A PCB DEMONSTRATION TEST ON A MIXED WASTE VACUUM THERMAL DESORBER

Treating RCRA and Low Level Radioactive Waste

by

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With Support from
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M&EC VTD
(Vacuum Thermal Desorber)

• In operation since 2001 at Oak Ridge, TN

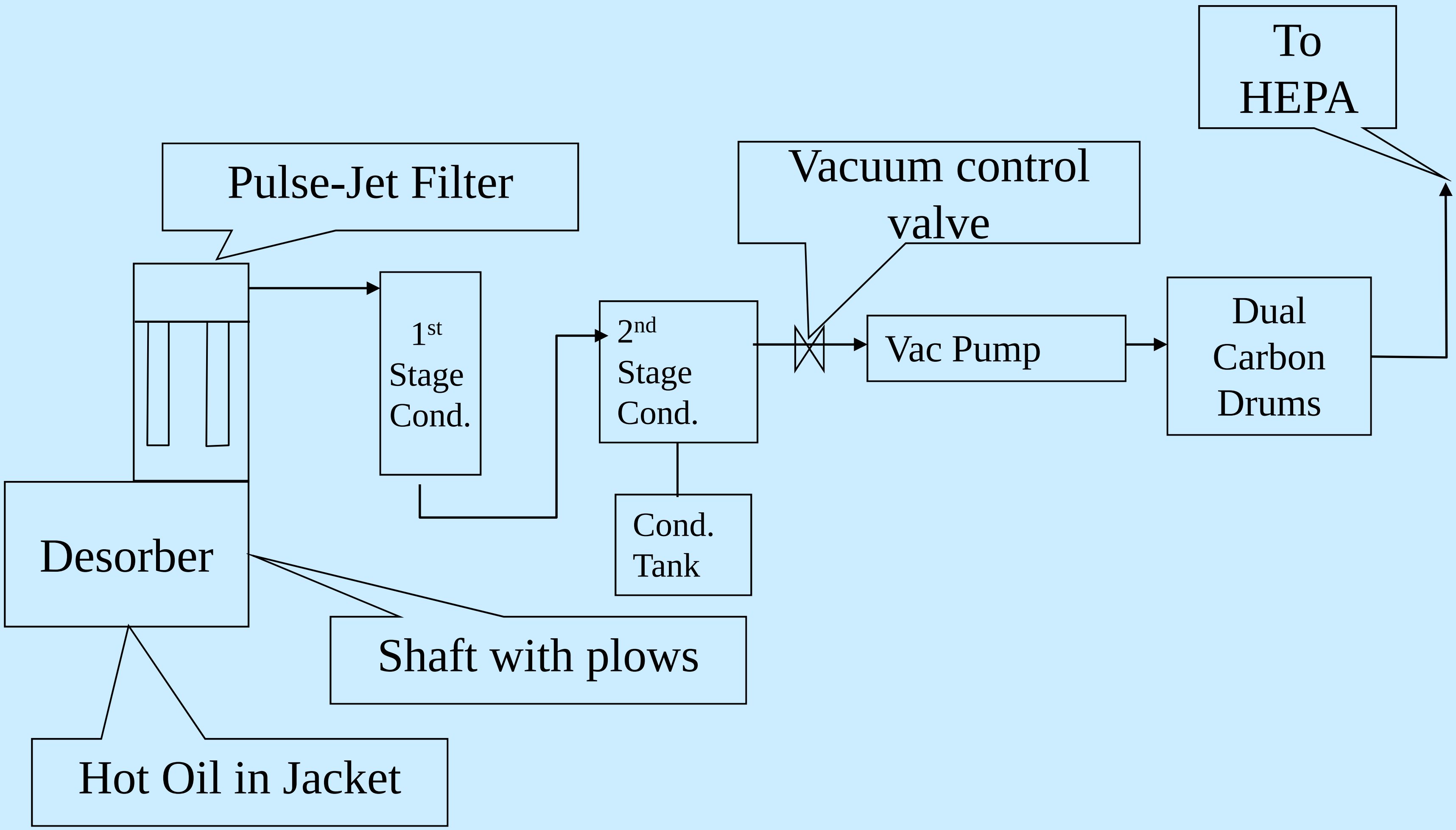
• PCB Demo Test Run May - June 2004

• VTD uses temperature and vacuum to remove water and organics

• Processes mixed waste – RCRA organic plus low level radioactive material, plus TSCA PC Bs

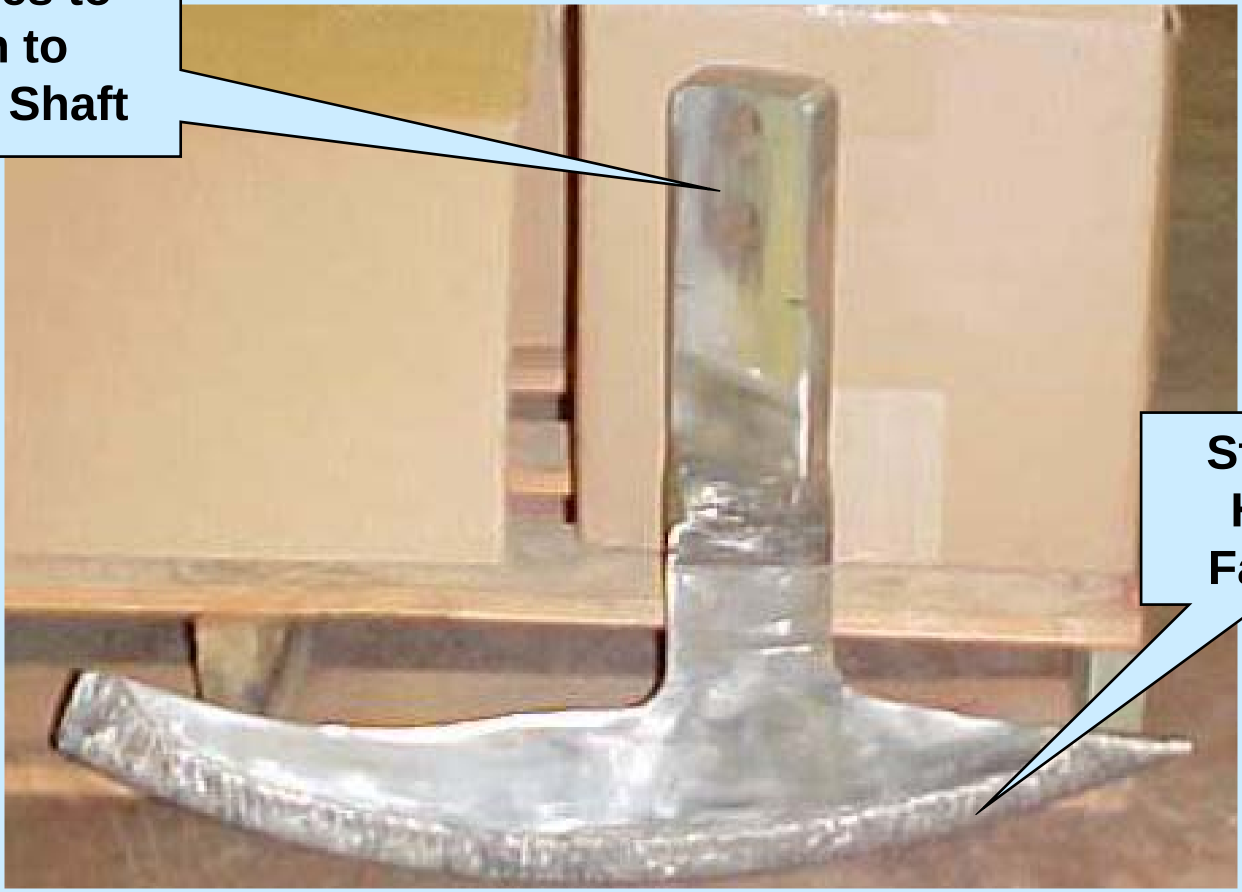
• Matrix ranges from dry solids to wet, sloppy material, soils to paint sludge to activated carbon

Process Flow for VTD System



VTD Desorber

VTD Desorber Plow



Vacuum Thermal Desorber

- **How the desorber works**
- **Pulse-back filter**
- **Vacuum pump/vacuum & pressure issues**
- **Condenser**
- **Safety issues and oxidizing reactions**
- **Vapor Pressure curves**

How the Desorber Works

- Heat is transferred indirectly through the wall to the waste via heat from the hot oil jacket.

- The plows keep the waste mixed and help to spread it on the hot wall.

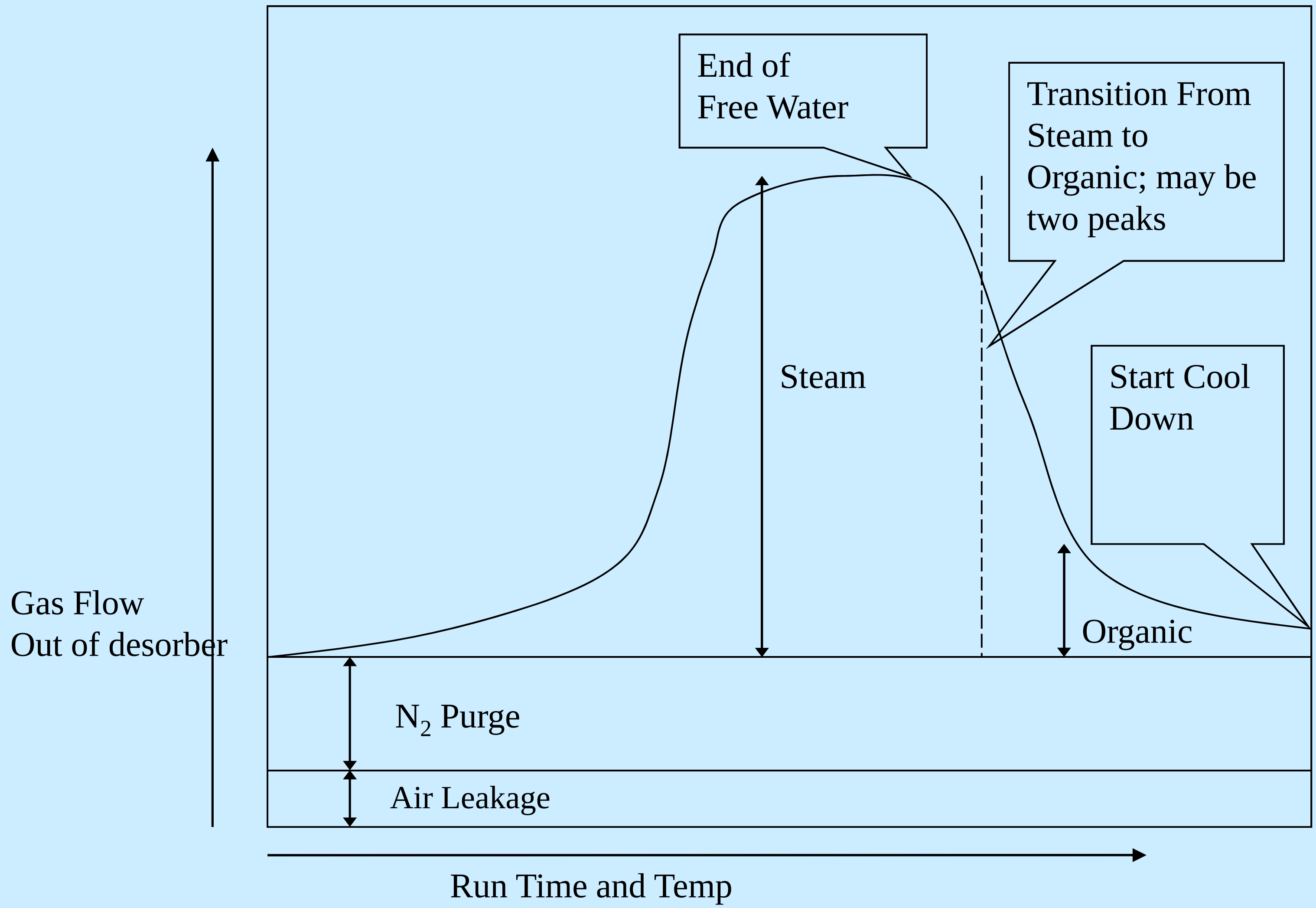
- When the waste is at the boiling point of water (212F at 0"Hg vac, or 203F at 5"Hg vac), water is vaporized.

- Some water/organics evaporate below boiling point.

- When the waste reaches the boiling point of the organics, they are vaporized; if the core material is above the boiling point, all, or almost all, organics will be gone (exception: activated carbon, which holds on to organics)

- Nitrogen used as purge gas.

Desorber Cycle: Heating up the Waste and Driving Off Vapors – Typical Curves



Plow Power Adds Heat Too

- **Rub your hands together hard and fast and what do you get? Heat! You are converting mechanical energy into friction, and that generates heat.**

If the 150 hp motor is run at 30% load, and 85% of the motor load is transferred to the shaft (with 15% lost as heat from the motor, drive and seal friction), the heat transferred is:

150 hp x 0.30 x 0.85 x 2545 Btu/hr-hp= 97,000 Btu/hr

This heat input will raise the core temperature:

Q = M/Cp delta T; solving for temp, delta T = Q/MCp,

Delta T = 97,000 Btu/hr / 4000 lb x 0.3 Btu/lb-F = 81°F per hour rise in core temperature.

Pulse-Jet Bag Filter

- **Removes particulates from gas stream, located upstream of condensers**

- **High temperature bags or metallic filters required**

- **Nitrogen used for bag pulse based on automatic control tied to pressure drop**

Vacuum Pump

and

Vacuum and Pressure Issues

Vacuum Pump

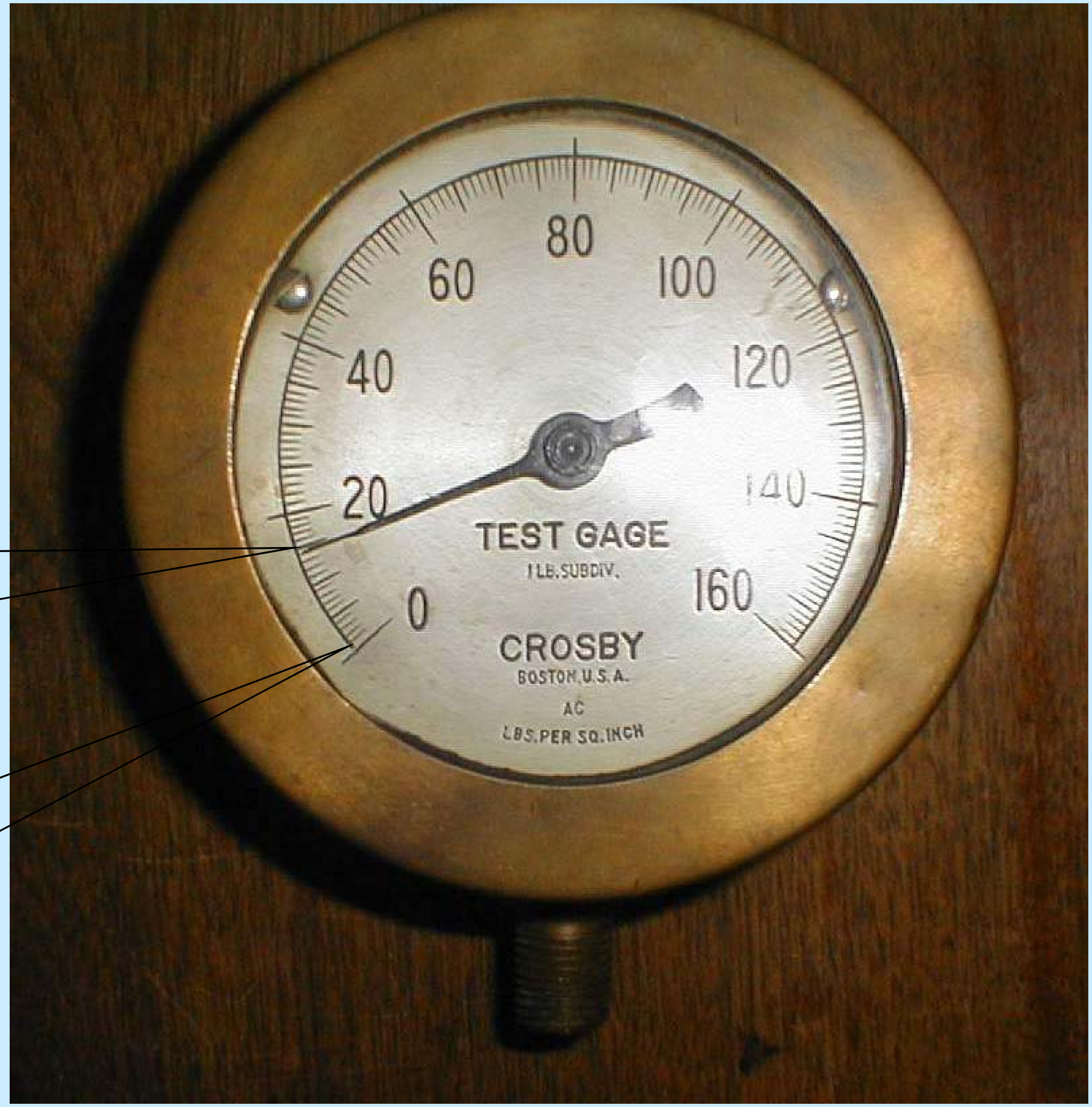
• **The vacuum pump provides the ability to pull gas through the desorber and condensers and push it through activated carbon**

• **Liquid ring type, capable of operating up to 29” Hg vacuum**

• **Positive displacement type, with operating range 15”-29” Hg vac; at less than 15” Hg, high volume causes excessive power demand**

Vacuum and Pressure Measurement

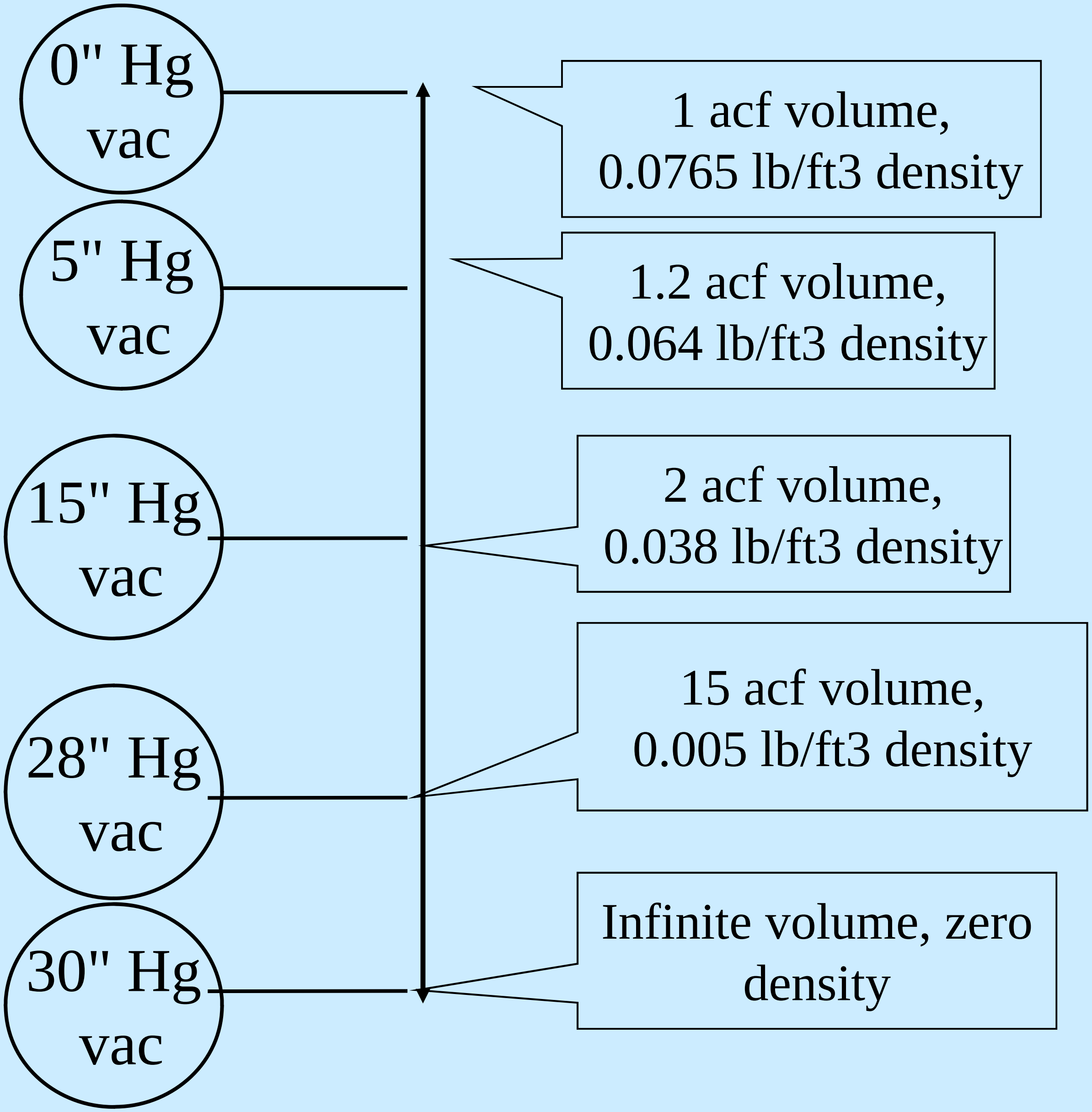
Compound Gage



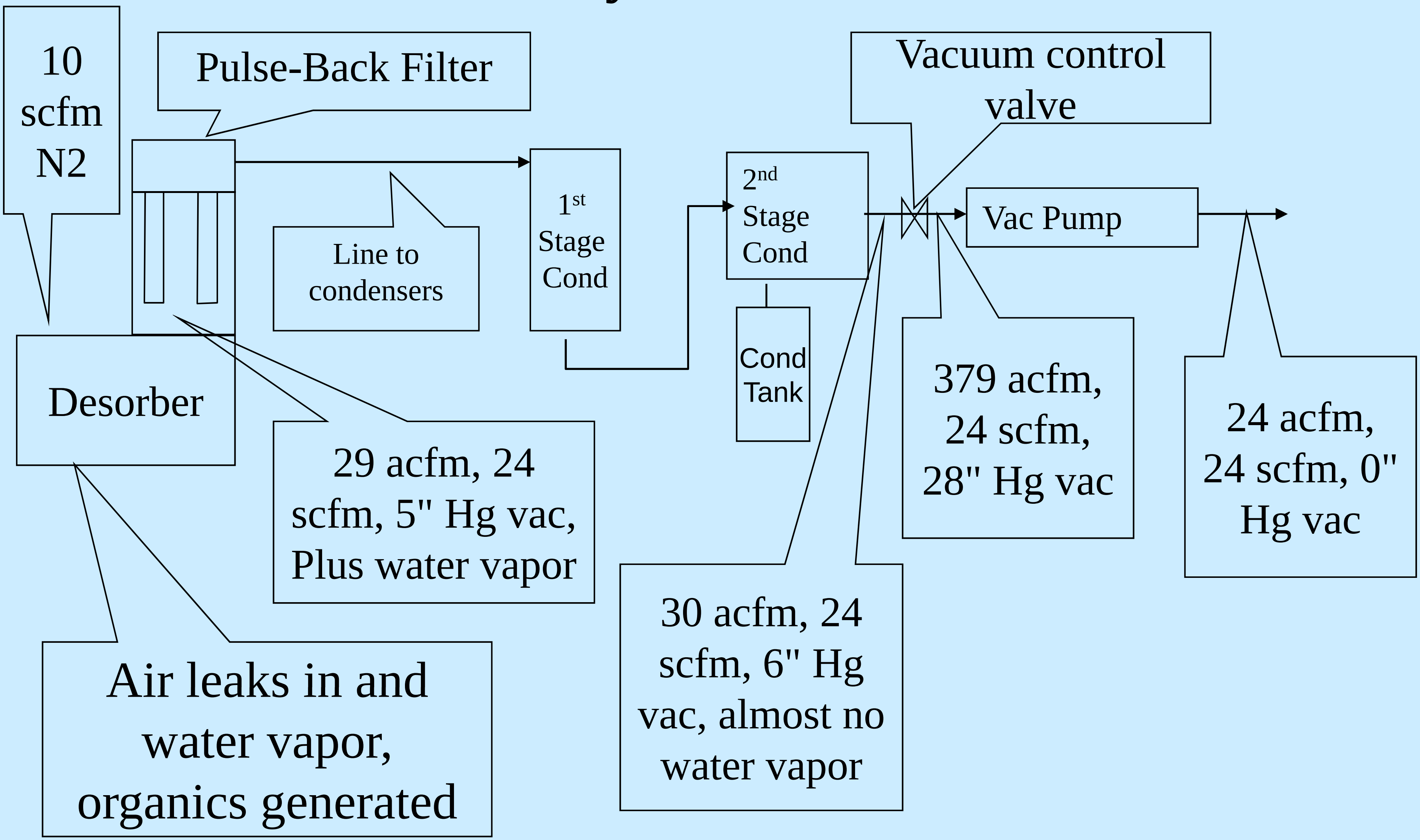
One Atmosphere, 14.7 psia

Full Vacuum, 0 psia

Vacuum and Volume Based on 1 scf of Air



Vacuum and Volume — Where It Is in the System Counts!



Condensers

Basics of Condensation

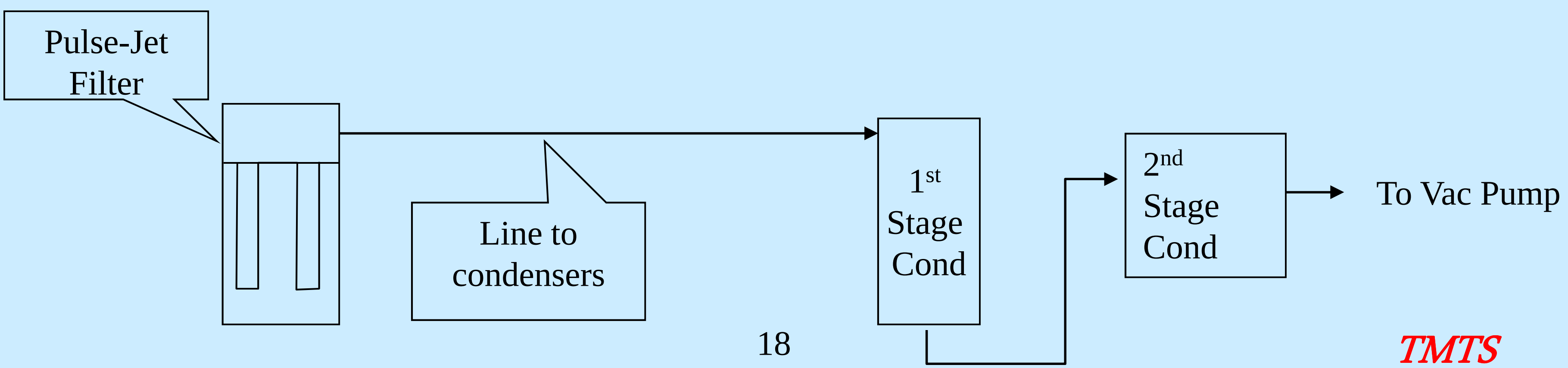
Vapors condense to liquid when they drop below the dewpoint.

Examples: Water on a bathroom mirror, on the outside of a cold glass on a summer day, dew on grass on cool mornings.

Oils will condense in the condenser if the walls of the condenser are below the dewpoint. If the organic is viscous and thick at the condenser temperature, it may build up a greasy layer.

Condensers Reduce Gas Volume

- **Water and organic vapor pass through the filter**
- **Almost all the water and organic vapor condense in the primary or secondary condenser as the gas stream temperature drops to less than 200F in the primary condenser and to about 50F in the chilled-water-supplied secondary condenser**.
- **A small amount of water vapor, organic vapor, N2 and O2 pass through the vacuum pump, through the carbon, and are vented to the HEPA filters.**



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Condenser Operating Issue:

Beware of Single Solvent Wastes!

- **If a waste is high in any one organic compound, it may come off rapidly when the core temperature/prevailing vacuum equals the boiling point.**

- **Example: Hexane boils at 140°F at 5" Hg vac. If vacuum is raised in the desorber at the organic's boiling point, the organic will flash rapidly for a brief period.**

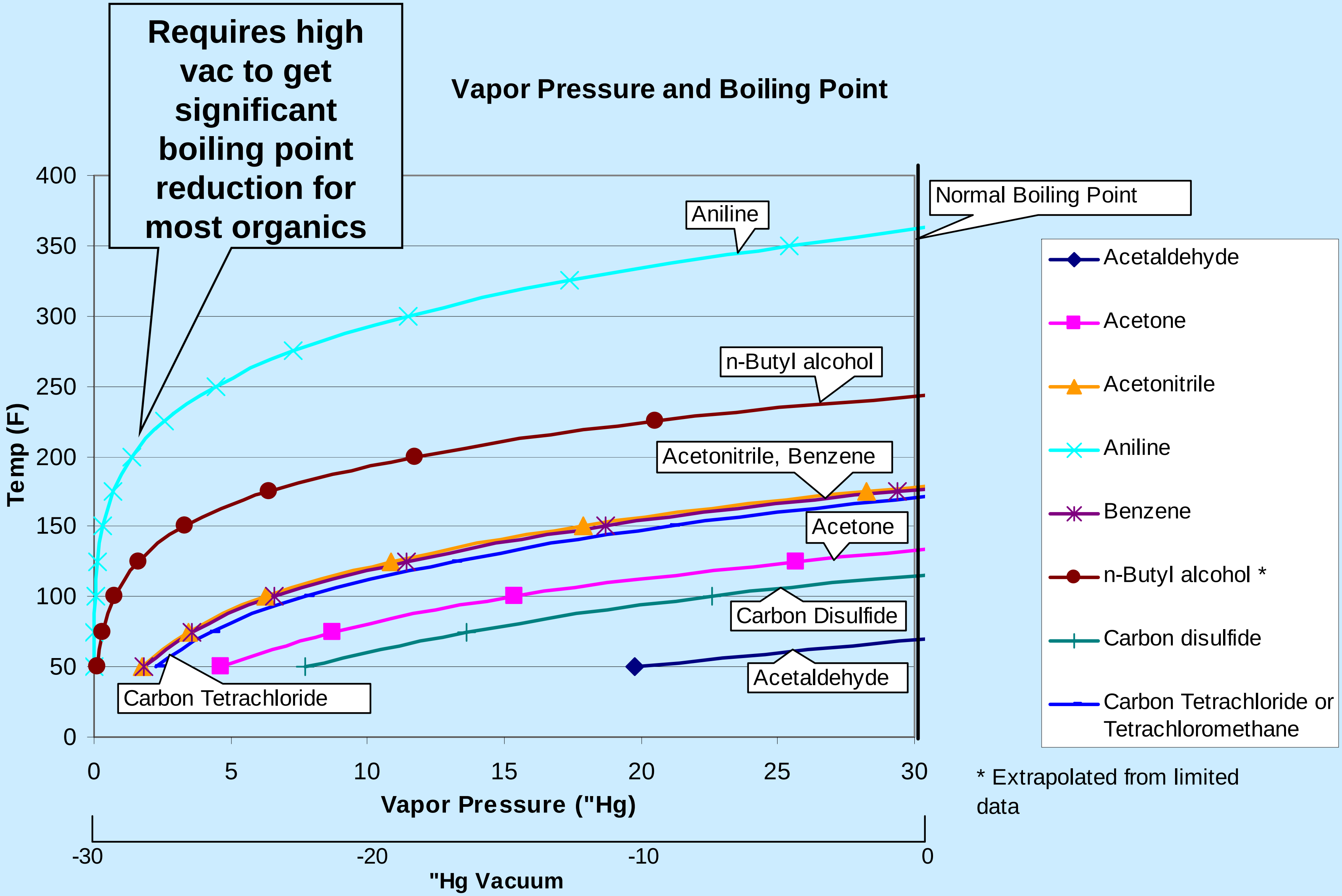
- **It may overwhelm condenser thermal and flow capacity and backpressure the desorber**

Safety Issues Regarding Oxidizing Reactions

Oxygen Concentration is the Key

- **LOC (limiting oxygen concentration) approach allowed by NFPA to prevent deflagrations from air and organics in desorber** **(Ref: NFPA 86 for LOC values, and NFPA 69 for application of LOC)**
- **Ignition source exists – rotating plows and static electricity due to dusts**
- **Requires oxygen meter at end of process**
- **Use nitrogen (or steam) purge to reduce oxygen content**
- **Must maintain seals to reduce air leakage**

Vapor Pressure Curves



* Extrapolated from limited data

PCB Demo Test

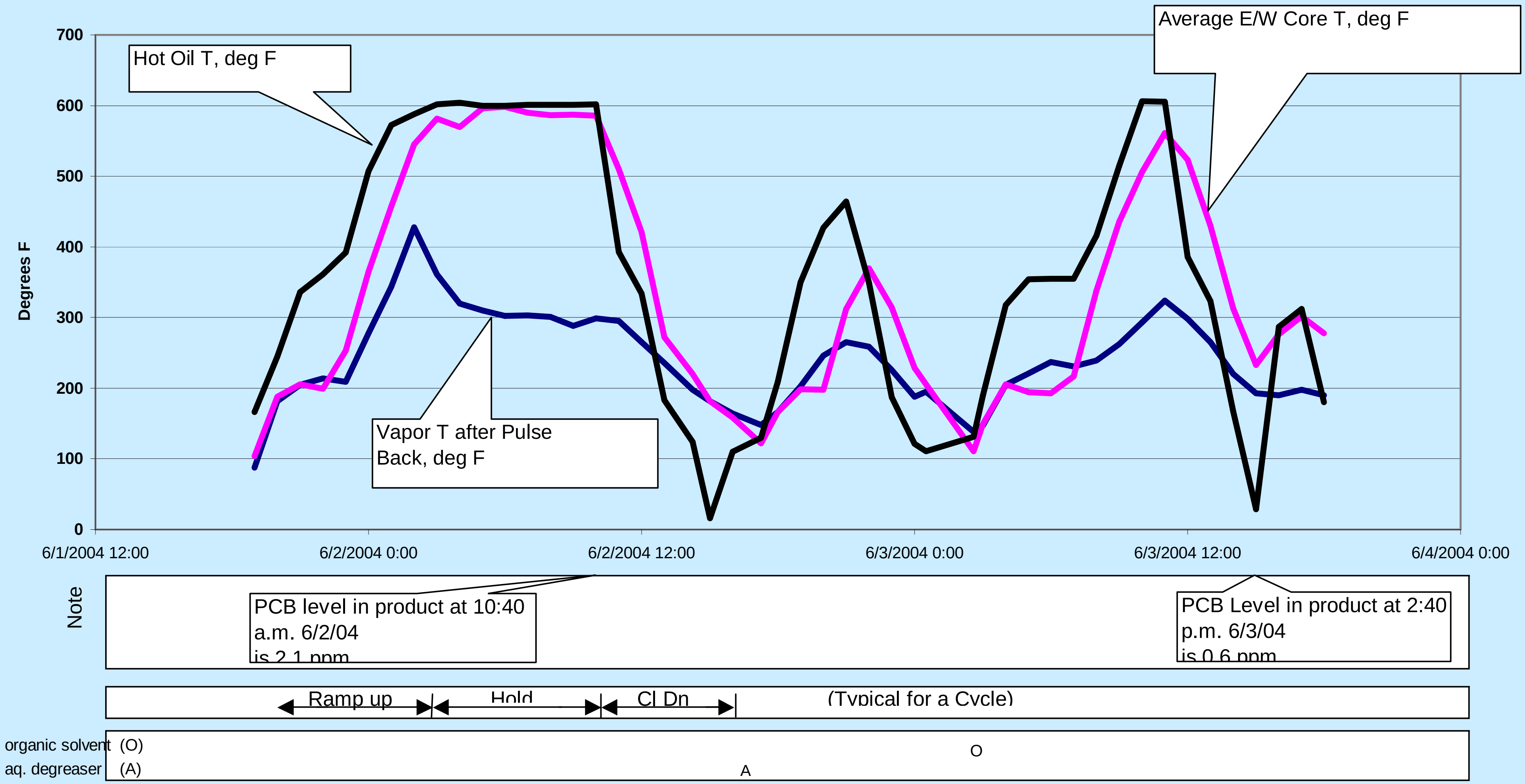
- M&EC had RCRA and low level rad permits
- PCB Demo test performed May/June 2004
- Three tests run with different waste matrixes, including sand, kaolin clay and soil/sediment
- PCBs spiked 19,283 to 101,158 ppm
- Passed test requirements, with interim operating permit signed 11/22/04

PCB Demo Test Process Data

- Max core (solids) temp 625°F
- Max desorber vacuum 28” Hg
- Max hold times 24-36 hrs per cycle
- Found significant decrease in PCB concentration (>90%) during the first eight hours of hold time, less after that

Typical Temperature Trends

PCB Run 2
6/1/04 to 6/3/04
Hot Oil, Core, and Vapor after Pulse Back Temperatures



PCB Demo Test Charge Data

Run	Criteria	Pure PCB	Hours	No. Cycles
1	1600 lb/726 kg Kaolin clay, 440 lb/200 kg Askeral 400 lb/181 kg water	112 lb (51 kg)	**104**	**6**
2	3116 lb/1413 kg sand, 226 lb/103 kg Askarel, 440 lb/200 kg water and 140 lb/64 kg diesel	33 lb (15 kg)	**52**	**3**
3	2000 lb/907 kg of sand, 909 lb/412 kg of BSOIL soil/sediment, 645 lb/293 kg Askarel, and 375 lb/170 kg water	161 lb (73 kg)	**118 +78**	**6+4**

PCB Test Results Detail

Test	PCB DRE	PCB in Product, PPM	PCB Spike, PPM
1	99.99999990%	1.9	101,158
2	99.99999934%	0.6	19,283
3	99.99999975%	0.92	90,466

PCB Test Results Detail

Test Run	PCB DRE	PCB in solid Product (ppmw)	2,3,7,8-TCDD TEQ (ng/dscm)	HCl + Cl_2 (lb/hr)
1	99.99999990%	1.9	<0.011	NA
2	99.99999934%	0.60	<0.040	NA
3	99.99999975%	0.92	<0.100	0.51

PCB Test Results Summary

Parameter	Criteria	Final Result
PCB emissions	> 99.9999% removal	99.99999966% avg (1/290 of limit, or 0.34% of limit)
HCl emissions	< 4 lb/hr	0.17 lb/hr (avg) (1/24 or 4.3%)
PCDD emissions	< 0.41 ng/m^3	0.035 ng/m^3 (avg) (1/12 or 8.5%)
PCBs in treated soil	< 2 ppm	1.0 ppm (avg) (1/2 or 50%)

PCB Test Results

- Several heating cycles required to reduce PCB to less than 2 ppm in kaolin clay matrix, some case hardening of pellets found
- Easier to get to 2 ppm on sandy matrix
- Utilized steam stripping and proprietary solvents plus thermal processing to reach required level

The author would like to acknowledge the support of Steve Douglas, and M&EC, Oak Ridge, Tennessee on this paper