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Working Together for Clean Air

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Testing on a Seattle Coffee Roaster

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Overview

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2. About the Coffee Roasting Process
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Background

1. Puget Sound Region
   a. 60+ facilities
   b. Size Varies: Starbucks, to Costco, to micro-roasters
2. Smoke: odor, particulate, toxics, combustion products
3. BACT: normally afterburner & chaff collection

Tabletop micro-roaster

Larger commercial roaster

Typical Batch Coffee Roaster

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1. Beans loaded to roaster
2. Drum begins to spin & heat
3. Beans heated to 400–500 ºF (internal temp)
4. Beans drop to cooling tray
5. Air drawn through cooling tray to cool beans
6. Beans removed to storage

Typical Batch Coffee Roaster

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1. 15 min/batch
2. Larger roasters can be fully computer operated
3. Smaller roasters: operator checks coffee by hand throughout roasting process
4. Air from roaster goes to afterburner; heated to between 1100 -1400 ºF

Beans: From Green to Roasted

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Green

Lt. Brown (200-250 º F)

First Crack (~ 355 º F)

Note: These are internal coffee bean temperatures

Med. Roast (430-450 º F)

Dark Roast (450-500 º F)

Smoke from Coffee Roasting

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Why We Tested

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1. **Toxics of concern:**
   acetaldehyde, formaldehyde, and acrolein
2. **No AP-42 data**
3. **Starbucks test for catalytic oxidizer**
4. **Other data sources were old and/or test methods were know to yield low recovery**
5. **Improved permitting review**

Partnering

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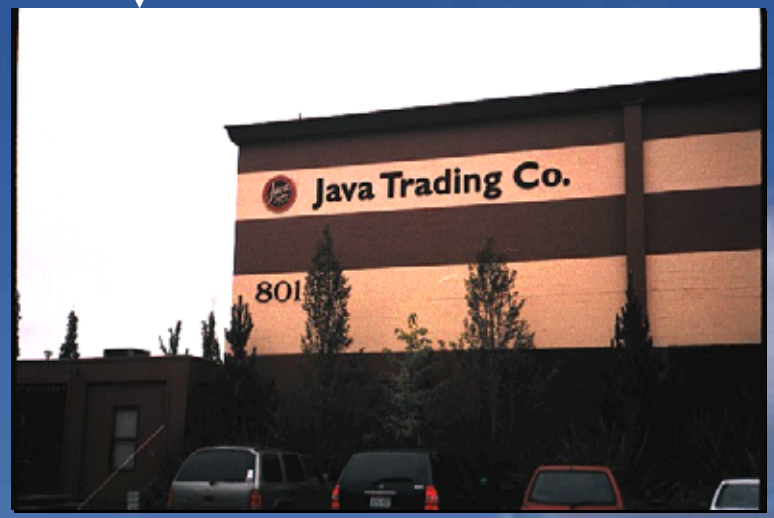
Java Trading Roasting Plant in Renton WA



1. Java Trading roasts 2100 tpy
2. Grown from 1 to 9 commercial roasters
3. Proposed roaster test
4. Hired Valid Results

Planning

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1. Test plan review - Java & Valid Results
2. JPR150 roaster chosen
3. CARB Method 430 HPLC analysis
4. QC (Tester & Lab)
5. Batch operation
6. Process data
7. Simultaneous inlet and outlet

Planning Meeting at Java Trading

Planning cont.

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9. DNPH in impingers (2,4-dinitrophenyl-hydrazine)
10. Hexane/methylene chloride added in field to stabilize samples before shipping
11. Field blanks and reagent blanks
12. Sufficient sample volume – 1 hour, 30 liters
13. Triplicate samples
14. Afterburner test at 1100 and 1300 F

Test Day

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1. Sept. 11, 2003
2. Coffee Type: French Roast
3. Process data
4. Tested inlet to afterburner simultaneously with outlet
5. Outlet tested at 1100 ºF & 1300 ºF

Impingers with DNPH

Afterburner Inlet Testing

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Roaster Operational Data

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1. Afterburner temperature maintained - 1100 ºF & 1300 °F
2. Arabica beans (blend of Brazil, Columbian, and Costa Rica)
3. French Roast coffee
4. 150 lb/batch
5. Tested only during roaster firing

Afterburner Outlet Testing

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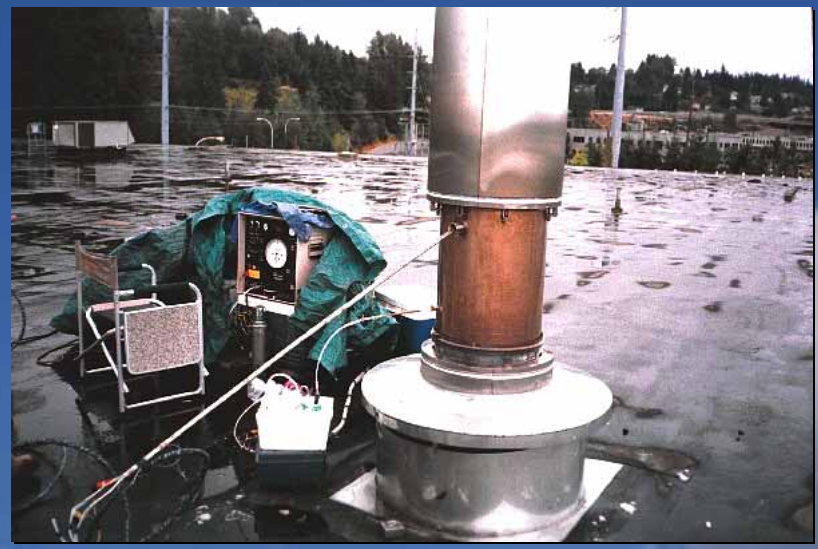

QA/QC

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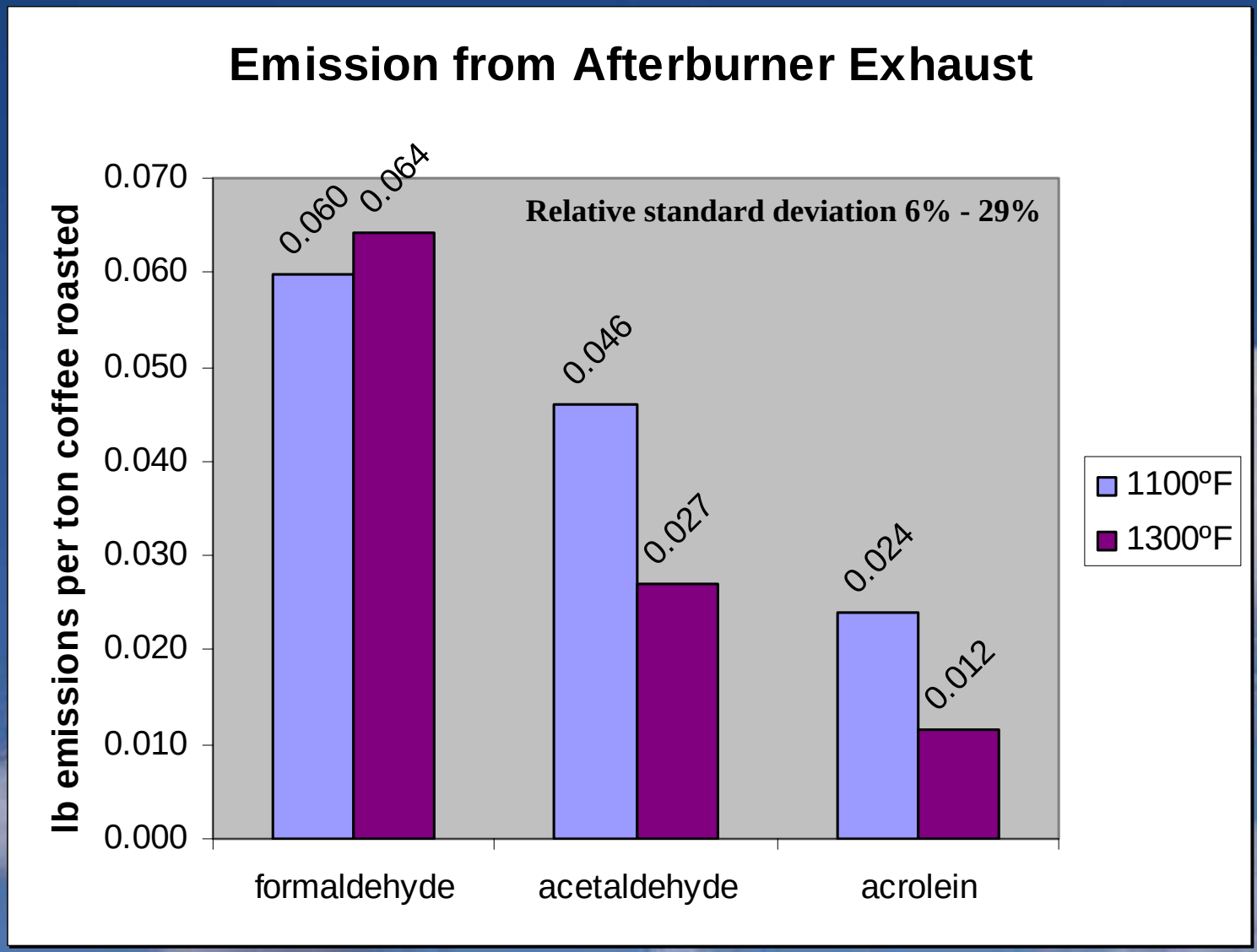
1. Glassware cleaning, HPLC grade reagents
2. DNPH holding time 48 hours – made on 9/9/03
3. Sample holding time (7 d to extraction (9/17) & 30 d to analysis (9/17 & 9/18)
4. Precision std dev of 3 runs: Outlet 6-29% and inlet 46-114%
5. Field matrix spike recoveries: 91% to 109%
6. Field blank 1% to 20% of sample results

Results - Emissions



Results – Inlet Data

1. **Inlet test data questionable**
   - **Formaldehyde: 0.02 lb/ton +/- 46% (outlet higher than inlet)**
   - **Acetaldehyde: 0.08 lb/ton +/- 98%**
   - **Acrolein: 0.015 +/- 114% (about the same as the outlet)**
2. **CARB 430 Aldehyde method - not designed for acrolein**
3. **Challenge: high concentrations, heavy smoke, wet from bean quench, cyclonic flow**

Summary of Outlet Emissions Results

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Pollutant	Emission Factor	Units
Formaldehyde	0.062	Lb/ton beans
Acetaldehyde	0.036	Lb/ton beans
Acrolein	0.018	Lb/ton beans

Conclusions

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1. **Reliable emission factors**
2. **Improved acrolein: CARB website lists 0.000121 lb/ton (vs 0.018)**
3. **Increasing afterburner temperature from 1100 to 1300 F**
   - **Decreased acetaldehyde and acrolein by half**
   - **No change in formaldehyde**
4. **Improved permitting and operational flexibility**

Acknowledgements

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1. Java Trading
2. Valid Results
3. Atmospheric Analysis and Consulting Laboratories