

Appendix A.2 Emission factors for particles from uncontrolled metallurgical processes (abstracted from US EPA, 1972; Bond and Straub, 1972; and US NTIS, 1979, 1980a, 1980b, 1981, and 1986).

<u>process</u>	<u>EF (kg particles/Mg raw material)</u>
aluminum production	
aluminum hydroxide	100.00
bauxite grinding	3.00
crucible furnace	0.95
prebake cell	47.00
reverberatory furnace	2.60
secondary aluminum smelting	
crucible furnace	0.95
reverberatory furnace	2.15
sweating furnace	7.20
gray iron fugitive emissions	
cleaning, finishing	8.50
cooling	5.00
core making, baking	0.60
inoculation	1.5-2.5
magnesium treatment	2.50
pouring	2.50
sand handling, preparation, mulling	20.00
scrap and charge handling	0.30
shakeout	16.00
gray iron furnaces	
cupolas (average)	8.55
less than 48 in ID	6.45
48-60 in ID	9.75
greater than 60 in ID	9.45
electric arc	5.00
electric induction	0.75
reverberatory	1.00

Appendix A.2 (continued)

<u>process</u>	<u>EF (kg particles/Mg raw material)</u>
iron and steel mills	
blast furnaces	
cast house (kg/Mg hot metal)	
tap hole and trough	0.15
slips (kg/slip)	39.5
electric arc furnaces (kg/Mg steel)	
charging, tapping, slagging	0.7
melting and refining (carbon steel)	19.0
melting, refining, charging, tapping, slagging	
alloy steel	5.65
carbon steel	25.0
machine scarfing (kg/Mg steel)	0.05
miscellaneous (boilers, soaking pits, slab reheat furnaces, blast furnace gas, coke oven gas) (kg/ 1000 mJ)	0.015
open hearth furnaces (kg/Mg steel)	
melting and refining	10.55
sintering (kg/Mg finished sinter)	
basic oxygen furnaces (kg/Mg steel)	
BOF monitor (all sources)	0.25
charging, at source	0.3
discharging (breaker and hot screens)	3.40
hot metal transfer, at source	0.095
tapping, at source	0.46
top blown melting and refining	14.25
windbox leaving grate	5.56
teeming (kg/Mg steel)	
leaded steel at source	0.405
unleaded steel at source	0.035
lead products	
cable covering	0.30
type metal production	0.35
melting of red brass (< 7% zinc)	
electric furnaces	1.50
crucible or pot furnaces	1.65
reverberatory furnaces	8.40
rotary furnace	10.60
melting of bronze	
crucible furnace	1.90
rotary furnace	15.30

Appendix A.2 (continued)

<u>process</u>	<u>EF (kg particles/Mg raw material)</u>
primary lead smelting	
blast furnace	180.50
dross reverberatory furnace	10.00
fugitive emissions	
conveyor loading, car charging (sinter)	0.25
dross kettle	0.24
ladle operation	0.46
lead casting	0.44
ore mixing and pelletizing	1.13
reverberatory furnace leakage	1.50
silver retort building	0.90
sinter crushing, screening, discharge	0.75
sinter machine leakage	0.34
sinter transfer to dump	0.10
slag cooling	0.24
zinc fuming furnace vents	2.30
ore crushing	1.00
sintering (updraft)	106.50
secondary copper smelting	
cupola	
insulated copper wire	115
scrap copper and brass	35
reverberatory	
brass and bronze	18
copper	2.55
rotary, brass and bronze	150
crucible, pot for brass and bronze	10.50
electric arc	
copper	2.50
brass and bronze	5.50
electric induction	
copper	3.50
brass and bronze	10.00
secondary lead	
fugitive emissions	
casting	0.44
smelting	1.4-7.9
sweating	0.8-1.8
smelting	
blast (cupola)	96.50
reverberatory	73.50
sweating	16-35

Appendix A.2 (continued)

<u>process</u>	<u>EF (kg particles/Mg raw material)</u>
secondary zinc smelting	
crushing, screening	0.5-3.8
electric resistance sweating	<5
galvanizing	2.50
kettle sweating	
general metallic scrap	5.50
residual scrap	12.50
muffle distillation, oxidation	10-20
muffle sweating	5.4-16.0
retort and muffle distillation	
casting	0.1-0.2
muffle distillation	22.50
pouring	0.2-0.4
retort distillation, oxidation	10-20
retort reduction	23.50
reverberatory	
general metallic scrap	6.50
residual scrap	16.0
rotary sweating	5.5-12.5
sodium carbonate leaching	
calcining	44.50
crushing, screening	0.5-3.8
fugitive emissions	
casting	0.0075
crucible melting furnace	0.0025
crushing, screening	2.13
electric induction melting	0.0025
electric resistance sweating	0.25
kettle (pot) melting	0.0025
kettle (pot) sweating	0.28
muffle sweating	0.54
retort and muffle distillation	1.18
reverberatory melting furnace	0.0025
reverberatory sweating	0.63
rotary sweating	0.45

Appendix A.3 Emission factors for volatile hydrocarbons from uncontrolled sources (abstracted from US EPA, 1972 and 1980; Bond and Straub, 1972; Hoogheem et al., 1979; US NIOSH, 1981; and US NTIS, 1979, 1980a, 1980b, 1981, and 1986).

<u>source</u>	<u>emission factor, EF</u>
degreasers	
all	1000 kg/Mg
cold cleaner (0.39 kg/hr m ²)	430 kg/Mg
conveyorized	850 kg/Mg
fabric scouring	500 kg/Mg
open top vapor (0.73 kg/hr m ²)	775 kg/Mg
nonmethane hydrocarbon vapor emissions	
compressor seals	
hydrocarbon service	0.98 lbm/hr
hydrogen service	0.10 lbm/hr
drains (all)	0.070 lbm/hr
heavy liquid streams	0.029 lbm/hr
light liquid/two-phase streams	0.085 lbm/hr
flanges (all)	0.00058 lbm/hr
gas-vapor	0.0005 lbm/hr
heavy liquid streams	0.0007 lbm/hr
light liquid/two-phase streams	0.0005 lbm/hr
pump seals	
heavy liquid streams	0.045 lbm/hr
light liquid streams	0.26 lbm/hr
relief valves (all)	0.19 lbm/hr
gas-vapor streams	0.36 lbm/hr
heavy liquid streams	0.019 lbm/hr
light liquid/two-phase streams	0.013 lbm/hr
valves	
gas-vapor streams	0.047 lbm/hr
heavy liquid streams	0.0007 lbm/hr
light liquid/ two-phase streams	0.023 lbm/hr
rotogravure printing	
dryer exhaust	840 kg/Mg
fugitive	130 kg/Mg
printed product	30 kg/Mg

Appendix A.3 (continued)

<u>source</u>	<u>emission factor, EF</u>
surface coating	
enamel	420 kg/Mg
interior printed panels	
basecoat	
conventional paint	2.4 kg/ 100 m ²
ultraviolet coating	0.24 kg/100 m ²
water borne	0.2 kg/ 100 m ²
ink	
conventional paint	0.3 kg/ 100 m ²
ultraviolet coating	0.1 kg/ 100 m ²
water borne	0.1 kg/ 100 m ²
topcoat	
conventional paint	1.8 kg/ 100 m ²
ultraviolet coating	Negligible
water borne	0.4 kg/ 100 m ²
filler	
conventional paint	3.0 kg/ 100 m ²
ultraviolet coating	Negligible
water borne	0.3 kg/100 m ²
sealer	
conventional paint	0.5 kg/ 100 m ²
ultraviolet coating	0
water borne	0.2 kg/ 100 m ²
lacquer	770 kg/Mg
paint	560 kg/Mg
plywood veneer dryers	
Douglas fir, heartwood	6.7 kg/10,000 m ²
Douglas fir, sapwood	
steam fired	2.3 kg/ 10,000 m ²
gas fired	38.6 kg/10,000 m ²
larch	1.0 kg/ 10,000 m ²
southern pine	15.1 kg/10,000 m ²
primer (zinc chromate)	660 kg/Mg
varnish and shellac	500 kg/Mg

Appendix A.3 (continued)

<u>source</u>	<u>emission factor, EF</u>
transfer of hydrocarbons by tank cars and trucks	
gasoline in transit (fully loaded)	0.001-0.009 kg/m ³
splash loading-balance service	
crude oil	0.6 kg/m ³
gasoline	1.0 kg/m ³
JP-4	0.3 kg/m ³
splash loading-normal service	
crude oil	0.8 kg/m ³
gasoline	1.4 kg/m ³
JP-4	0.5 kg/m ³
kerosene	0.005 kg/m ³
no. 2	0.004 kg/m ³
no. 6	0.00004 kg/m ³
submerged loading-balance service	
crude oil	0.6 kg/m ³
gasoline	1.0 kg/m ³
JP-4	0.3 kg/m ³
submerged loading-normal service	
crude oil	0.4 kg/m ³
gasoline	0.6 kg/m ³
JP-4	0.18 kg/m ³
kerosene	0.002 kg/m ³
no. 2	0.001 kg/m ³
no. 6	0.00001 kg/m ³

Solvent emission rate relative to evaporation of carbon tetrachloride.

<u>hydrocarbon (HC)</u>	<u>(HC evaporation rate / CCl₄ evaporation rate)</u>
acetone	0.91
benzene	0.49
sec-butanol	0.094
n-butanol	0.035
carbon tetrachloride	1.00
cyclohexane	0.02
ethers (petroleum)	1.00
hexane	1.13
methyl ethyl ketone	0.45
methylene chloride	1.47
mineral spirits	0.0063
naphtha, coal tar	0.015-0.12
naphtha, safety (standard)	0.015-0.12
perchloroethylene	0.27
toluene	0.12
1,1,1-trichloroethane	1.39
trichloroethylene	0.69
trichlorotrifluoroethane	2.80
o-xylene	0.055

Appendix A.4 Emission factors for uncontrolled mineral processes (abstracted from US EPA, 1972; and US NTIS, 1979, 1980a, 1980b, 1981, and 1986).

<u>process</u>	<u>EF (kg/Mg raw material)</u>
asphalt concrete	
fugitive particles	
cold and dried aggregate elevator	0.10
screening hot aggregate	0.013
unloading aggregate to bins	0.05
hot mix dryer drum (particles)	2.45
stack gas	
aldehydes	
1-butanal	0.0012
formaldehyde	0.000075
3-methylbutanal	0.008
2-methylpropanal	0.00065
carbon monoxide	0.019
particles	0.137
polycyclic organic compounds	0.000013
sulfur dioxide	0.146 times % sulfur
volatile organic hydrocarbons	0.1
brick	
curing and firing (fluorides)	
gas, oil, or coal-fired kiln	0.4
raw material handling (particles)	
drying	35
grinding	38
storage	17
ceramic clay (particles)	
drying	35
grinding	38
storage	17
clay and fly-ash sintering (particles)	
clay mixed with coke	20
fly ash	55
natural clay	6
concrete batching (particles)	
loading dry-batch truck	0.02
loading mix truck	0.01
loading mixer with raw materials	0.01
transfer of cement to silos	0.12
transfer of sand and aggregate to bins	0.02

Appendix A.4 (continued)

<u>process</u>	<u>EF (kg/Mg raw material)</u>
glass fiber (particles)	
forming-wool	
flame attenuation	1
rotary spun	29
glass furnace-wool	
electric	0.25
gas-recuperative	13-15
gas-regenerative	11
gas-unit melter	4.5
glass furnace-textile	
recuperative	1
regenerative	8
unit melter	3
mixing and weighing	0.3
oven curing and cooling-textile	0.6
oven curing-wool	
flame attenuation	3
rotary spun	4.5
rotary spun	
cooling-wool	0.65
storage bins	0.1
unloading and conveying	1.5
glass frit smelters	
rotary furnace	
fluorides	2.5
particles	8
glass manufacture (soda-lime)	
particles	1
gypsum (particles)	
calciner	45
conveying	0.35
primary grinder	0.5
raw material dryer	20
lime (particles)	
calcining	
crushing, primary	15.5
rotary kiln	100
vertical kiln	4
mineral wool (particles)	
blow furnace	8.5
cooler	1
cupola	11
curing oven	2
reverberatory furnace	2.5

Appendix A.4 (continued)

<u>process</u>	<u>EF (kg/Mg raw material)</u>
phosphate rock processing (particles)	
calcining	7.7
drying	2.9
grinding	0.8
open storage piles	20
transfer and storage	1
Portland cement (particles)	
dry process	
dryers, grinders	48
kilns	123
wet process	
dryers, grinders	16
kilns	100
stone quarrying and processing (particles)	
crushing	
finer mill	3
primary	0.25
recrushing and screening	2.5
screening, conveying, and handling	1
secondary crushing and screening	0.75
storage pile losses	5
tertiary crushing and screening	3

Appendix A.5 Emission factors for uncontrolled chemical processes (abstracted from US EPA, 1972; and US NTIS, 1979, 1980a, 1980b, 1981, and 1986).

<u>process</u>	<u>EF (kg/Mg raw material)</u>
ammonium sulfate	
fluidized bed dryers	
particles	109
volatile organic hydrocarbons	0.11
rotary dryers	
particles	23
volatile organic hydrocarbons	0.74
carbon black	
oil furnace	
CO boiler and incinerator	
carbon monoxide	0.88
hydrocarbons	0.99
hydrogen sulfide	0.11
particles	1.04
sulfur oxides	17.5
flare	
carbon monoxide	122
hydrocarbons	1.85
hydrogen sulfide	1
particles	1.35
sulfur oxides	25
main process vent	
carbon monoxide	1.4
hydrocarbons	50
hydrogen sulfide	30
particles	3.27
charcoal (without chemical recovery plant)	
acetic acid	116
carbon monoxide	160
crude methanol	76
hydrocarbons (as methane)	50
particles	200
paint and varnish manufacture	
paint	
particles	1 (kg/Mg pigment)
undefined hydrocarbons	15 (kg/Mg pigment)
varnish (undefined hydrocarbons)	
acrylic	10 (kg/Mg pigment)
alkyd	80 (kg/Mg pigment)
bodying oil	20 (kg/Mg pigment)
oleoresinous	75 (kg/Mg pigment)

Appendix A.5 (continued)

<u>process</u>	<u>EF (kg/Mg raw material)</u>
plastics manufacturing	
polypropylene	
particles	1.5
propylene gas	0.35
polyvinyl chloride	
particles	17.5
vinyl chloride gas	8.5
printing ink (condensed organics)	
vehicle cooking	
alkyds	80
general	60
oils	20
oleoresinous	75
synthetic fibers	
dacron, oil mist	3.5
nylon	
hydrocarbons	3.5
oil mist	7.5
viscose rayon	
carbon disulfide	27.5
hydrogen sulfide	3
synthetic rubber	
alkanes	
dethylheptane	0.5
pentane	1
alkenes	
butadiene	20
butylene	1.5
methyl propene	7.5
pentadiene	0.5
carbonyls	
acrolein	1.5
acrylonitrile	8.5
ethanenitrile	0.5

Appendix A.6 Emission factors for uncontrolled food processes (abstracted from US EPA, 1972; and US NTIS, 1979, 1980a, 1980b, 1981, and 1986).

process	EF
coffee roasting	
direct-fired	
aldehydes	0.1 kg/Mg
organic acids	0.45 kg/Mg
particles	3.8 kg/Mg
indirect-fired	
aldehydes	0.1 kg/Mg
organic acids	0.45 kg/Mg
particles	2.1 kg/Mg
instant coffee spray dryer, particles	0.7 kg/Mg
stoner and cooler, particles	0.7 kg/Mg
cotton gin, particles	
cleaner	0.45 kg/bale
miscellaneous	13.6 kg/bale
stick and burr machine	1.36 kg/bale
unloading fan	2.27 kg/bale
feed and grain mills and elevators (particles)	
grain processing	
barley flour milling	1.5 kg/Mg
barley or wheat cleaner	0.1 kg/Mg
corn meal	2.5 kg/Mg
milo cleaner	0.2 kg/Mg
soybean	305 kg/Mg
terminal elevators	
drying	3 kg/Mg
screening and cleaning	2.5 kg/Mg
shipping or receiving	0.5 kg/Mg
transferring, conveying, etc.	1 kg/Mg
fermentation, beer and whiskey	
hydrocarbons (whiskey)	0.024 kg/Mg
particles	
drying spent grains	2.5 kg/Mg
grain handling	1.5 kg/Mg
meat smoking	
aldehydes (HCOH)	0.04 kg/Mg
carbon monoxide	0.3 kg/Mg
hydrocarbons (methane)	0.035 kg/Mg
organic acids (acetic)	0.1 kg/Mg
particles	0.15 kg/Mg

Appendix A.7 Emission factors for indoor processes and activities.**Cigarettes** (abstracted from Committee on Indoor Pollution, 1981 and Lofroth et al., 1989):

general	<u>mainstream (inhaled)</u>	<u>sidestream (smoldering)</u>
duration (sec)	20	550
particles (no./cigarette)	1.05×10^{12}	3.5×10^{12}
tobacco burned (mg)	347	441
emissions (mg/cigarette)	<u>mainstream (inhaled)</u>	<u>sidestream (smoldering)</u>
acrolein	0.084	0.825
CO	18.3	86.3
HCN	0.24	0.16
NH ₃	0.16	7.4
NOx	0.014	0.051
particles		
filtered cigarette		
nicotine	0.46	1.27
tar	10.2	34.5
unfiltered cigarette		
nicotine	0.92	1.69
tar	20.8	44.1

Gas ranges and kerosene space heaters ($\mu\text{g}/\text{kcal}$) (abstracted from Meyer, 1983):

<u>compound</u>	<u>gas range (2500 kcal/hr)</u>	<u>space heater (2800 kcal/hr)</u>
CH ₂ O	7.1	
CO	890	632
CO ₂	209,000	200,000
NO	31	76
NO ₂	85	46
SO ₂	0.8	

Formaldehyde (abstracted from Meyer, 1983):

<u>material</u>	<u>emission factor, EF [$\text{mg}/(\text{m}^2 \text{ day})$]</u>
100% cotton drapery fabric	0.2-0.7
fiberglass ceiling panel	2.8
fiberglass insulation	0.45
foam backed carpet	0.12
hardwood paneling (UF)	1-34
latex-backed fabric	0.19
nylon upholstery fabric	0.018
OF-foam insulation	1-50
paper cups and plates	0.33-0.7
particleboard (std, UF)	2-34
plywood (UF-bonded)	1-34

Appendix A.7 (continued)**Common household aerosols in 1970** (abstracted from Meyer, 1983):

<u>material</u>	<u>emission factor, EF (g/month)</u>
air fresheners	28-56
deodorant spray	112-140
disinfectant sprays	112
dust sprays	28-56
furniture polish	56
hairspray	84-112
oven cleaners	84
shaving foam	84-112

Small stoves (abstracted from Butcher and Ellenbecker, 1982):

<u>material</u>	<u>emission factor, EF (g/kg fuel)</u>
anthracite coal	
carbon monoxide	21
particles	0.5
bituminous coal	
carbon monoxide	116
particles	10.4
wood	
carbon monoxide	100
particles	1.6-6.4