wire Power

Design Point	Capacity, %	Number of Blowers	Total Flow, SCFM	Flow/ Blower, SCFM	Pressure, psia Baro	Pressure, psia Outlet	Inlet Temp, degF	Rel Hum, %	Wire Power Per Blower, KW	Wire Power All Blowers, KW
1	100	3	11,500	3,833	12.55	22.55	115	36	187.5	562.5
2	80	3	9,200	3,067	12.55	22.55	85	70	140.5	421.5
3	60	2	5,520	2,760	12.55	22.55	65	70	121.9	243.8
4	50	1	2,150	2,150	12.55	22.55	20	60	91.6	91.6

*Wire KW consists of Blower, Motor, VFD or inverter, and any cooling or other auxiliary systems if used.

--SCFM measured at 14,7 PSIA, 68 degF, 65% RH

B. The guaranteed wire power KW numbers at the above specified operating points shall be "guaranteed" per ASME PTC-10 testing numbers with zero tolerance.

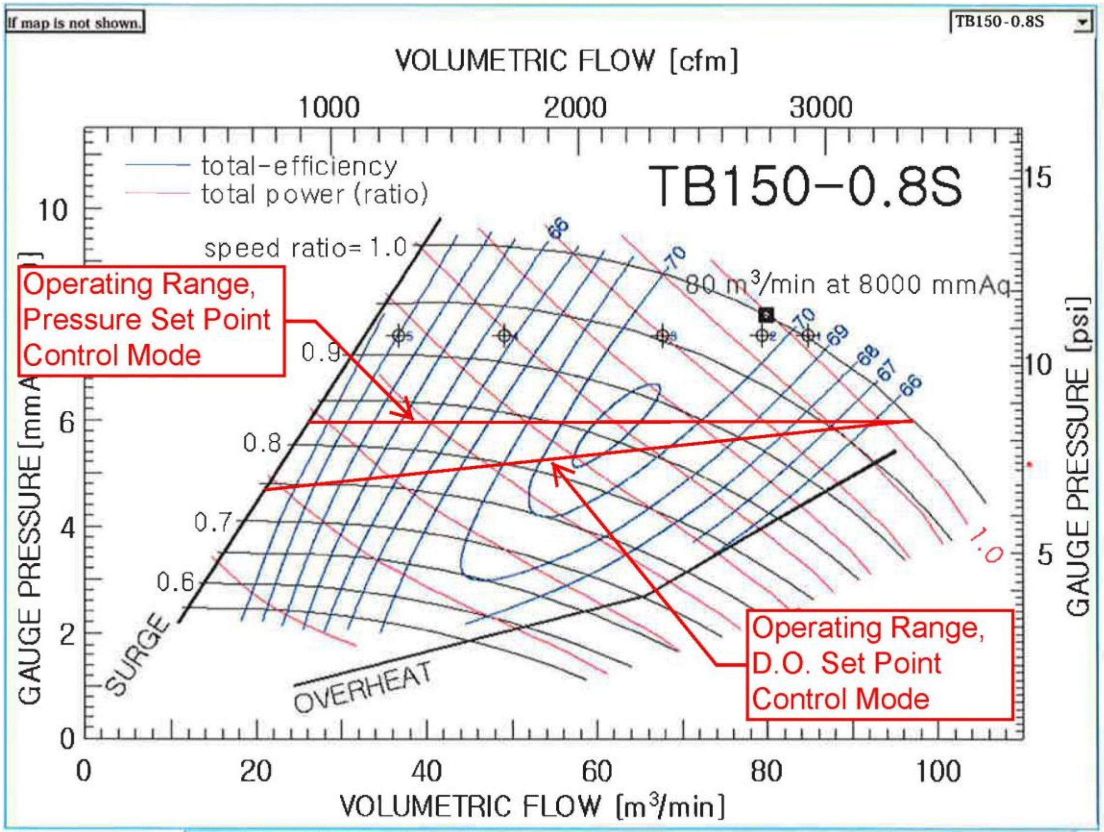
High Speed Turbo Blowers and Dissolved Oxygen Control

- Typical D.O./Blower Control
  - Cascade loop
    - D.O. controlled by modulating valves to maintain D.O. set point
    - Blower controlled by modulating inlet valve to maintain discharge pressure set point.
- Turndown capability of Turbo Blowers allows D.O. control of Blower

HDR

High Speed Turbo Blowers and Dissolved Oxygen Control

- Advantage of D.O. control of blower – Power Savings



- TITLE Columbia Falls, MT (HDR Inc.) 2500 SCFM @ 8.5 PSIG (Final Bid Selection) (Nameplated as 175 Hp.)
- UNIT SYSTEM US (ft-lb)

HDR

Conclusions

- Turbo technology has become more accepted in the U.S.
- Energy savings and many other benefits
- Cost competitive

HDR

Blower Sizing Considerations

Calculate O_2 required by process

Review Existing Data

O_2 Transfer Efficiency

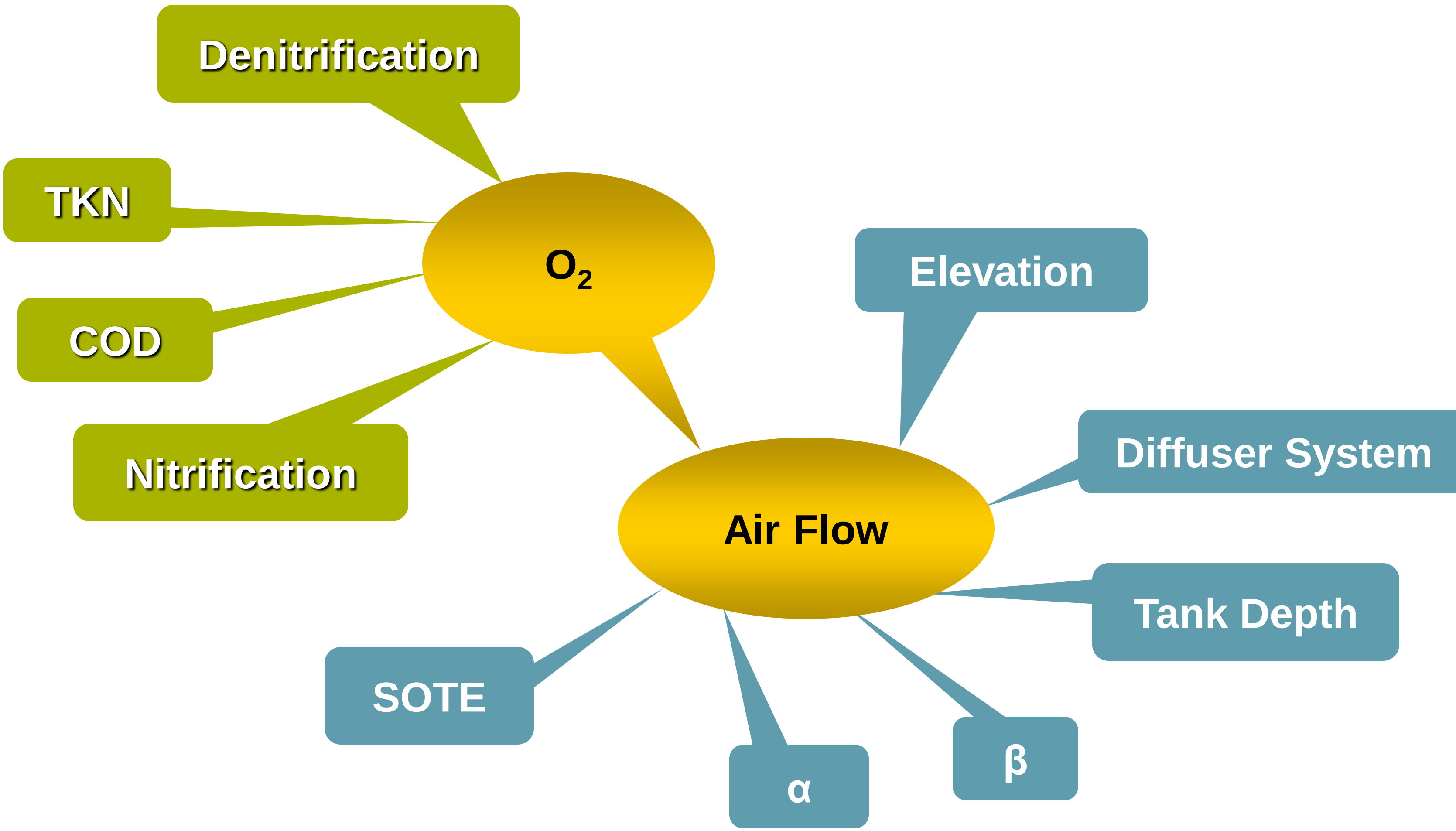
Calculate O_2 that must be <u>delivered</u> to meet process requirements

O_2 in air constant at standard conditions

Convert O_2 Requirements to Air Flow (scfm, m^3/hr, kg/s)

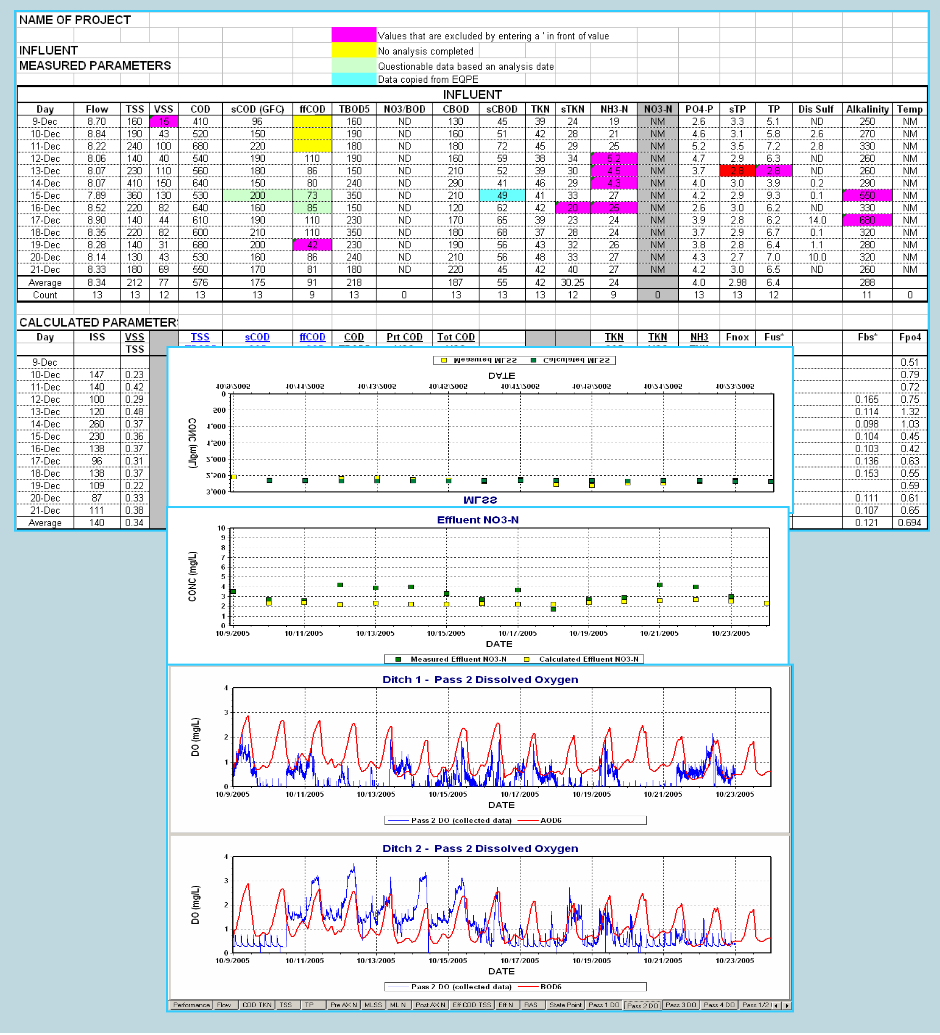
Adjust "Standard" to "Actual" Conditions

Determining SCFM
Depends on a Number of Factors



Blower Sizing Results From A Multi-Step Design Process

1. Existing data evaluation
2. Influent wastewater characterization – fill data gaps
3. Model calibration and verification
4. Preliminarily size new facilities
5. Incorporate airflow into model output



NAME OF PROJECT

INFLUENT
MEASURED PARAMETERS

Values that are excluded by entering a ' in front of value
No analysis completed
Questionable data based an analysis date
Data copied from EQPE

INFLUENT

Day	Flow	TSS	VSS	COD	sCOD (GFC)	ffCOD	TBOD5	NO3/BOD	CBOD	sCBOD	TKN	sTKN	NH3-N	NO3-N	PO4-P	sTP	TP	Dis Sulf	Alkalinity	Temp
9-Dec	8.70	160	15	410	96		160	ND	130	45	39	24	19	NM	2.6	3.3	5.1	ND	250	NM
10-Dec	8.84	190	43	520	150		190	ND	160	51	42	28	21	NM	4.6	3.1	5.8	2.6	270	NM
11-Dec	8.22	240	100	680	220		180	ND	180	72	45	29	25	NM	5.2	3.5	7.2	2.8	330	NM
12-Dec	8.06	140	40	540	190	110	190	ND	160	59	38	34	5.2	NM	4.7	2.9	6.3	ND	260	NM
13-Dec	8.07	230	110	560	180	86	150	ND	210	52	39	30	4.5	NM	3.7	2.8	2.8	ND	260	NM
14-Dec	8.07	410	150	640	150	80	240	ND	290	41	46	29	4.3	NM	4.0	3.0	3.9	0.2	290	NM
15-Dec	7.89	360	130	530	200	73	350	ND	210	49	41	33	27	NM	4.2	2.9	9.3	0.1	550	NM
16-Dec	8.52	220	82	640	160	85	150	ND	120	62	42	20	25	NM	2.6	3.0	6.2	ND	330	NM
17-Dec	8.90	140	44	610	190	110	230	ND	170	65	39	23	24	NM	3.9	2.8	6.2	14.0	680	NM
18-Dec	8.35	220	82	600	210	110	350	ND	180	68	37	28	24	NM	3.7	2.9	6.7	0.1	320	NM
19-Dec	8.28	140	31	680	200	42	230	ND	190	56	43	32	26	NM	3.8	2.8	6.4	1.1	280	NM
20-Dec	8.14	130	43	530	160	86	240	ND	210	56	48	33	27	NM	4.3	2.7	7.0	10.0	320	NM
21-Dec	8.33	180	69	550	170	81	180	ND	220	45	42	40	27	NM	4.2	3.0	6.5	ND	260	NM
Average	8.34	212	77	576	175	91	218		187	55	42	30.25	24		4.0	2.98	6.4		288	
Count	13	13	12	13	13	9	13	0	13	13	13	12	9	0	13	13	12		11	0

CALCULATED PARAMETERS

Day	ISS	VSS/TSS	Fbs*	Fpo4
9-Dec				0.51
10-Dec	147	0.23		0.79
11-Dec	140	0.42		0.72
12-Dec	100	0.29	0.165	0.75
13-Dec	120	0.48	0.114	1.32
14-Dec	260	0.37	0.098	1.03
15-Dec	230	0.36	0.104	0.45
16-Dec	138	0.37	0.103	0.42
17-Dec	96	0.31	0.136	0.63
18-Dec	138	0.37	0.153	0.55
19-Dec	109	0.22		0.59
20-Dec	87	0.33	0.111	0.61
21-Dec	111	0.38	0.107	0.65
Average	140	0.34	0.121	0.694

Steps Required in Blower Selection

- Finalize blower size based on:
  - air requirements (scfm, m3/hr, kg/s)
  - inlet air temperature range
  - inlet air relative humidity range
  - inlet pressure range
  - discharge pressure range
- Determine horsepower (kW) to produce the required airflow at the required inlet air conditions
- Compare different blower performance predictions on a Net Present Value basis

HDR

Important Facts Related to Blower Design and Operation

- Blowers usually designed for 3 to 5 performance points:
  - Capacity
  - Discharge pressure
  - Inlet air temperature
  - Inlet relative humidity
- Blowers almost never operate at these “selected” points due to changing conditions
  - air inlet conditions
  - air flow requirements
  - discharge pressure varies, but to a lesser extent (depends on required air flow and head loss, and tank depth fluctuations)

The most efficient blower systems respond quickly to changes and must be efficient across the normal “range” of flows.

HDR

Conclusions

- **Minimum airflow quantity and duration are important.**
- **Maximum day is not as important as once thought,** and can skew airflow rates resulting in unnecessarily large blowers.
- Discrete airflow requirements are generated as a normal part of process modeling during design.
- **Multiple point evaluation (more than 3-5) enables a more realistic comparison of the true value of different manufacturers' offerings.**
- Blowers are expensive to purchase and operate - sufficient time must be invested to perform a thorough evaluation.
- **Each plant is unique and the blower requirements must be evaluated based on the site specific requirements.**
- Witness testing is a must!

Questions?