National Cotton Ginning Particulate Matter Emissions Study Update

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Project Objectives

1. Cotton gin emission factors (AP-42 Section 9.7)
   - Develop $PM_{2.5}$ emission factors
   - Update PM_{10} & Total PM emission factors
2. Characterize PM emitted from cotton gins (AP-42 Appendix B.1)
3. Develop a robust PM dispersion modeling data set

AP-42 Compilation of Air Pollutant Emission Factors

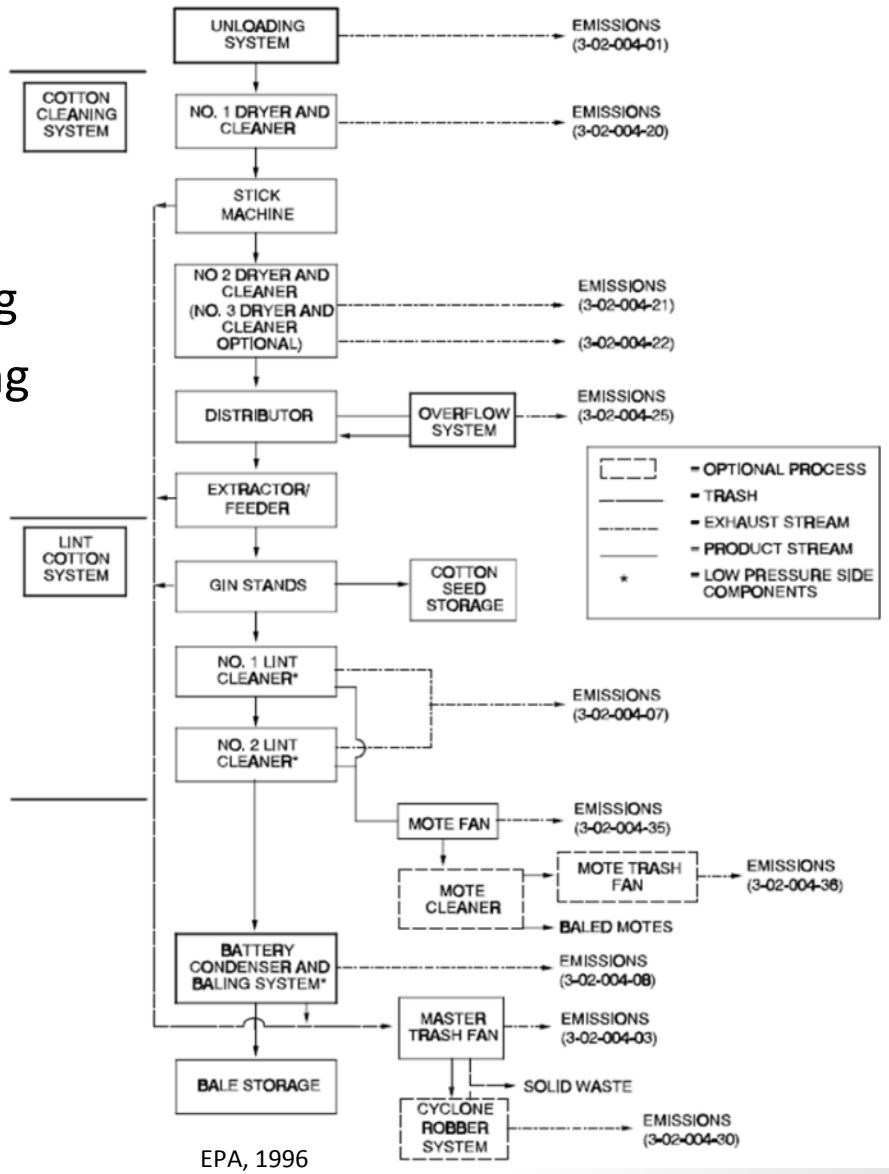
- Relates quantity of pollutant to activity releasing pollutant
- First published in 1972
  - Last complete update in 1995 (5th ed.)
  - Post- 1995 chapters supplemented and updated
- Emission factor quality ratings: A – E
- States can use AP-42
  - Modeling for SIPs
  - Industry air quality permits
    - Operation permits
    - Construction permits
  - Not all states use AP-42

$$EF = \frac{Mass\ of\ Pollutant}{Unit\ of\ Production}$$

$$Emissions = activity\ rate \times EF$$

Typical Cotton Gin

- Typical emission points
  - Unloading
  - 1st stage seed-cotton cleaning
  - 2nd stage seed-cotton cleaning
  - Overflow
  - Combined lint cleaning
  - Combined mote
  - Battery condenser
  - Master trash



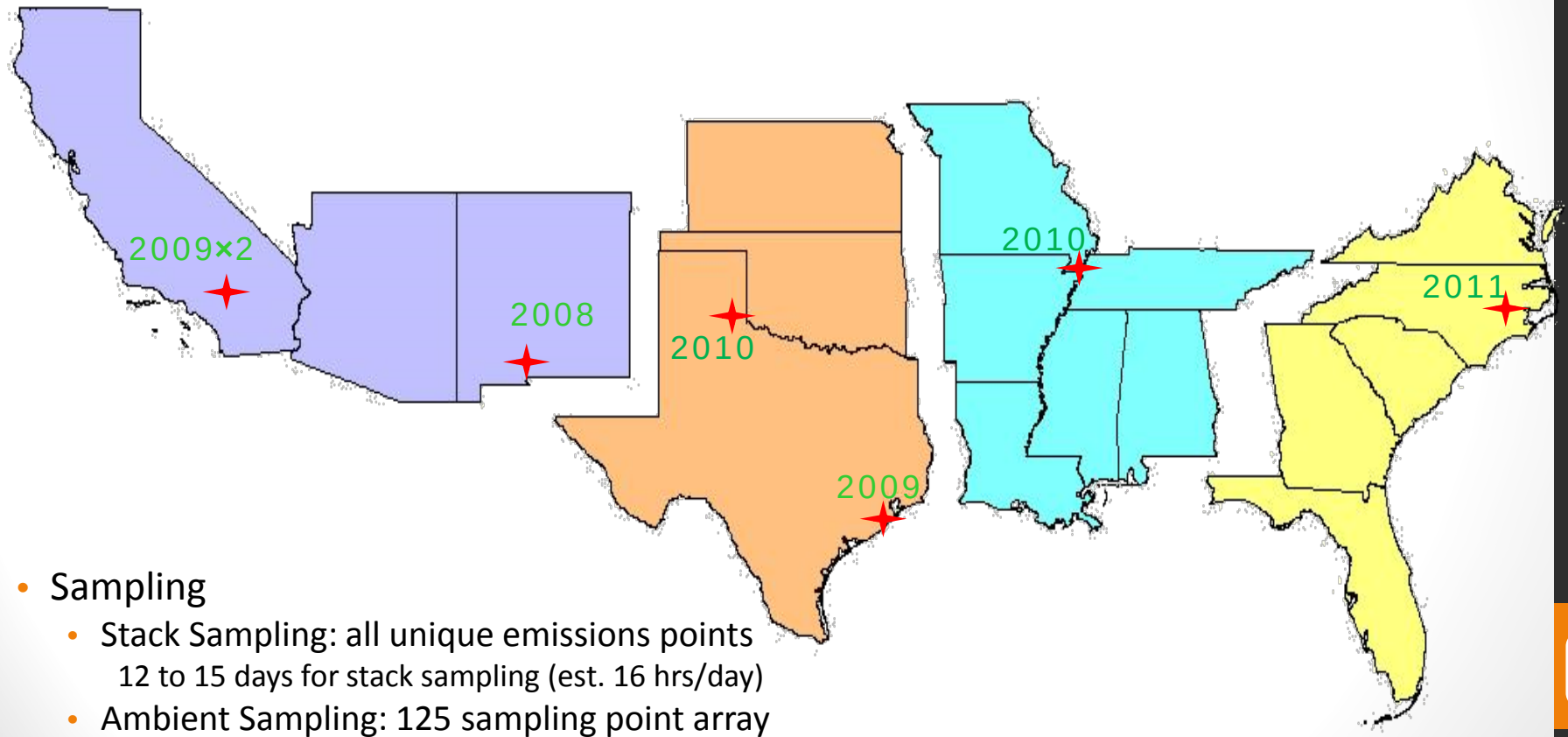
EPA, 1996

1996 AP-42 for Cotton Gins

System	$PM_{2.5}$ (lb/bale)	Factor Rating	PM_{10} (lb/bale)	Factor Rating	Total PM (lb/bale)	Factor Rating
Unloading	-	-	0.12	D	0.29	D
1st Stage Seed-Cotton Cleaning	-	-	0.12	D	0.36	D
2nd Stage Seed-Cotton Cleaning	-	-	0.093	D	0.24	D
3rd Stage Seed-Cotton Cleaning	-	-	0.033	D	0.095	D
1st Stage Lint Cleaning	-	-	-	-	-	-
2nd Stage Lint Cleaning	-	-	-	-	-	-
Combined Lint Cleaning	-	-	0.24	D	0.071	D
Battery Condenser	-	-	0.014	D	0.58	D
Cyclone Robber	-	-	0.052	D	0.18	D
1st Stage Mote	-	-	-	-	-	-
2nd Stage Mote	-	-	-	-	-	-
Combined Mote	-	-	0.13	D	0.28	D
Mote Cyclone Robber	-	-	-	-	-	-
Mote Cleaner	-	-	-	-	-	-
Mote Trash	-	-	0.021	D	0.077	D
Master Trash	-	-	0.074	D	0.039	D
Overflow	-	-	0.026	D	0.54	D
Typical Gin			0.82	D	2.4	D

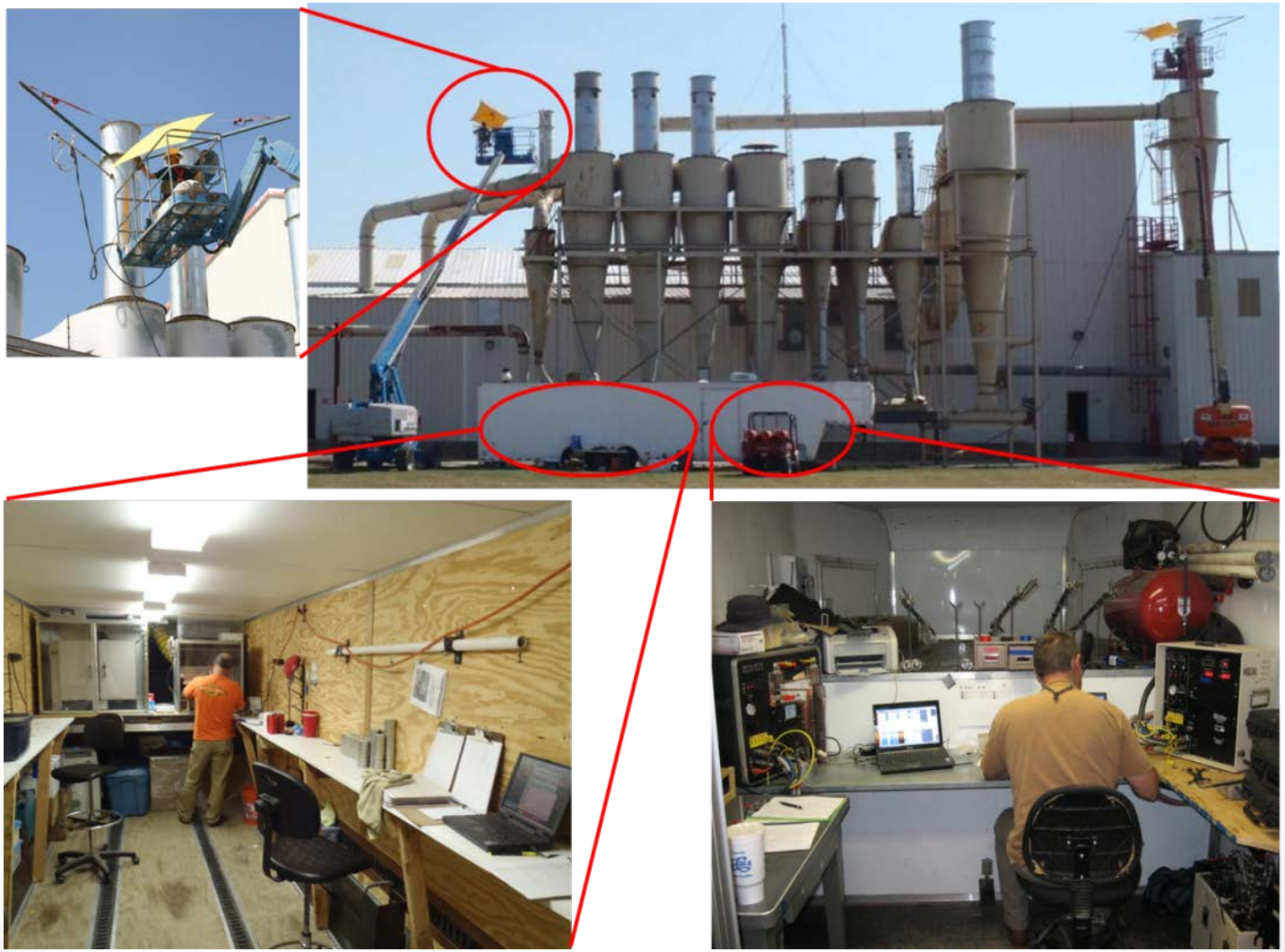
System Abatement Device Requirements

Sampling Timelines

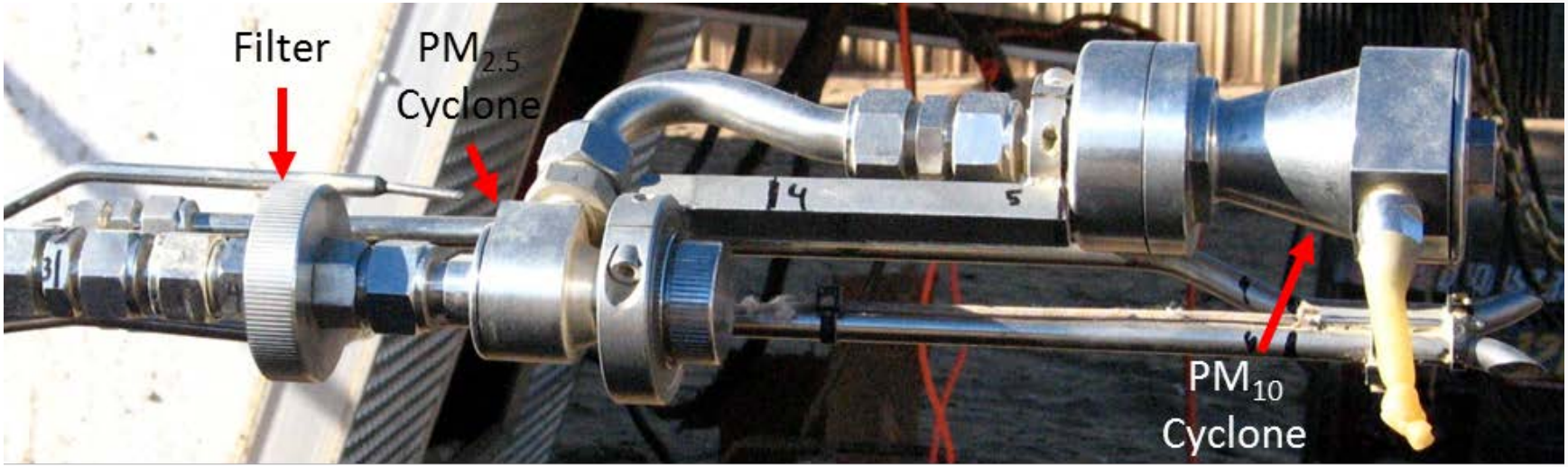


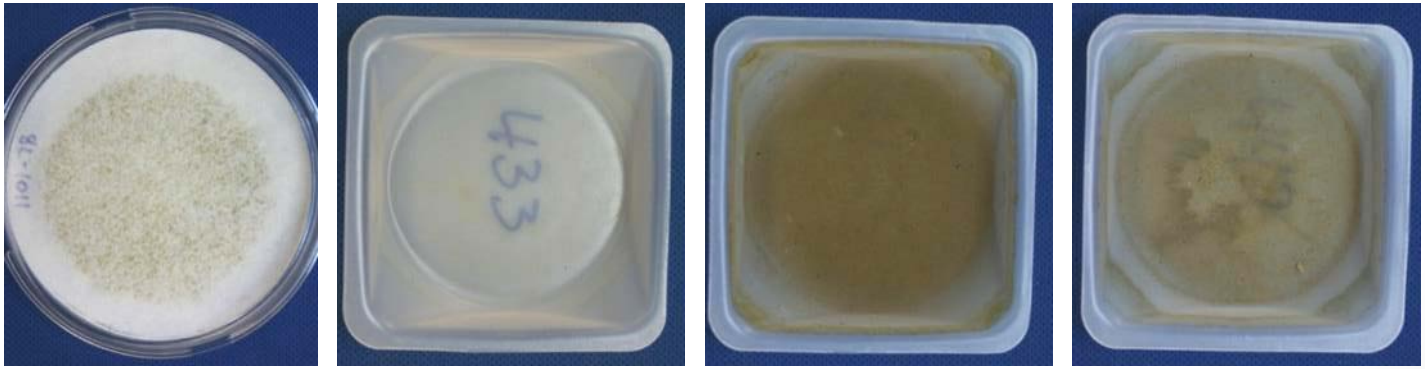
- Sampling
  - Stack Sampling: all unique emissions points
    12 to 15 days for stack sampling (est. 16 hrs/day)
  - Ambient Sampling: 125 sampling point array
    - 10 to 15 days (24 hrs/day)
  - Ambient and stack sampling will overlap

Stack Sampling

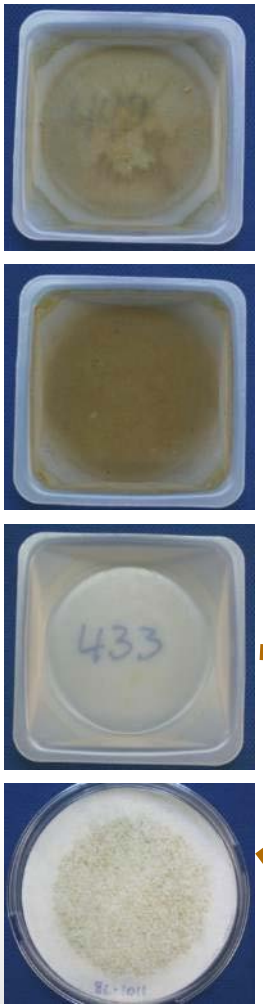


$PM_{2.5}$ Stack Sampling





$PM_{2.5}$ Stack Sampling

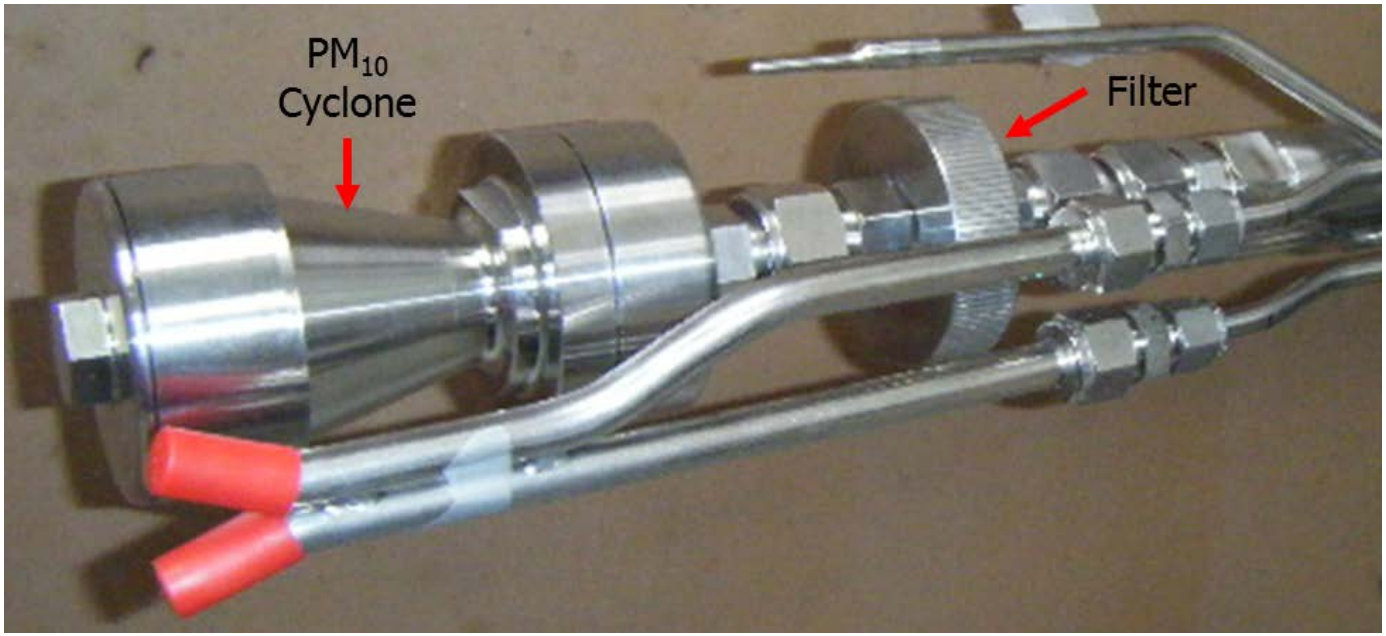


Total Particulate – sum the mass of all 4 samples

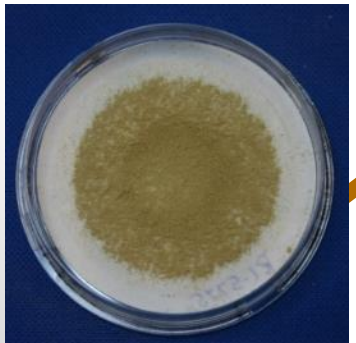
PM_{10} – sum of the mass from the filter, back half of the $PM_{2.5}$ cyclone, and the back half of the PM_{10} cyclone

$PM_{2.5}$ – sum the mass from the filter and back half of the $PM_{2.5}$ cyclone

PM_{10} Stack Sampling



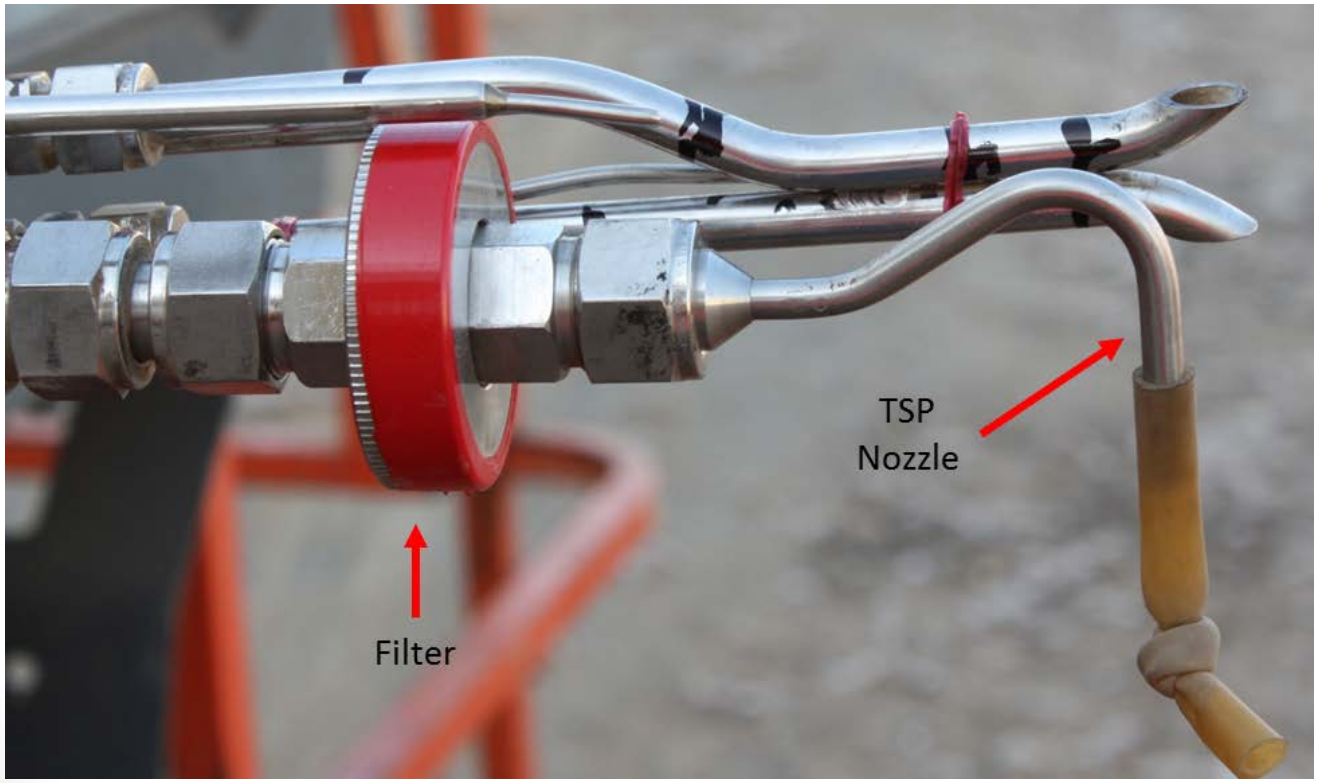
PM_{10} Stack Sampling

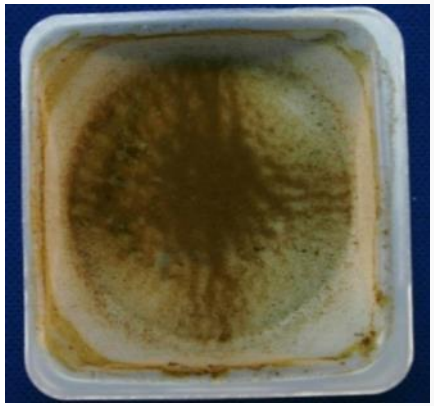


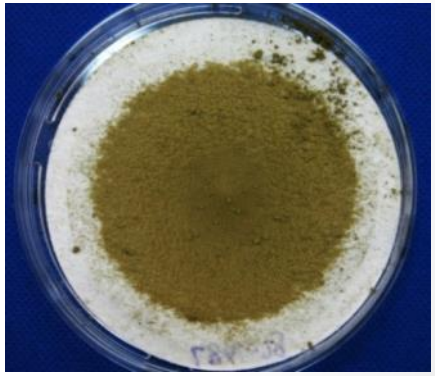
Total Particulate – sum the mass of all 3 samples

PM_{10} – sum of the mass from the filter and back half of the PM_{10} cyclone

Total Particulate Stack Sampling



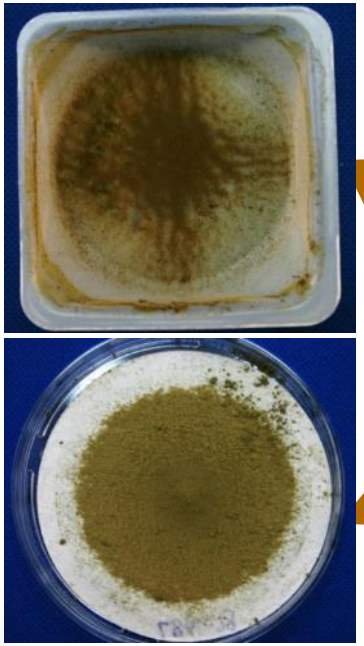


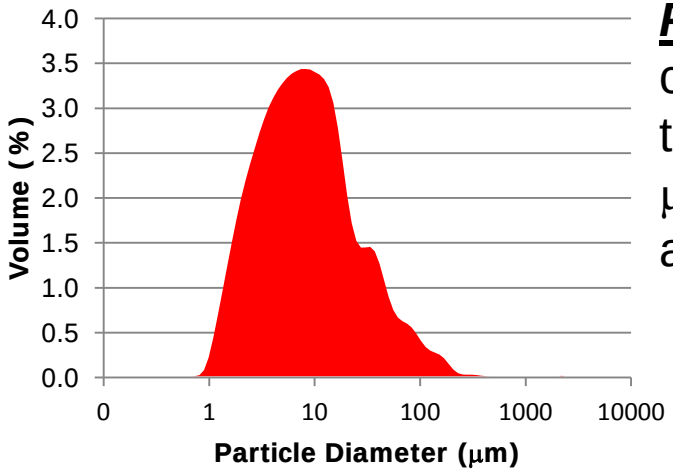


Isokinetic sampling

100 ± 10% for valid total particulate test runs

Total Particulate Stack Sampling





Total Particulate – sum the mass of both samples

$PM_{2.5}$ – total particulate concentration times % of the particles less than 2.5 μm from the particle size analysis

PM_{10} – total particulate concentration times % of the particles less than 10 μm from the particle size analysis

Stack Sampling Data Collected

- There were a total of 594 test runs

Test Method	Test Run Emission Factors		
	$PM_{2.5}$	PM_{10}	Total PM
OTM 27 w/PM_{10} and $PM_{2.5}$ Sizing Cyclones	198	198	198
Method 201a (pre-12/2010) w/PM_{10} Sizing Cyclone		198	198
Method 17			198
Particle Size Analysis	198	198	
Total	396	594	594

68 Technical Reports Completed

Particle Size Distribution Characteristics of Cotton Gin 1st Stage Seed-Cotton Cleaning System Total Particulate Emissions

Part of the National Characterization of Cotton Gin Particulate Matter Emissions Project

Final Report: OSU13-02 Ver. 2.0
December 2013 (Revised June 2014)

Submitted to:
San Joaquin Valley Air Pollution Study Agency
Cotton Incorporated
Cotton Foundation
National Cotton Ginners Association
Southern Cotton Ginners Association
Southeastern Cotton Ginners Association
California Cotton Growers and Ginners Association
Texas Cotton Ginners Association

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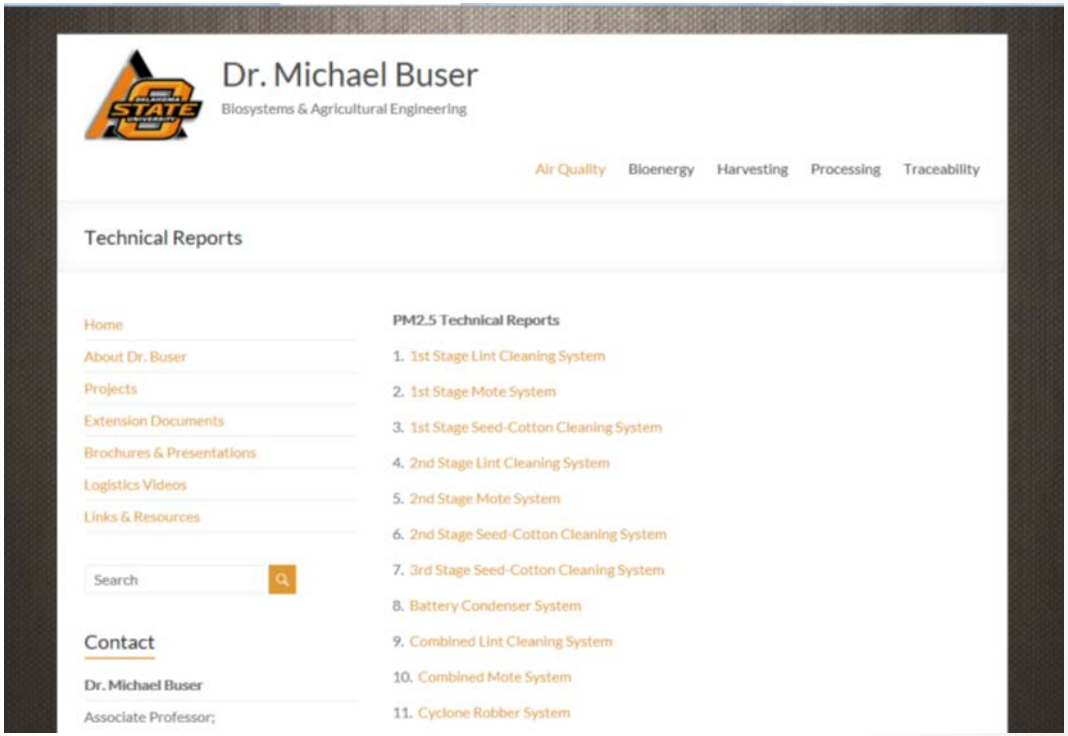


http://buser.okstate.edu/air-quality/cotton-gin/technical-reports/

EPA's 2013 Emission Factor Development Procedures

- Data screening
  - Inconsistent gin operation
  - Lab errors
  - Statistical outliers - residual analysis
- Data Quality- Individual Test Rating (ITR)
  - Submitter review- document inclusion
  - Regulatory review- quality of documentation
- Factors rated by "representativeness" of industry
  - Poorly
  - Moderately
  - Highly
- Non EPA-approved methods allowed
- No geographic considerations

ITR Development

Supporting documentation and regulatory agency review questions

	Agency Data Quality Rating	Score	2
	Supporting Documentation Provided	**Response**	
1	As described in ASTM D7036-12 Standard Practice for Competence of Air Emission Testing Bodies, does the testing firm meet the criteria as an AETB or is the person in charge of the field team a QI for the type of testing conducted? A certificate from an independent organization (e.g., STAC, CARB, NELAP) or self declaration provides documentation of competence as an AETB.	Yes	
2	Was a representative of the regulatory agency on site during the test?	No	
3	Is a description and drawing of test location provided?	N/A	
4	Is there documentation that the source or the test company sought and obtained approval for deviations from the published test method prior to conducting the test or that the tester's assertion that deviations were not required to obtain data representative of operations that are typical for the facility?		
5	Were all test method deviations acceptable?		
6	Is a full description of the process and the unit being tested (including installed controls) provided?		
7	Has a detailed discussion of source operating conditions, air pollution control device operations and the representativeness of measurements made during the test been provided?		

Individual Test Rating

Gin *N* Test

Submitter questions- 16

Regulatory review questions- 47

Emission Factor and Quality Calculation

- Sort ITR in descending order
- Use ITRs to calculate Composite Test Rating (CTR)

$$CTR = \left[\frac{\sum_{i=1}^{n}\left(\frac{1}{ITR}\right)^2}{N}\right]^{-0.5}$$

- Use CTR to calculate Factor Quality Index (FQI)

$$FQI = \frac{100}{CTR * N^{0.5}}$$

- Use FQI to determine factor representativeness
  - Poorly representative: FQI > 0.5774
  - Moderately representative: 0.3015 < FQI < 0.5774
  - Highly representative: FQI < 0.3015

Emission Factors Based on EPA's 2013 Development Procedures (National Study Data Only)

System	$PM_{2.5}$ Emission Factor†	$PM_{2.5}$ Rating*	PM_{10} Emission Factor†	PM_{10} Rating*	Total PM Emission Factor†	Total PM Rating*
Unloading	0.0221	P	0.1034	M	0.1284	M
1st Stage Seed Cotton Cleaning	0.0081	M	0.0847	H	0.1360	H
2nd Stage Seed Cotton Cleaning	0.0036	M	0.0376	M	0.0559	H
3rd Stage Seed Cotton Cleaning	0.0040	P	0.0209	M	0.0257	M
1st Stage Lint Cleaning	0.0085	M	0.0599	M	0.0813	H
2nd Stage Lint Cleaning	0.0048	M	0.0197	M	0.0334	H
Combined Lint Cleaning	0.0138	M	0.1369	M	0.2459	M
1st Stage Mote	0.0039	M	0.0203	M	0.0286	H
2nd Stage Mote	0.0022	M	0.0097	M	0.0121	H
Combined Mote	0.0095	P	0.1012	M	0.1403	M
Battery Condenser	0.0035	M	0.0181	H	0.0352	H
Cyclone Robber	0.0016	P	0.0078	M	0.0171	M
Mote Cyclone Robber	0.0043	P	0.0264	M	0.0452	M
Master Trash	0.0044	M	0.0559	M	0.1611	H
Overflow (Distributer)	0.0041	M	0.0218	M	0.0385	H
Mote Cleaner	0.0130	P	0.0598	M	0.1003	M
Mote Trash	0.0011	P	0.0107	M	0.0190	M
Typical Gin	0.0692		0.5596		0.9413	
Typical Gin (split lint cleaning and mote systems)	0.0653		0.4310		0.7105	

* P – Poorly, M – Moderately, H – Highly

† **kg/bale**

Comparison to 2013 National Study Technical Reports and 1996 AP-42

	Percent difference from				
	$PM_{2.5}$		PM_{10}		Total PM
System	National Study	1996 AP-42	National Study	1996 AP-42	National Study
Unloading	-0.4	90	-3.8	-2.4	-4.4
1st Stage Seed Cotton Cleaning	-1.0	56	-13	-17	-10
2nd Stage Seed Cotton Cleaning	0.2	-11	-4.7	-49	-4.5
3rd Stage Seed Cotton Cleaning	-0.4	40	9.7	-40	9.0
1st Stage Lint Cleaning	-1.2	-	45	-	16
2nd Stage Lint Cleaning	-3.7	-	11	-	47
Combined Lint Cleaning	1.2	26	-9.1	-6.5	16
1st Stage Mote	-5.4	-	1.6	-	12.8
2nd Stage Mote	-13	-	19	-	16
Combined Mote	-0.3	72	3.8	10	-3.6
Battery Condenser	-5.1	185	11	99	10.9
Cyclone Robber	-13	-67	-22	-79	-16.3
Mote Cyclone Robber	-6.3	-	-4.6	-	-10.3
Master Trash	5.4	66	0.1	-34	-13
Overflow (Distributer)	2.9	85	66	19	35
Mote Cleaner	264	-	21	-	-4.7
Mote Trash	0.5	12	-5.7	-46	7.4
Typical Gin	0.2	50	-3.2	-14	-0.7
Typical Gin (Split lint cleaning and mote systems)	-5.5	16	-25	-35	-25

EPA's Current Method for Incorporating 1996 AP-42 Data

- Current AP-42 source test ratings converted to ITR
  - A = 80
  - B = 60
  - C = 45
  - D = 30

	A	B	C	E	F	G	H
1							
2					Emissions Factor		0.3017191
3	Individual Test Value	ITR	N	CTR	FQI	Use for EF Average?	EF Representativeness
4	0.22367	100	1	100.00	1.0000	Yes	Poorly
5	0.260414	100	2	100.00	0.7071	Yes	Poorly
6	0.663662	100	3	100.00	0.5774	Yes	Moderately
7	0.107266	100	4	100.00	0.5000	Yes	Moderately
8	0.483476	100	5	100.00	0.4472	Yes	Moderately
9	0.071825	100	6	100.00	0.4082	Yes	Moderately
10	0.043	60	7	89.30	0.4232	No	
11	0.062	60	8	83.21	0.4249	No	
12	0.011	60	9	79.24	0.4207	No	
13	0.16	60	10	76.45	0.4137	No	
14	0.22	60	11	74.37	0.4054	No	
15	0.93	60	12	72.76	0.3967	No	

- Excluded from emission factor calculation:
  - PM_{10} - 100%
  - Total PM - 33%

Incorporation of 1996 AP-42 Data

- Rating current AP-42 data with ITR methodology
- PM_{10}:
  - 80 – 100: 78%
  - 60 – 80: 15%
  - < 60: 7% (excluded)
- Total PM:
  - 80 – 100: 80%
  - 60 – 80: 11%
  - < 60: 9% (excluded)

	A	B	C	E	F	G	H
1							
2					Emissions Factor		0.2696929
3	Individual Test Value	ITR	N	CTR	FQI	Use for EF Average?	EF Representativeness
4	0.22367	100	1	100.00	1.0000	Yes	Poorly
5	0.260414	100	2	100.00	0.7071	Yes	Poorly
6	0.663662	100	3	100.00	0.5774	Yes	Moderately
7	0.107266	100	4	100.00	0.5000	Yes	Moderately
8	0.483476	100	5	100.00	0.4472	Yes	Moderately
9	0.071825	100	6	100.00	0.4082	Yes	Moderately
10	0.043	89	7	98.18	0.3850	Yes	Moderately
11	0.93	87	8	96.54	0.3662	Yes	Moderately
12	0.16	85	9	95.02	0.3508	Yes	Moderately
13	0.011	85	10	93.86	0.3369	Yes	Moderately
14	0.22	73	11	91.19	0.3306	Yes	Moderately
15	0.062	72	12	88.98	0.3244	Yes	Moderately

Determine Additional Data Needs

- Tests needed using final CTR (combined with 1996 AP-42)
  - Moderately representative:

$$N = 30{,}000 * CTR^{-2}$$

NOTE: Only 7 systems were poorly representative ($PM_{2.5}$)

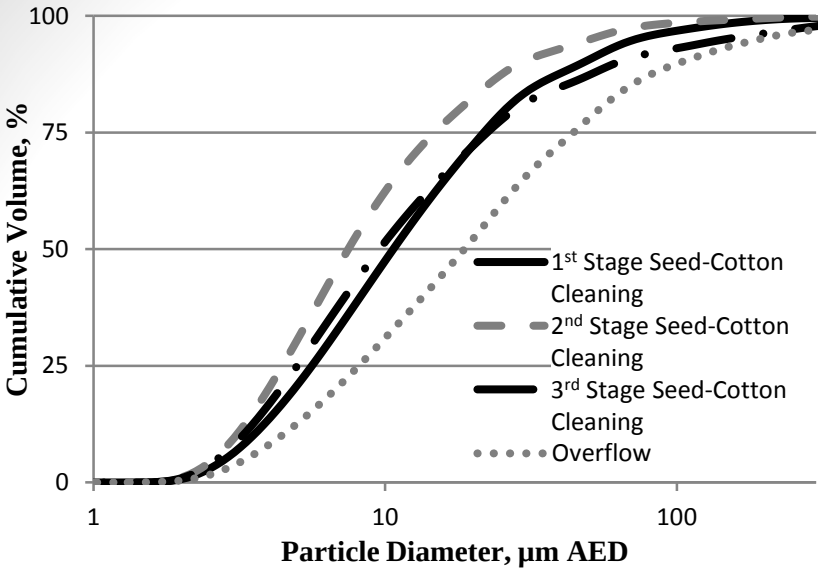
  - Highly representative:

$$N = 110{,}000 * CTR^{-2}$$

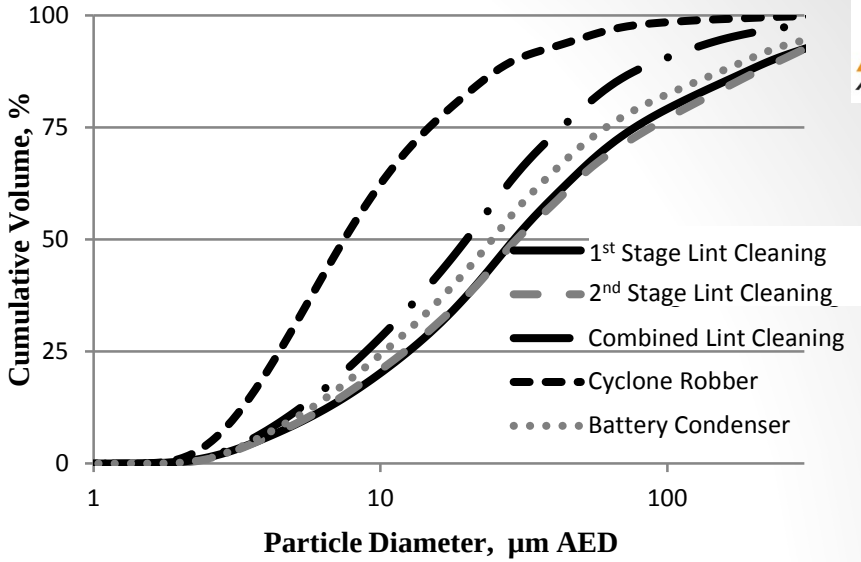
System	Additional *N* Needed for "Highly Representative"		
	$PM_{2.5}$	PM_{10}	Total PM
Unloading	9	2	-
1st Stage Seed Cotton Cleaning	5	-	-
2nd Stage Seed Cotton Cleaning	7	-	-
3rd Stage Seed Cotton Cleaning	10	7	5
1st Stage Lint Cleaning	8	4	-
2nd Stage Lint Cleaning	8	4	-
Combined Lint Cleaning	8	2	-
1st Stage Mote	7	1	-
2nd Stage Mote	7	1	-
Combined Mote	9	-	-
Battery Condenser	6	-	-
Cyclone Robber	9	6	2
Mote Cyclone Robber	9	6	5
Master Trash	6	1	-
Overflow (Distributer)	8	2	-
Mote Cleaner	9	7	8
Mote Trash	9	6	4
Total	134	49	24

Particle Size Distribution

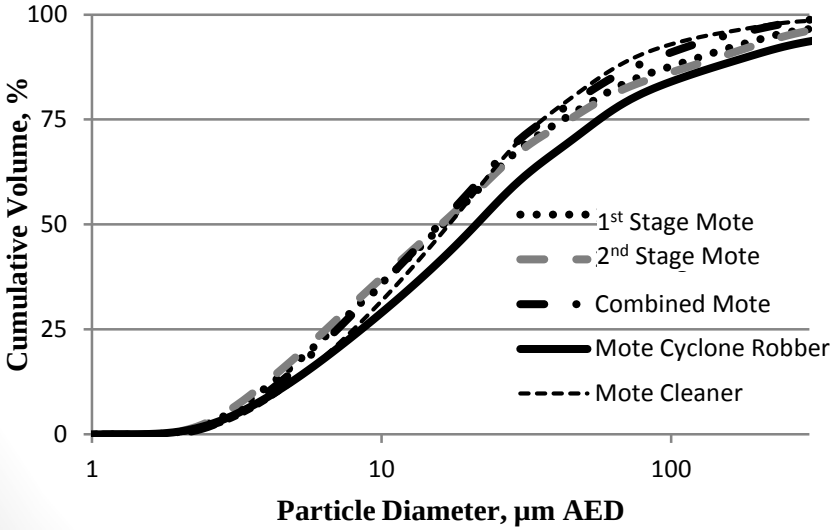
System	Test Runs	MMD	% < 2.5 µm	% < 6 µm	% < 10 µm
Unloading	9	8.0	3.24	36.1	59.6
1st Stage Seed Cotton Cleaning	21	10.7	2.99	27.5	47.5
2nd Stage Seed Cotton Cleaning	15	12.2	2.42	25.1	43.2
3rd Stage Seed Cotton Cleaning	6	9.6	3.84	32.2	51.5
1st Stage Lint Cleaning	10	29.2	1.39	11.1	20.2
2nd Stage Lint Cleaning	5	29.8	1.04	11.4	20.9
Combined Lint Cleaning	9	19.9	1.50	15.3	28.2
1st Stage Mote	14	16.4	2.49	21.6	36.0
2nd Stage Mote	15	16.1	2.87	23.0	37.3
Combined Mote	6	15.8	1.75	20.4	35.7
Battery Condenser	18	24.5	1.11	13.2	24.3
Cyclone Robber	9	20.3	2.10	17.5	30.3
Mote Cyclone Robber	9	21.2	2.20	16.9	29.0
Master Trash	15	20.6	1.86	14.0	25.7
Overflow (Distributer)	12	18.7	1.67	17.0	31.0
Mote Cleaner	6	17.1	1.53	17.1	31.8
Mote Trash	6	23.9	1.75	13.3	24.2



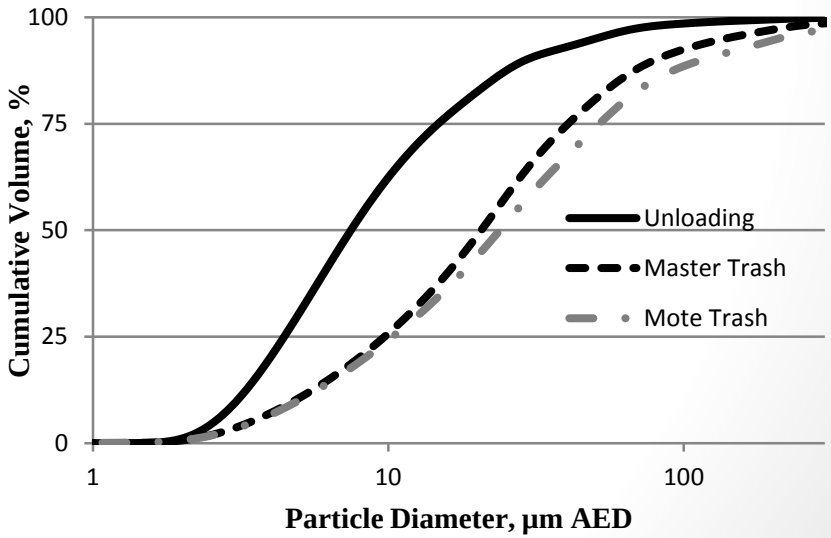
Pre-cleaning systems



Lint cleaning systems



Mote systems



Unloading and trash systems

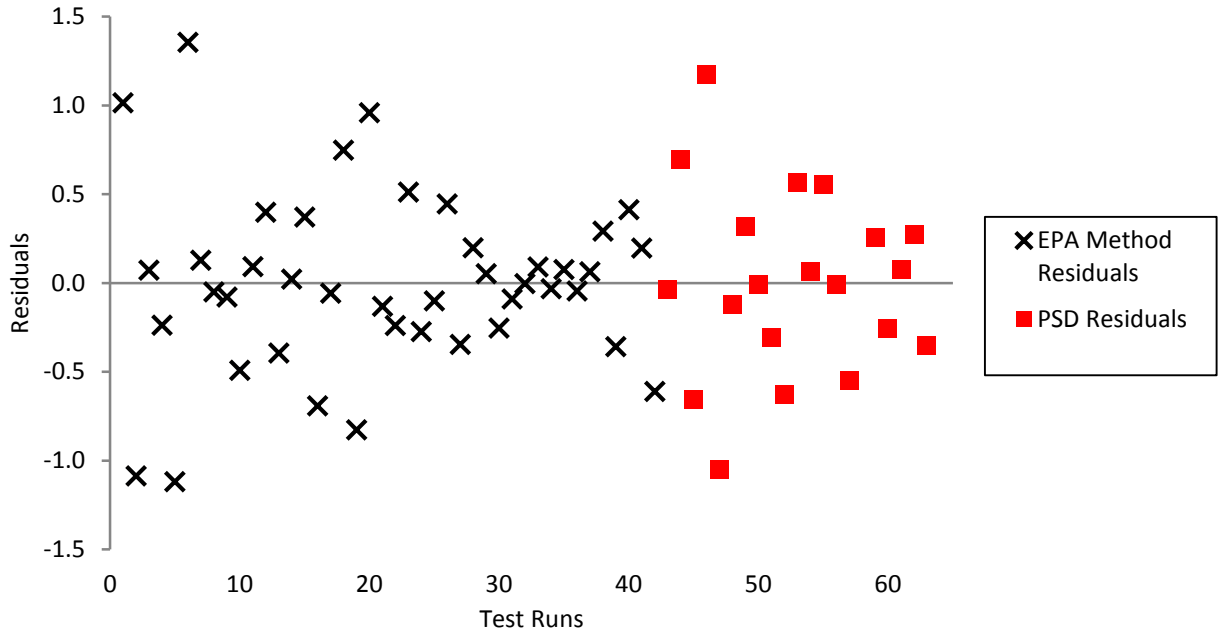
PSD Based Emission Factors

System	$PM_{2.5}$ Emission Factor†	PM_{6} Emission Factor†	PM_{10} Emission Factor†	Rating*
Unloading	0.0027	0.047	0.0536	P
1st Stage Seed Cotton Cleaning	0.0050	0.040	0.0643	M
2nd Stage Seed Cotton Cleaning	0.0013	0.015	0.0258	M
3rd Stage Seed Cotton Cleaning	0.0012	0.010	0.0135	P
1st Stage Lint Cleaning	0.0010	0.011	0.0148	M
2nd Stage Lint Cleaning	0.00031	0.0049	0.0050	P
Combined Lint Cleaning	0.0035	0.038	0.0552	M
1st Stage Mote	0.00064	0.0065	0.0091	M
2nd Stage Mote	0.00032	0.0030	0.0043	M
Combined Mote	0.0024	0.027	0.0517	P
Battery Condenser	0.00041	0.0049	0.0075	M
Cyclone Robber	0.00033	0.0045	0.0047	M
Mote Cyclone Robber	0.0013	0.0085	0.0167	P
Master Trash	0.0027	0.022	0.0395	M
Overflow (Distributer)	0.00075	0.0061	0.0105	M
Mote Cleaner	0.0013	0.018	0.0275	P
Mote Trash	0.00031	0.0029	0.0038	P
Typical Gin	0.0187	0.1998	0.3081	
Typical Gin (Split lint cleaning and mote systems)	0.0150	0.1605	0.2343	

* P – Poorly, M – Moderately, H – Highly †**kg/bale**

Combine EPA-Approved Method and PSD Data?

- No outliers based on residuals



- No outliers found by ProUCL
- PSD could be combined with EPA-approved methods

Emission Factor Conclusions

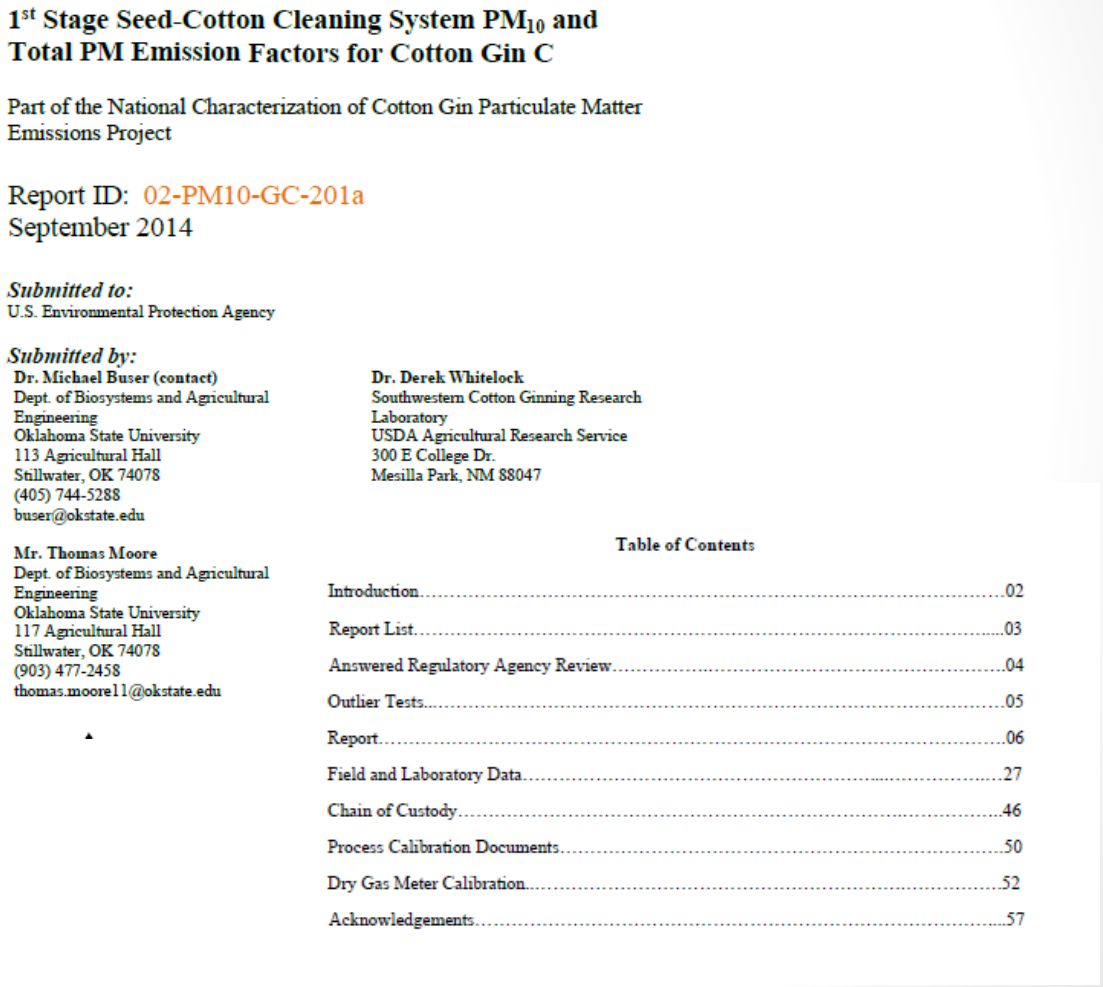
- AP-42 Section 9.7 cotton gin datasets could be expanded (pending EPA approval)
  - $PM_{2.5}$- 0 → 65
  - PM_{10}- 38 → 171
  - Total PM- 50 → 253
- Six additional systems could be added to the AP-42
  - Splitting combined lint cleaning and mote systems for typical gin reduced emission factors-
    - $PM_{2.5}$: 6.5%
    - PM_{10}: 16%
    - Total PM: 22%
- $PM_{2.5}$ emission factors
  - 59% moderately representative
  - 41% poorly representative

Emission Factor Conclusions

- If the 1996 AP-42 datasets have value, they must be rerated using ITR methodology
- Improved quality rating of PM_{10} and total PM emission factors
  - PM_{10}- 24% highly representative
  - Total PM- 71% highly representative
  - No poorly representative factors
- AP-42 Appendix B.1 cotton gin datasets could be expanded (pending EPA approval)
  - 2 systems → 17 systems
  - Particle size distribution characteristics
- Emission factors from Method 17 coupled with particle size analyses could be merged with AP-42 Section 9.7 emission factors based on statistical outlier analyses

Finalized Cotton Gin Study Recommended Emission Factors and Data Quality Rating Reports Submitted to EPA

- 280 technical reports
- Submitted: February 2015



1st Stage Seed-Cotton Cleaning System PM_{10} and Total PM Emission Factors for Cotton Gin C

Part of the National Characterization of Cotton Gin Particulate Matter Emissions Project

Report ID: 02-PM10-GC-201a
September 2014

Submitted to:
U.S. Environmental Protection Agency

Submitted by:

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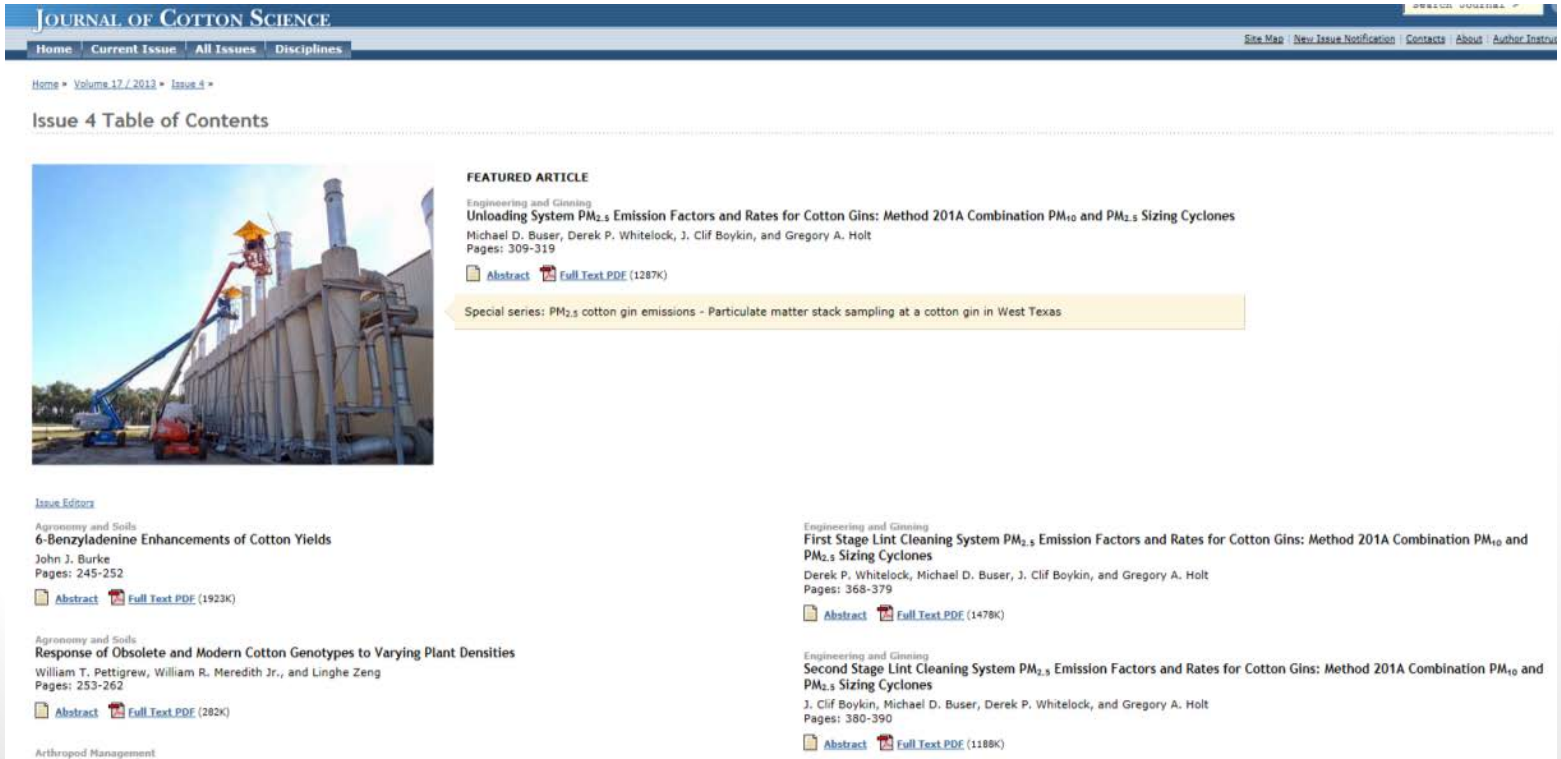
Table of Contents

http://buser.okstate.edu/air-quality/cotton-gin/technical-reports-sent-to-epa/

Journal of Cotton Science Manuscripts (Referred Journal Articles)

- 17-$PM_{2.5}$ manuscripts published Jan 2014
- 17-PM_{10} manuscripts published Sept 2014
- 17 total PM manuscripts published April 2015
- 17 PSD manuscripts published September 2015?



Project Objectives

1. Cotton gin emission factors (AP-42 Section 9.7)
   - Develop $PM_{2.5}$ emission factors
   - Update PM_{10} & Total PM emission factors
2. Characterize PM emitted from cotton gins (AP-42 Appendix B.1)
3. Develop a robust PM dispersion modeling data set

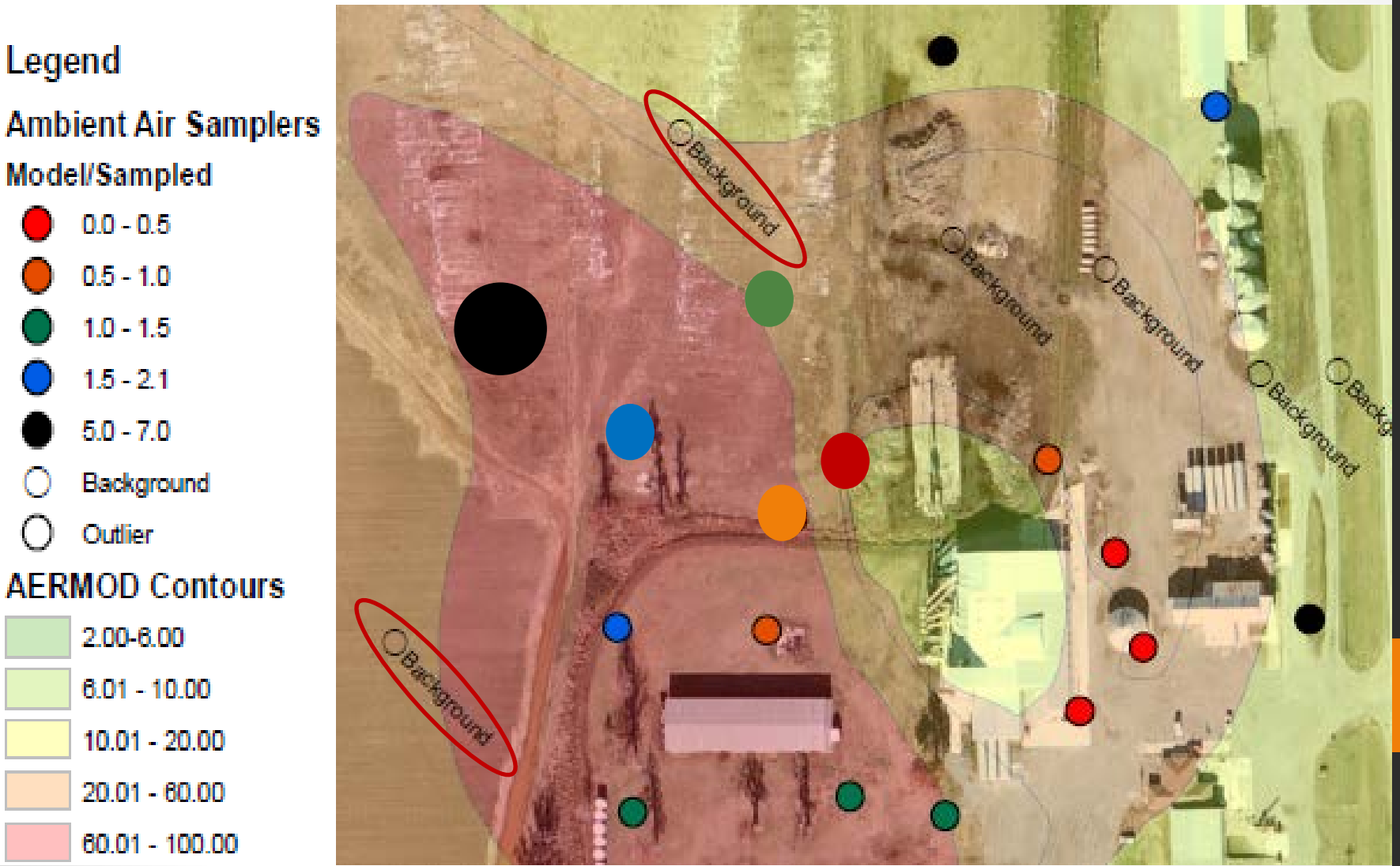
Status/Timeline

- Stack sampling data – ready
- Ambient sampling data – compiled
  - Error checking – 93% complete
- Meteorology data – 86% complete
- Structures data – 72% complete
- Modeling evaluation
  - Jason Throckmorton - M.S. student started Jan. 2015
    - Hope to have initial results to present at the 2016 Beltwide Cotton Conferences
  - Develop a modeling advisory group (August 2015 is the target deadline for forming this group):
    - EPA – Joel Huey?
    - Missouri DNR – Dawn Froning
    - TCEQ - ?
    - USDA NRCS – Greg Zwicke
    - Lakes Environmental – Dr. The'
    - Others

Dispersion Modeling Evaluations

- Models that will be evaluated:
  - AERMOD, AERSCREEN, ISC3, …
- Develop model specific concentration databases
  - Geospatial and temporal values will directly correspond to the measured ambient data
- Statistically compare the actual measured TSP concentrations and modeled TSP concentrations.
  - Effects of using on-site meteorology data versus local or region data
  - Can on-site wind field data set be used in explaining some of the differences between the modeled and measured concentrations?
  - Will using particle size data help?

Dispersion Modeling



National Cotton Ginning Particulate Matter Emissions Study Update

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and Michael D. Buser

Biosystems & Agricultural Engineering
Oklahoma State University

USDA Agricultural Air Quality Task Force
April 23, 2015