



Emission Factors 101

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March 16, 2005



What Role do Emission Factors Play?

- Emission factors used at other Intel sites, commonly used by other industries, and accepted by regulatory agencies
- Intel NM permit requires quarterly reporting of NO_x, CO, VOC, HAPs, TAPs and TSP from HMDS
- Methods to calculate emissions set in permit
- Utilize:

Chemical Use

Fuel Use

Hours Operated

x

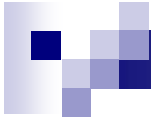
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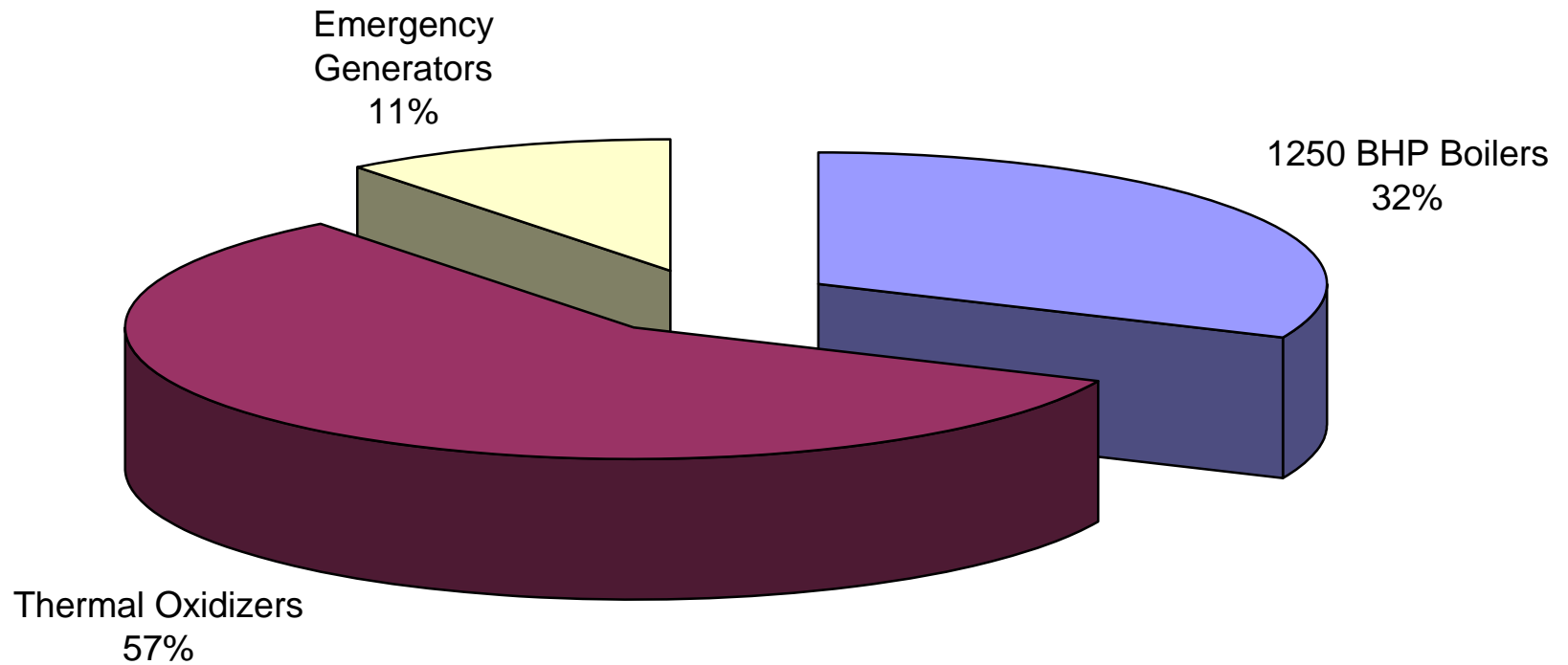
Emissions



Source of Emissions	Emissions	Where Emissions Factors come from?
Combustion Sources (Boilers, Thermal Oxidizers, Emergency Generators)	NOx/CO SO ₂ , TSP/PM ₁₀ , VOC	<ul style="list-style-type: none"> ■ On-site emissions testing and operational data ■ Manufacture's data for EG ■ Manufacture's data and AP-42
Manufacturing Process (exhausted to scrubbers and thermal oxidizers)	VOCs/HAPs VOCs/HAPs – untreated emissions TAPs	<ul style="list-style-type: none"> ■ Tool testing and process recipes ■ EPA sink equation ■ No emission factors, i.e. chemical use = emissions ■ No emissions factors, i.e. chemical use = emissions ■ EPA sink equation
Tanks	VOCs/HAPs	<ul style="list-style-type: none"> ■ EPA tank equation

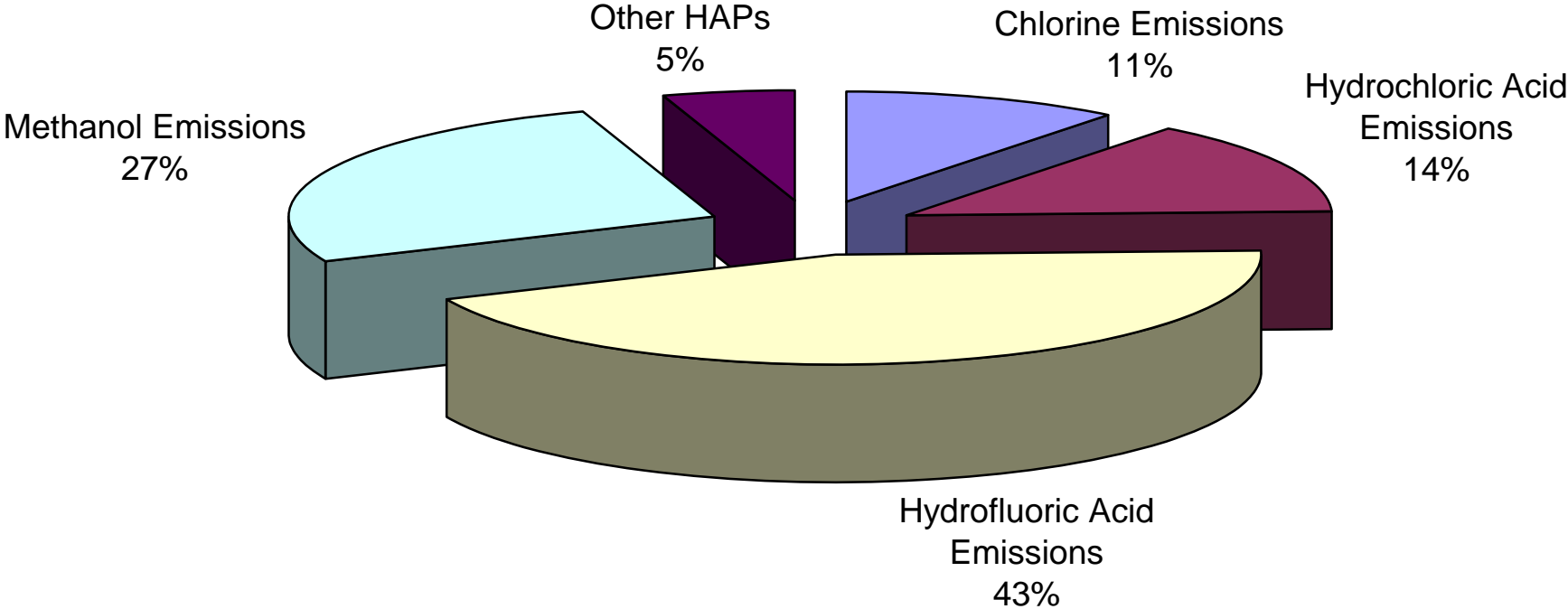


**Combustion Source Emissions
NO_x/CO/VOC
56 tons in 2004
95.7/94.7/96.5 ton per year permit limits NO_x/CO/VOC**





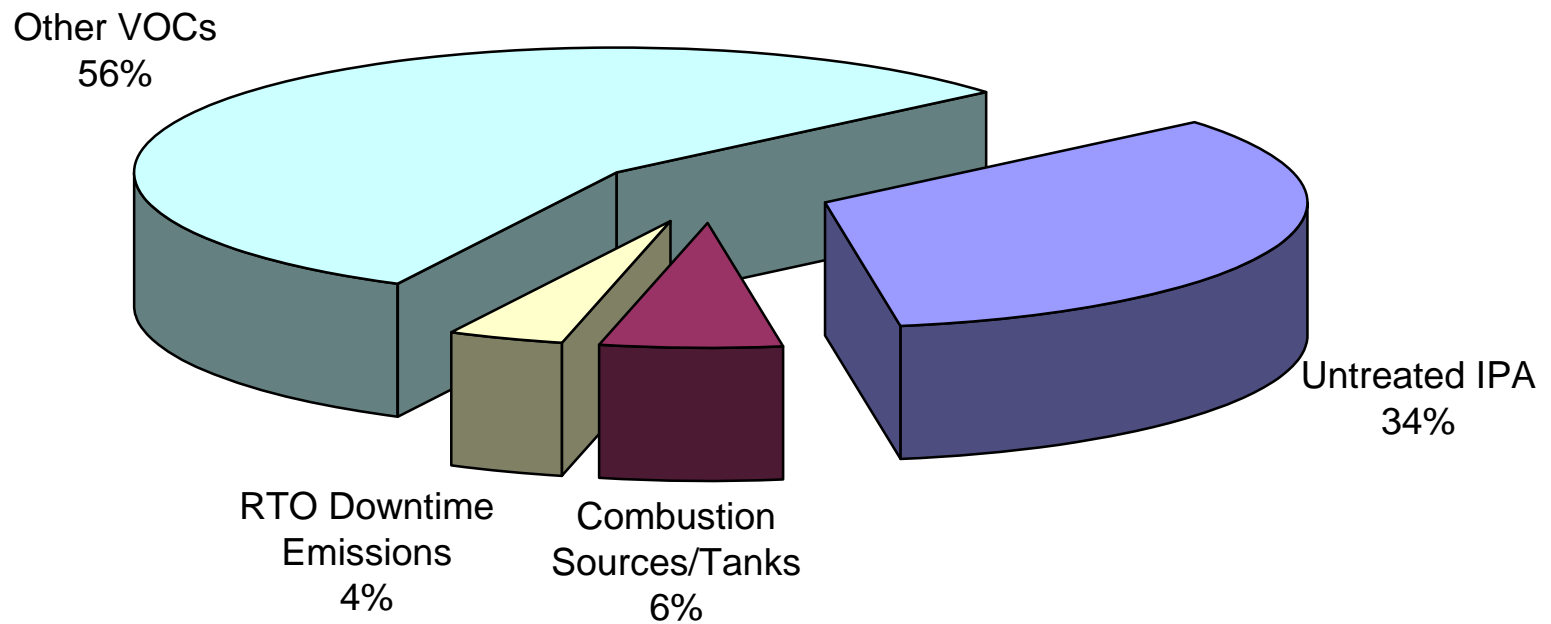
HAP Emissions
10.2 tons in 2004
9* ton per year individual/24 ton per year total permit limit



* some HAPs have less than 9 ton per year permit limit



VOC Emissions
50 tons in 2004
96.5 ton per year permit limit





Boiler Emission Factors – NO_x/CO

- Boilers operate at 10 different lever positions
- Emission factor utilizes:
 - average firing rate for each lever position
 - maximum testing data at each position
- Permit requires annual update to emission factors based on 3 years of operational and testing data
- Permit requires annual compliance testing
 - NMED typically observes
 - NMED performed spot check with their equipment during 2004 inspection – used to validate compliance testing



Thermal Oxidizer Emission Factors

– NO_x/CO

- Requesting to update emission factors
- Emission factors similar to boilers
 - Average firing rate
 - Maximum testing data
- Utilizing 2 years of data
- NO_x/CO data collected during quarterly compliance testing



HAP & VOC Emission Factors Process Development

- Product lines developed in development factories
- Defined process recipe for each step in manufacturing
 - Recipe characteristics – type(s) of chemical/gas, amount of chemical/gas, temperature, flow rate, etc.- set during development
- Tool exhaust is designed to handle all recipes on a tool – i.e. solvents tools to solvent exhaust
- Approval required for recipe changes and modifications
 - All changes are documented and tracked



HAP & VOC Emission Factors Tool Testing

- Tools tested at development site as part of product development
- Tools tested using an FTIR
 - Documented protocol is used for testing
- Emissions verified at 1st high volume manufacturing site product is taken too
 - Select 12” process tools currently running in Fab 11X were tested Q2’04 (Robert S. from NMED observed testing)



HAP & VOC Emission Factors

What information is used?

- Chemical Use
 - The amount of each chemical used in the process on a lb/wafer basis
 - Each process has a specific recipe that is used for each step of the process and determines the amount of chemical used per wafer run
- Tool Testing
 - Emissions measured directly from the individual tool
 - The airflow in the tool exhaust also measured
 - The total mass of emissions (lbs) is calculated for the process step by determining the average concentration in the exhaust and multiplying by the air flow rate
- Product Loading
 - Multiple products made at the site
 - Actual product loading and actual chemical use are used to weight the emissions from the various products each quarter



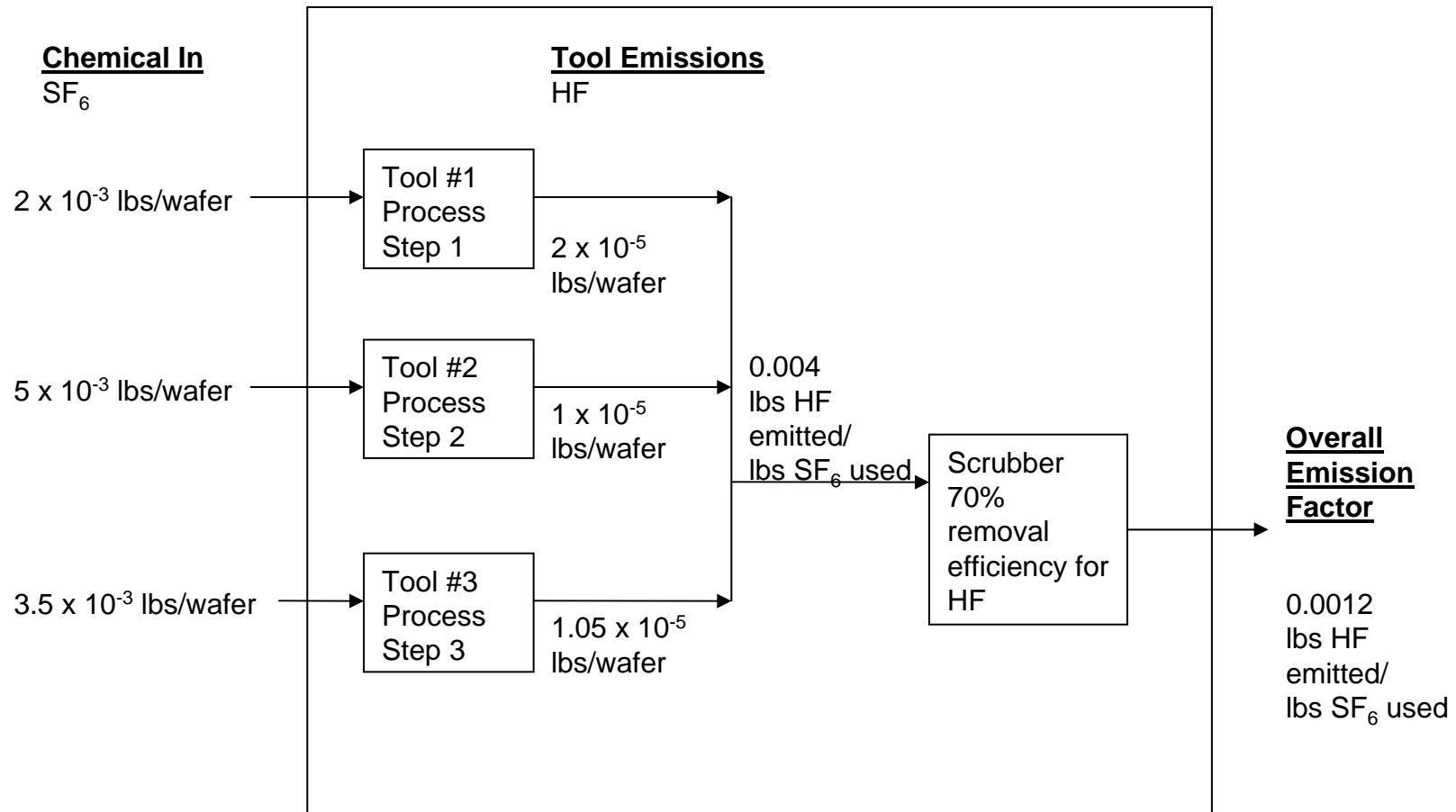
HAP & VOC Emission Factors

Example Calculation

- One process step uses 0.0025 lbs of Cl₂ per wafer
- Results in emissions of both Cl₂ and HCl (formed as a byproduct)
- Emissions testing on this step measured both of these pollutants and produced an average result of:
 - 8.3x10⁻⁵ lbs of HCl per wafer
 - 0.0018 lbs of Cl₂ per wafer
- The emission factor results would be:
 - Cl₂ to HCl EF = $(8.3 \times 10^{-5}) / (0.0025) = 0.03$
 - Cl₂ to Cl₂ EF = $(0.0018) / (0.0025) = 0.72$
- In other words, every 100 lbs of Cl₂ used will generate 3 lbs of HCl emissions and 72 lbs of Cl₂ emissions
- This type of information is then developed for every step which creates these emissions and an overall emission factor is developed

HAP & VOC Emission Factors

Example Calculation





Emission Factor Verification

- Internal verification for HAPs & VOC emission factors
 - Peer environmental engineers from all Intel sites review all changes made to emission factors
 - Verification testing done at 1st high volume manufacturing site product taken to
 - Quarterly review of data from each site running process
- External verification of all Intel emission factors
 - Permit requires recordkeeping of all information used to calculate emissions
 - NMED reviews records during inspections
 - Compliance Testing
 - Requirements set in permit
 - NMED typically observes