GE Energy

Pocket Reference Guide

imagination at work

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Conversion Factors

To Convert	To	Multiply By
Acre	Sq. feet	43560
Acres	Sq. kilometers	0.0040469
Acres	Sq. miles	0.0015625
Acres	Sq. yards	4840
Atmospheres	Bars	1.01325
Atmospheres	Feet of H_2O (39.2°F)	33.8995
Atmospheres	Inches of H_2O (32°F)	407.3
Atmospheres	Inches of mercury (32°F)	29.9213
Atmospheres	mm of mercury (0°C)	760
Atmospheres	lbs/sq. inch or psi	14.696
Bars	lbs/sq. inch or psi	14.5038
Bars	Atmospheres	0.9869
Barrels (oil, US)	Gallons (US)	42
Barrels (US, liquid)	Gallons (US)	31.5
Btu	Calories (gram)	252
Btu	Horsepower – hrs	3.93015×10^{-4}
Btu	Joules	1055.056
Btu	Kilogram – meters	107.5858
Btu	Kilowatt – hrs	2.93071×10^{-4}
Btu	Therms	0.00001
Btu/hr	Foot – lbs/sec	0.216158
Btu/hr	Kilowatts	0.0002930711
Btu/hr	Watts	0.2930711
Btu(mean)/hr	Horsepower (boiler)	2.98992×10^{-5}
Btu/lb	Joules/kilogram	2326
Btu/min	Horsepower	0.023581
Btu/min	Kilowatts	0.017584267
Btu/min	Kilogram – calories/min	0.251995801
Btu/min	Foot – lbs/min	778.1694
Btu/min	Watts	17.584267
Btu/sec	Kilowatts	1.055056
Calories (gram)	Btu	3.96825×10^{-3}
Calories (gram)	Joules	4.1868
Calories/gram	Joules/kilogram	4186.8
Centimeters	Feet	3.2808×10^{-2}
Centimeters	Inches	0.39370079
Centimeters/sec	Feet/min	1.9685039
Cubic centimeters	Cubic inches	0.0610237
Cubic centimeters	Gallons (US, liquid)	2.6417205×10^{-4}
Cubic cm/min	mL/min for water only	1.0
Cubic cm/min	Gallons/hr	0.015850323
Cubic feet	Cubic inches	1728
Cubic feet	Cubic meters	0.028316847
Cubic feet	Cubic yards	0.03704
Cubic feet	Gallons (US, liquid)	7.4805195
Cubic feet	Liters	28.316847
Cubic feet of H_2O (60°F)	lbs of H_2O	62.37

Conversion Factors (Cont.)

To Convert	To	Multiply By
Cubic feet/hr	Liters/min	0.47193
Cubic feet/min	Liters/min	28.31605
Cubic feet/sec	Gallons/min	448.8
Cubic feet/sec	Cubic meters/sec	0.028316847
Cubic inches	Cubic centimeters	16.387064
Cubic inches	Cubic feet	5.787×10^{-4}
Cubic inches	Cubic meters	1.6387×10^{-5}
Cubic inches	Cubic yards	2.14335×10^{-5}
Cubic inches	Liters	0.016387064
Cubic meters	Cubic feet	35.31467
Cubic meters	Cubic inches	61023.9824
Cubic meters	Liters	1000
Cubic meters/sec	Cubic feet/sec	35.31467
Cubic yards	Cubic feet	27
Cubic yards	Cubic inches	46,656
Cubic yards	Gallons (US, liquid)	201.97403
Degrees	Minutes	60
Degrees	Radians	0.017453293
Degrees (angle)	Seconds	3,600
Drams (avdp)	Grains	27.34375
Drams (avdp)	Grams	1.7718452
Drams (avdp)	lbs (avdp)	0.00390625
Drams (avdp)	Ounces (avdp)	0.0625
Fathoms	Feet	6
Feet	Centimeters	30.48
Feet	Fathoms	0.166666667
Feet	Meters	0.3048
Feet	Miles (statute)	1.89394×10^{-4}
Feet of H_2O	Atmospheres	0.029499
Feet of H_2O	Inches of mercury	0.882646
Feet/min	Centimeters/sec	0.508
Feet/min	Miles/hr	0.01136363
Feet/min	Meters/sec	0.00508
Feet/sec	Meters/sec	0.3048
Feet/sec	Miles/hr	0.6818182
Foot – lbs/min	Btu/min	0.0012851
Foot – lbs/sec	Btu/hr	4.626249
Gallons (US)	Barrels (oil, US)	0.02381
Gallons (US)	Barrels (US, liquid)	0.03175
Gallons (US, liquid)	Cubic centimeters	3785.4118
Gallons (US, liquid)	Cubic feet	0.133680555
Gallons (US, liquid)	Cubic yards	4.9511317×10^{-3}
Gallons (US, liquid)	Liters	3.7854118
Gallons H_2O in air 4°C	lbs of H_2O	8.33585
Gallons/min	Cubic feet/sec	0.002228164
Gallons/hr	Cubic cm/min	63.09020
Grains	Drams (avdp)	0.0365714

Conversion Factors (Cont.)

To Convert	To	Multiply By
Grains	Grams	0.06479891
Grains	lbs (avdp)	1.4285714×10^{-4}
Grains	lbs (troy)	1.7361111×10^{-4}
Grains	Ounces (avdp)	2.2857143×10^{-3}
Grams	Drams (avdp)	0.56438339
Grams	Grains	15.432358
Grams	Ounces (avdp)	0.035273962
Grams	lbs (avdp)	2.2046226×10^{-3}
Horsepower	Btu/min	42.4072
Horsepower	Kilowatts	0.7457
Horsepower	Watts	745.6999
Horsepower (boiler)	Btu(mean)/hr	33445.7
Horsepower (boiler)	Kilowatts	9.8095
Horsepower – hrs	Btu	2544.43
Inches	Centimeters	2.54
Inches	Millimeters	25.4
Inches	Meters	0.0254
Inches of H_2O (32°F)	Atmospheres	0.0024552
Inches of H_2O (39.2°F)	lbs/sq.inch	0.036126
Inches mercury (32°F)	Atmospheres	0.0334211
Inches of mercury	Feet of H_2O	1.132957041
Inches mercury (32°F)	lbs/sq. inch	0.4911542
Inches mercury	Pascals	3386
Joules	Calories (gram)	0.238846
Joules	Btu	9.47817×10^{-4}
Joules/kilogram	Btu/lb	4.29923×10^{-4}
Joules/kilogram	Calories/gram	2.38846×10^{-4}
Kilograms	lbs (avdp)	2.2046226
Kilograms	Ounces (avdp)	35.27396
Kilograms	Tons (Metric)	0.001
Kilograms	Tons (short)	0.00110232
Kilogram – calories/min	Btu/min	3.96832
Kilogram – meters	Btu	0.0092949
Kilograms/cm^2	lbs/sq. inch	14.2233433
Kilograms/m^3	lbs/ft^3	0.0624298
Kilometers	Miles (statute)	0.6213712
Kilometers/hr	Miles/hr	0.6213712
Kilopascals	lbs/sq. inch	0.1450326
Kilowatts	Btu/hr	3412.14
Kilowatts	Btu/min	56.8690
Kilowatts	Btu/sec	0.9478170
Kilowatts	Horsepower	1.34102
Kilowatts	Horsepower (boiler)	0.101942
Kilowatts	Watts	1000
Kilowatt – hrs	Btu	3412.1412
Knots (Int)	Miles/hr	1.150779
lbs (avdp)	Drams (avdp)	256

Conversion Factors (Cont.)

To Convert	To	Multiply By
lbs (avdp)	Grains	7000
lbs (avdp)	Grams	453.59237
lbs (avdp)	Kilograms	0.45359
lbs (avdp)	lbs (troy)	1.2153
lbs (avdp)	Ounces (avdp)	16
lbs (avdp)	Tons (short)	0.0005
lbs (troy)	Grains	5760
lbs (troy)	lbs (avdp)	0.822842
lbs (troy)	Pennyweights	240
lbs/million Btu	Nanogram/Joule (ng/J)	430
lbs/sq.inch	Atmospheres	0.068046
lbs/sq.inch	Bars	0.0689476
lbs/sq.inch	Inches of H_2O (39.2°F)	27.6807
lbs/sq.inch	Inches of mercury	2.03602
lbs/sq.inch	Kilograms/cm^2	0.070306958
lbs/sq.inch	Kilopascals	6.895
lbs/sq.inch	Millibars	68.9476
lbs/sq.inch	mm of H_2O	703.089
lbs/sq.inch	mm of mercury	51.7149
lbs/sq.inch	Pascals	6895
lbs/ft^3	Kilograms/m^3	16.018
Liters	Cubic feet	0.035314667
Liters	Cubic inches	61.023744
Liters	Cubic meters	0.001
Liters	Gallons (US, liquid)	0.26417205
Liters/min	Cubic feet/hr	2.118882
Liters/min	Cubic feet/min	0.0353147
Meters	Feet	3.28084
Meters	Inches	39.370079
Meters/sec	Feet/min	196.8504
Meters/sec	Feet/sec	3.28084
Miles (statute)	Feet	5280
Miles (statute)	Kilometers	1.609344
Miles (statute)	Yards	1760
Miles/hr	Feet/min	88.0
Miles/hr	Feet/sec	1.4666666
Miles/hr	Kilometers/hr	1.609344
Miles/hr	Knots (Int)	0.86897624
mL/min for water only	Cubic cm/min	1.0
Millibars	lbs/sq. inch	0.01450377
Millimeters	Inches	0.039370079
mm of H_2O	lbs/sq. inch	0.001422295
mm of mercury (0°C)	Atmospheres	0.00131579
mm of mercury	lbs/sq. inch	0.019336787
mm of mercury	Pascals	133.3
Minutes	Degrees	0.016666667
Minutes	Radians	0.000290888

Conversion Factors (Cont.)

To Convert	To	Multiply By
Nanogram/Joule (ng/J)	lbs/million Btu	0.002325581
Ounces (avdp)	Drams (avdp)	16.0
Ounces (avdp)	Grains	437.5
Ounces (avdp)	Grams	28.349523
Ounces (avdp)	Kilograms	0.028350
Ounces (avdp)	lbs (avdp)	0.0625
Pascals	Inches of mercury	0.000295
Pascals	lbs/sq. inch	1.45033×10^{-4}
Pascals	mm of mercury	0.0075
Pennyweights	lbs (troy)	0.004166667
ppm (density = 1 g/mL for solvent)	Grains/gallon (US)	0.0584162
ppm (density = 1 g/mL for solvent)	Grains/gallon (Brit.)	0.07015488
Radians	Degrees	57.295779
Radians	Minutes	3437.7468
Seconds	Degrees (angle)	0.0002778
Sq. centimeters	Sq. feet	1.0763867×10^{-3}
Sq. centimeters	Sq. inches	0.15500031
Sq. feet	Acres	2.295684×10^{-5}
Sq. feet	Sq. centimeters	929.03415
Sq. feet	Sq. inches	144
Sq. feet	Sq. meters	0.0929
Sq. feet	Sq. miles	3.5870064×10^{-8}
Sq. inches	Sq. centimeters	6.4516
Sq. inches	Sq. feet	0.0069444
Sq. kilometers	Acres	247.10538
Sq. meters	Sq. feet	10.7643
Sq. meters	Sq. yards	1.195990
Sq. miles	Acres	640
Sq. miles	Sq. feet	27878,400
Sq. miles	Sq. yards	$3.0976 \times 10^{+6}$
Sq. yards	Acres	2.0661157×10^{-4}
Sq. yards	Sq. meters	0.83612736
Sq. yards	Sq. miles	3.22831×10^{-7}
Therms	BTUs	100000
Tons (Metric)	Kilograms	1000
Tons (short)	lbs (avdp)	2000
Tons (short)	Kilograms	907.18
Watts	Btu/hr	3.41214
Watts	Btu/min	0.056869
Watts	Horsepower	0.001341022
Watts	Kilowatts	0.001
Yards	Miles (statute)	5.68182×10^{-4}

Common Elements

Element	Symbol	Atomic Weight
Aluminum	Al	26.98
Antimony	Sb	121.76
Arsenic	As	74.91
Barium	Ba	137.36
Beryllium	Be	9.01
Cadmium	Cd	112.41
Calcium	Ca	40.08
Carbon	C	12.01
Chromium	Cr	52.01
Copper	Cu	63.54
Hydrogen	H	1.00
Iron	Fe	55.85
Lead	Pb	207.21
Magnesium	Mg	24.32
Manganese	Mn	54.94
Mercury	Hg	200.61
Molybdenum	Mo	95.95
Nickel	Ni	58.71
Nitrogen	N	14.00
Oxygen	O	16.00
Phosphorus	P	30.97
Potassium	K	39.10
Selenium	Se	78.96
Silicon	Si	28.09
Silver	Ag	107.88
Sodium	Na	22.99
Sulfur	S	32.07
Thallium	Tl	204.37
Zinc	Zn	65.38

Periodic Table

Hydrogen H 1.008																	Helium He 4.003
Lithium Li 6.939	Beryllium Be 9.012											Boron B 10.811	Carbon C 12.011	Nitrogen N 14.007	Oxygen O 15.999	Fluorine F 18.998	Neon Ne 20.183
Sodium Na 22.990	Magnesium Mg 24.312											Aluminium Al 26.982	Silicon Si 28.086	Phosphorus P 30.974	Sulfur S 32.064	Chlorine Cl 35.453	Argon Ar 39.948
Potassium K 39.102	Calcium Ca 40.08	Scandium Sc 44.956	Titanium Ti 47.90	Vanadium V 50.942	Chromium Cr 51.996	Manganese Mn 54.938	Iron Fe 55.847	Cobalt Co 58.933	Nickel Ni 58.71	Copper Cu 63.54	Zinc Zn 65.37	Gallium Ga 69.72	Germanium Ge 72.59	Arsenic As 74.922	Selenium Se 78.96	Bromine Br 79.909	Krypton Kr 83.80
Rubidium Rb 85.47	Strontium Sr 87.62	Yttrium Y 88.905	Zirconium Zr 91.22	Niobium Nb 92.906	Molybdenum Mo 95.94	Technetium Tc (98.91)	Ruthenium Ru 101.07	Rhodium Rh 102.905	Palladium Pd 106.4	Silver Ag 107.870	Cadmium Cd 112.40	Indium In 114.82	Tin Sn 118.69	Antimony Sb 121.75	Tellurium Te 127.60	Iodine I 126.904	Xenon Xe 131.30
Cesium Cs 132.905	Barium Ba 137.34	See Lanthanides	Hafnium Hf 178.49	Tantalum Ta 180.948	Tungsten W 183.85	Rhenium Re 186.2	Osmium Os 190.2	Iridium Ir 192.2	Platinum Pt 195.09	Gold Au 196.967	Mercury Hg 200.59	Thallium Tl 204.37	Lead Pb 207.19	Bismuth Bi 208.980	Polonium Po (210.00)	Astatine At (209.99)	Radon Rn (222.02)
Francium Fr (223.02)	Radium Ra (226.03)	See Actinides	*Unq (261.11)	*Unp (262.11)	*Unh (263.12)	*Uns (262.12)	* Uno	* Une									

Rare Earth Elements

Lanthanides	Lanthanum La 138.91	Cerium Ce 140.12	Praseodymium Pr 140.907	Neodymium Nd 144.24	Promethium Pm (146.00)	Samarium Sm 150.35	Europium Eu 151.96	Gadolinium Gd 157.25	Terbium Tb 158.924	Dysprosium Dy 162.50	Holmium Ho 164.930	Erbium Er 167.26	Thulium Tm 168.934	Ytterbium Yb 173.04	Lutetium Lu 174.97
Actinides	Actinium Ac (227.03)	Thorium Th 232.038	Protactinium Pa (231.04)	Uranium U 238.03	Neptunium Np (237.05)	Plutonium Pu (244.06)	Americium Am (243.06)	Curium Cm (247.07)	Berkelium Bk (247.07)	Californium Cf (251.08)	Einsteinium Es (252.08)	Fermium Fm (257.10)	Mendelevium Md (258.10)	Nobelium No (259.10)	Lawrencium Lw (260.11)

* Symbols based on IUPAC systematic names.

Summary of Units

Multiplication Factor			Prefix	Symbol
1,000,000,000,000,000,000	=	10^{18}	exa-	E
1,000,000,000,000,000	=	10^{15}	peta-	P
1,000,000,000,000	=	10^{12}	tera-	T
1,000,000,000	=	10^{9}	giga-	G
1,000,000	=	10^{6}	mega-	M
1,000	=	10^{3}	kilo-	k
100	=	10^{2}	hecto-	h
10	=	10^{1}	deka-	da
0.1	=	10^{-1}	deci-	d
0.01	=	10^{-2}	centi-	c
0.001	=	10^{-3}	milli-	m
0.000 001	=	10^{-6}	micro-	μ
0.000 000 001	=	10^{-9}	nano-	n
0.000 000 000 001	=	10^{-12}	pico-	p
0.000 000 000 000 001	=	10^{-15}	femto-	f
0.000 000 000 000 000 001	=	10^{-18}	atto-	a

GE routinely analyzes air, water, and soil samples to the parts-per-million (ppm), parts-per-billion (ppb), and even parts-per-trillion (ppt) level. To understand the sensitivity of these measurements, consider the following:

- One part per million is the equivalent of about one ounce of contamination in a typical 10,000-gallon railroad tank car, full of water.
- One part per billion is the equivalent of about one drop of contamination in the same 10,000-gallon railroad tank car.
- One part per trillion is the equivalent of about one drop of contamination in one thousand, 10,000-gallon railroad tank cars.

Soil/Water Solutions Table

SOIL/WATER SOLUTIONS AT 4˚C

Commonly Used Notation		To Convert from Row Units to Column Units Multiply by Value at the Intersection					
	Percent		g/Kg or g/L	mg/Kg or mg/L	mg/Kg or mg/L	ng/Kg or ng/L	pg/Kg or pg/L
Parts per Thousand PPK	0.1%	g/Kg or g/L	1	1,000	1,000,00	1,000,000,000	1,000,000,000,000
Parts per Million PPM	0.0001%	g/Kg or g/L	0.001	1	1,000	1,000,000	1,000,000,000
Parts per Billion PPB	0.0000001%	mg/Kg or mg/L	0.000001	0.001	1	1,000	1,000,000
Parts per Trillion PPT	0.0000000001%	ng/Kg or ng/L	0.000000001	0.000001	0.001	1	1,000
Parts per Quadrillion PPQ	0.0000000000001%	pg/Kg or pg/L	0.000000000001	0.000000001	0.000001	0.001	1

Common Equations

OHM'S Law

$$I = \frac{E}{R}$$

I = current in amps
E = voltage in volts
R = resistance in ohms

Power—AC Circuits

$$\text{Three-Phase Kilowatts} = \frac{\text{Volts} \times \text{Amperes} \times \text{Power Factor} \times 1.732}{1000}$$

$$\text{Three-Phase Volt-Amperes} = \text{Volts} \times \text{Amperes} \times 1.732$$

$$\text{Horsepower (3 Phase)} = \frac{\text{Volts} \times \text{Amperes} \times 1.732 \times \text{Efficiency} \times \text{Power Factor}}{746}$$

$$\text{Single-Phase Kilowatts} = \frac{\text{Volts} \times \text{Amperes} \times \text{Power Factor}}{1000}$$

$$\text{Single-Phase Amperes} = \frac{746 \times \text{Horsepower}}{\text{Volts} \times \text{Efficiency} \times \text{Power Factor}}$$

$$\text{Horsepower (1 Phase)} = \frac{\text{Volts} \times \text{Amperes} \times \text{Efficiency} \times \text{Power Factor}}{746}$$

Power—DC Circuits

$$\text{Horsepower} = \frac{\text{Volts} \times \text{Amperes} \times \text{Efficiency}}{746}$$

Common Equations (Cont.)

Pump Horsepower

$$BHP = \frac{GPM \times FT \times Specific\ Gravity}{3{,}960 \times Efficiency\ of\ Pump}$$

$$BHP = \frac{GPM \times PSI \times Specific\ Gravity}{1{,}713 \times Efficiency\ of\ Pump}$$

Fan/Blower Horsepower

$$BHP = \frac{CFM \times PSF}{33{,}000 \times Efficiency\ of\ Fan}$$

$$BHP = \frac{CFM \times PIW}{6{,}344 \times Efficiency\ of\ Fan}$$

$$BHP = \frac{CFM \times PSI}{229 \times Efficiency\ of\ Fan}$$

where:
BHP = Brake Horsepower
CFM = Cubic Feet per Minute
FT = Head in Feet
GPM = Gallons per Minute
PIW = Inches of Water Gauge
PSI = Pounds per Square Inch
PSIG = Pounds per Square Inch, gauge
PSF = Pounds per Square Foot
Specific Gravity of Water = 1.0
Head in Feet = 2.31 x PSIG

Common Equations (Cont.)

Heating & Cooling

Cooling Capacity of Chillers

Btu/hr = Specific Heat of Fluid x Flow Rate (GPM) x ΔT (°F)

where the following specific heats can be used:

Water	500 Btu/hr/GPM-°F
Ethylene Glycol (100%)	316 Btu/hr/GPM-°F

Heating Flowing Water

kW = 0.16 (kW/GPM-°F) x Flow Rate (GPM) x ΔT (°F)

where the specific heat includes a 10% contingency for losses.

Heating Water in Tanks*

$$kW = \frac{\text{Volume (gallons)} \times \Delta T\ (°F)}{325 \times \text{Heat-up time (hours)}}$$

Heating Oil in Tanks*

$$kW = \frac{\text{Volume (gallons)} \times \Delta T\ (°F)}{800 \times \text{Heat-up time (hours)}}$$

* these formulas are approximate and include contingency for losses

Common Equations (Cont.)

Humidity

Absolute Humidity

$$D = \frac{804}{1 + 0.00366 \times T} \times \frac{e}{P_o} = \frac{804}{1 + 0.00366 \times T} \times \frac{e_s}{P_o} \times \frac{RH}{100}$$

Relative Humidity

$$RH = \frac{e}{e_s} \times 100 = \frac{D}{D_s} \times 100$$

Saturation Vapor Pressure (at 1 atm)

$$e_s = 4.6 \times \exp\left[\frac{17.502 \times T}{240.9 + T}\right]$$

where:

D = absolute humidity (g water/m^3 dry air)
D_S = absolute humidity at saturation (g water/m^3 dry air)
e = water vapor pressure (mm Hg)
e_S = water vapor pressure at saturation (mm Hg)
P_o = standard air pressure (mm Hg)
RH = relative humidity (% RH)
T = temperature (ºC)

Temperature

°F = (9/5 x °C) + 32
°C = 5/9 (°F – 32)
K = °C + 273.15
°R = °F + 459.67

Emissions Testing

Stack (or Duct) Volume Flow Rate

Stack (or Duct) Gas Velocity

$$V_s = K \times C_p \times \left[\Delta P \times \frac{T_s + T_{Ref}}{MW_s \times P_s} \right]^{1/2}$$

Stack (or Duct) Gas Volume Flow Rate

$$Q = V_S \times A_S \times 60 \text{ (sec/min)}$$

$$Q_{sd} = Q \times (1 - B_{WS}) \times \frac{T_{std}}{(T_S + T_{Ref})} \times \frac{P_S}{P_{std}} \times 60 \text{ (min/hr)}$$

Q_{sd} (DSCFH) =

$$Q \text{ (ft}^3\text{/min)} \times (1 - B_{WS}) \times \frac{P_S \text{ (in Hg)}}{(T_S \text{ (°F)} + 460)} \times 1058.823 \text{ (°R/in Hg)(min/hr)}$$

Q_{sd} (DSCMH) =

$$Q \text{ (m}^3\text{/min)} \times (1\text{-}B_{WS}) \times \frac{P_S \text{ (mm Hg)}}{(T_S \text{ (°C)} + 273)} \times 23.132 \text{ (°K/mm Hg)(min/hr)}$$

Emissions Testing (Cont.)

Stack (or Duct) Volume Flow Rate (Cont.)

where:

	Parameter[1]	English			Metric		
		Units	Value	Typical	Units	Value	Typical
V_S	gas velocity	ft/sec			m/sec		
A_S	stack area	ft^2			m^2		
Q	actual volumetric flowrate	ft^3/min or ACFM			m^3/min		
Q_{sd}	dry volumetric flow rate at standard conditions[2]	dry ft^3/hr or DSCFH			dry m^3/hr or DSCFH		
K	pitot tube constant	ft/sec[3]	85.49		m/sec[4]	34.97	
C_p	pitot tube calibration coefficient	–	0.99[5]		–	0.99[5]	
ΔP	measured velocity head	in H2O			mm H2O		
T_S	gas temperature in stack	°F			°C		
T_{REF}	absolute temperature conversion	°F to °R	460		°C to °K	273	
MW_S	gas molecular weight	lb/lb-mol		29[6]	g/g-mol		29[6]
P_S	absolute gas pressure in stack	in Hg		29.92[6]	mm Hg		760[6]
B_{WS}	gas moisture content			0.02[7]			0.02[7]

(1) Subscript 's' refers to gas in stack or duct
(2) Standard (std) Conditions = 1 atm (29.92 in Hg; 760 mm Hg) & 528°R (293°K)
(3) Full units: (ft/sec)[(lb/lb-mol)(in Hg)/(°R)(in H_2O)^0.5
(4) Full units: (m/sec)[(g/g-mol)(mm Hg)/(°K)(mm H_2O)]^0.5
(5) For standard pitots; use 0.84 for most S-type pitots
(6) For most emissions sources
(7) For most ambient air

Emissions Testing (Cont.)

Gas Constant (R) Conversion Factors

R = 0.0821 (atm)(L)/(g-mole)(K)
R = 1.987 g-cal/(g-mole)(K)
R = 1.987 Btu/(lb-mole)(°R)
R = 1.987 c.h.u./(lb-mole)(K)
R = 8.314 J/(g-mole)(K)
R = 1,546 (ft-lbf)/(lb-mole)(°R)
R = 10.73 (ft-lbf/sq. in.)(cu ft)/(lb-mole)(°R)
R = 18510 (ft-lbf/sq. in.)(cu in.)/(lb-mole)(°R)
R = 0.7302 (atm)(cu ft)/(lb-mole)(°R)
R = 8.48×10^5 (kg/m^2)(cu cm)/(lb-mole)(K)

Molar Volume of Ideal Gas

The molar volume of an ideal gas at standard conditions of 1 atm (29.92 in Hg, 760 mm Hg) and 32°F (0°C) is:

22.41 m^3/kg-mol
22.41 l/g-mol
359 ft^3/lb-mol

The volume of an ideal gas at other conditions (e.g., such as a different reference temperature) can be found from the following expression derived from the ideal gas law:

$V_2 = V_1 \times (P_1/P_2) \times (T_2/T_1)$

where:
V_2 = gas volume at P_2 and T_2
V_1 = gas volume at P_1 and T_1
T = absolute gas temperature (°R or °K)
P = absolute gas pressure

Emissions Testing (Cont.)

Gaseous Pollutant Concentration Conversion

The following equations permit the conversion of concentration units between ppm (by volume) and $\mu g/m^3$ or mg/m^3 at a given pressure (P) and temperature (T):

$$\frac{\mu g}{m^3} = (ppm)41.577mw\left[\left(\frac{P}{P_0}\right)\left(\frac{T_0}{T}\right)\right]$$

$$ppm = \left(\frac{\mu g}{m^3}\right)\frac{0.024052}{mw}\left[\left(\frac{P_0}{P}\right)\left(\frac{T}{T_0}\right)\right]$$

$$\frac{mg}{m^3} = (ppm)0.041577mw\left[\left(\frac{P}{P_0}\right)\left(\frac{T_0}{T}\right)\right]$$

$$ppm = \left(\frac{mg}{m^3}\right)\frac{24.052}{mw}\left[\left(\frac{P_0}{P}\right)\left(\frac{T}{T_0}\right)\right]$$

where:

mw is the molecular weight of the pollutant and the quantity in square brackets is a correction factor which is identically 1 at the standard conditions of $P_0 = 1$ atmosphere to $T_0 = 293$ °K (20 °C) or 528 °R (68 °F)

Emissions Testing (Cont.)

Conversion of ppm to Pollutant Mass Flow Rate

$m_P = ppmv \times MW_P \times Q_{sd} \times C_1$

where:

m_P = mass flow rate of pollutant (lbs/hr or kg/hr)

ppmv = concentration of pollutant in gas by volume (parts per million)

MW_P = molecular weight of pollutant (lb/lb-mol or kg/kg-mol)

Q_{sd} = dry volumetric flow rate at std. conditions (ft^3/min or m^3/min)

C_1 = constant = 1.5574×10^{-7} (lb-mol/ft^3)(min/hr)
= constant = 2.4946×10^{-6} (kg-mol/m^3)(min/hr)

and standard conditions are 1 atm (29.92 in Hg, 760 mm Hg) and 68°F (528°R) or 20°C (293°K). Note that Q_{sd} = DSCFH/60 or DSCMH/60.

Emissions Testing (Cont.)

PPM Correction to Different Excess Oxygen Levels

Pollutant concentrations can be converted from one excess oxygen level to another by use of the following formula:

ppmv (at a% O_2) = ppmv (at b%O_2) x (20.9 - a)/(20.9 - b)

where “b” is the oxygen concentration corresponding to the given ppmv and “a” is the oxygen concentration at the desired ppmv.

Emissions Testing (Cont.)

PPM Conversion to Mass Per Fuel Energy

Pollutant concentrations can be converted from ppmv to units of mass per fuel energy by use of the following formula (for reference, see 40CFR, Part 60, Appendix A-7, Method 19):

$$E = ppmv \times C_1 \times F_d \times (20.9)/(20.9 - \%O_{2d})$$

where:

E = pollutant emissions rate (lb/million Btu or ng/J)

ppmv = pollutant concentration in gas on a dry basis (parts per million)

$\%O_{2d}$ = oxygen concentration in gas on a dry basis (% O_2)

and C_1 is a conversion factor that depends on the pollutant being converted and the system of units:

C1 (for ppm SO_2) = 2.66×10^{6} (ng/SCM)/(ppm SO_2)
C1 (for ppm NO_X) = 1.912×10^{6} (ng/SCM)/(ppm NO_X)
C1 (for ppm SO_2) = 1.660×10^{-7} (lb/SCF)/(ppm SO_2)
C2 (for ppm NO_X) = 1.194×10^{-7} (lb/SCF)/(ppm NO_X)

and F_d corresponds to the volume of flue gas generated per unit of fuel heat content at stoichiometric conditions and can be found from the following formula:

$$F_d \text{ (dscf/}10^6 \text{ Btu)} = \frac{10^6 \times (3.64\%H + 1.53\%C + 0.57\%S + 0.14\%N - 0.46\%O)}{GCV}$$

$$F_d \text{ (dscm/J)} = \frac{10^{-5} \times (22.7\%H + 9.57\%C + 3.54\%S + 0.86\%N - 2.85\%O)}{GCV}$$

Emissions Testing (Cont.)

PPM Conversion to Mass Per Fuel Energy (Cont.)

where %H, %C, %S, %N, and %O are the concentrations of, respectively, hydrogen, carbon, sulfur, nitrogen, and oxygen in the fuel on a percent weight basis and GCV is the fuel gross calorific value (Btu/lb or kJ/kg).

The F_d for common fuels depends upon the fuel type, but is not very sensitive to the actual fuel analysis within a given fuel type. The following values may be used when the fuel ultimate analysis is not known:

Anthracite	$= 2.71 \times 10^{-7}$ dscm/J	$= 10{,}100$ dscf/10^6 Btu
Bituminous Coal	$= 2.63 \times 10^{-7}$ dscm/J	$= 9{,}780$ dscf/10^6 Btu
Lignite	$= 2.65 \times 10^{-7}$ dscm/J	$= 9{,}860$ dscf/10^6 Btu
Fuel Oil	$= 2.47 \times 10^{-7}$ dscm/J	$= 9{,}190$ dscf/10^6 Btu
Natural Gas	$= 2.34 \times 10^{-7}$ dscm/J	$= 8{,}710$ dscf/10^6 Btu

Note that the above conversions assume standard conditions of 1 atm (29.92 in Hg, 760 mm Hg) and 68°F (20°C).

Based upon these factors, the concentration of NOx or SO_2 can be converted from ppmv (dry, 3%O_2) to lb/million Btu by multiplication by the following conversion factors:

Fuel	NOx	SO_2
Bituminous Coal	1.3634×10^{-3}	1.8956×10^{-3}
Fuel Oil	1.2812×10^{-3}	1.7812×10^{-3}
Natural Gas	1.2143×10^{-3}	1.6882×10^{-3}

or to ng/J by multiplication by the following conversion factors:

Fuel	NOx	SO_2
Bituminous Coal	0.5871	0.8168
Fuel Oil	0.5514	0.7671
Natural Gas	0.5224	0.7268

Emissions Testing (Cont.)

PPM Conversion to Mass Per Volume

Multiplication of the pollutant concentration in ppmv by conversion factor C1 in the preceding section converts from ppmv to units of mass per volume (lb/SCF or ng/SCM).

To convert pollutant concentration in ppmv to units of mass per volume (mg/SCM), multiply the concentration in ppmv by conversion factor C1 in the preceding section or by the following:

C1 (for ppm SO_2) = 2.660 (mg/SCM)/(ppm SO_2)
C1 (for ppm NO_x) = 1.912 (mg/SCM)/(ppm SO_2)

Federal Regulations—40 CFR Air Programs

Part 50	National Primary and Secondary Ambient Air Quality Standards
Part 50	Ambient Test Methods (Appendix A-N)
Part 51	Requirements for Preparation, Adoption, and Submittal of Implementation Plans
Part 53	Ambient Air Monitoring Reference and Equivalent Methods
Part 60	Standards of Performance for New Stationary Sources
Part 60	Test Methods for New Stationary Sources (Appendix A)
Part 60	CEMS (Appendix B-F)
Part 61	Emissions Standards for Hazardous Air Pollutants
Part 61	Test Methods (Appendix B)
Part 63	Emissions Standards for Hazardous Air Pollutants for Source Categories
Part 63	Test Methods (Appendix A)
Part 68	Chemical Accident Prevention Provisions (Risk Management Plan)
Part 70	State Operating Permit Programs
Part 71	Federal Operating Permit Programs
Part 72	Permits Regulation
Part 75	Continuous Emissions Monitoring
Part 76	Acid Rain Nitrogen Oxides Emissions Reduction Program

Federal Regulations—40 CFR Solid & Hazardous Waste

Part 240	Guidelines for the Thermal Processing of Solid Wastes
Part 243	Guidelines for the Storage and Collection of Residential, Commercial, and Institutional Sources
Part 246	Source Separation for Materials Recovery Guidelines
Part 256	Guidelines for Development and Implementation of State Solid Waste Management Plans
Part 257	Criteria for Classification of Solid Waste Disposal Facilities and Practices
Part 258	Criteria for Municipal Solid Waste Landfills
Part 260	Hazardous Waste Management System: General
Part 261	Identification and Listing of Hazardous Waste
Part 262	Standards Applicable to Generators of Hazardous Waste
Part 263	Standards Applicable to Transporters of Hazardous Waste
Part 264	Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal
Part 265	Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage
Part 266	Standards for the Management of Specific Hazardous Wastes and Specific Types of Hazard
Part 268	Land Disposal Restrictions
Part 270	EPA Administered Permit Programs: The Hazardous Waste Permit Program
Part 273	Standards for Universal Waste Management
Part 279	Standards for the Management of Used Oil
Part 280	Technical Standards and Corrective Action Requirements for Owners and Operators of Underground Storage Tanks
Part 281	Approval of State Underground Storage Tank Programs
Part 282	Approved Underground Storage Tank Programs

Federal Regulations—40 CFR Wastewater Pretreatment

Part 401	General Provisions
Part 403	General Wastewater Pretreatment Regulations for Existing and New Sources of Pollution
Part 405	Dairy Products Processing Point Source Category
Part 406	Grain Mills Point Source Category
Part 407	Canned and Preserved Fruits and Vegetables Processing Point Source Category
Part 408	Canned and Preserved Seafood Processing Point Source Category
Part 409	Sugar Processing Point Source Category
Part 410	Textile Mills Point Source Category
Part 411	Cement Manufacturing Point Source Category
Part 412	Feedlots Point Source Category
Part 413	Electroplating Point Source Category
Part 414	Organic Chemicals, Plastics, and Synthetic Fibers
Part 415	Inorganic Chemicals Manufacturing Point Source Category
Part 417	Soap and Detergent Manufacturing Point Source Category
Part 418	Fertilizer Manufacturing Point Source Category
Part 419	Petroleum Refining Point Source Category
Part 420	Iron and Steel Manufacturing Point Source Category
Part 421	Nonferrous Metals Manufacturing Point Source Category
Part 422	Phosphate Manufacturing Point Source Category
Part 423	Steam Electric Power Generating Point Source Category
Part 424	Ferroalloy Manufacturing Point Source Category
Part 425	Leather Tanning and Finishing Point Source Category
Part 426	Glass Manufacturing Point Source Category
Part 427	Asbestos Manufacturing Point Source Category
Part 428	Rubber Manufacturing Point Source Category
Part 429	Timber Products Processing Point Source Category
Part 430	Pulp, Paper, and Paperboard Point Source Category

Federal Regulations—40 CFR Wastewater Pretreatment (Cont.)

Part 432	Meat Products Point Source Category
Part 433	Metal Finishing Point Source Category
Part 434	Coal Mining Point Source Category BPT, BAT, BCT Limitations and New Source Performance Standard
Part 435	Oil and Gas Extraction Point Source Category
Part 436	Mineral Mining and Processing Point Source Category
Part 439	Pharmaceutical Manufacturing Point Source Category
Part 440	Ore Mining and Dressing Point Source Category
Part 443	Effluent Limitations Guidelines for Existing Sources and Standards of Performance
Part 446	Paint Formulating Point Source Category
Part 447	Ink Formulating Point Source Category
Part 454	Gum and Wood Chemicals Manufacturing Point Source Category
Part 455	Pesticide Chemicals
Part 457	Explosives Manufacturing Point Source Category
Part 458	Carbon Black Manufacturing Point Source Category
Part 459	Photographic Point Source Category
Part 460	Hospital Point Source Category
Part 461	Battery Manufacturing Point Source Category
Part 463	Plastics Molding and Forming Point Source Category
Part 464	Metal Molding and Casting Point Source Category
Part 465	Coil Coating Point Source Category
Part 466	Porcelain Enameling Point Source Category
Part 467	Aluminum Forming Point Source Category
Part 468	Copper Forming Point Source Category
Part 469	Electrical and Electronic Components Point Source Category
Part 471	Nonferrous Metals Forming and Metal Powders Point Source Category

Federal Regulations—40 CFR
OTHERS

Part 112	Oil Pollution Prevention
Part 122	The National Pollutant Discharge Elimination System
Part 302	Spill Reporting; Designation, Reportable Quantities, and Notification
Part 355	Emergency Planning and Notification
Part 370	Hazardous Chemical Reporting – Community Right-To-Know
Part 372	Toxic Chemical Release Reporting – Community Right-To-Know
Part 761	PCBs

Electronic Data Reporting—40 CFR Part 75

Table 1: EDR Electronic Reporting Record Types

RECORD TYPES			
GROUP	**SUB-GROUP**	**RECORD TYPE**	**RECORD**
Facility Information (100)	Facility Information	Facility Identification (Modified)	100
		Record Types Submitted (Optional)	101
		Facility Location and Identification Information (New)	102
Monitoring Data (200)	Pollutant Gas Concentrations	SO_2 Concentration Data	200
		NO_x Concentration Data (Modified)	201
		CO_2 Concentration Data (Modified)	202
	Diluent Gas Concentrations	CO_2 Diluent Concentration Data (Modified)	210
		O_2 Diluent Concentration Data (Modified)	211
	Moisture Data	Moisture Data (New)	212
	Volumetric Flow	Volumetric Flow Data (Modified)	220
	Daily Quality Assurance Data and Results	Daily Calibration Test Data and Results (Modified)	230
		Flow Daily Interference Check Results	231
	Reference Method Backup QA Data	Hourly Pollutant and Diluent Concentration Data from RM Backup Analyzers	260
		Quality Assurance Run Data for Reference Method Analyzers or Systems Used as Backup CEMS	261
		Reference Method Backup Flow Rate Monitor (Run Summary) (Modified)	262
Unit Data (300)	Unit Operating and Cumulative Emissions Data	Unit Operating Parameters (Modified)	300
		Quarterly Cumulative Emissions Data (Modified)	301
		Oil Fuel Flow (Modified)	302
		Gas Fuel Flow (Modified)	303
		Quarterly Heat Input from Long Term Fuel Flow Measurements for Qualifying Low Mass Emission Units (New)	305
		Cumulative Nox Mass Emissions Data (New)	307
	SO2Mass Emissions Data	SO_2 Mass Emissions Data (Modified)	310
		SO_2 Mass Emissions Alternative Estimation Parameters for Oil (Modified)	313
		SO_2 Mass Emissions Alternative Estimation Parameters for Natural Gas (Modified)	314
	NoxEmissions Data	NO_x Emission Rate Data	320
		NO_x Emission Rate Alternative Estimation Parameters for Oil and Gas (Modified)	323
		NO_x Emission Rate Estimation Based on Appendix E (New)	324
		NO_x Emission Rate Estimation Based on Appendix E for Multiple Fuel Hours (New)	325
		NO_x Mass Emissions (New)	328

Electronic Data Reporting—40 CFR Part 75 (Cont.)

Table 1: EDR Electronic Reporting Record Types

RECORD TYPES			
GROUP	**SUB-GROUP**	**RECORD TYPE**	**RECORD**
Unit Data (300)	CO_2 Mass Emissions Data	CO_2 Mass Emissions Data (Modified)	330
		CO_2 Mass Emissions Estimation Parameters	331
	Qualifying Low Mass Emissions Unit Data	Hourly Emissions Data for Qualifying Low Mass Emissions Units (New)	360
Monitoring Plan Information (500)		Stack/Pipe Header Definition Table (Modified)	503
		Unit Information (New)	504
		Program Indicator for Report (New)	505
		EIA Cross Reference Information (New)	506
		Fuel Usage Data to Qualify as a Peaking Unit or an Acid Rain Program Gas-fired Unit (New)	507
		Subpart H Reporting Frequency Change (New)	508
		Monitoring Systems/Analytical Components Table (Modified)	510
		Formula Table	520
		Span Table (Modified)	530
		Maximums, Minimums, Defaults and Constants (New)	531
		Unit and Stack Operating Load Data (New)	535
		Range of Operation, Normal Load, and Load Usage (New)	536
		Fuel Flowmeter Data (Modified)	540
		Reasons for Monitoring System Downtime or Missing Parameter (Optional)	550
		Monitoring System Recertification, Maintenance, or Other Events (New)	556
		Appendix E NO_x Correlation Curve Segments (New)	560
		Monitoring Methodology Information (New)	585
		Control Equipment Information (New)	586
		Unit Fuel Type (New)	587
Certification Test Data (600)	Calibration/Error Tests	7-Day Calibration Error Test Data and Results (Modified)	600
	Linearity Checks	Linearity Check Data (Modified)	601
		Linearity Check Results (Modified)	602
	Leak Checks	Flow Leak Check Results (Modified)	603
	Flow/Load Checks	Reference Data for Flow-to-Load Ratio or Gross Heat Rate Evaluation (New)	605
		Quarterly Flow-to-Load Ratio or Gross Heat Rate Check (New)	606

Electronic Data Reporting—40 CFR Part 75 (Cont.)

Table 1: EDR Electronic Reporting Record Types

RECORD TYPES			
GROUP	**SUB-GROUP**	**RECORD TYPES**	**RECORD**
Certification Test Data (600)	RATA/Bias Tests	RATA and Bias Test Data (Modified)	610
		RATA and Bias Test Results (Modified)	611
		Reference Method Supporting Data for Flow RATA Tests (New)	614
		Reference Method Supporting Data for Flow RATA Tests (New)	615
		Reference Method Supporting Data for Flow RATA Tests (New)	616
	Cycle Time Test	Cycle Time Test Data and Results (Modified)	621
	On Line/Off Line Calibration Demonstration	Qualifying Test for Off-line Calibration Error Tests (New)	623
	Miscellaneous QA Test/Activity	Other QA Activities (New)	624
	Fuel Flowmeter Accuracy Tests	Fuel Flowmeter Accuracy Test (New)	627
		Accuracy Test for Orifice, Nozzle, or Venturi Type Fuel Flowmeters (New)	628
	Quarterly Fuel-Flow-to-Load Analysis	Baseline Data for Fuel-Flow-to-Load Ratio or Gross Heat Rate Check for Fuel Flowmeters (New)	629
		Quarterly Fuel-Flow-to-Load Test for Fuel Flowmeters (New)	630
	Alternative Monitoring Petition Data	Alternative Monitoring System Approval Petition Data (Renumbered from EDR v1.3 RT 630)	640
		Alternative Monitoring System Approval Petition Results and Statistics (Renumbered from EDR v1.3 RT 631)	641
	LME Certification	Qualifying Data for Low Mass Emissions Units Excepted Methodology (New)	645
	Appendix E and Unit Specific Default Emission Rate Test Data	NOx Emission Rate Correlation Test Data (Modified)	650
		NOx Emission Rate Correlation Results (Modified)	651
		Heat Input from Oil Combusted During Test (Modified)	652
		Heat Input from Gas Combusted During Test (Modified)	653
		Unit Group Testing (New)	660
	QA Test Extensions/Exemption Claims	Single-load Flow RATA Claim (New)	695
		Fuel Flowmeter Accuracy Test Extension (New)	696
		RATA Deadline Extension or Exemption (New)	697
		Quarterly QA Test Exemption Claim (New)	698
		QA Test Extension Claim Based on Grace Period (New)	699

Electronic Data Reporting—40 CFR Part 75 (Cont.)

Table 1: EDR Electronic Reporting Record Types

RECORD TYPES			
GROUP	**SUB-GROUP**	**RECORD TYPES**	**RECORD**
Certification Data (900)	Certification Data	Part 75 Certification Statement and Designated Representative Signature	900
		Part 72 Certification Statement	901
		Cover Letter Text (file specific) (Optional)	910
		Cover Letter Text (not specific to file) (Optional)	920
		Subpart H Certification Statement and NOx Authorized Account Representative Signature (New)	940
		Subpart H General Certification Statement (New)	941
		Contact Person Record (New) (Optional)	999

Air Emissions Test Methods— USEPA 40 CFR Part 51

Appendix M

Method		Description
201		PM-10 (EGR procedure)
201A		PM-10 (CSR procedure)
202		Condensable PM
203	proposed	Transmissometer for opacity compliance
203A	proposed	M-9 revision – 2-6 min. avg.
203B	proposed	M-9 revision – time exception
203C	proposed	M-9 revision – instantaneous
204		TE (total enclosure) criteria
204A		VOC content in liquid streams
204B		VOC emissions in captured gas streams
204C		VOC emissions in captured gas streams – dilution technique
204D		VOC emissions in fugitive gas streams in TE (total enclosure)
204E		VOC emissions in fugitive gas streams in building enclosures
204F		VOC content in liquid input
205		Gas dilution calibration
206		(CTM-027) Ammonia
207	proposed	Isocyanates

Air Emissions Test Methods— USEPA 40 CFR Part 60

Appendix A

Method		Description
1		Selection of traverse points
1A		Traverse points in small ducts
2		Flow rate – type S pitot
2A		Flow rate in small ducts – vol. meters
2B		Flow rate – stoichiometry
2C		Flow rate in small ducts – standard pitot
2D		Flow rate in small ducts – rate meters
2E		Flow rate from landfill wells
2F		Flow rate using 3-D probes
2G		Flow rate with Yaw angle adjustment
2H		Wall effect determination
3		Molecular weight
3A		Instrumental method for O_2 (oxygen) and CO_2 (carbon dioxide)
3B		Orsat for correction factors and excess air
3C		Gas composition from landfill gases
4		Moisture Content in Stack Gas
5		PM (particulate matter)
5A		PM from asphalt roofing (Prop. as M-26)
5B		Nonsulfuric acid PM
5C	tentative	PM from small ducts
5D		PM from baghouses – without stacks
5E		PM from fiberglass plants
5F		PM from FCCU (fluidized catalytic cracking units)
5G		PM from wood stove – dilution tunnel
5H		PM from wood stove – stack
5I		Low Level PM Emissions

Air Emissions Test Methods— USEPA 40 CFR Part 60 (Cont.)

Appendix A

Method	Description
6	SO_2 (sulfur dioxide)
6A	SO_2/CO_2
6B	Auto SO_2/CO_2
6C	Instrumental method for SO_2
7	NOx (nitrogen oxides)
7A	Ion chromatograph NOx analysis
7B	UV NO_x analysis for nitric acid plants
7C	Alkaline permanganate/colorimetric for NO_x
7D	Alkaline permanganate/IC for NO_x
7E	Instrumental method for NO_x
8	Sulfuric acid (H_2SO_4) mist and SO_2
9	Visual Opacity
10	CO
10A	Colorimetric method (used with PS-4)
10B	CO by GC method used with PS-4
11	H_2S (hydrogen sulfide)
12	Pb (lead)
13A	F – colorimetric method
13B	F – SIE method
14	F for primary aluminum plants
14A	Total F from selected sources at primary aluminum plants

Air Emissions Test Methods— USEPA 40 CFR Part 60 (Cont.)

Appendix A

Method	Description
15	TRS (Total Reduced Sulfur) from petroleum refineries
15A	TRS alternative/oxidation
16	TRS from kraft pulp mills
16A	TRS alternative (by oxidation)
16B	TRS alternative/GC analysis of SO_2
17	PM, in-stack
18	VOC, general GC method
19	F-factor, fuel sampling
20	NOx from gas turbines
21	VOC leaks
22	Fugitive Opacity (Visible Emissions)
23	Dioxins/Furans
24	Solvent in surface coatings
24A	Solvent in ink
25	TGNMO (Total Gaseous Non-Methane Organics)
25A	TOC/FID
25B	TOC/NDIR
25C	VOC from landfills
25D	VOC from TSDF – purge procedure
25E	VOC from TSDF – vapor pressure procedure

Air Emissions Test Methods—USEPA 40 CFR Part 60 (Cont.)

Appendix A

Method	Description
26	HCl (Hydrogen Chloride)
26A	Isokinetic HCl and halogens
27	Tank truck leaks
28	Wood stove certification
28A	Air-to-fuel ratio
29	Metal emissions from stationary sources

Appendix B—CEM Performance Specifications

Method	Description
PS-1	Opacity
PS-2	SO_2 and NOx
PS-3	CO_2 and O_2
PS-4	CO
PS-4A	CO in MWC (municipal waste combustors)
PS-5	TRS
PS-6	Velocity and mass emissions rate
PS-7	H_2S
PS-8	VOC
PS-8A	THC
PS-9	VOC/GC
PS-11	Particulate Matter
PS-12A	Mercury
PS-15	Extractive FTIR

Air Emissions Test Methods— USEPA 40 CFR Part 60 (Cont.)

Appendix F—CEM Performance Specifications

Method	Description
Proc 1	CEMS Quality Assurance

Appendix J

Method	Description
App-J	Wood stove thermal efficiency

Alternative Procedures and Miscellaneous

S-Factor method for sulfuric acid plants
Corrections to S-Factor publication
Add fuel analysis procedures for gas turbines

Alternative PST for low-level concentrations
Misc. revisions to Appendix A, 40 CFR Part 60
Monitoring revisions to Subpart J (Petr. Ref.)

Air Emissions Test Methods—USEPA 40 CFR Part 61

Appendix B

Method	Description
101	Hg in air streams
101A	Hg in sewage sludge incinerators
102	Hg in H_2 streams
103	Revised Be screening method
104	Revised beryllium
105	Hg in sewage sludge
106	Vinyl chloride
107	VC in process streams
107A	VC in process streams
108	Inorganic arsenic
108A	Arsenic in ore samples
108B	Arsenic in ore alternative
108C	Arsenic in ore alternative
111	Polonium-210
114	Monitoring of radionuclides
115	Radon-222

Air Emissions Test Methods—
USEPA 40 CFR Part 63

Method		Description
301		Field data validation protocol
302	tentative	Generic GC/MS procedure
303		By-Product Coke Oven Batteries
303A		Non-Recovery Coke Oven Batteries
304A		Biodegradation rate (vented)
304B		Biodegradation rate (enclosed)
305		Compound specific liquid waste
306		Hexavalent Chromium
306A		Simplified chromium sampling
306B		Surface tension for tanks electroplating/anodizing
307		Emissions from solvent vapor cleaners
308		Procedure for methanol emissions
310A		Residual Hexane
310B		Residual Solvent
310C		Residual Hexane in EDPM Rubber
311		HAPS in paints and coatings
312A		Styrene in SBR Latex (GC)
312B		Styrene in SBR Latex by Capillary GC
312C		Styrene in SBR Latex Produced by Emissions Polymerization
313A		Residual Hydrocarbon in Rubber Crumb
313B		Residual HC in Rubber Crumb by Capillary GC
315		PM and MCEM from aluminum production facilities
316		Formaldehyde in the mineral wool & fiberglass industries
318		Extractive FTIR measurement for the mineral wool & fiberglass industries
319	proposed	Filtration efficiency for paint overspray arrestors
320		Vapor Phase Organic & Inorganic Emissions by Extractive FTIR
321		Gaseous HCl Emissions at Portland Cement Kilns by FTIR
322	proposed	HCl Emissions from Portland Cement Kilns by GFCIR
323	proposed	Formaldehyde Emissions
324	proposed	Mercury (Dry Sorbent Trap)

Air Emissions Test Methods—USEPA 40 CFR Part 75

Acid Rain

Method	Description
App A	Specifications and test procedures
App B	QA/QC procedures
App C	Missing data estimation procedures
App D	Optional SO_2 emissions
App E	Optional NOx emissions
App F	Conversion procedures
App G	Determination of CO_2 emissions

USEPA SW-846 Sampling & Analytical Test Methods

Test Methods for Evaluating Solid Waste, SW-846, Third Edition, November 1986

Air Sampling

Method	Description
0010	Modified Method 5 Sampling Train
0011	Sampling for formaldehyde emissions from stationary sources
0020	SASS (Source Assessment Sampling System)
0023A	Sampling Method for Polychlorinated Dibenzo-p-Dioxins and Polychlorinated Dibenzofuran Emissions from Stationary Sources
0030	VOST (Volatile Organic Sampling Train)
0031	Sampling Method for Volatile Organic Compounds (SMVOC)
0040	Sampling of Principal Organic Hazardous Constituents from Combustion Sources using TEDLAR® Bags
0050	Isokinetic HCl/CI2 Emissions Sampling Train
0051	Midget impinger HCl/Cl_2 Emissions Sampling Train
0060	Determination of Metals in Stack Emissions
0061	Determination of Hexavalent Chromium Emissions from Stationary Sources
0100	Sampling for Formaldehyde and Other Carbonyl Compounds in Indoor Air
5041A	Analysis for Desorption of Sorbent Cartridges from Volatile Organic Sampling Train (VOST)

USEPA SW-846 Sampling & Analytical Test Methods (Cont.)

Test Methods for Evaluating Solid Waste, SW-846, Third Edition, November 1986

Analytical, GC

Method	Description
8011	1,2-Dibromoethane and 1,2-Dibromo-3-chloropropane by Microextraction and Gas Chromatography
8015B	Nonhalogenated Organics Using GC/FID
8021B	Aromatic and Halogenated Volatiles by Gas Chromatography Using Photoionization and/or Electrolytic Conductivity Detectors
8031	Acrylonitrile by Gas Chromatography
8032A	Acrylamide by Gas Chromatography
8033	Acetonitrile by Gas Chromatography with Nitrogen-Phosphorus Detection
8041	Phenols by Gas Chromatography
8061A	Phthalate Esters by Gas Chromatography with Electron Capture Detection (GC/ECD)
8070A	Nitrosamines by Gas Chromatography
8081A	Organochlorine Pesticides by Gas Chromatography
8082	Polychlorinated Biphenyls (PCBs) by Gas Chromatography
8091	Nitroaromatics and Cyclic Ketones by Gas Chromatography
8100	Polynuclear Aromatic Hydrocarbons
8111	Haloethers by Gas Chromatography
8121	Chlorinated Hydrocarbons by Gas Chromatography: Capillary Column Technique
8131	Aniline and Selected Derivatives by Gas Chromatography
8141A	Organophosphorus Compounds by Gas Chromatography: Capillary Column Technique
8151A	Chlorinated Herbicides by GC Using Methylation or Pentafluorobenzylation Derivatization

USEPA SW-846 Sampling & Analytical Test Methods (Cont.)

Test Methods for Evaluating Solid Waste, SW-846, Third Edition, November 1986

Analytical, GC/MS

Method	Description
8260B	Volatile Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS)
8270C	Semivolatile Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS)
8275A	Semivolatile Organic Compounds (PAHs and PCBs) in Soils/Sludges and Solid Wastes Using Thermal Extraction/Gas Chromatography/Mass Spectrometry (TE/GC/MS)
8280A	The Analysis of Polychlorinated Dibenzo-p-Dioxins and Polychlorinated Dibenzofurans by High Resolution Gas Chromatography/Low Resolution Mass Spectrometry (HRGC/LRMS)
8290	Polychlorinated Dibenzodioxins (PCDDs) and Polychlorinated Dibenzofurans (PCDFs) by High Resolution Gas Chromatography/High Resolution Mass Spectrometry (HRGC/HRMS)

USEPA SW-846 Sampling & Analytical TEST METHODS (Cont.)

Test Methods for Evaluating Solid Waste, SW-846, Third Edition, November 1986

Analytical, GC/MS

Method	Description
8310	Polynuclear Aromatic Hydrocarbons
8315A	Determination of Carbonyl Compounds by High Performance Liquid Chromatography (HPLC) Appendix A: Recrystallization of 2,4-Dinitrophenylhydrazine (DNPH)
8316	Acrylamide, Acrylonitrile and Acrolein by High Performance Liquid Chromatography (HPLC)
8318	N-Methylcarbamates by High Performance Liquid Chromatography (HPLC)
8321A	Solvent Extractable Nonvolatile Compounds by High Performance Liquid Chromatography/Thermospray/Mass Spectrometry (HPLC/TS/MS) or Ultraviolet (UV) Detection
8325	Solvent Extractable Nonvolatile Compounds by High Performance Liquid Chromatography/Particle Beam/Mass Spectrometry (HPLC/PB/MS)
8330	Nitroaromatics and Nitramines by High Performance Liquid Chromatography (HPLC)
8331	Tetrazene by Reverse Phase High Performance Liquid Chromatography (HPLC)
8332	Nitroglycerine by High Performance Liquid Chromatography

USEPA SW-846 Sampling & Analytical TEST METHODS (Cont.)

Test Methods for Evaluating Solid Waste, SW-846, Third Edition, November 1986

Infrared Methods

Method	Description
8410	Gas Chromatography/Fourier Transform Infrared (GC/FT-IR) Spectrometry for Semivolatile Organics: Capillary Column
8430	Analysis of Bis(2-chloroethyl) Ether and Hydrolysis Products by Direct Aqueous Injection GC/FT-IR
8440	Total Recoverable Petroleum Hydrocarbons by Infrared Spectrophotometry

Other Methods

Method	Description
8520	Continuous Measurement of Formaldehyde in Ambient Air

Ambient Air Test Methods

Compendium of methods for the determination of toxic organic compounds in ambient air.
EPA – 600/4-84-041

Method	Description
TO-1	VOCs (volatile organic compounds) in Ambient Air using Tenax-Adsorption and GC/MS (gas chromatography/mass spectrometry)
TO-2	VOCs in Ambient Air by Carbon Molecular Sieve Adsorption and GC/MS
TO-3	VOCs in Ambient Air using Cryogenic Preconcentration Techniques and GC with Flame Ionization and Electron Capture Detection
TO-4A	Organochlorine Pesticides and Polychlorinated Biphenyls in Ambient Air
TO-5	Aldehydes and Ketones in Ambient Air using HPLC (high performance liquid chromatography)
TO-6	Phosgene in Ambient Air using HPLC
TO-7	N-Nitrosodimethylamine in Ambient Air using GC
TO-8	Phenol and Methylphenols (Cresols) in Ambient Air using HPLC
TO-9A	PCDDs (polychlorinated dibenzo-p-dioxins) in Ambient Air using High Resolution Gas Chromatography/High Resolution Mass Spectrometry

Ambient Air Test Methods (Cont.)

Compendium of methods for the determination of toxic organic compounds in ambient air.
EPA - 600/4-84-041

Method	Description
TO-10A	Organochlorine Pesticides in Ambient Air using Low Volume PUF (polyurethane foam) Sampling with GC/ECD (gas chromatography/electron capture detector)
TO-11A	Formaldehyde in Ambient Air using Adsorbent Cartridge Followed by HPLC (high performance liquid chromatography)
TO-12	NMOC (nonmethane organic compounds) in Ambient Air using Cryogenic PDFID (preconcentration and direct flame ionization detection)
TO-13A	PAHs (polynuclear aromatic hydrocarbons) in Ambient Air using High Volume Sampling with GC/MS (gas chromatography/mass spectrometry) and HPLC Analysis
TO-14A	VOCs (volatile organic compounds) in Ambient Air using SUMMA Polished Canister Sampling and GC Analysis
TO-15	The Determination of Volatile Organic Compounds (VOCs) in Air Collected in Summa Canisters and Analyzed by Gas Chromatography/Mass Spectrometry (GC/MS)
TO-16	Long-Path Open-Path Fourier Transform Infrared Monitoring of Atmospheric Gases
TO-17	Determination of Volatile Organic Compounds in Ambient Air Using Active Sampling onto Sorbent Tubes

Clean Air Act Amendments of 1990
Titles

I	Attainment and Maintenance of National Ambient Air Quality Standards
II	Mobile Sources
III	Air Toxics (Hazardous Air Pollutants)
IV	Acid Deposition Control
V	Permits
VI	Stratospheric Ozone Protection
VII	Enforcement
VIII	Miscellaneous
IX	Clean Air Research
X	Disadvantaged Business Concerns
XI	Clean Air Employment Transition Assistance

PSD Significant Emissions Rates & De Minimis Monitoring Concentrations

Pollutant	Significant Emissions Rate (TPY)	De Minimis Concentration (µg/m3)
Sulfur Dioxide	40	13, 24-Hour
Particulate Matter (TSP)	25	10, 24-Hour
Particulate Matter (PM 10)	15	10, 24-Hour
Nitrogen Oxides	40	14, Annual
Carbon Monoxide	100	575, 8-Hour
Volatile Organic Compounds (Ozone)	40	100 TPYa
Lead	0.6	0.1, 3-Month
Sulfuric Acid Mist	7	NM
Total Fluorides	3	0.25, 24-Hour
Total Reduced Sulfur	10	10, 1-Hour
Reduced Sulfur Compounds	10	10, 1-Hour
Hydrogen Sulfide	10	0.2, 1-Hour
Asbestos	0.007	NM
Beryllium	0.0004	0.001, 24 Hour
Mercury	0.1	0.25, 24-Hour
Vinyl Chloride	1	15, 24-Hour

[a] No de minimis concentration; an increase in VOC emissions of 100 TPY or more will require monitoring analysis for ozone.

Note: Ambient monitoring requirements for any pollutant may be exempted if the impact of the increase in emissions is below de minimis monitoring concentrations.

Sources: 40 CFR 52.21; KNB, 1994.

List of Hazardous Air Pollutants* (HAPs)

Acetaldehyde
Acetamide
Acetonitrile
Acetophenone
2-Acetylaminofluorene
Acrolein
Acrylamide
Acrylic acid
Acrylonitrile
Allyl chloride
4-Aminobiphenyl
Aniline
o-Anisidine
Asbestos
Benzene (including benzene from gasoline)
Benzidine
Benzotrichloride
Benzyl chloride
Biphenyl
Bis(2-ethylhexyl) phthalate (DEHP)
Bis(chloromethyl) ether
Bromoform
1,3-Butadiene
Calcium cyanamide
Captan
Carbaryl
Carbon disulfide
Carbon tetrachloride
Carbonyl sulfide
Catechol
Chloramben
Chlordane
Chlorine
Chloroacetic acid
2-Chloroacetophenone
Chlorobenzene
Chlorobenzilate
Chloroform
Chloromethyl methyl ether
Chloroprene
Cresols/Cresylic acid (isomers and mixture)
o-Cresol
m-Cresol
p-Cresol
Cumene
2,4-D, salts and esters
DDE
Diazomethane
Dibenzofurans
1,2-Dibromo-3-chloropropane
Dibutylphthalate
1, 4-Dichlorobenzene (p)
3, 3-Dichlorobenzidene
Dichloroethyl ether
1, 3-Dichloropropene
Dichlorvos
Diethanolamine
Diethyl sulfate
3, 3-Dimethoxybenzidine

*The Clean Air Act Amendment of 1990, Title III, Section 112(b).

List of Hazardous Air Pollutants* (HAPs) (Cont.)

Dimethyl aminoazobenzene
N,N-Dimethylanaline
3,3'-Dimethylbenzidine
Dimethyl carbamoyl chloride
Dimethylformamide
1,1-Dimethylhydrazine
Dimethyl phthalate
Dimethyl sulfate
4,6-Dinitro-o-cresol, and salts
2,4-Dinitrophenol
2,4-Dinitrotoluene
1,4-Dioxane
1,2-Diphenylhydrazine
Epichlorohydrin
1,2-Epoxybutane
Ethyl acrylate
Ethylbenzene
Ethyl carbamate (Urethane)
Ethyl chloride (Chloroethane)
Ethylene dibromide (Dibromoethane)
Ethylene dichloride (1,2-Dichloroethane)
Ethylene glycol
Ethyleneimine (Aziridine)
Ethylene oxide
Ethylene thiourea
Ethylidene dichloride (1,1-Dichloroethane)
Formaldehyde
Heptachlor
Hexachlorobenzene
Hexachlorobutadiene
Hexachlorocyclopentadiene
Hexachloroethane
Hexamethylene-1,6-diisocyanate
Hexamethylphosphoramide
Hexane
Hydrazine
Hydrochloric acid
Hydrogen fluoride (Hydrofluoric acid)
Hydroquinone
Isophorone
Maleic anhydride
Methanol (Methyl Alcohol)
Methoxychlor
Methyl bromide (Bromomethane)
Methyl chloride (Chloromethane)
Methyl chloroform (1,1,1-Trichloroethane)
Methyl ethyl ketone (2-Butanone)
Methyl hydrazine
Methyl iodide (Iodomethane)
Methyl isobutyl ketone (Hexone)

*The Clean Air Act Amendment of 1990, Title III, Section 112(b).

List of Hazardous Air Pollutants* (HAPs) (Cont.)

Methyl isocyanate
Methyl methacrylate
Methyl tert-butyl ether
4,4-Methylene bis(2-chloroaniline)
Methylene chloride (Dichloromethane)
4,4' Methylene diphenyl diisocyanate (MDI)
4,4'-Methylenedianiline
Naphthalene
Nitrobenzene
4-Nitrobiphenyl
4-Nitrophenol
2-Nitropropane
N-Nitroso-N-methylurea
N-Nitrosodimethylamine
N-Nitrosomorpholine
Parathion
Pentachloronitrobenzene
Pentachlorophenol
Phenol
p-Phenylenediamine
Phosgene
Phosphine
Phosphorus
Phthalic anhydride
Polychlorinated biphenyls (Aroclors)
1,3-Propane sultone
beta-Propiolactone
Propionaldehyde
Propoxur (Baygon)
Propylene dichloride (1,2 Dichloropropane)
Propylene oxide
1,2-Propylenimine (2-Methyl aziridine)
Quinoline
Quinone
Styrene
Styrene oxide
2,3,7,8-Tetrachlorodibenzo-p-dioxin
1,1,2,2-Tetrachloroethane
Tetrachloroethylene (Perchloroethylene)
Titanium tetrachloride
Toluene
2,4-Toluene diamine
2,4-Toluene diisocyanate
o-Toluidine
Toxaphene
1,2,4-Trichlorobenzene
1,1,2-Trichloroethane
Trichloroethene
2,4,5-Trichlorophenol
2,4,6-Trichlorophenol
Triethylamine
Trifluralin
2,2,4-Trimethylpentane
Vinyl acetate
Vinyl bromide
Vinyl chloride
Vinylidene chloride (1,1-Dichloroethylene)
Xylenes (isomers and mixture)
o-Xylenes
m-Xylenes
p-Xylenes

*The Clean Air Act Amendment of 1990, Title III, Section 112(b).

List of Hazardous Air Pollutants* (HAPs) (Cont.)

Compounds

Antimony compounds
Arsenic compounds
(inorganic including arsenic)
Beryllium compounds
Cadmium compounds
Chromium compounds
Cobalt compounds
Coke oven gases
Cyanide compounds
Glycol ethers
Lead compounds
Manganese compounds
Mercury compounds
Fine mineral fibers
Nickel compounds
Polycylic organic matter
Radionuclides (including radon)
Selenium Compounds

*The Clean Air Act Amendment of 1990, Title III, Section 112(b).

National Emission Standards For Hazardous Air Pollutants (NESHAPS)
For Source Categories Adopted by EPA – 40 CFR

Source Category	Compliance Date	Subpart	Regulatory Citation
Perchloroethylene Drycleaning Facilities	September 22, 1996	M	63.320
Coke Oven Batteries	October 27, 1996	L	300
HON (Hazardous Organic NESHAP for the Synthetic Organic Chemical Manufacturing Industry or SOCMI)	April 22, 1997	F, G, H & I	63.100
Industrial Process Cooling Towers	September 8, 1997	Q	63.400
Halogenated Solvent Cleaning	December 2, 1994	T	63.460
Ethylene Oxide Emissions Standards for Sterilization Facilities	December 6, 1998	O	63.360
Gasoline Distribution Facilities (Bulk Gasoline Terminals and Pipeline Breakout Stations)	December 14, 1997	R	63.420
Magnetic Tape Manufacturing Operations	December 15, 1997	EE	63.701
Chromium Emissions from Hard and Decorative Chromium Electroplating and Chromium Anodizing Tanks	January 25, 1996	N	63.340
Epoxy Resins and Non-Nylon Polyamides Production	March 8, 1998	W	63.520
New and Existing Secondary Lead Smelters	June 23, 1997	X	60.541
Petroleum Refineries	August 18, 1998	CC	63.640
Aerospace Manufacturing and Rework Facilities	September 1, 1998	GG	63.741

National Emission Standards For Hazardous Air Pollutants (NESHAPS)
For Source Categories Adopted by EPA – 40 CFR

Source Category	Compliance Date	Subpart	Regulatory Citation
Shipbuilding and Ship Repair	December 15, 1996	II	63.780
Printing and Publishing Industry	May 30, 1999	KK	63.820
Offsite Waste and Recovery Operations	July 1, 1996	DD	63.680
Group 1 Polymers and Resins	September 5, 1996	U	63.480
Marine Tank Vessel Loading	September 19, 1998, 1999	Y	63.560
Wood Furniture	December 7, 1997	JJ	63.800
Tanks-Level 1	July 1, 1996	OO	63.900
Containers	July 1, 1996	PP	63.920
Surface Impoundments	July 1, 1996	QQ	63.940
Individual Drain Systems	July 1, 1996	RR	63.960
Oil Water Separators	July 1, 1996	VV	63.1040
Group IV Polymers	September 12, 1997	JJJ	63.1310
Portland Cement Manufacturing	June 14, 2002	LLL	63.1340

National Emission Standards For Hazardous Air Pollutants (NESHAPS)
For Source Categories Adopted by EPA 40 CFR

Source Category	Compliance Date	Subpart	Regulatory Citation
Steel Pickling—HCl Process	June 22, 2001	CCC	63.1155
Primary Lead Smelting	June 4, 2001	TTT	63.1541
Pharmaceuticals Production	September 21, 2002	GGG	63.1250
Phosphoric Acid	June 10, 2002	AA	64FR31358
Phosphate Fertilizers	June 10, 2002	BB	64FR31358
Primary Aluminum	October 7, 1999	LL	63.840
Natural Gas Transmission/Storage	September 17, 2002	HHH	63.1270
Pulp and Paper	April 15, 2001	S	63.440
Pesticide Active Ingredient Production	December 23, 2003	MMM	63.1360
Oil and Natural Gas Production	June 17, 1999	HH	63.760
Flexible Polyurethane Foam	October 7, 2001	III	63.1290
Generic MACT+	June 29, 2002	YY	64FR34853
Polymers and Resins III	January 20, 2003	OOO	65FR3275

National Emission Standards For Hazardous Air Pollutants (NESHAPS)
For Source Categories Adopted by EPA 40 CFR

Source Category	Compliance Date	Subpart	Regulatory Citation
Wool Fiberglass Manufacturing	June 14, 2001	NNN	63.1380
Publicly Owned Treatment Works (POTW)	June 26, 2001	VVV	64FR57572
Secondary Aluminum	March 23, 2003	RRR	65FR15689
Ferroalloys Production	May 20, 2001	XXX	63.1650
Mineral Wool Production	June 1, 2002	DDD	63.1175
Polyether Polyols Production	June 10, 2002	PPP	63.1420
Boat Manufacturing	August 22, 2004	V V V V	66FR44217
Combustion Sources at Kraft, Soda, and Sulfite Pulp & Paper Mills	April 14, 2006	MM	68FR18007
Leather Finishing Operations	February 27, 2005	TTTT	67FR915510
Manufacturing Nutritional Yeast	May 21, 2004	CCCC	66FR27876
Solvent Extraction for Vegetable Oil Production	April 12, 2004	GGGG	66FR19006

Section 112 (r)-Risk Managment Plan (RMP) Toxic Chemicals

Section 112r of the CAAA of 1990 requires that all stationary sources that have a regulated substance present in a process in excess of a threshold quantity (See Table Below) develop a risk management plan (RMP) by June 21, 1999. Section 112r requires that the company provide an analysis of the worst case release scenario, provide a five-year accident history, and develop and implement an emergency response plan for each regulated substance present at the facility.

RMP Toxic Chemicals and Threshold Quantities (TQ)

Chemical Name	CAS No.	EPA RMP TQ
Acrolein [2-Propenal]	107-02-8	
Acrylonitrile [2-Propenenitrile]	107-13-1	20,000
Acrylyl chloride [2-Propenoyl chloride]	814-68-6	5,000
Allyl alcohol [2-Propen-1-ol]	107-18-61	15,000
Allylamine [2-Propen-1-amine]	107-11-9	10,000
Ammonia [anhydrous]	7664-41-7	10,000
Ammonia [conc. 20% or greater]	7664-41-7	20,000
Arsenous trichloride	7784-34-1	15,000
Arsine	7784-42-1	1,000
Boron trichloride [Borane, trichloro-]	10294-34-5	5,000
Boron trifluoride [Borane, trifluoro-]	7637-07-2	5,000

Section 112 (r)-Risk Managment Plan (RMP) Toxic Chemicals (Cont.)

RMP Toxic Chemicals and Threshold Quantities (TQ)

Chemical Name	CAS No.	EPA RMP TQ
Boron trifluoride compound with methyl ether (1:1) [Boron, trifluoro[oxybis[metane]]-, T-4-Bromine	353-42-4	15,000
Bromine	7726-95-6	10,000
Carbon disulfide	75-15-0	20,000
Chlorine	7782-50-5	2,500
Chlorine dioxide [Chlorine oxide (ClO2)]	10049-04-4	1,000
Chloroform [Methane, trichloro-]	67-66-3	20,000
Chloromethyl ether [Methane, oxybis[chloro-]]	542-88-1	1,000
Chloromethyl methyl ether [Methane, chloromethoxy-]	107-30-2	5,000
Crotonaldehyde [2-Butenal]	4170-30-3	20,000
Crotonaldehyde, (E)-[2-Butenal, (E)-]	123-73-9	20,000

Section 112 (r)-Risk Managment Plan (RMP) Toxic Chemicals (Cont.)

RMP Toxic Chemicals and Threshold Quantities (TQ)

Chemical Name	CAS No	EPA RMP TQ
Cyanogen chloride	506-77-4	10,000
Cyclohexylamine [Cyclohexanamine]	108-91-8	15,000
Diborane	19287-45-7	2,500
Dimethyldichlorosilane [Silane, dichlorodimethyl-]	75-78-5	5,000
1,1-Dimethylhydrazine [Hydrazine, 1,1-dimethyl-]	57-14-7	15,000
Epichlorohydrin [Oxirane, (chloromethyl)-]	106-89-8	20,000
Ethylenediamine [1,2-Ethanediamine]	107-15-3	20,000
Ethyleneimine [Aziridine]	151-56-4	10,000
Ethylene oxide [Oxirane]	75-21-8	10,000
Fluorine	7782-41-4	1,000
Formaldehyde (solution)	50-00-0	15,000

Section 112 (r)-Risk Managment Plan (RMP) Toxic Chemicals (Cont.)

RMP Toxic Chemicals and Threshold Quantities (TQ)

Chemical Name	CAS No.	EPA RMP TQ
Furan	110-00-9	5,000
Hydrazine	302-01-2	15,000
Hydrochloric acid (conc. 37% or greater)	7647-01-0	15,000
Hydrocyanic acid	74-90-8	2,500
Hydrogen chloride (anhydrous) [Hydrochloric acid]	7647-01-0	5,000
Hydrogen fluoride/Hydrofluoric acid (conc. 50% or greater) [Hydrofluoric acid]	7664-39-3	1,000
Hydrogen selenide	7783-07-5	500
Hydrogen sulfide	7783-06-4	10,000
Iron, pentacarbonyl- [Iron carbonyl (Fe(CO)5), (TB-5-11)-]	13463-40-6	2,500
Isobutyronitrile [Propanenitrile, 2-methyl-]	78-82-0	20,000
Isopropyl chloroformate [Carbonochloridic acid,1-methylethyl ester]	108-23-6	15,000

Section 112 (r)-Risk Managment Plan (RMP) Toxic Chemicals (Cont.)

RMP Toxic Chemicals and Threshold Quantities (TQ)

Chemical Name	CAS No.	EPA RMP TQ
Methacrylonitrile [2-Propenenitrile, 2-methyl-]	126-98-7	10,000
Methyl chloride [Methane, chloro-]	74-87-3	10,000
Methyl chloroformate [Carbonochloridic acid, methylester]	79-22-1	5,000
Methyl hydrazine [Hydrazine, methyl-]	60-34-4	15,000
Methyl isocyanate [Methane, isocyanato-]	624-83-9	10,000
Methyl mercaptan [Methanethiol]	74-93-1	10,000
Methyl thiocyanate [Thiocyanic acid, methyl ester]	556-64-9	20,000
Methyltrichlorosilane [Silane, trichloromethyl-]	75-79-6	5,000
Nickel carbonyl	13463-39-3	1,000
Nitric acid (conc. 80% or greater)	7697-37-2	15,000
Nitric oxide [Nitrogen oxide (NO)]	10102-43-9	10,000
Oleum (Fuming Sulfuric acid) [Sulfuric acid, mixture with sulfur trioxide]	8014-95-7	10,000

Section 112 (r)-Risk Managment Plan (RMP) Toxic Chemicals (Cont.)

RMP Toxic Chemicals and Threshold Quantities (TQ)

Chemical Name	CAS No.	EPA RMP TQ
Peracetic acid [Ethaneperoxoic acid]	79-21-0	10,000
Perchloromethylmercaptan [Methanesulfenyl chloride, trichloro-]	594-42-3	10,000
Phosgene [Carbonic dichloride]	75-44-5	500
Phosphine	7803-51-2	5,000
Phosphorus oxychloride [Phosphoryl chloride]	10025-87-3	5,000
Phosphorus trichloride [Phosphorous trichloride]	7719-12-2	15,000
Piperidine	110-89-4	15,000
Propionitrile [Propanenitrile]	107-12-0	10,000
Propyleneimine [Aziridine, 2-methyl-]	75-55-8	10,000
Propyl chloroformate [Carbonochloridic acid, propylester]	109-61-5	15,000

Section 112 (r)-Risk Managment Plan (RMP) Toxic Chemicals (Cont.)

RMP Toxic Chemicals and Threshold Quantities (TQ)

Chemical Name	CAS No.	EPA RMP TQ
Propylene oxide [Oxirane, methyl-]	75-56-9	10,000
Sulfur dioxide (anhydrous)	7446-09-5	5,000
Sulfur tetrafluoride [Sulfur fluoride (SF4), (T-4)-]	7783-60-0	2,500
Sulfur trioxide	7446-11-9	10,000
Tetramethyllead [Plumbane, tetramethyl-]	75-74-1	10,000
Tetranitromethane [Methane, tetranitro-]	509-14-8	10,000
Titanium tetrachloride [Titanium chloride (TiCl4) (T-4)-]	7550-45-0	2,500
Toluene 2,4-diisocyanate [Benzene, 2,4-diisocyanato-1-methyl]	584-84-9	10,000
Toluene 2,6-diisocyanate [Benzene, 1,3-diisocyanato-2-methyl-]	91-08-7	10,000
Toluene diisocyanate (unspecified isomer) [Benzene, 1,3-diisocyanatomethyl-]	26471-62-5	10,000
Trimethylchlorosilane [Silane, chlorotrimethyl-]	75-77-4	10,000
Vinyl acetate monomer [Acetic acid ethenyl ester]	108-05-4	15,000

Section 112 (r)-Risk Managment Plan (RMP) Flammable Substances

RMP FLAMMABLE SUBSTANCES AND THRESHOLD QUANTITIES

Chemical Name	CAS No.	EPA RMP TQ
Acetaldehyde	75-07-0	10,000
Acetylene [Ethyne]	74-86-2	10,000
Bromotrifluorethylene [Ethene, bromotrifluoro-]	598-73-2	10,000
1,3 Butadiene	106-99-0	10,000
Butane	106-97-8	10,000
1-Butene	106-98-9	10,000
2-Butene	107-01-7	10,000
Butene	25167-67-3	10,000
2-Butene-cis	590-18-1	10,000
2-Butene-trans [2-Butene, (E)]	624-64-6	10,000
Carbon oxysulfide [Carbon oxide sulfide (COS)]	463-58-1	10,000
Chlorine monoxide [Chlorine oxide]	7791-21-1	10,000
2-Chloropropylene [1-Propene, 2-chloro-]	557-98-2	10,000

Section 112 (r)-Risk Managment Plan (RMP) Flammable Substances (Cont.)

RMP FLAMMABLE SUBSTANCES AND THRESHOLD QUANTITIES

Chemical Name	CAS No.	EPA RMP TQ
1-Chloropropylene [1-Propene, 1-chloro-]	590-21-6	10,000
Cyanogen [Ethanedinitrile]	460-19-5	10,000
Cyclopropane	75-19-4	10,000
Dichlorosilane [Silane, dichloro-]	4109-96-0	10,000
Difluoroethane [Ethane, 1,1-difluoro-]	75-37-6	10,000
Dimethylamine [Methanamine, N-methyl-]	124-40-3	10,000
2,2-Dimethylpropane [Propane, 2,2-dimethyl-]	463-82-1	10,000
Ethane	74-84-0	10,000
Ethyl acetylene [1-Butyne]	107-00-6	10,000
Ethylamine [Ethanamine]	75-04-7	10,000
Ethyl chloride [Ethane, chloro]	75-00-3	10,000
Ethylene [Ethene]	74-85-1	10,000
Ethyl ether [Ethane, 1,1-oxybis-]	60-29-7	10,000

Section 112 (r)-Risk Managment Plan (RMP) Flammable Substances (Cont.)

RMP FLAMMABLE SUBSTANCES AND THRESHOLD QUANTITIES

Chemical Name	CAS No.	EPA RMP TQ
Ethyl mercaptan [Ethanethiol]	75-08-1	10,000
Ethyl nitrite [Nitrous acid, ethyl ester]	109-95-5	10,000
Hydrogen	1333-74-0	10,000
Isobutane [Propane, 2-methyl]	75-28-5	10,000
Isopentane [Butane, 2-methyl-]	78-78-4	10,000
Isoprene [1,3-Butadiene, 2-methyl-]	78-79-5	10,000
Isopropylamine [2-Propanamine]	75-31-0	10,000
Isopropyl chloride [Propane, 2-chloro-]	75-29-6	10,000
Methane	74-82-8	10,000
Methylamine [Methanamine]	74-89-5	10,000
3-Methyl-1-butene	563-45-1	10,000
2-Methyl-1-butene	563-46-2	10,000
Methyl ether [Methane, oxybis-]	115-10-6	10,000

Section 112 (r)-Risk Managment Plan (RMP) Flammable Substances (Cont.)

RMP FLAMMABLE SUBSTANCES AND THRESHOLD QUANTITIES

Chemical Name	CAS No.	EPA RMP TQ
Methyl formate [Formic acid, methyl ester]	107-31-3	10,000
2-Methylpropene [1-Propene, 2-methyl-]	115-11-7	10,000
1,3-Pentadiene	504-60-9	10,000
Pentane	109-66-0	10,000
1-Pentene	109-67-1	10,000
2-Pentene, (E)-	646-04-8	10,000
2-Pentene, (Z)-	627-20-3	10,000
Propadiene [1,2-Propadiene]	463-49-0	10,000
Propane	74-98-6	10,000
Propylene [1-Propene]	115-07-1	10,000
Propyne [1-Propyne]	74-99-7	10,000
Silane	7803-62-5	10,000
Tetrafluoroethylene [Ethene, tetrafluoro-]	116-14-3	10,000

Section 112 (r)-Risk Managment Plan (RMP) Flammable Substances (Cont.)

RMP FLAMMABLE SUBSTANCES AND THRESHOLD QUANTITIES

Chemical Name	CAS No.	EPA RMP TQ
Tetramethylsilane [Silane, tetramethyl-]	75-76-3	10,000
Trichlorosilane [Silane, trichloro-]	10025-78-2	10,000
Trifluorochloroethylene [Ethene chlorotrifluoro-]	79-38-9	10,000
Trimethylamine [Methanamine, N,N-dimethyl-]	75-50-3	10,000
Vinyl acetylene [1-Buten-3-yne]	689-97-4	10,000
Vinyl chloride [Ethene, chloro-]	75-01-4	10,000
Vinyl ethyl ether [Ethene, ethoxy-]	109-92-2	10,000
Vinyl fluoride [Ethene, fluoro-]	75-02-5	10,000
Vinylidene chloride [Ethene, 1,1-dichloro-]	75-35-4	10,000
Vinylidene fluoride [Ethene, 1,1-difluoro-]	75-38-7	10,000
Vinyl methyl ether [Ethene, methody-]	107-25-5	10,000

Common Organic Contaminants in Disposal Site Groundwater

The 50 most commonly detected organic contaminants in disposal site groundwater*

Ranking	Constituent	Chemical Class
1	Methylene chloride	V
2	Trichloroethene	V
3	Tetrachloroethylene	V
4	trans-1,2-Dichloroethene	V
5	Chloroform	V
6	1,1-Dichloroethane	V
7	1,1-Dichloroethene	V
8	1,1,1-Trichloroethane	V
9	Toluene	V
10	1,2-Dichloroethane	V
11	Benzene	V
12	Ethyl benzene	V
13	Phenol	A
14	Chlorobenzene	V
15	Vinyl chloride	V
16	Carbon tetrachloride	V
17	bis-(2-ethylhexyl) phthalate	B
18	Naphthalene	B
19	1,1,2-Trichloroethane	V
20	Chloroethane	V
21	Acetone	MV
22	1,2-Dichlorobenzene	B
23	Isophorone	B
24	Fluorotrichloromethane	V
25	1,4-Dichlorobenzene	B

A = acid extractable B = base/neutral V = volatile
MV = designates a volatile compound capable of being detected as part of the designated subgroup but not included on the original priority pollutant listing and not always reported.

* Reference: R. H. Plumb, "The Occurrence of Appendix IX Organic Contaminants in Disposal Site Groundwater," Groundwater Monitoring Review, Spring 1991.

Common Organic Contaminants in Disposal Site Groundwater (Cont.)

The 50 most commonly detected organic contaminants in disposal site groundwater*

Ranking	Constituent	Chemical Class
26	2-Butanone	MV
27	1,2,4-Trichlorobenzene	B
28	2,4-Dimethylphenol	A
29	1,2-Dichloropropane	V
30	Dichlorodifluoromethane	V
31	PCB-1242	P
32	PCB-1254	P
33	Lindane	P
34	di-N-Butyl phthalate	B
35	2,4-D	RP
36	1,1,2,2-Tetrachloroethane	V
37	Hexachlorobenzene	B
38	Hexachlorobutadiene	B
39	Diethyl phthalate	B
40	Fluorene	B
41	Phenanthrene	B
42	o-Xylene	MV
43	1,3-Dichlorobenzene	B
44	Bromodichloromethane	V
45	Pentachlorophenol	A
46	Butyl benzyl phthalate	B
47	Fluoranthene	B
48	g-BHC	P
49	Acenaphthene	B
50	2,4-Dichlorophenol	A

A = acid extractable B = base/neutral P = pesticide
RP = RCRA pesticide V – volatile
MV = designates a volatile compound capable of being detected as part of the designated subgroup but not included on the original priority pollutant listing and not always reported.

Typical Hydraulic Conductivities of Various Unconsolidated Sediments & Rock Types

Sediment or Rock Type	Hydraulic Conductivity[A] (Centimeters/second)	Flow Distance[B] Per Year (Centimeters)	Flow Distance[B] Per Year (Feet)
Sandstone	1×10^{-10} to 1×10^{-6}	0.00003 to 0.3	9.8×10^{-7} to 9.8×10^{-3}
Clay	1×10^{-9} to 1×10^{-7}	0.0003 to 0.03	9.8×10^{-6} to 9.8×10^{-4}
Limestone	1×10^{-9} to 1×10^{-6}	0.0003 to 0.3	9.8×10^{-6} to 9.8×10^{-3}
Silt	1×10^{-7} to 1×10^{-5}	0.03 to 3.2	9.8×10^{-4} to 0.1
Silty Sand	1×10^{-5} to 1×10^{-3}	3.2 to 315.4	0.1 to 10.3
Sand	1×10^{-3} to 1×10^{-1}	315.4 to 31,536.0	10.3 to 1,034.6
Gravel	1×10^{-2} to 1×10^{-1}	3,153.6 to 31,536.0	103.5 to 1,034.6

* Reference: Groundwater, by R. Allen Freeze and John A. Cherry, 1979.

A Hydraulic conductivity is a measure of the ability of soil or rock to conduct the flow of water. Hydraulic conductivity is usually stated in centimeters per second (cm/s), which is, in essence, velocity. For example, low hydraulic conductivity values would be 1×10^{-9} to 1×10^{-7} cm/s (clay), while high hydraulic conductivity would be 1×10^{-2} to 1×10^{-1} cm/s, or greater (gravel).

B Flow distance is based on an isotropic, homogenous aquifer of infinite extent and subjected to a uniform gradient of 0.010 centimeters/1.0 centimeters.

Common Analytical Methods & Target Compounds

RCRA[A] Metals

EPA Method: See Below

Instrumentation: See Below

Analyte	EPA Method
Instrumentation: CVAA[B]	
Mercury	7470A
Instrumentation: GFAA[C]	
Arsenic	7060A
Cadmium	7131A
Lead	7421
Selenium	7740
Instrumentation: ICP[D]	
Barium	6010B
Chromium	6010B
Silver	6010B

[A]RCRA = Resource Conservation and Recovery Act
[B]CVAA = Cold vapor atomic absorption spectroscopy
[C]GFAA = Graphite furnace atomic absorption spectroscopy
[D]ICP = Inductively coupled plasma atomic absorption spectroscopy

Toxicity Characteristic[a] Constituents & Threshold Levels

Title 40 Code of Federal Regulations

EPA HW[b] Number	Constituent	HW[b] Threshold Level (mg/L)
D001	Ignitable	
D002	Corrosive Wastes	
D003	Reactive Wastes	
D004	Arsenic	5.0
D005	Barium	100.0
D018	Benzene	0.5
D006	Cadmium	1.0
D019	Carbon tetrachloride	0.5
D020	Chlordane	0.03
D021	Chlorobenzene	100.0
D022	Chloroform	6.0
D007	Chromium	5.0
D023	o-Cresol	200.0[c]
D024	m-Cresol	200.0[c]
D025	p-Cresol	200.0[c]
D026	Cresol	200.0[c]
D016	2,4-D	10.0
D027	1,4-Dichlorobenzene	7.5
D028	1,2-Dichloroethane	0.5
D029	1,1-Dichloroethene	0.7

[a] Toxicity Characteristic Leaching Procedure (TCLP) is a method used to quantify the amount of a hazardous substance that will leach from a solid when that solid is subjected to water.

[b] Hazardous waste as defined in the Resource Conservation and Recovery Act.

[c] If o-, m-, and p-cresol concentrations cannot be differentiated, the total cresol (D026) concentration is used. The regulatory level for total cresol is 200 mg/L.

Toxicity Characteristic[a] Constituents & Threshold Levels (Cont.)

Title 40 Code of Federal Regulations

EPA HW[b] Number	Constituent	HW[b] Threshold Level (mg/L)
D030	2,4-Dinitrotoluene	0.13[d]
D012	Endrin	0.02
D031	Heptachlor (and its epoxide)	0.008
D032	Hexachlorobenzene	0.13[d]
D033	Hexachloro-1, 3-butadiene	0.5
D034	Hexachloroethane	3.0
D008	Lead	5.0
D013	Lindane	0.4
D009	Mercury	0.2
D014	Methoxychlor	10.0
D035	Methyl ethyl ketone	200.0
D036	Nitrobenzene	2.0
D037	Pentachlorophenol	100.0
D038	Pyridine	5.0[d]
D010	Selenium	1.0
D011	Silver	5.0
D039	Tetrachloroethene	0.7
D015	Toxaphene	0.5
D040	Trichloroethene	0.5
D041	2,4,5-Trichlorophenol	400.0
D042	2,4,6-Trichlorophenol	2.0
D017	2,4,5-TP (Silvex)	1.0
D043	Vinyl chloride	0.2

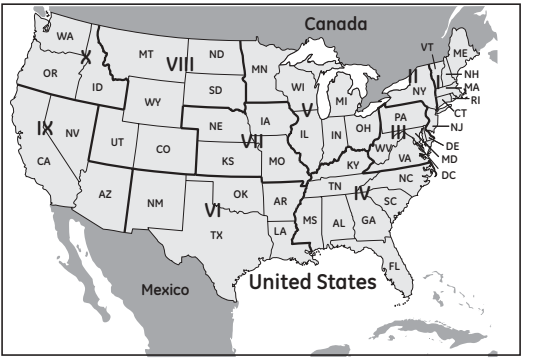
[a] Toxicity Characteristic Leaching Procedure (TCLP) is a method used to quantify the amount of a hazardous substance that will leach from a solid when that solid is subjected to water.

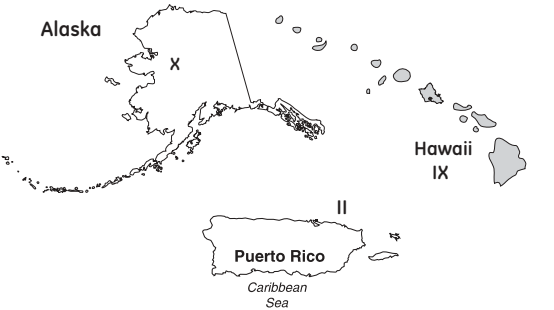
[b] Hazardous waste as defined in the Resource Conservation and Recovery Act.

[c] If o-, m-, and p-cresol concentrations cannot be differentiated, the total cresol (D026) concentration is used. The regulatory level for total cresol is 200 mg/L.

[d] Quantitation limit is greater than the calculated regulatory level. The quantitation limit therefore becomes the regulatory level.

USEPA—Regions Map





USEPA—Telephone Directory

Region I—Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont

Regional Administrator	(617) 918-1010
Director, ECO System	(617) 918-1510
Director, Office of Public Affairs	(617) 918-1051
General Information	(617) 918-1111

Region II—New Jersey, New York, Puerto Rico, Virgin Islands

Regional Administrator	(212) 637-5000
Director, Enforcement & Compliance	(212) 637-4000
Director, Communications	(212) 637-3660

Region III—Delaware, District of Columbia, Maryland, Pennsylvania, West Virginia, Virginia

Regional Administrator	(215) 814-2900
Director, Hazardous Waste Management Division	(215) 814-3110
Director, Air, Radiation, & Toxics Division	(215) 814-2100

Region IV—Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee

Regional Administrator	(404) 562-8357
Director, Air, Pesticides, & Toxic Management Division	(404) 562-9077
Director, Waste Management Division	(404) 562-8651
Director, Office of External Affairs	(404) 562-8327
Freedom of Information Act	(404) 562-9900

USEPA—Telephone Directory (Cont.)

Region V—Illinois, Indiana, Michigan, Minnesota, Ohio, Wisconsin

Regional Administrator	(312) 886-3000
Director, Air Division	(312) 353-2212
Director, Waste Management Division	(312) 886-7435

Region VI—Arkansas, Louisiana, New Mexico, Oklahoma, Texas

Regional Administrator	(214) 665-2100
Director, Multimedia Division	(214) 665-7201
Director, Enforcement Division	(214) 665-2210
Director, Superfund	(214) 665-6701
Director, Pesticides	(214) 665-3103
Director Toxic Materials	(214) 665-6780
Director, Office of External Affairs	(214) 665-2200
Freedom of Information Act	(214) 665-6597

Region VII—Iowa, Kansas, Missouri, Nebraska

Regional Administrator	(913) 551-7006
Director, Water, Wetland & Pesticide Division	(913) 551-7030
Director, Air, RCRA & Toxic Management Division	(913) 551-7020
Director, Office of Public Affairs	(913) 551-7003

Region VIII—Colorado, Montana, North Dakota, South Dakota, Utah, Wyoming

Regional Administrator	(303) 312-6308
Information	(303) 312-6312

USEPA—Telephone Directory (Cont.)

Region IX—Arizona, California, Hawaii, Nevada, Guam, American Samoa, Trust Territories of the Pacific

Regional Administrator	(415) 947-8702
Director, Air & Toxics Division	(415) 947-8715
Director, Hazardous Waste Management Division	(415) 947-8709
Director, Office of External Affairs	(415) 947-8704

Region X—Washington, Oregon, Idaho, Alaska

Regional Administrator	(206) 553-0479
Air Quality Office	(206) 553-2770
Director, Hazardous Waste Office	(206) 553-1266
Director, Office of External Affairs	(206) 553-4269

	EPA STATE AGENCIES			
STATE	AIR MANAGEMENT	HAZARDOUS WASTE MANAGEMENT	UNDERGROUND STORAGE TANKS	WATER MANAGEMENT
ALABAMA	(334) 271-7861	(334) 271-7730	(334) 270-5655	(334) 271-7823
ALASKA	(907) 465-5354	(907) 269-7586	(907) 465-5200	(907) 465-5354
ARIZONA	(602) 207-2308	(602) 207-4153	(602) 207-4255	(602) 207-2303
ARKANSAS	(501) 682-0730	(501) 682-0831	(501) 682-0993	(501) 682-0654
CALIFORNIA	(916) 322-2990	(916) 324-1826	(916) 445-3846	(916) 341-5611
COLORADO	(303) 692-3100	(303) 692-3300	(303) 620-4300	(303) 692-3500
CONNECTICUT	(860) 424-3028	(860) 424-3372	(860) 424-3374	(860) 424-3018
DELAWARE	(302) 739-4791	(302) 739-3689	(302) 395-2500	(302) 739-4860
DISTRICT OF COLUMBIA	(202) 564-7400	(703) 412-9810	(202) 645-6080	(215) 814-2300
FLORIDA	(850) 488-0114	(850) 488-0300	(850) 488-3935	(850) 921-9428
GEORGIA	(404) 363-7022	(404) 656-7802	(404) 362-2687	(404) 362-2680
HAWAII	(808) 839-7929	(808) 587-4226	(808) 586-4226	(808) 587-0214
IDAHO	(206) 373-0502	(206) 373-0502	(208) 373-0502	(208) 327-7900
ILLINOIS	(217) 785-4140	(217) 782-6761	(217) 782-6762	(217) 782-1654
INDIANA	(317) 233-0178	(317) 232-8941	(317) 232-8941	(317) 232-8670
IOWA	(515) 281-8034	(515) 281-8934	(515) 281-8934	(515) 281-8934
KANSAS	(785) 296-1579	(785) 296-1600	(785) 296-1684	(785) 296-3410
KENTUCKY	(502) 573-3382	(502) 564-6716	(502) 564-6716	(502) 564-3410
LOUISIANA	(225) 765-0219	(225) 765-0219	(225) 765-2554	(225) 765-0219
MAINE	(207) 287-2437	(207) 287-2651	(207) 287-7688	(207) 287-7804
MARYLAND	(410) 631-3215	(410) 631-3343	(410) 631-3442	(410) 631-3706
MASSACHUSETTS	(617) 292-5609	(617) 292-5898	(617) 292-5720	(617) 292-5706
MICHIGAN	(517) 373-7023	(517) 373-2730	(517) 373-8168	(517) 373-1170
MINNESOTA	(651) 296-6300	(651) 296-6300	(651) 296-6300	(651) 296-6300
MISSISSIPPI	(601) 961-5171	(601) 961-5654	(601) 961-5171	(601) 961-5171
MISSOURI	(573) 751-4817	(573) 751-3176	(573) 751-7428	(573) 751-1300

USEPA State Agencies—Telephone Directory (Cont.)

STATE	STATE AGENCIES			
	AIR MANAGEMENT	HAZARDOUS WASTE MANAGEMENT	UNDERGROUND STORAGE TANKS	WATER MANAGEMENT
MONTANA	(406) 444-0284	(406) 444-4096	(406) 444-1420	(406) 444-3080
NEBRASKA	(402) 471-2189	(402) 471-4217	(402) 471-9465	(402) 471-2541
NEVADA	(775) 687-4670	(702) 687-4670	(702) 687-5872	(775) 687-4670
NEW HAMPSHIRE	(603) 271-1370	(603) 271-3644	(603) 271-3644	(603) 271-3503
NEW JERSEY	(609) 984-3023	(609) 633-1418	(609) 633-0716	(609) 292-4543
NEW MEXICO	(505) 827-0031	(505) 827-1557	(505) 827-0188	(505) 827-0187
NEW YORK	(518) 402-8452	(518) 402-8651	(518) 402-8060	(518) 402-8233
NORTH CAROLINA	(919) 733-3340	(919) 733-4996	(919) 733-4996	(919) 733-7015
NORTH DAKOTA	(701) 328-5188	(701) 328-5166	(701) 328-5166	(701) 328-5210
OHIO	(614) 644-2270	(614) 644-2917	(614) 752-7938	(614) 644-2752
OKLAHOMA	(405) 702-4100	(405) 702-5100	(405) 702-5100	(405) 702-8100
OREGON	(503) 229-5359	(503) 229-5913	(503) 229-5774	(503) 229-5279
PENNSYLVANIA	(717) 787-9702	(717) 787-6239	(717) 772-5599	(717) 787-2666
PUERTO RICO	(787) 977-5870	(787) 977-5870	(787) 977-5870	(787) 977-5870
RHODE ISLAND	(401) 222-2808	(401) 222-2797	(401) 222-2797	(401) 222-3961
SOUTH CAROLINA	(803) 898-4123	(803) 896-4000	(803) 898-4350	(803) 898-4300
SOUTH DAKOTA	(605) 773-3151	(605) 773-3153	(605) 773-3296	(605) 773-3351
TENNESSEE	(615) 532-0554	(615) 532-0854	(615) 532-0945	(615) 837-5225
TEXAS	(512) 239-1250	(512) 239-2334	(512) 239-2160	(512) 239-4050
UTAH	(801) 887-0760	(801) 538-6170	(801) 536-4100	(801) 538-6146
VERMONT	(802) 241-3840	(802) 241-3888	(802) 241-3888	(802) 241-3822
VIRGINIA	(804) 698-4024	(804) 698-4199	(804) 698-4269	(804) 698-4037
WASHINGTON	(360) 407-6800	(360) 407-6700	(360) 407-7177	(360)-407-6405
WEST VIRGINIA	(304) 558-4002	(304) 558-5929	(304) 558-5929	(304) 558-5929
WISCONSIN	(608) 266-7718	(608) 266-2111	(608) 266-9767	(608) 266-7662
WYOMING	(307) 777-7391	(307) 777-7752	(307) 777-7096	(307) 777-7781

Hotlines—Telephone Directory

Chemtrec (Chemical Transportation Emergency Center)	(800) 424-9300
National Technical Information Service	(800) 553-6847
Office of Hazardous Materials and Transportation, U.S. Department of Transportation	(202) 366-4488
Resource Conservation and Recovery Act/ Superfund Hotline	(800) 424-9346
Toxic Substances Control Act Hotline	(202) 554-1404
U.S. Environmental Protection Agency Public Document Information Center	(800) 490-9198
U.S. Environmental Protection Agency Safe Drinking Water Hotline	(800) 426-4791
U.S. Environmental Protection Agency Small Business and Asbestos Ombudsman	(800) 368-5888
GE Energy Environmental Services	(800) 821-2222

Trade Associations—Telephone Directory

Air & Waste Management Association http://www.awma.org/	(412) 232-3444
American Chemical Society http://www.chemistry.org	(800) 227-5558
American Chemistry Council http://www.americanchemistry.com/	(703) 741-5000
American Industrial Hygiene Association http://www.aiha.org/	(703) 849-8888
American Society for Testing and Materials http://www.astm.org	(610) 832-9585
EPRI (Electric Power Research Institute) http://www.epri.com/	(650) 855-2000
Instrument Society of America http://www.isa.org/	(919) 549-8411
National Ground Water Association http://www.ngwa.org/	(800)-551-7379
Water Environment Federation http://www.wef.org/	(703) 684-2400
American Society of Mechanical Engineers http://www.asme.org	(800) 843-2763

State Agencies—Web Sites

State	Website Address
Alabama	www.adem.state.al.us/
Alaska	www.state.ak.us/dec/
Arizona	www.adeq.state.az.us/
Arkansas	www.adeq.state.ar.us/
California	www.calepa.ca.gov/
Colorado	www.cdphe.state.co.us/cdphehom.asp
Connecticut	www.dep.state.ct.us/aboutdep/aboutdep.htm
Delaware	www.dnrec.state.de.us/
Florida	www.dep.state.fl.us/
Georgia	www.ganet.org/dnr/environ/
Hawaii	www.hawaii.gov/dlnr/
Idaho	www.state.id.us/deq/
Illinois	www.epa.state.il.us/
Indiana	www.ai.org/idem/
Iowa	www.iowadnr.com
Kansas	www.kdhe.state.ks.us/
Kentucky	www.eqc.ky.gov/
Louisiana	www.deq.state.la.us/
Maine	www.state.me.us/dep/
Maryland	www.mde.state.md.us/
Massachusetts	www.mass.gov/dep/
Michigan	www.michigan.gov/deq
Minnesota	www.pca.state.mn.us/
Mississippi	www.deq.state.ms.us
Missouri	www.dnr.state.mo.us/alpd/esp/esp_aqm.htm
Montana	www.deq.state.mt.us/

State Agencies—Web Sites

State	Website Address
Nebraska	www.deq.state.ne.us/
Nevada	www.ndep.nv.gov/
New Hampshire	www.des.state.nh.us/
New Jersey	www.state.nj.us/dep/
New Mexico	www.nmenv.state.nm.us/
New York	www.dec.state.ny.us/
North Carolina	www.enr.state.nc.us/
North Dakota	www.health.state.nd.us/ndhd/environ/
Ohio	www.epa.state.oh.us/
Oklahoma	www.deq.state.ok.us/
Oregon	www.deq.state.or.us/
Pennsylvania	www.dep.state.pa.us/
Rhode Island	www.state.ri.us/dem/
South Carolina	www.scdhec.net/eqc/
South Dakota	www.state.sd.us/denr/denr.html
Tennessee	www.state.tn.us/environment/
Texas	www.tceq.state.tx.us
Utah	www.eq.state.ut.us/
Vermont	www.anr.state.vt.us
Virginia	www.deq.state.va.us/
Washington	www.ecy.wa.gov/ecyhome.html
West Virginia	www.dep.state.wv.us/
Wisconsin	www.dnr.state.wi.us/Environment.html
Wyoming	http://deq.state.wy.us/eqc/

Canadian Provincial Agencies—Web Sites

Alberta	http://www3.gov.ab.ca/env/index.html
British Columbia	http://www.gov.bc.ca/wlap/
Manitoba	http://www.gov.mb.ca/conservation/
New Brunswick	http://www.gnb.ca/0009/index-e.asp
Newfoundland	http://www.gov.nf.ca/env/
Nova Scotia	http://www.gov.ns.ca/enla/
Ontario	http://www.ene.gov.on.ca/
Saskatchewan	http://www.gov.sk.ca/main
Quebec	http://www.bape.gouv.qc.ca/

ACRONYMS

ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ATSDR	Agency for Toxic Substances and Disease Registry
BACT	Best Available Control Technology
BTEX	Benzene, Toluene, Ethylbenzene, and Xylene
CAA	Clean Air Act
CAAA	Clean Air Act Amendments (of 1990)
CAM	Compliance Assurance Monitoring
CDM	Continuous Dynamics Monitoring
CEM	Continuous Emissions Monitoring
CEMS	Continuous Emissions Monitoring System
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CERCLIS	CERCLA Information System
CFR	Code of Federal Regulations
CGA	Cylinder Gas Audit
CTG	Control Techniques Guidelines
CWA	Clean Water Act
DAHS	Data Acquisition and Handling System
DLN	Dry Low NOx
DOE	U.S. Department of Energy
EDR	Electronic Data Report
EPA	U.S. Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
FGD	Flue Gas Desulphurization
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FWQC	Federal Water Quality Criteria
HAP	Hazardous Air Pollutant
HEI	Heat Exchange Institute
HON	Hazardous Organic NESHAP
HRS	Hazard Ranking System
HSWA	Hazardous and Solid Waste Amendments
LAER	Lowest Achievable Emissions Rate
LUST	Leaking Underground Storage Tank
MACT	Maximum Achievable Control Technology

ACRONYMS (Cont.)

MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
MPAS	Monitoring Plan Accuracy Services
NADB	National Allowance Data Base
NBAR	Nonbinding Preliminary Allocation of Responsibility
NCP	National Contingency Plan
NESHAP	National Emissions Standards for Hazardous Air Pollutants
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NRC	National Response Center
NSPS	New Source Performance Standards
OAQPS	Office of Air Quality Planning and Standards
OPC	OLE Process Control
OSC	On-Scene Coordinator
OSH ACT	Occupational Safety and Health Act
OSHA	Occupational Safety and Health Administration
PEMS	Predictive Emissions Monitoring System
PLC	Programmable Logic Controller
PRP	Potentially Responsible Party
PSD	Prevention of Significant Deterioration
PTC	Performance Test Code
RACT	Reasonably Available Control Technology
RAP	Remedial Action Plan
RATA	Relative Accuracy Test Audit
RCRA	Resource Conservation and Recovery Act
RDLNT	Remote Dry Low NOx Tuning
REMS	Remote Exhaust Measurement System
RI/FS	Remedial Investigation/Feasibility Study
RM&D	Remote Monitoring & Diagnostics
ROD	Record of Decision
RPM	Remedial Project Manager
RQ	Reportable Quantity
SARA	Superfund Amendments and Reauthorization Act
SCAP	Superfund Comprehensive Accomplishments Plan
SCR	Selective Catalytic Reduction

ACRONYMS (Cont.)

SDWA	Safe Drinking Water Act
SNCR	Selective Non-Catalytic Reduction
SWDA	Solid Waste Disposal Act (RCRA predecessor)
SWMU	Solid Waste Management Unit
TPM	Thermal Performance Management
TSCA	Toxic Substances Control Act
UOSM	Universal On Site Monitor
UST	Underground Storage Tank
USEPA	United States Environmental Protection Agency
WQS	Water Quality Standards

GE Energy Capabilities—Air Emissions Source Testing

Extensive Experience Measuring

- NO_x, NO_2, NH_3, SO_2, SO_3, Sulfates, O_2, CO, CO_2, HCl, Total Hydrocarbons (THC), H_2S
- Particle Size & Distribution, Mass Emissions & Condensibles, PM10, PM2.5 & Aerosols
- Trace Metals (incl. Speciated Mercury)
- Volatile and Semi-Volatile Organics including Dioxins, Furans, Formaldahyde, Polycyclic Aromatic Hydrocarbons (PAH) and Polychlorinated Biphenyls (PCBs)
- INSITU Resisitivity
- SCR & Control Equipment Performance
- Total Reduced Sulfur (Total and Speciated)

State-of-the-Art Equipment

- Mobile Dilution CEM Systems
- On-Site Gas Chromatography
- More than 40 Mobile Laboratories
- Continuous Emissions Monitoring (CEM) Systems
- Fourier Transform Infrared Spectroscopy (FTIR)

Industry Experience

- Gas Turbines, Stationary Diesel, Spark Ignition Engines
- Industrial and Utility Boilers
- Refinery Process Heaters, FCCUs and CO Boilers
- Incinerators Burning Municipal, Hazardous, Medical or Mixed Wastes
- RCRA/TSCA Incinerator Testing and Trial Burns
- Recovery and Power Boilers, Thermal Oxidizers, Lime Kilns, Dissolving Tanks and Other Pulp and Paper-Related Sources
- Cement Kilns
- Aerospace Manufacturing Facilities
- Wastewater Treatment Plants
- Petrochemical Manufacturing Facilities
- Steel Plants, Foundries and Smelters
- Printing and Coating Plants
- High-Temperature, High-Pressure Environments
- Other Commercial, Industrial and Utility Plants

GE Energy Capabilities—Particulate Testing and Monitoring

Particulate Testing

- Particulate control baseline/guarantee data
- Opacity solutions
- Emissions inventories
- Rulemaking advocacy
- Site permitting/applications
- Health risk analyses
- Source apportionment studies

Particulate Monitoring and Detection

- Advanced light scintillation technology
- Full cross duct sampling, up to 50 ft.
- Relative (0-100% scale) or Quantative (mg/M^3 or gr/dscf) measurements
- Meets all EPA guidelines for broken bag detection and monitoring systems
- Detects only moving particles, build up does not affect reading
- Dual stage emissions alarms and maintenance alarm
- Single or multipoint capability

GE Energy Capabilities—Continuous Air Emissions Monitoring

GE Energy offers you a cost-efficient air emissions monitoring solution. We design and build our continuous emissions monitoring systems (CEMS) in-house, integrating a data acquisition and handling system (DAHS) that we developed to maximize system performance.

We develop reports specific to your monitoring requirements, install your monitor and take you through the certification process. We can work with you to develop required Quality Assurance/Quality Control (QA/QC) programs, train your operators and perform quarterly audits. We know your system inside and out, and offer options for continuing maintenance and emergency response with same-day parts availability. And as your process or regulatory needs change, we can upgrade your system's hardware, software or analyzers.

CEMS & DAHS Equipment and Services

- CEMS & DAHS system design specification development
- CEMS & DAHS design and fabrication
- Data Acquisition and Handling Systems
- Installation supervision
- Start-up
- Certification
- Performance and compliance testing services
- QA/QC programs and monitoring plans
- Factory and field training programs
- Quarterly audits & electronic data reporting (EDR) services
- Annual testing and reporting services
- Service & maintenance
- Emergency response
- Replacement parts
- Software and hardware upgrades
- Ongoing operations management

GE Energy Capabilities—Continuous Air Emissions Monitoring (Cont.)

CEMS & DAHS Equipment and Services – continued

- Integration into Corporate Information Management System
- Predictive emissions monitoring systems
- Parametric monitoring systems
- Ambient air monitoring
- Mobile laboratories
- Temporary CEMS

GE Energy Qualifications

- Over 30 years CEMS/DAHS experience
- CEMS & DAHS system design regulatory specialists, engineers and programmers in-house
- National and international field capability
- Factory-trained field technicians
- Single source responsibility
- Research and development of prevailing technologies

GE Energy Capabilities—NETDAHS Air Emissions Monitoring

GE Energy offers NetDAHS, a cutting edge, robust, compliant data acquisition and handling system (DAHS) product, to support the following regulatory requirements:

- 40 CFR Part 60 and associated subparts and appendices
- 40 CFR Part 75 and associated subparts and appendices
- NOx budget program
- NOx SIP call and section 126
- State level reporting

DAHS architecture/features

- Microsoft® Windows® operating system
- Industry-standard relational database
- Client/server architecture
- Web architecture
- Microsoft® standard graphic user interface (GUI) applications
- PLC-based communications – including GE 90/30 Series and Allen-Bradley® controllers

Plant communications

- Distributed control system (DCS) communications including Honeywell®, Bailey®, Westinghouse and GE
- OLE for process control (OPC) for interfacing with plant information (PI) system
- Allen-Bradley® data highway
- Modbus serial and Ethernet communications (master and slave)

GE Energy Capabilities—NETDAHS Air Emissions Monitoring (Cont.)

Services available

- DAHS support 24 hours per day, 7 days per week
- Electronic data report (EDR) generation
- Monitoring plan accuracy service (MPAS)
- Training workshops for operators, system administrators and regulatory specialists

GE Energy Capabilities—Air Quality Systems for Gas Turbines

GE Energy offers four nitric oxide (NOx) control technologies for new and existing gas turbines:

- Dry Low NOx combustion systems
- Dry Low Emissions (DLE) combustion system
- Diluent injection systems
- Catalytic combustion systems

Dry Low NOx combustion systems minimize the generation of NOx during the combustion process for our heavy-duty gas turbines using lean-premixed combustion technology. There are two basic design configurations: DLN-1 and DLN-2.

DLN-1 systems are two-stage premixed combustors designed for low emissions operation without use of diluent while burning natural gas fuel. Diluent injection (usually water) is used to reduce NOx levels when operating on liquid fuels.

GE's DLN-2 combustion systems were specifically designed for machines which operate at higher firing temperatures than the units that utilize DLN-1 systems. These single-stage dual mode combustors can operate on both gaseous and liquid fuels. On gas, the combustors operate in the diffusion mode at low loads (less than 50 percent) and in premixed mode at high loads. Diffusion mode is used for burning liquid fuels.

Dry Low Emissions (DLE) combustion systems can reduce nitrogen oxide (NOx) emissions from our line of aeroderivative combustion turbines. These lean pre-mixed annular combustion systems can reduce NOx levels in some circumstances to less than 25 ppmvd (at 15 percent O_2) on gas fuels without using exhaust cleanup technology such as Selective Catalytic Reduction. When operating on liquid fuels, the systems use water or steam injection to reduce NOx emissions in some circumstances to 42 ppmvd.

GE Energy Capabilities—Air Quality Systems for Gas Turbines (Cont.)

Diluent injection systems reduce the generation of NOx within a heavy-duty or aeroderivative gas turbine combustion system by injecting diluent (either water or steam) directly into the combustor to reduce flame temperature. The level of NOx reduction achieved is proportional to the amount of diluent injected. The increased mass flow provided by the diluent will provide an increase in power.

NOx levels (ppmvd) that can be achieved for operation on gas and liquid fuels in some situations are: 25 or 42 ppmvd (on gas) and 42 or 65 (oil). Several aeroderivative engines can in some situations achieve NOx levels as low as 15 ppm on gas fuel using steam injection.

GE Energy Capabilities—Performance Evaluation Services

Comprehensive analysis of power plant (GT, ST, CC) efficiencies to reduce fuel costs, improve output, and lower emissions.

Acceptance and Compliance Testing For:

- Simple cycle gas turbines
- Combined cycle plants
- Industrial / cogen steam turbines
- Fossil-fired steam turbines
- Nuclear steam turbines

- **Performance Acceptance Testing per ASME, ISO, IEC**
  - Output, Heat Rate, HP/IP Efficiency, Exhaust Energy, Temperature, Flow
  - Acoustics
- **Gas Turbine Combustion System Integrated Tuning**
- **Baseline & Periodic Tests**
- **Pre- & Post-outage Tests**
- **Post-outage Acceptance Tests**
- **Capacity Tests**

Evaluations and Audits

- **Gas Turbine Performance Evaluation**: Providing recommendations and solutions to recover performance
- **Steam Turbine Performance Evaluation**: Detailed diagnostics of the steam turbine/feedwater cycle and/or condenser and vacuum system
- **Combined Cycle Performance Evaluation**: Determine causes of CC Plant Performance shortfalls and provide recommendations to recover performance
- **Condenser and Vacuum System Performance Evaluation**: Analyze condenser and vacuum system performance to quantify causes of high condenser pressure

GE Energy Capabilities—Performance Evaluation Services (Cont.)

- **Plant Performance Evaluation**: Total Plant Solutions combines the boiler, steam turbine, and condenser diagnostic expertise within GE Energy to identify and quantify all boiler, steam turbine, feedwater heater and condenser contributors to lost plant performance AND to provide specific recommendations to recover lost performance and optimize operations. This service applies to all steam turbine plants with fired boilers
- **Steam Path Audit**: Combines thermal and structural evaluations of internal steam turbine parts
- **Condenser and Vacuum System Performance Audit**: Determines the impact of condenser and vacuum system parts condition on unit performance

OpFlex™

- **Airflow**: Offers incremental output of up to 4%, with higher base output and the same or lower combustion dynamics
- **Peak**: Offers incremental output of up to 2.5%, with peak output and the same or lower combustion dynamics
- **Turndown**: Offers 5-15% extended turndown capability with the same or lower combustion dynamics

GE Energy Capabilities—Remote Monitoring & Diagnostics

GE Energy utilizes our Remote Services Technology and Specialist Engineers to provide our customers with valuable products and services focused on improving their equipment availability, reliability and performance. Collaborative working also helps to enhance customer knowledge.

- **Remote Services Platform (Universal On Site Monitor – uOSM):** Remote services technology which facilitates secure communications/data transfers between customer sites and GE's remote services centers
- **Global Operations Center – Remote Monitoring & Diagnostics:** 24/7 gas & steam turbine monitoring and decision support
- **OnSite Support℠ – Remote Controls & Electrical System Diagnostics:** 24/7 instant access to GE controls specialists (applicable to PowerGen, Industrial & BOP equipment)
- **Thermal Performance Management – Remote Performance Diagnostics:** Continuous and/or elective performance diagnostics and testing
- **Continuous Dynamics Monitoring (CDM):** Continuous gas turbine combustion dynamics monitoring system
- **Remote Dry Low NOx Tuning (RDLNT):** Remote controls adjustments to optimize gas turbine combustion dynamics & emissions levels
- **Remote Exhaust Measurement System (REMS):** Continuously measuring emissions data taken directly from gas turbine exhaust duct to improve speed and accuracy of RDLNT
- **NetDAHS – Data Acquisition & Handling System:** Web-based viewing platform for site's Continuous Emissions Monitoring System

GE Energy Capabilities—Remote Monitoring & Diagnostics (Cont.)

- **24/7 DAHS Software Support Services:** Remotely supporting the O&M of emissions monitoring equipment
- **Precipitator Remote Diagnostics:** 24/7 access to GE electrostatic precipitator specialists

GE Energy Capabilities—Combustion Modification and Optimization

NOx Control Technologies for Boilers

- **Low NOx Burners:** GE Energy's low NOx burner for wall- and cell-fired coal-fired boilers and furnaces is custom-engineered to match your furnace conditions, fuel and NOx control requirements. It offers proven performance, typically reducing NOx emissions by 50 percent or more while maintaining unsurpassed mechanical reliability. Retrofitting your boilers or modifying your burners with GE Energy's low NOx burner can reduce NOx emissions for as low as $1 to $6 USD per kilowatt. The simple, rugged design features axially moving components-no gears or complicated linkage-and is manufactured with a high-strength, heat-resistant alloy to ensure a long service life.
- **Overfire Air (OFA):** Overfire air is a combustion modification technology that stages the combustion process to reduce nitrogen oxide emissions. The typical NOx reduction for application of overfire air to utility boilers is between 20 and 40 percent, depending on the application, design and unit operation. Overfire air systems can be installed independently, but are typically used in conjunction with low NOx burners or reburn systems.

  Combustion air is diverted from the main burner zone and injected through ports located above the main burners. GE's unique dual concentric zone port design provides variable swirl and flow control to adjust the flow characteristics to optimize the mixing conditions for all operating conditions. GE has extensive experience installing overfire air systems on a range of boiler designs including tangential, cell, wall or cyclone firing configurations with varying main and reburn fuels, including coal, oil and gas.

GE Energy Capabilities—Combustion Modification and Optimization (Cont.)

- **Reburn Systems:** Reburn is a commercially proven combustion modification process that can achieve "deep" NOx control at low cost per ton of NOx removed.

  Reburn utilizes sequential fuel and air staging to reduce NOx emissions by as much as 60 percent. Reburn systems can be installed on many different boiler configurations, including wall fired, tangential, cell and cyclone. The NOx reduction that can be achieved depends on the conditions in the main combustion and reburn zones. Temperatures, residence times and furnace flow patterns are important in determining the effectiveness of the process. GE has experience with a wide range of reburn fuels including gas, oil, orimulsion, coal and biomass. GE's reburn systems can be a cost-effective alternative to SCR for NOx SIP Call compliance.

Coal Balancing Products

- **Balancing Damper:** This product is a simple yet rugged adjustable orifice that provides the ability to balance coal flow to each burner online. Dampers can be equipped with actuators and combined with coal flow monitors and controls to automatically balance flow for different loads and operating conditions.
- **RotorProbe™ System:** This system samples the coal-air mixtures at 64 points representing equal cross-sectional areas of the coal pipe.

GE Energy Capabilities—Combustion Modification and Optimization (Cont.)

Emissions Control Services

- **SCR and SNCR Assessments:** Our combustion expertise can help maximize the effectiveness of your selective catalytic reduction (SCR) and selective noncatalytic reduction (SNCR) systems. In SCR, careful design and operation, such as reagent dosage control and good mixing, are necessary to keep NH_3 emissions to a concentration of a few ppm. In SNCR, a reducing agent (typically NH_3 or urea) is injected into the furnace above the combustion zone, where it reacts with NOx. Critical factors in applying SNCR are sufficient residence time in the appropriate temperature range and uniform distribution and mixing of the reducing agent across the full furnace cross section. Let us help improve the performance of your system through comprehensive analysis and monitoring.
- **Mercury Removal and Testing:** Managing mercury emissions requires fine control of combustion conditions and coal properties. At GE, we are developing a method of controlling mercury through optimization of combustion conditions and coal composition to increase mercury removal with existing particulate control devices. Pilot and field testing has demonstrated that optimization of combustion conditions to form reactive fly ash improved the efficiency of NOx reduction and could result in significantly increased mercury removal for combustion systems equipped with a baghouse or ESP.

GE Energy Capabilities—Combustion Modification and Optimization (Cont.)

We have also developed advanced techniques to address the challenges faced in mercury testing, including test method interferences and biases, low concentrations and detectable limits, test locations, sample recovery and preparation, sample contamination and clean, leak-free equipment. We also have substantial experience with many of the emerging continuous emission mercury monitors. We have performed numerous mercury tests at many locations around the world, and we have a team of trained personnel and state-of-the-art equipment ready to support your mercury testing needs.

GE Energy Capabilities—Post Combustion Air Pollution Control

Fabric Filter Collector Upgrades

- Filter bags and cages
- Fine filtration products
  (pleated filter elements, ePTFE membrane filters)
- Engineered services
- Baghouse accessories
- Troubleshooting seminars

Electrostatic Precipitator Upgrades

- Precipitator electronics
- Precipitator mechanical parts
- Engineered services
- Troubleshooting / controls seminars

Max-9™ – Electrostatic Fabric Filter

New technology that combines discharge electrodes and fabric filters in the same casing providing maximum efficiency (99.99+%) at a lower pressure drop than traditional baghouses.

Acoustic Cleaning Systems

- Baghouse
- Precipitators
- Boiler tubes
- Heat transfer surfaces
- SCR
- Variety of processing and storage equipment

Notes

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