

Symbols and Acronyms

A	Area of transmission loss
A²/O	Anaerobic/anoxic/oxic
AC	Alternating current
A/O	Anoxic/oxic
ABF	Activated biofilter
ACOE	Army Corps of Engineers
AD	Apparent density
ADA	Americans with Disabilities Act
AD/AT	Factor representing number of diffusers per unit area of basin
ADF	Average daily flow
AE	Aeration (electrical) efficiency
AIDS	Acquired immune deficiency syndrome
AIHA	American Industrial Hygiene Association
AlCl₃	Aluminum chloride
Al₂(SO₄)₃	Aluminum sulfate
AMA	American Management Association
AMB	Approximate mass balance
ANSI	American National Standards Institute
APHA	American Public Health Association
APWA	American Public Works Association
ASA	American Standards Institute
ASCE	American Society of Civil Engineers
ASD	Adjustable speed drives
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
ASM	Activated sludge models
ASM2	Activated sludge models, second model

Operation of Municipal Wastewater Treatment Plants

ASM3	Activated sludge models, third model
ASP	Application service provider
ATAD	Autothermal thermophilic aerobic digestion
AST	Activated sludge treatment
ATS	Automatic transfer switch
AWWA	American Water Works Association
AWWARF	American Water Works Association Research Foundation
Ax	Anoxic
AxSF	Anoxic step feed
B	Y-axis intercept
BACT	Best available control technology
BBP	Blood-borne pathogen
BEP	Best engineering practices
BEPs	Best efficiency points
BETX	benzene, ethyl benzene, toluene, and xylene isomers
BF/AS	Biofilter/activated sludge
BFP	Belt filter press
BHC	Benzenehexachloride
BioP	<i>Acinetobacter</i>
BioP	Biological phosphorus
BMPs	Best management practices
BMR	Baseline monitoring report
BNR	Biological nutrient removal
BOD	Biochemical oxygen demand
BOD₅	Five-day biochemical oxygen demand
BOD_{2INF}	Influent BOD
BOT	build-own-transfer
BOOT	build-own-operate-transfer
BPR	Biological phosphorus removal
BrCl	Bromine chloride
BTU	British thermal unit
CH₃COOH	Acetic acid
C₂H₄O₃	Peracetic acid
C	Carbon
C	Constant: 0.25 for fecal coliform and 0.9 for total coliform
CF	Float solids concentration (percent) at the top of the unit
C_s	Specific heat of sludge
C:N	Carbon-to-nitrogen ratio
CAC	Combined available chlorine
CAD	Computer-aided design
CaO	Calcium oxide
CaCO₃	Calcium carbonate
Ca(OH)₂	Calcium hydroxide
Ca(OCl)₂ · 4 H₂O	Calcium hypochlorite

CAS	Chemical Abstracts Service
CAS	Conventional activated sludge
CBOD	Carbonaceous biochemical oxygen demand
CBOD₅	Five-day carbonaceous biochemical oxygen demand
CBOD_{5,IN}	Influent carbonaceous biochemical oxygen demand
CBOD_{5,SE}	Secondary effluent carbonaceous biochemical oxygen demand
CCP	Composite Correction Program
CDs	Computer disks
CD-ROM	Compact disc read-only memory
CDX	Central data exchange
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFD	Computational fluid dynamics
CFM	Computational fluid mixing
CFR	<i>Code of Federal Regulations</i>
CFU	Colony forming units
CH₄	Methane
CHIP	Chemicals Hazard Information and Packaging Regulations
CIUs	Categorical industrial users
Cl₂	Chlorine
ClO₂	Chlorine dioxide
CM	Corrective maintenance
CMMS	Computerized maintenance management systems
CMOM	Capacity, management, operation, and maintenance
C:N	carbon-to-nitrogen ratio
CPE	Comprehensive performance evaluations
CPU	Central processing unit
CO	Carbon monoxide
CO₂	Carbon dioxide
COD	Chemical oxygen demand
COTS	Commercial off-the-shelf
CPR	Cardiopulmonary resuscitation
CPVC	Chlorinated polyvinyl chloride
CSF	Clarifier safety factor
CSOs	Combined sewer overflows
CST	Capillary suction time
CSTRs	Completely stirred tank reactors
CT	Contact time
CWA	Clean Water Act
CWF	Combined waste stream formula
CWSRF	Clean Water State Revolving Fund
D	Diameter
D	UV dose
dB	Depth of float below the water level

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dW	Height of float above water level
dB + dW	Total float depth
DAF	Dissolved air flotation
dB	Decibels
DBO	Design–build–operate
DBPs	Disinfection byproducts
DC	Direct current
DCS	Distributed control systems
DDD	dichlorodiphenyldichloroethane
DDE	dichlorodiphenyldichloroethylene
DDT	dichlorodiphenyltrichloroethane
DMRs	Discharge monitoring reports
dN	Denitrification
DNA	Deoxyribonucleic acid
dN/dt	Rate of change of the number of organisms population
DO	Dissolved oxygen
DOB	Depth of blanket
DOT	Department of Transportation
DPAM	Dry polyacrylamide
DPIV	Digital particle image velocimetry
DV	Digester volume
DWP	Dynamic wet pressure
E	Effluent rate
E	Effluent concentration
e_c	Corrected effluent concentration
e_m	Measured effluent concentration
EBPR	Enhanced biological phosphorus removal
ED₅₀	Effective dose at the 50% level
EDMS	Electronic document management system
EHS	Extremely hazardous substances
EH&S	Environmental Health and Safety
EM	Electromotive force
EMP	Energy management plan
EMS	Environmental management system
EPAct	Energy Policy Act
EPAM	Emulsion polyacrylamide
EPCRA	Emergency Planning and Community Right-to-Know Act
EQ	Exceptional quality
ERG	Enforcement response guide
ERP	Enforcement response plan
U.S. EPA	U.S. Environmental Protection Agency
ES	Extended Service
ESD	Egg-shaped digesters
ESEERCo.	Empire State Electrical Energy Research Corporation

E_x	Ultraviolet reactor dispersion coefficient
F	Force
F	Feed rate
f	Feed concentration
F:M	Food-to-microorganism ratio
FAC	Free available chlorine
f_c	Corrected feed concentration
Fe	Iron
FeCl₂	Ferrous chloride
FeCl₃	Ferric chloride
FEMA	Federal Emergency Management Agency
f_m	Measured feed concentration
FF/SG	Fixed-film and suspended growth processes
FFT	Fast Fourier transform
FIS	Financial information system
FOG	Fats, oil, and grease
FR	Federal Regulations
FRP	Fiberglass-reinforced plastic
FSS	Fixed suspended solids
FWA	Flow-weighted average
G	Balance quality grade number
GAC	Granular activated carbon
GALPs	Good automated laboratory practices
GASB	Government Accounting Standards Board
GBT	Gravity belt thickener
GC	Gas chromatography
GFI	Ground fault interrupter
GISs	Geographic information systems
GPS-X	General purpose simulator
GS	General service
GW&PCA	Georgia Water and Pollution Control Association
H	Head
H₂	Hydrogen
HAZCOM	Hazardous Communication Standard
HID	High-intensity discharge
HO	High output
H/O/A	Hand-off-auto
HCO₃⁻	Biocarbonate
HS⁻	Hydrosulfide
H₂CO₃	Carbonic acid
H₂O	Water
H₂O₂	Hydrogen peroxide
H₂SO₄	Sulfuric acid
H₂S	Hydrogen sulfide

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H_3PO_4	Phosphoric Acid
HCl	Hydrochloric acid
HDPE	High-density polyethylene
HGL	Hydraulic grade line
HIV	Human immunodeficiency virus
h_L	Headloss
HLR	Hydraulic loading rate
HOA	Hand-off automatic
H/O/A	Hands/off/automatic
HOBr	Hypobromous acid
HOCl	Hypochlorous acid
HP	Horsepower
HPO	High-purity oxygen
HS-1 ^{A/M}	Start/stop handswitch
HS-2 ^{S/S}	Automatic/manual handswitch
HRMS	Human resources management system
HRR	High resolution redox
HRT	Hydraulic residence (retention) time;
HVAC	Heating, ventilation, and air conditioning
<i>I</i>	Intensity of UV radiation
I&C	Instrumentation and control
ICMA	International City and County Management Association
IFAS	Integrated fixed-film activated sludge
IMLR	Internal mixed-liquor recirculation
IRS	U.S. Internal Revenue Service
ISO	International Organization for Standardization
ISV	Initial settling velocity
IT	Information technology
iTSS _{2INF}	Inert total suspended solids in secondary influent
IUs	Industrial users
IWA	International Water Association
JHB	Johannesburg
<i>K</i>	Disinfection rate constant
<i>k</i>	Organism die-off rate constant
<i>k</i>	Rate constant
KMnO ₄	Potassium permanganate
KVAR	Kilovar
<i>L</i>	Concentration of organisms after ultraviolet exposure
<i>L</i>	Effective length of rectangular draft
<i>L</i> ₀	Concentration of organisms before ultraviolet exposure
LAN	Local area network
LiCl	Lithium chloride
LIF	Laser-induced fluorescence
LC ₅₀	Lethal concentration at the 50% level

LDA	Laser Doppler anemometry
LE	Ludzack–Ettinger
LEL	Lower explosivity limit
LIMS	Laboratory information management systems
LMMSS	Lockheed Martin Michoud Space Systems
LP-LI	Low pressure–low intensity
μ	Biomass growth rate
μ_{\max}	Maximum growth rate
m	Slope of straight line
M	Mass
M_{Ox}	Mass of oxic zone
MAs	Member associations
MAHL	Maximum allowable headworks loading
MBRs	Membrane bioreactors
MCCs	Motor control center
MCRT	Mean cell residence time
$MCRT_{\min}$	Minimum mean cell residence time
$MCRT_{Ox}$	Oxic zone mean cell residence time
$MgNH_4PO_4$	Magnesium ammonium phosphate
MIL	Moisture indicator light
MIS	Management information system
ML	Mixed liquor
mLE	Modified Ludzack–Ettinger
MLR	Mixed-liquor recycle
MLR_{Ax}	Denitrified mixed-liquor recycle
MLR_{Ax}	Mixed-liquor recycle anoxic zone
MLR_{ox}	Mixed-liquor recycle oxic zone
MLSS	Mixed-liquor suspended solids
MLVSS	Mixed-liquor volatile suspended solids
MMR	Mumps, Measles, and Rubella
MOP	Manual of Practice
MPN	Most probable number
MS	Mass spectrometry
MSDS	Material safety data sheet
MW	Medium wave
MWWTP	Minneapolis (Minnesota) Wastewater Treatment Plant
N	Effluent bacteria density after ultraviolet radiation
N	Rotating speed
N	Number of surviving organisms per unit volume at any given time
N	Speed
N/dN	Nitrify/denitrify
N_0	Influent bacteria density before ultraviolet radiation
N_2	Nitrogen
NaCl	Sodium chloride

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$\text{Na}_2\text{Al}_2\text{O}_4$	Sodium aluminate
Na_2CO_3	Sodium carbonate
Na_2SO_3	Sodium sulfite
NaClO_2	Sodium chlorite
NaHCO_3	Sodium bicarbonate
NaOCl	Sodium hypochlorite
NaOH	Sodium hydroxide
NaS_2O_5	Sodium metabisulfite
NACWA	National Association of Clean Water Agencies
NASA	National Aeronautics and Space Administration
NBP	National Biosolids Partnership
NBOD	Nitrogenous biochemical oxygen demand
NEC	National Electric Code
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
NH_3	Ammonia
$\text{NH}_3\text{-N}$	Ammonia as nitrogen
$\text{NH}_3\text{-N}_{IN}$	Influent total ammonia-nitrogen
$\text{NH}_3\text{-N}_{SE}$	Influent total Kjeldahl nitrogen
NH_4^+	Ammonia ion
NH_4HCO_3	Ammonium bicarbonate
NH_4OH	Ammonium hydroxide
NIOSH	National Institute for Occupational Safety and Health
NO_2^-	Nitrite
NO_3^-	Nitrate
NO_3, IN	Influent nitrate concentration
NO_3, SE	Secondary effluent nitrate concentration
$\text{NO}, \text{NO}_2, \text{ and } \text{NO}_x$	Nitrogen oxides
NOD	Nitrogenous oxygen demand
NO_x	Nitrogen oxide
NO_{x2EFF}	Secondary effluent nitrogen oxide concentration
NPDES	National Pollutant Discharge Elimination System
NPSH	Net positive suction head
NRC	National Research Council
NTU	Nephelometric turbidity unit
NWRI	National Water Research Institution
NYSERDA	New York State Energy Research and Development Authority
O&M	Operations and maintenance
O_2	Molecular or free oxygen
O_3	Ozone
OC	Oxygenation capacity
OCI^-	Hypochlorite ion
OCP	Operator control panel
OD	Oxygen demand

OH⁻	Hydroxyl
OMS	Operations management system
ORP	Oxidation–reduction potential
OSHA	Occupational Safety and Health Act
OTE	Oxygen transfer efficiency
OTR	Oxygen transfer rate
OTMAX	Oxygen transferred to the mixed liquor
OUR	Oxygen uptake rate
Ox	Aerobic or oxic
αFk_{La}	Oxygen mass transfer coefficient
<i>P</i>	Brake horsepower
P	Phosphorus
<i>P</i>	Polymer rate
P	Predictive
P	True power
P3	Public–private partnerships
P_{atm}	Absolute atmospheric pressure
P&IDs	Process and instrumentation drawings
PAM	Polyacrylamide
PASS	Pull, aim, squeeze, sweep
<i>P_B</i>	<i>Brake power</i>
<i>P_M</i>	Wire or motor power
P_{atm}	Absolute atmospheric pressure
<i>P_{vp}</i>	Fluid vapor pressure
<i>P_W</i>	Water power
PAOs	Phosphorus-accumulating organisms
PAC	Powdered activated carbon
PCs	Personal computers
PCBs	Polychlorinated biphenyls
PCS	Process control system
PD	Positive displacement
PDA	Personal digital assistant
PDM	Predictive maintenance
PELs	Permissible exposure limits
PFC	Power factor correction
PFRP	Processes to further reduce pathogens
PLCs	Programmable logic controllers
PM	Preventive maintenance
PMP	Planned maintenance program
PMS	Personnel management system
PO₄⁻	Phosphate
POs	Purchase orders
POTWs	Publicly owned treatment works
PP	Polypropylene

PPE	Personal protective equipment
P/PM	Predictive/preventive maintenance
PR	Pumping rate
PSA	Pressure swing adsorption
PSRPs	Processes to significantly reduce pathogens
PRV	Pressure-reducing valve
PTFE	Polytetrafluoroethylene
PUCs	Public utilities commissions
PVC	Polyvinyl chloride
PVDF	Fluorinated polyvinylidene
Q	Digester transmission loss
Q	Flow capacity
Q	Sludge heating requirement
Q	Reactive power
Q _{digested sludge}	Volumetric flowrate of the digested sludge
Q _{feed}	Volumetric flowrate of the feed sludge
Q _{2INF}	Secondary influent flow
Q _{IN}	Influent wastewater flowrate
Q _S	Solids loading rate
Q _{WW}	Wastewater flow
QA	Quality assurance
QAP	Quality assurance plan
QAPP	Quality assurance project plan
QAU	Quality assurance unit
QC	Quality control
Q _{RAS}	Return activated sludge flow
Q _{WAS}	Waste activated sludge flow
RAS	Return activated sludge
RBCs	Rotating biological contactors
RCM	Reliability centered maintenance
RCFA	Root-cause failure analysis
RCRA	Resource Conservation and Recovery Act
RDT	Rotary drum thickeners
RF/AS	Roughing filter activated sludge
RFP	Request for proposals
RFQ	Request for qualifications
RMP	Risk management program
RNA	Ribonucleic acid
RTDs	Resistance temperature detectors
S	Solids or sludge mass flowrate
S	Solids or cake rate
S	Apparent power
s	Solids or cake concentration
SA	Surface area

SAE	Standard aeration (electrical) efficiency
SAR	Sodium adsorption ratio
SARA	Superfund Amendments and Reauthorization Act
SARS	Severe acute respiratory syndrome
SBOD	Soluble biochemical oxygen demand
SBR	Sequencing batch reactors
SCADA	Supervisory control and data acquisition
SCBA	Self-contained breathing apparatus
SDNRs	Super digital noise reductions
SGT-HEM	Silica gel treated <i>n</i> -hexane extractable material
SIK	Timer, indicator, and control
SIU	Significant industrial user
SK	Spulkraft
SLA	Service level agreement
SLR	Solids loading rate
SMR	Self-monitoring report
SNDN	Simultaneous nitrification/denitrification
SO ₂	Sulfur dioxide
SOL	Soluble organic loading
SOPs	Standard operating procedures
SOTR	Standard oxygen transfer rate
SOUR	Specific oxygen uptake rate
SP	Soluble phosphorus
SPAM	Solution polyacrylamide
SPCC	Spill prevention and countermeasures control
SPDES	State Pollution Discharge Elimination System
SRF	State Revolving Fund
SRT	Solids residence (retention) time
SS	Suspended solids
SSO	Sanitary sewer overflow
SSV	Settled sludge volume
STOWA	Foundation for Applied Water Research
SVI	Sludge volume index
SWD	Side-water depth
<i>t</i>	Time of exposure
T _i	Temperature of influent
T _o	Digester operating temperature
T _s	Temperature of surroundings
<i>T</i>	Turbidity
t _c	Float scraper cycle time
t _{OFF}	Time that the scraper is off during a given cycle
t _{ON}	Time that the scraper is on during a given cycle
TCDD	tetrachlorodibenzo- <i>p</i> -dioxin
TD	Tetanus and diphtheria

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TDH	Total dynamic head
TDS	Total dissolved solids
TF	Trickling filter
TF/AS	Trickling filter/activated sludge
TF/RBC	Trickling filter/rotating biological contactor
TF/SC	Trickling filter/solids contact
THMs	Trihalomethanes
TIMS	Training information management system
TKN	Total Kjeldahl nitrogen
TKN_{SE}	Secondary effluent TKN
TOC	Total organic carbon
TOD	Total oxygen demand
TOL	Total organic loading
TP	Total phosphorus
TPAD	Temperature-phased anaerobic digestion
TR	Turnover rate
TRE	Toxicity reduction evaluation
TSCA	Toxic Substances Control Act
TS	Total solids
TSS	Total suspended solids
TSS_{2EFF}	Total suspended solids in secondary effluent
TSS_{WAS}	Total suspended solids in waste activated sludge
TSU	Total sludge units
TTO	Total toxic organics
TWAS	Total waste activated sludge
TWUA	Texas Water Utilities Association
<i>U</i>	Fluid velocity
<i>U_{per}</i>	Permissible unbalance
<i>U</i>	Heat transfer coefficient
UCT	University of Capetown
UEL	Upper explosive limit
U.K.	United Kingdom
UL	Underwriters Laboratory
UPSs	Uninterruptible Power Systems
U.S.	United States
USD	United States dollar
USDA	United States Department of Agriculture
U.S.S.R	Union of Soviet Socialist Republics
UV	Ultraviolet
<i>V</i>	Velocity of travel of scrapers
<i>V</i>	Voltage
<i>V</i>	Volume of reactor
<i>V_{AX}</i>	Anoxic volume
<i>V_{AB}</i>	Volume of aeration basin

V_B	Basin volume
v_L	Downflow rate
$v^2/2g$	Velocity head
VA/ALK	Volatile acid-to-alkalinity ratio
VAR	Vector attraction reduction
VFA	Volatile fatty acid
VHO	Very high output
VIP	Virginia Initiative Plant
VOC	Volatile organic compound
VFDs	Variable frequency drives
VS	Volatile solids
$VS_{\text{digested sludge}}$	Volatile solids concentration of the digested sludge
VS_{feed}	Volatile solids concentration of the feed sludge
VSA	Vacuum swing adsorption
VSR	Volatile solids reduction
VSS	Volatile suspended solids
$VSS_{2\text{INF}}$	Volatile suspended solids in secondary influent
W	Watts
W	Weight
W	Wash water rate
W/WW ITA	Water and Wastewater Instrumentation Testing Association
ω	Rotational speed
WA	Weight alarm
WAN	Wide area network
WAS	Waste activated sludge
WEAO	Water Environment Association of Ontario
WEF	Water Environment Federation
WEFTEC	Water Environment Federation Technical Exposition and Conference
WERF	Water Environment Research Foundation
WPCF	Water Pollution Control Federation
WRFs	Water reclamation facilities
WRRC	Water Resources Research Center
WRS	White data medium reference signal
WS	Weight switch
WWTPs	Wastewater treatment plants
x	Forward distance traveled during exposure
Z_w	Vertical distance