EMISSION ESTIMATION & DATA QUALITY

Good Emissions Data Makes for Good Decisions

Redefining possible.

Emission Estimates

Air quality professionals spend an significant amount of time worrying about emission estimates.

These estimates almost always come down to an "Emission Rate", usually expressed in the units of grams per second (g/s).

This is the standard unit used in dispersion models.

The g/s is a little misleading however, and some idea of the averaging time is needed.

Emission Estimates

Emissions vary almost constantly with time, even in the most well-controlled process there will be variations.

Because of this, instantaneous emissions measurements can be problematic.

They way around this is to specify a time period over which we average the emissions.

This allows us to smooth out peaks and valleys in the instantaneous emission rates, and get a more realistic value.

Emission Estimates

Inevitably this results in something like a 1-hour, or perhaps a 24-hour average emission rate.

Conveniently, this is also often the unit of time we see used for process data, whether the BTU/h rating on a furnace, or the production rate of a given process in tonnes per day.

As we saw in the previous presentation, emissions are often directly related to this process data, so having the same time basis is helpful.

Emission Estimates

Once we learn all we can about the process in question, the time comes to put pencil to paper.

Emission estimates are normally developed using the following methods:

1. **Mass Balance (including stoichiometry)**
2. **Engineering Calculations**
3. **Emission Factors**
4. **Source Measurement**

Mass Balances

Mass Balances

The mass balance approach is based on the conservation of mass - what goes in, must come out.

Obviously it often won’t be the exact form it was when it went in, but the overall mass must balance.

In fundamental terms, the same atoms come out as went in, just in a different combination.

To develop a mass balance, direct process measurements must be possible.

Ideally we can measure the raw material inputs, the finished product outputs, and any liquid or solid waste that is generated.

Mass Balances

This leaves us with only one stream in our process flow diagram that is unaccounted for.

If we assume that any difference between the raw material inputs, the finished product outputs, and any liquid or solid waste that is generated is lost to the atmosphere, we have a mass balance emission estimate.

This is almost always worst-case, as some of the missing material could be due to leaks, or is present as a residue inside the process.

Regardless, good measurements and process understanding can improve the accuracy singifiantly.

Stoichiometry

Stoichiometry is the writing and balancing of chemical equations. Using the same principle of conservation of mass, it allows us to determine emission rates.

It can also provide information on volumetric or mass flow rates of both inlet and outlet streams.

Air quality professionals mostly use stoichiometry for estimating exhaust flow rates for combustion systems when we can't get it directly from a manufacturer.

This also means the Ideal Gas Law is something we can never forget.

Engineering Calculations

Engineering Calculations

If you took a first-year introductory chemical engineering course, you learned a lot of what you need to know about estimating emissions using engineering calculations.

Also, if the phrase "go back to first principles" sounds familiar, you're likely on the right track already.

Used primarily when dealing with evaporation processes, we often resort to standard references such as Perry's Handbook or other tomes of knowledge.

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Engineering Calculations

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A typical example is an inorganic liquid in a storage tank, perhaps an acid.

If we're lucky, we can consult a table showing the concentration of the contaminant above the air-liquid interface.

If we assume that the entire vapour space in the storage tank is at equilibrium, we can then apply this concentration to the entire vapour space.

When the tank is filled, that vapour is exhausted, and we can estimate the emissions based on the volume displaced.

Engineering Calculations

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While a simple example, we do these sort of calculations regularly.

Evaporation of volatile compounds above a pool, such as a spill, is another example.

In this case we turn to mass transfer equations using temperature and airflow across the air-liquid interface to determine how quickly the material evaporates.

If you have long since lost your mass transfer textbook, I suspect used bookstores will have plenty of them.

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Emission Factors

Emission Factors

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Emission factors can be thought of as the air quality professional's Swiss Army knife.

Covering a mind-boggling variety of both natural and anthropogenic sources, they also come from a vast array of sources.

Generally though, there is one source that is trusted widely in the profession, the U.S. EPA compendium of emission factors known as AP-42 (Air Pollution document 42).

It remains the standard reference for anyone working in the field.

Emission Factors

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All emission factors relate the “activity” of a specific source, say a large natural gas boiler, to it’s emissions of various contaminants.

In some case you will need to know specific details about the source you’re dealing with – the process, the shape, and even what colour it’s painted.

Once you find the right factor, you just multiply it by the “activity factor”.

Emission Factors

$$E = A \times EF \times (1 - ER/100)$$

E = emissions

A = process parameter / activity factor / etc.

EF = emission factor

ER = overall emission reduction efficiency

Emission Factors

As an example, the next slide shows a typical table of emission factors from AP-42.

These emission rates are for stationary internal combustion engines, burning either gasoline or diesel.

These would be found running a generator, emergency generator, portable compressor or possibly a piece of industrial machinery.

Emission Factors

Pollutant	Gasoline Fuel (SCC 2-02-003-01, 2-03-003-01)		Diesel Fuel (SCC 2-02-001-02, 2-03-001-01)		EMISSION FACTOR RATING
	Emission Factor (lb/hp-hr) (power output)	Emission Factor (lb/MMBtu) (fuel input)	Emission Factor (lb/hp-hr) (power output)	Emission Factor (lb/MMBtu) (fuel input)	
NO_x	0.011	1.63	0.031	4.41	D
CO	0.439	62.7	6.68 E-03	0.95	D
SO_x	5.91 E-04	0.084	2.05 E-03	0.29	D
PM-10[b]	7.21 E-04	0.10	2.20 E-03	0.31	D
CO_2[c]	1.08	154	1.15	164	B
Aldehydes	4.85 E-04	0.07	4.63 E-04	0.07	D
TOC					
Exhaust	0.015	2.10	2.47 E-03	0.35	D
Evaporative	6.61 E-04	0.09	0.00	0.00	E
Crankcase	4.85 E-03	0.69	4.41 E-05	0.01	E
Refueling	1.08 E-03	0.15	0.00	0.00	E

Taken from AP-42 Emission factors for stationary IC engines: http://www.epa.gov/ttn/chief/ap42/ch03/final/c03s03.pdf

Emission Factors

Emission factors typically require a process parameter such as fuel consumption or a production rate.

These can be varied, but each emission factor is normally explained (in AP-42, at least) to help you understand what is required.

In many cases tables of factors have footnotes that must be read.

I can't stress this enough.

Many mistakes have occurred because of lack of attention to these foot notes.

Emission Factors

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Other emission factors can come from manufacturers, especially for the type of engines we just discussed.

Industrial associations can also be a great source of emission factors, but typically one must belong to the association to have access to those factors. These tend to be less conservative, but often provide data not available anywhere else.

There may also be factors published by government sources (our own MECP has a few), which tend to be very conservative, but usually get through reviews easily!

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Source Measurements

Source Measurement

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Last, but certainly not least is source measurement, possibly the be-all and end-all of emission rate determination.

Source measurement allows us to obtain emission, temperature, flow and other data at the same time.

In some cases, we can even obtain this data continuously, in near real-time.

Unfortunately, this is a course unto itself!

This is also not for the faint of heart.

Source Measurement

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DATA QUALITY

How good are your estimates?

Data Quality

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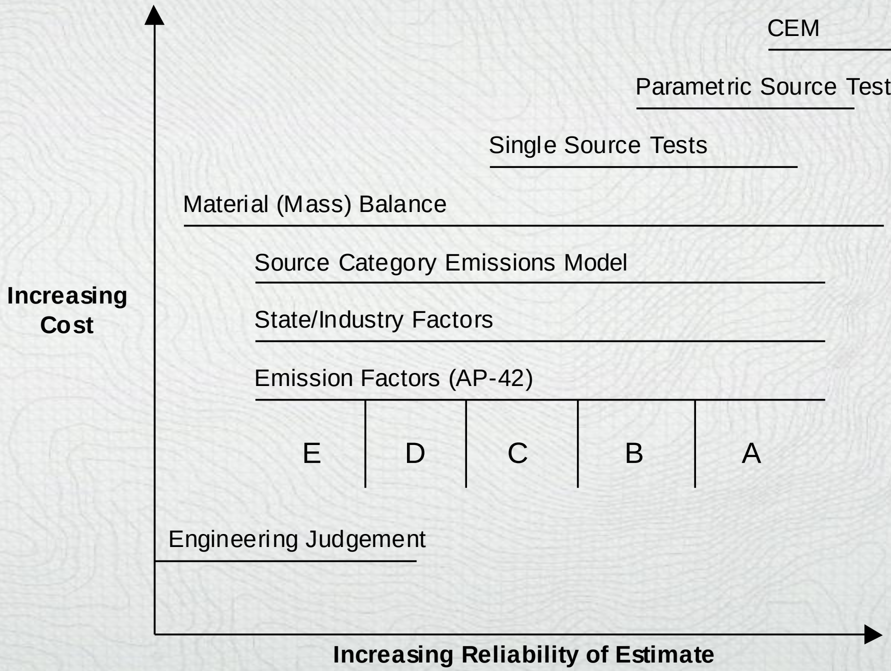
This brings us to data quality.

Every emission rate comes with an associated degree of quality. The air quality professional needs to know the quality of their data!

In fact, all Emission Summary and Dispersion Modelling Reports require an assessment of data quality.

The following figure represents relative data quality for the methods we have discussed.

Data Quality



THANK YOU!

Redefining possible.