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Lignite Fuel Enhancement
EPRI ELECTRIC POWER RESEARCH INSTITUTE
U.S. DEPARTMENT OF ENERGY

Coal Creek Prototype Fluidized Bed Coal Dryer:

Performance Improvement, Emissions Reduction, and Operating Experience

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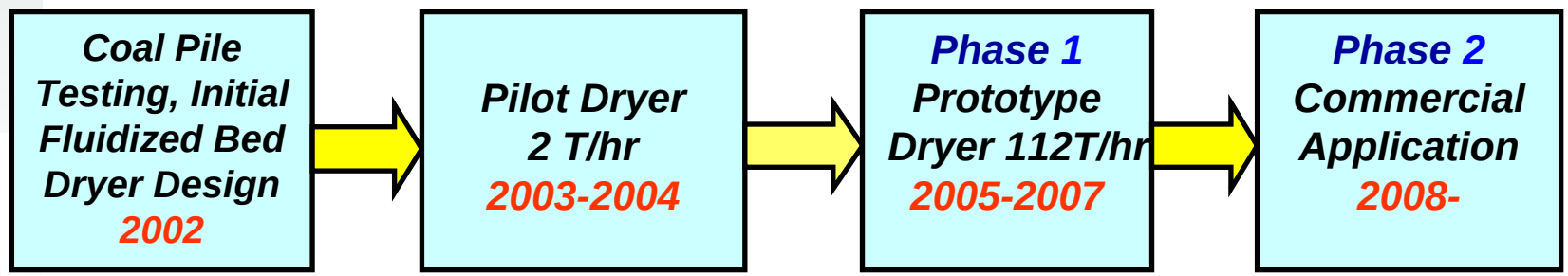
Introduction

- *Coal moisture has a large negative effect on boiler efficiency, station service power and unit heat rate.*
- *For a 600 MW lignite-fired unit, fuel moisture is responsible for:*
  - *9% higher coal flow rate*
  - *20 MW of station service power*
  - *20% higher flue gas flow rate*
  - *Increased operating and maintenance cost*
- *Can a low-temperature waste heat be used to reduce fuel moisture?*

Project Goals and Schedule

- **Goals and Objectives:**
  - *Reduce moisture content of lignite, PRB, and other high-moisture coals.*
  - *Use waste heat from the power plant.*
  - *Modify existing coal handling systems.*
  - *Increase competitive position of lignite-, PRB-, and other high moisture coal-fired power plants.*
  - *Reduce environmental impact of lignite-, PRB-, and other high-moisture coal-fired power plants*
- **Project Phases and Schedule:**



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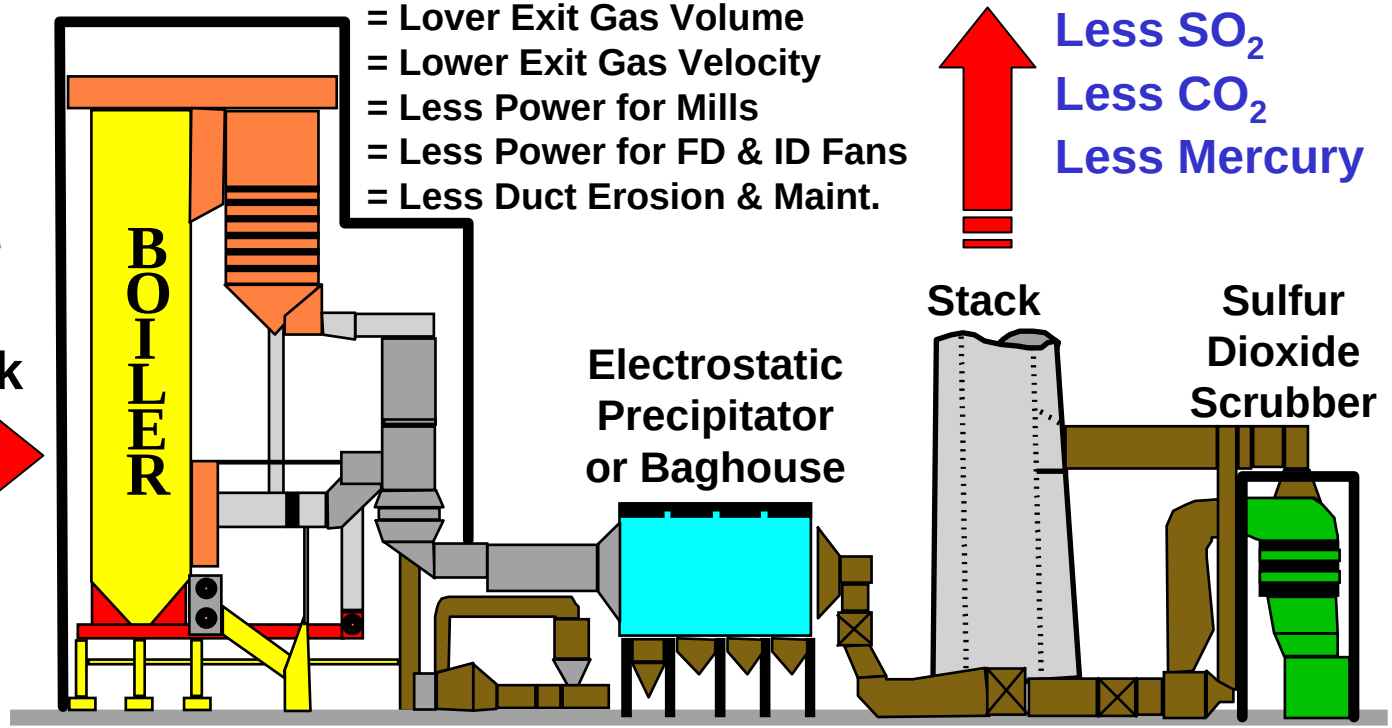
Lignite Fuel Enhancement: Incremental Moisture Reduction Project

Less Moisture:
= Lower Exit Gas Temperature
= Lover Exit Gas Volume
= Lower Exit Gas Velocity
= Less Power for Mills
= Less Power for FD & ID Fans
= Less Duct Erosion & Maint.

Less Ash
Less SO_2
Less CO_2
Less Mercury

Lower Moisture Lignite Feedstock



Increased Efficiency
More MW/Ton

Increased Efficiency
Less Flue Gas
Lower Velocity

Increased Efficiency
Less Flue Gas
Lower Velocity
Less Evaporation

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Previous Work

- **1997-1998**
  - *Preliminary studies and concept development*
- **1999**
  - *Lignite-drying tests at Coal Creek using low-temperature fixed-bed dryer.*
- **2000**
  - *Coal Creek boiler modeling*
  - *Laboratory lignite drying tests.*
  - *Full-scale test burns (20,000 tons of lignite dried using low-temperature air, and burned at Coal Creek).*
- **2001**
  - *Fluidized bed selected for coal drying*
  - *Laboratory drying tests at Lehigh University*
- **2002**
  - *Application filed with DOE under the Clean Coal Power Initiative (CCPI).*

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Previous Work

- **2003**
  - *Project selected for negotiation with DOE.*
  - *2 ton/hr pilot fluidized bed dryer built at Coal Creek with NDIC funding.*
  - *Pilot coal dryer testing at Coal Creek*
- **2004**
  - *Contract signed with DOE (Clean Coal Power Initiative).*
  - *DOE joined partnership under collaborative agreement.*
  - *Design of a prototype coal dryer and associate equipment.*
- **2005**
  - *Construction begins of a prototype coal dryer at Coal Creek Unit 2.*
- **2006**
  - *Prototype coal dryer checkout and start-up*
  - *Prototype coal dryer performance testing (in progress)*
  - *Unit performance testing (in progress)*
  - *August: **Phase 1 Milestone***

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Pilot Coal Dryer at Coal Creek

- *Pilot fluidized bed dryer was designed and operated to determine drying rates of North Dakota lignite.*
- *Low-temperature lignite drying process.*
- *No appreciable carbon oxidation, and devolatilization.*
- *No operational difficulties.*
- *Results showed it is possible to remove substantial fraction of S and Hg from the coal.*

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Description of Host Unit

- **Coal Creek Station:**
  - *1,200 MW lignite-fired*
  - *Two T-fired CE boilers*
  - *2,400 psig @ 1,000 ºF /1,000 ºF*
  - *Two single reheat GE G-2 turbines*
  - *3 Cooling towers*
  - *Fuel HHV = 6,200 BTU/lb*
  - *Fuel moisture = 38 percent*
  - *Coal fired = 900,000 lb/hr per unit*

Coal Creek Station

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Prototype Coal Drying System at Coal Creek

Prototype Coal Dryer

- Maximum capacity **112.5 t/hr**.
- Remove approx. ¼ of coal moisture.
  - Dry lignite from **38%** to **29.5%**.
  - Improve HHV from **6,200** to **7,045** BTU/lb
- Fully automated operation, integrated into the plant control system.
- Four patent applications on dryer design and control filed by GRE.

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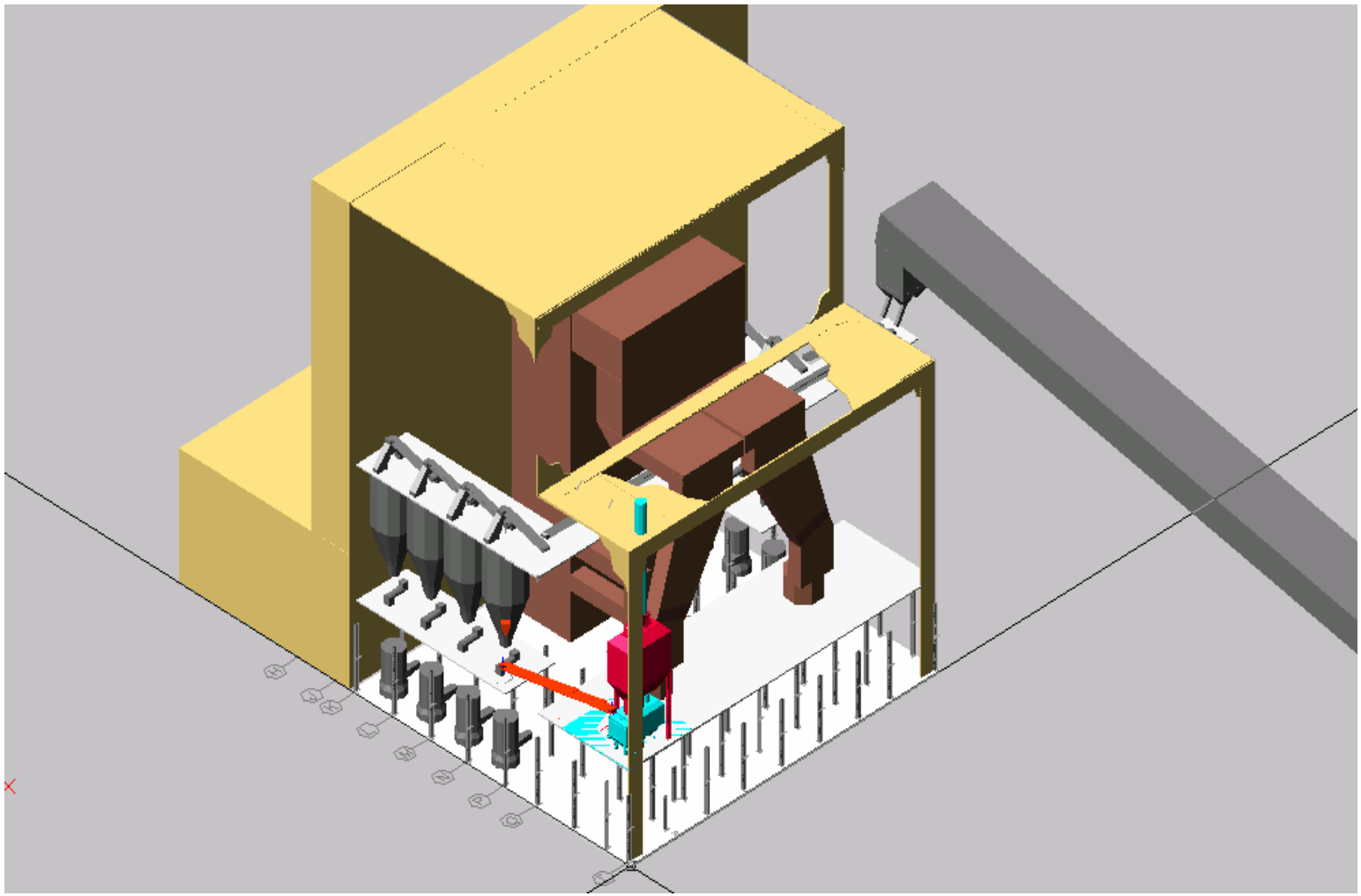
Prototype Dryer: Unit 2 East



Prototype Dryer Installation

Prototype CDS: Vibrating Coal Feeder

Prototype CDS: Feed Conveyer to Dryer

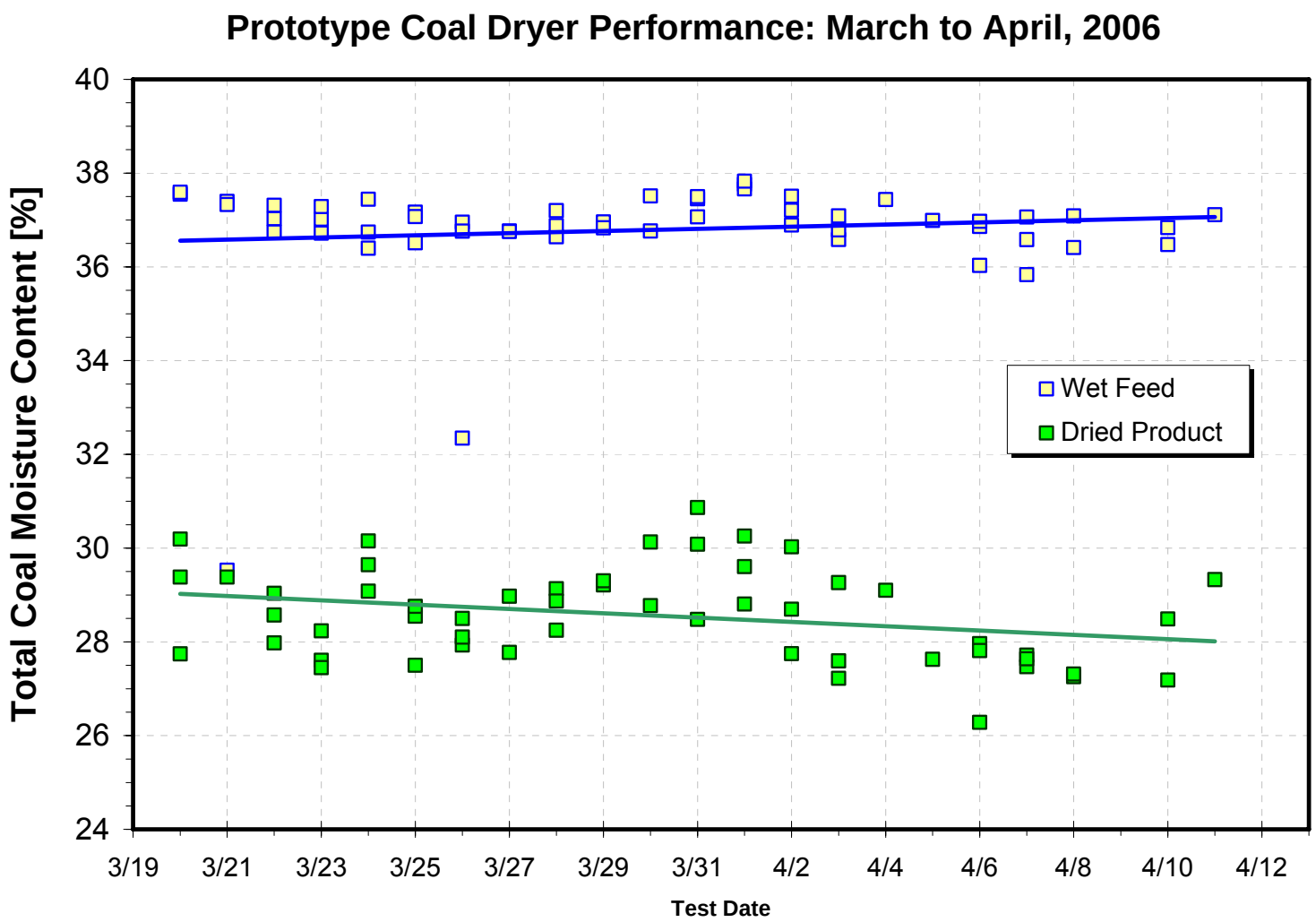
Prototype CDS: Fluidized Bed Coal Dryer

Prototype CDS Checkout, Start-Up, and Operation Summary

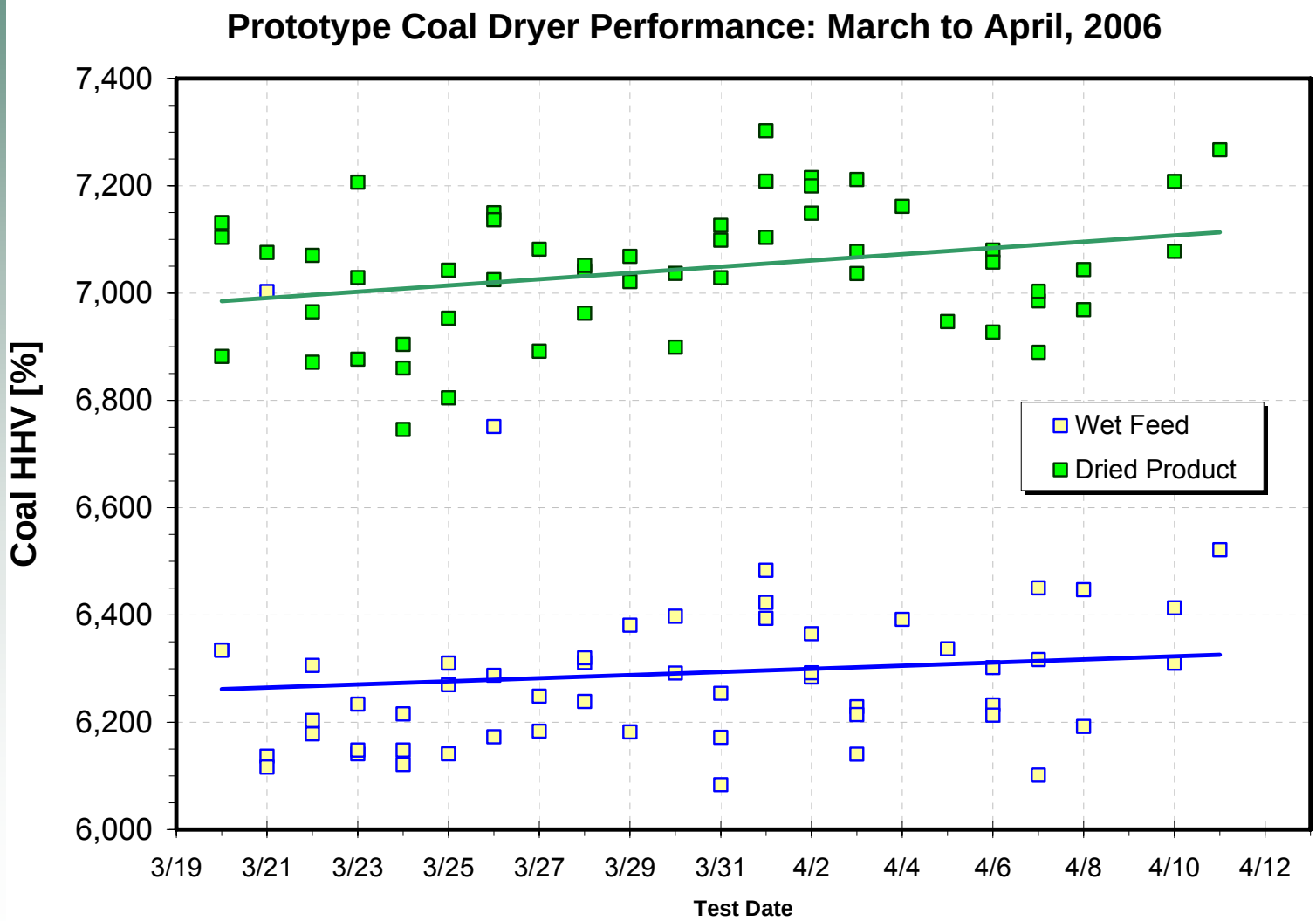
- Checkout and "shakedown" in December 2005.
  - No problems
- 1st coal on January 30th 2006.
- 7-hour daily tests
- Inspection on Feb11th,
  - No accumulation of material in the dryer
- Drying to 29.5%
- Segregator optimization Feb 27th to Mar 3rd 2006.
- Operator training before 24/7 operation
- Performance testing in March and April 2006.

Prototype Coal Dryer (CD26) Performance

CD26 Performance



CD26 Performance



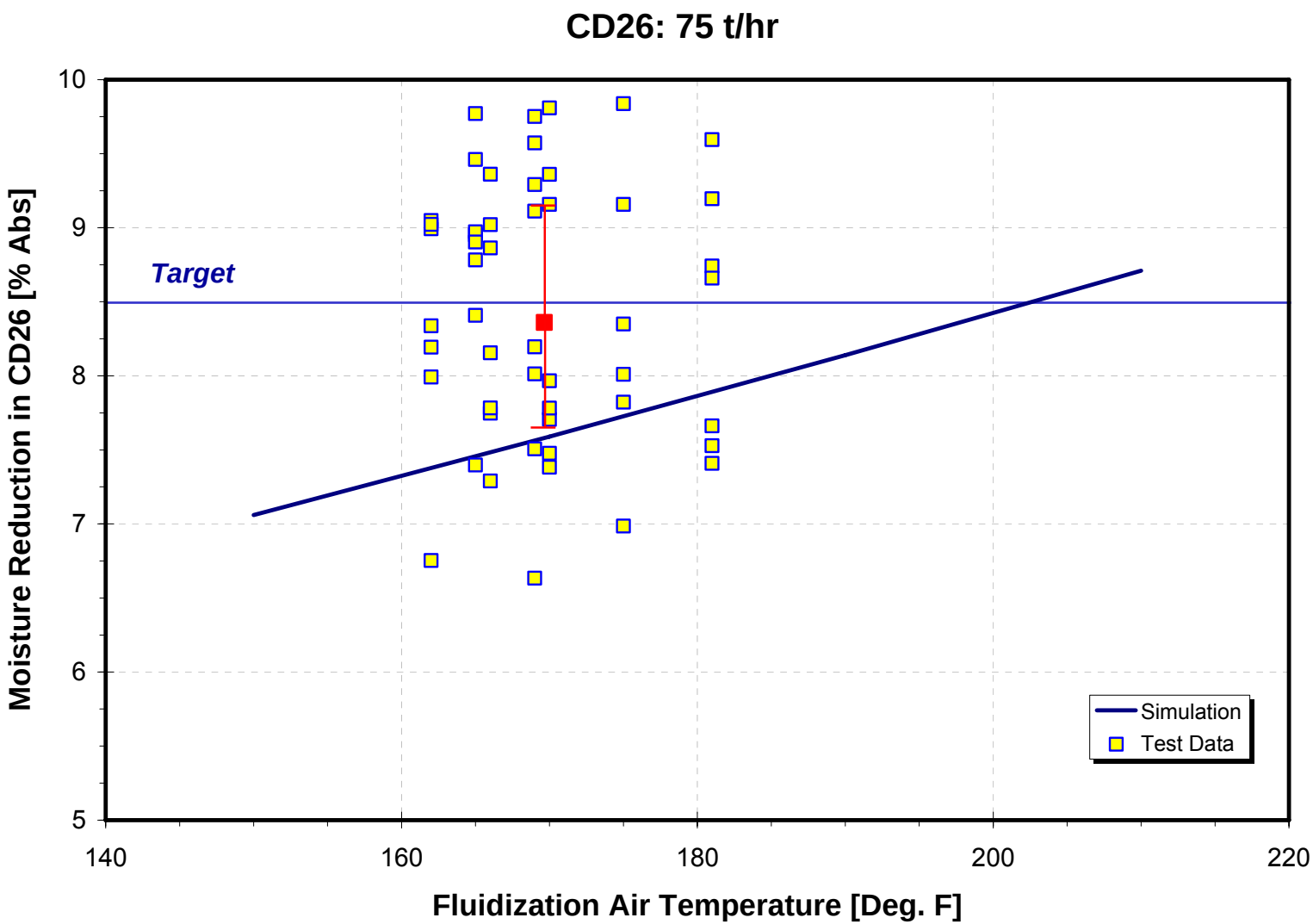
CD26 Performance

- *Feed rate: 75 tons/hr (14% of total)*

Parameter	Feed TM %	Product TM %	Change TM % Abs	Change TM % Rel
Average Total Moisture, TM	36.78	28.55	8.23	22.4
Std. Deviation	1.26	1.00	1.07	
Std. Deviation of the Mean	0.34	0.27	0.30	

Parameter	Feed HHV [BTU/lb]	Product HHV [BTU/lb]	Change HHV [BTU/lb]	Change HHV [%]
Average HHV	6,290	7,043	752	12.0
Std. Deviation	159	121	131	
Std.Deviation of the Mean	43	33	37	

CD26 Performance



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Unit Performance

Unit Performance: Summary

Parameter	Units	Coal Dryer in Service	Coal Dryer Out of Service	Change	Units of Change
Gross Power Output	MW	589	590	**NC**	
Throttle Steam Temperature	Deg. F	988	989	**NC**	
Reheat Steam Temperature	Deg. F	1,002	1,002	**NC**	
SHT Spray Flow	klbs/hr	46	52	**-6.4**	klbs/hr
Total Coal Flow Rate	klbs/hr	953	972	**-2.02**	%
Dried Coal	% of Total	14.62	0.00		
Stack Flow Rate	kscfm	1,611	1,626	**-0.96**	%
Specific Pulverizer Work	kJ/klb	4.09	4.29	**-4.65**	%
Total Pulverizer Power	kW	4,057	4,206	**-3.53**	%
NOx Mass Emissions	lb/hr	1,345	1,470	**-8.52**	%
SOx Mass Emissions	lb/hr	3,618	3,692	**-2.00**	%
APH 21 Gas Exit Temperature	Deg. F	353	362	**-8.6**	Deg. F
APH 22 Gas Exit Temperature	Deg. F	368	377	**-9.3**	Deg. F
Stack Temperature	Deg. F	180	184	**-4.2**	Deg. F

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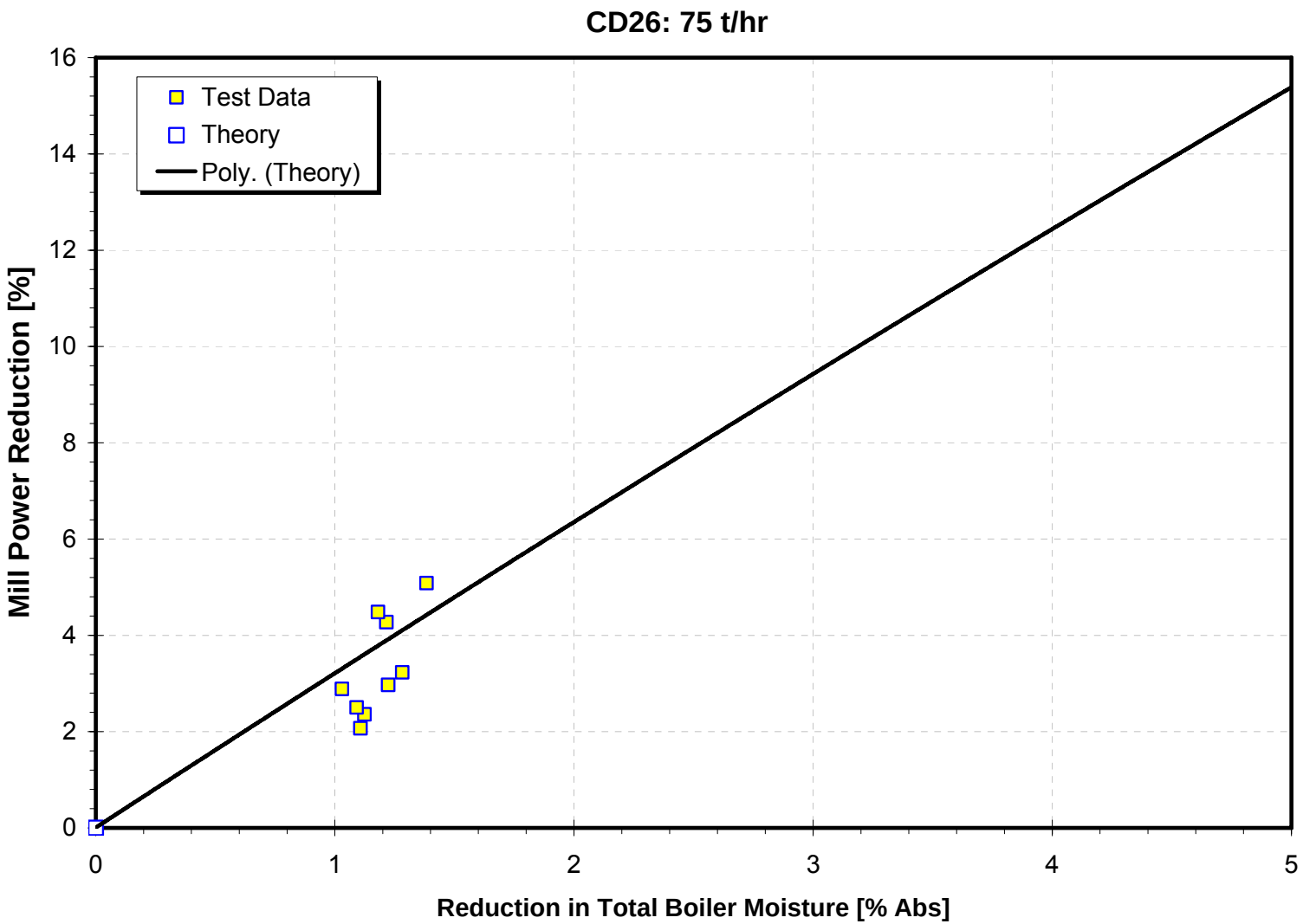
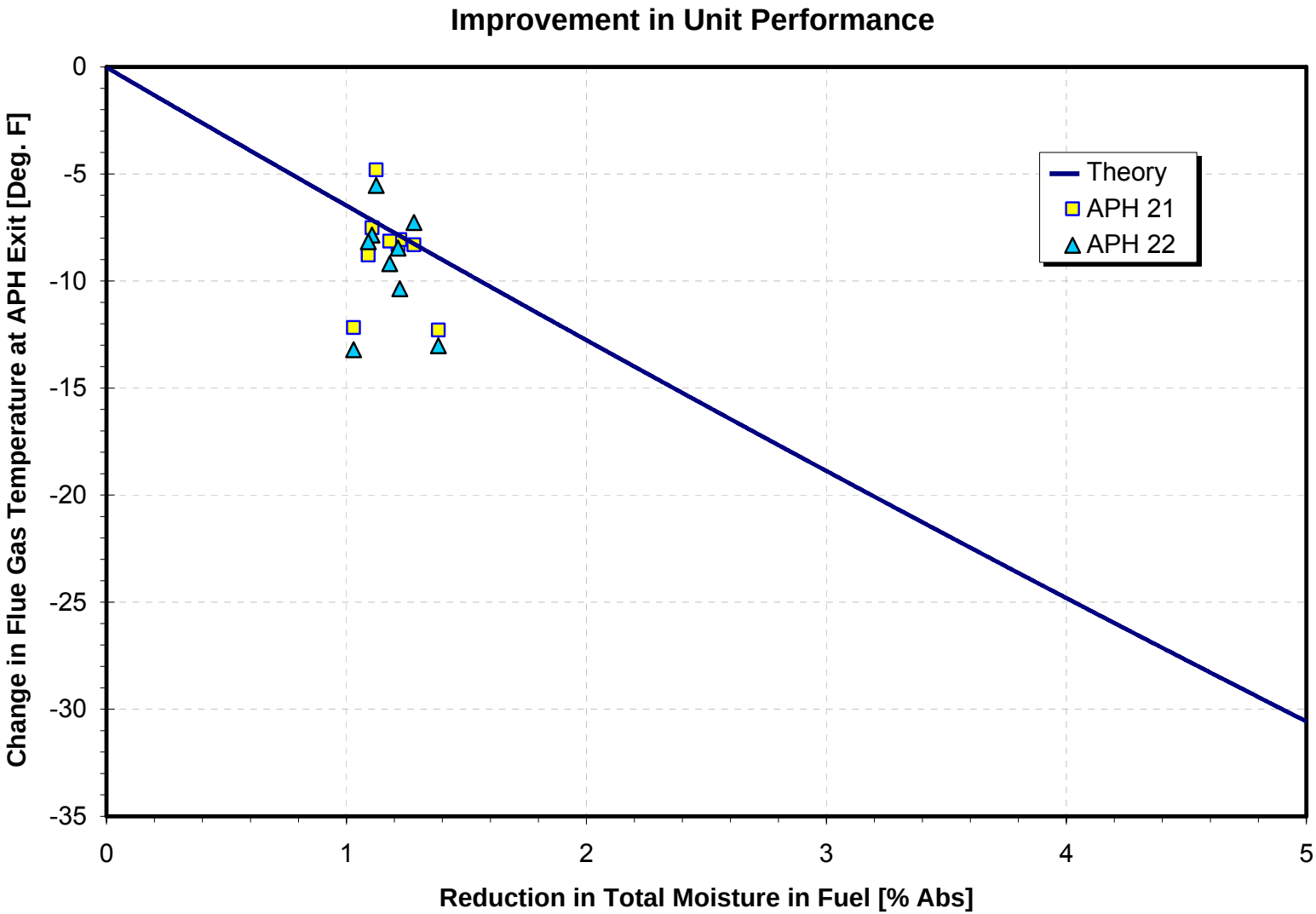
Mill Power Reduction



Decrease in APH Gas Outlet Temperature



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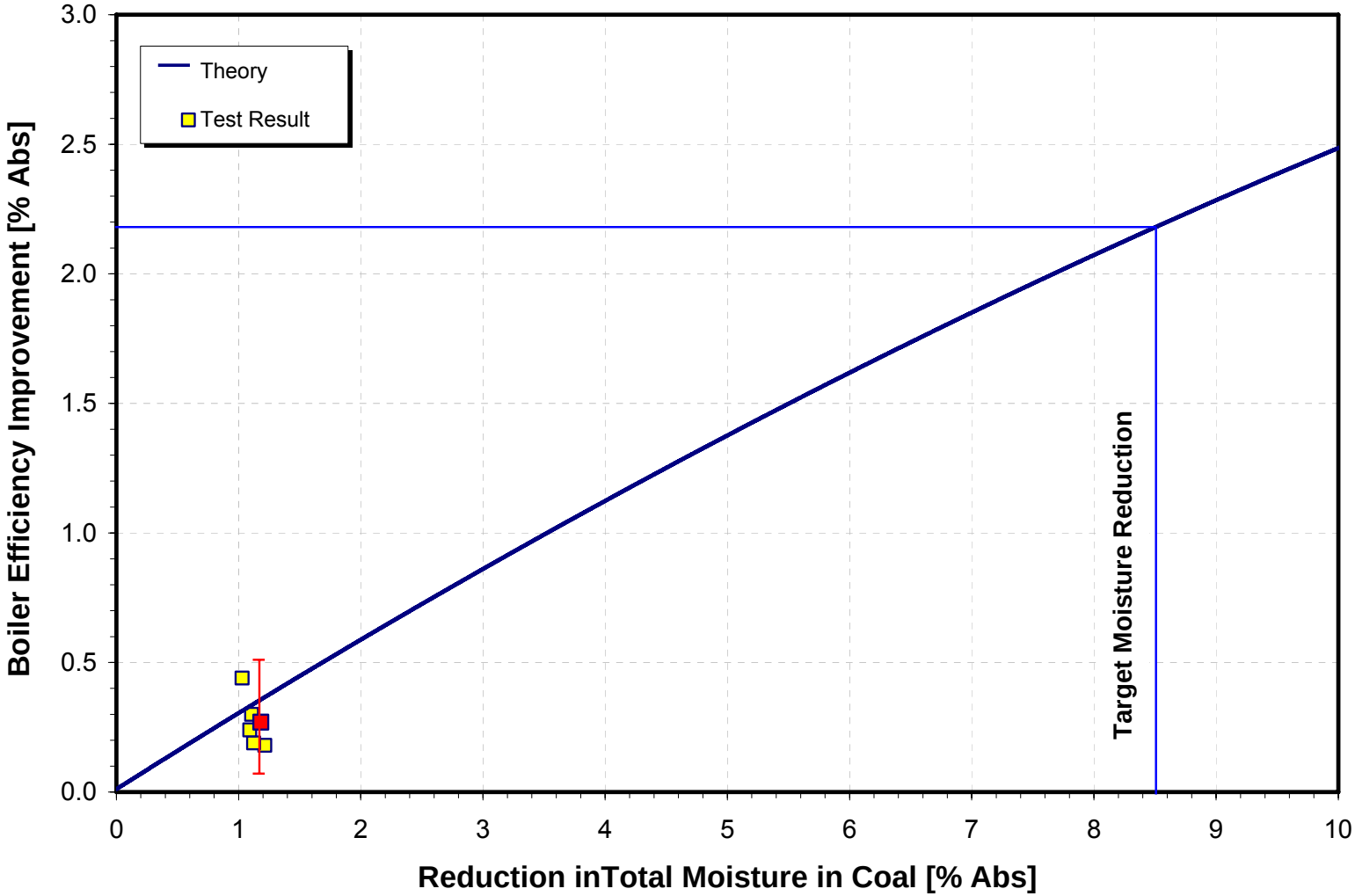
Boiler Efficiency Improvement



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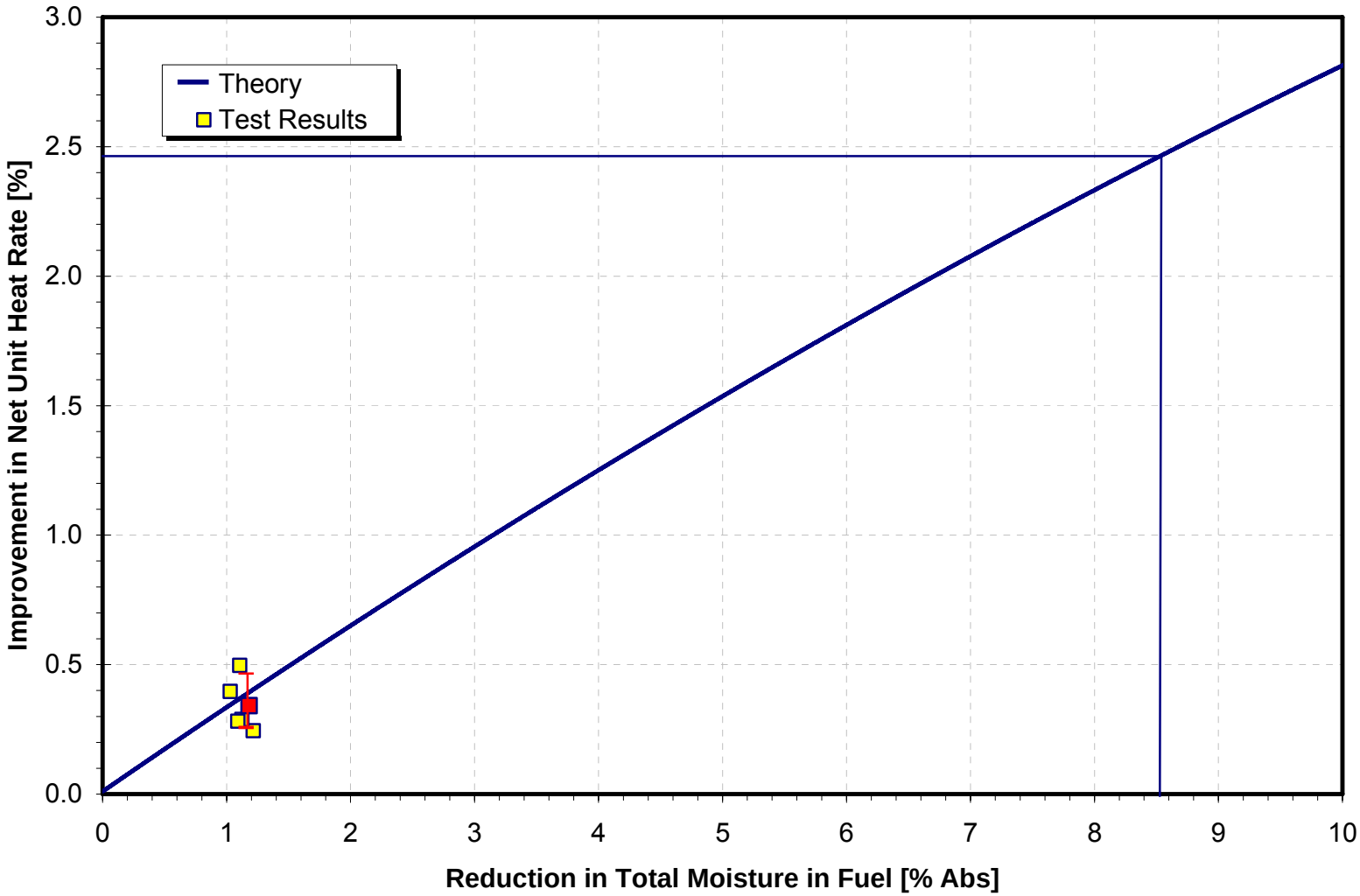
Unit Performance Improvement



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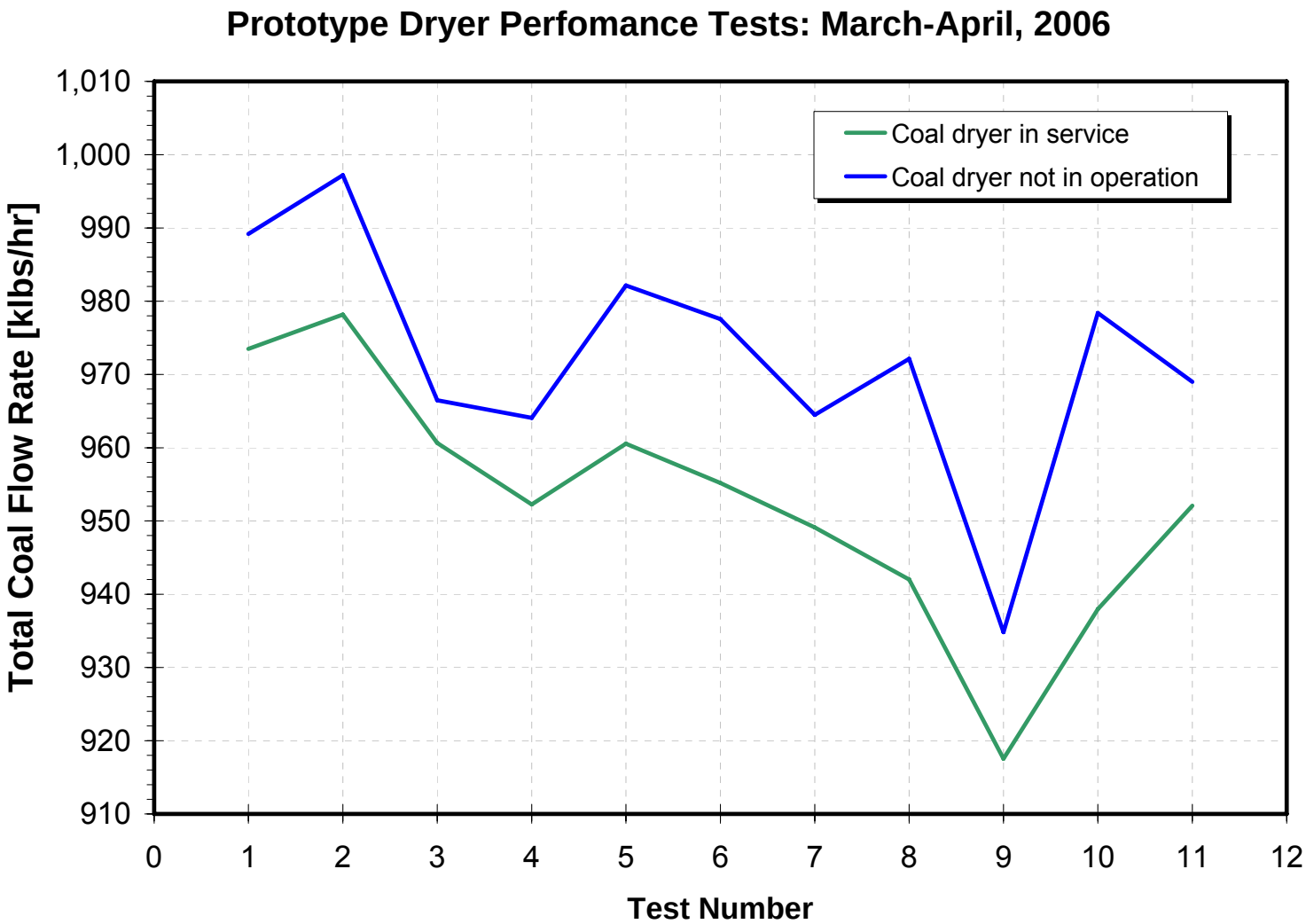
Test Data

Test Data: Coal Flow Rate



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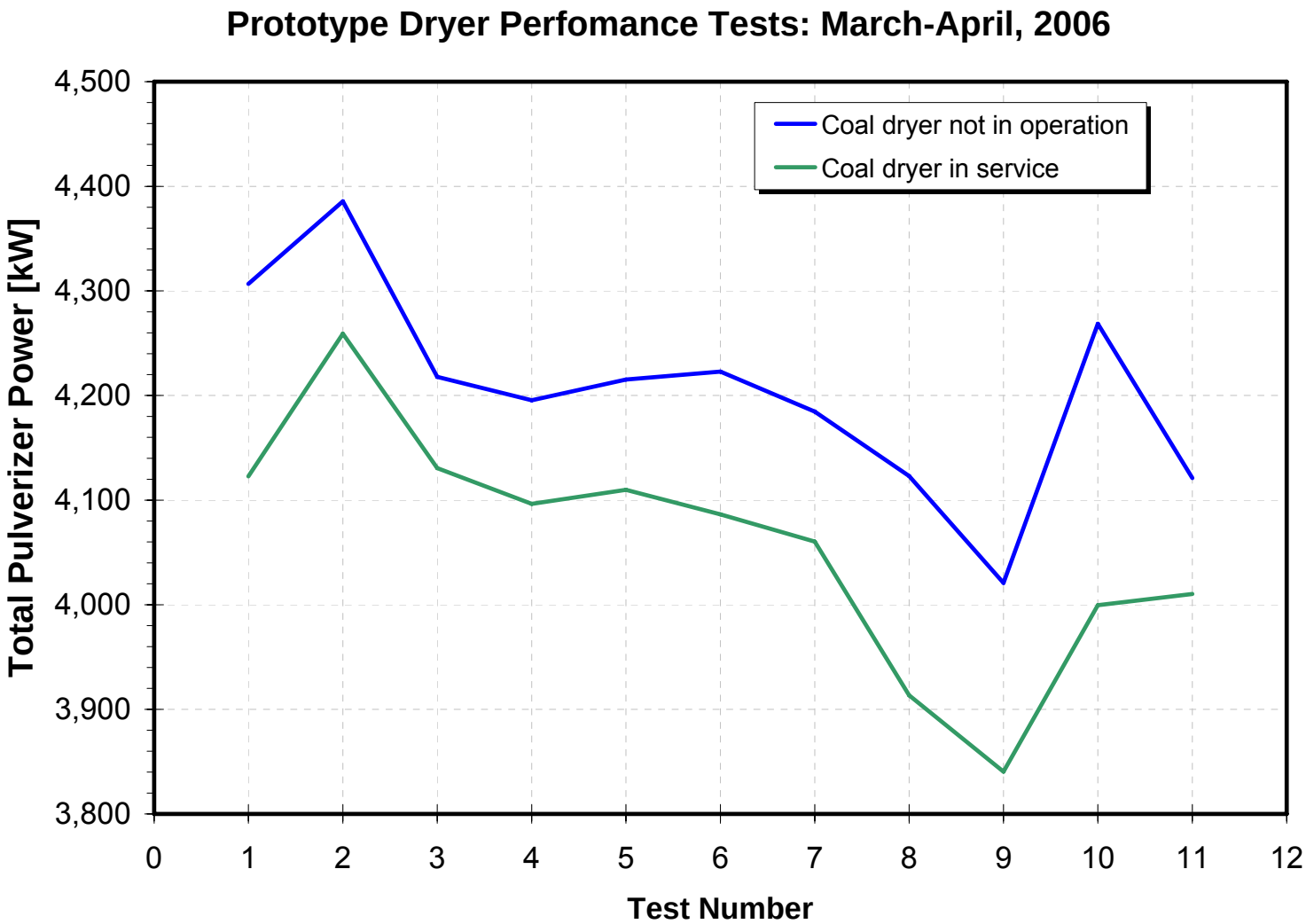
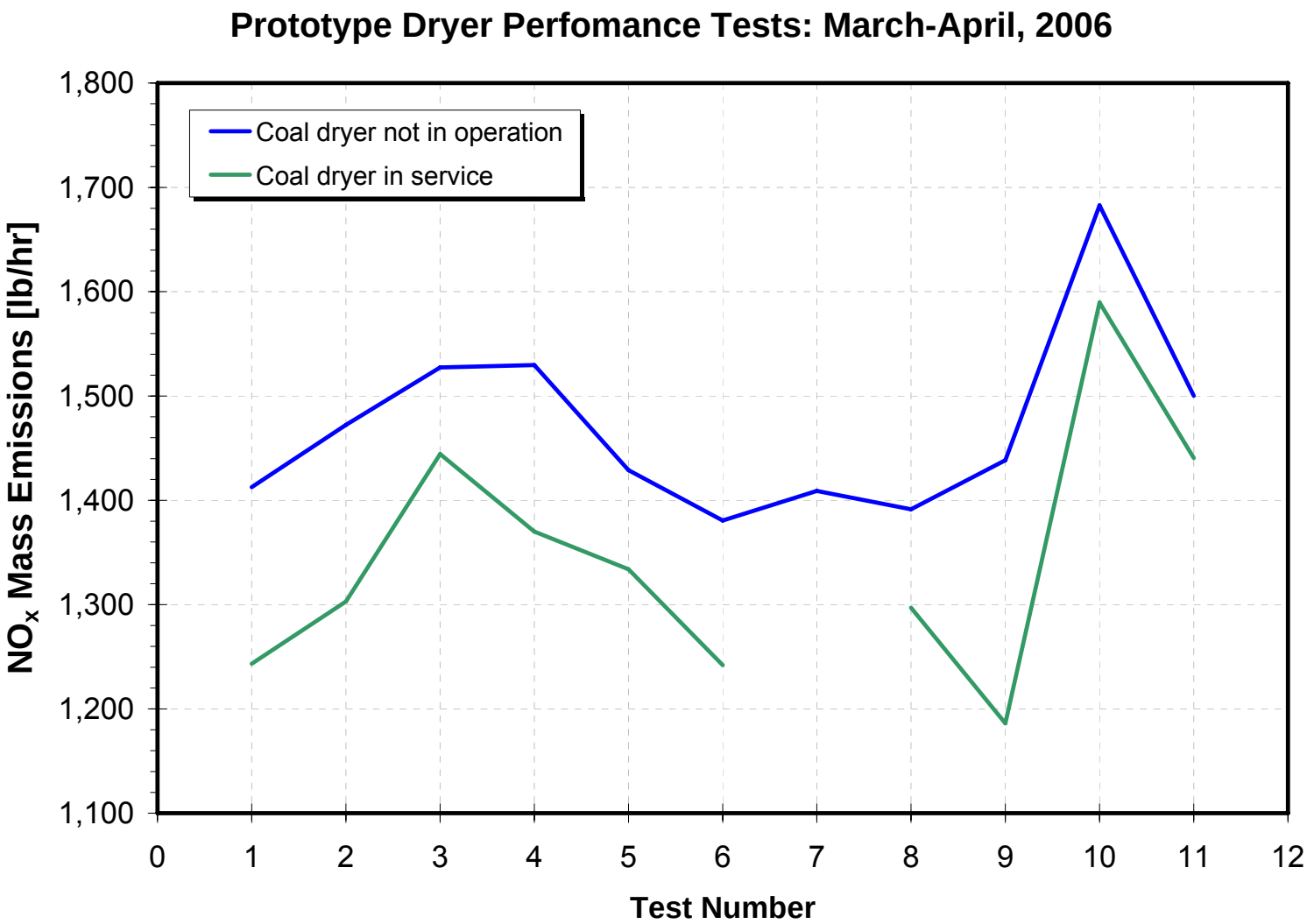
Test Data: Total Mill Power



Test Data: NO_x Emissions



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Evaporated Coal Moisture Discharged into the Atmosphere

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Conclusions

- *Prototype coal dryer (CD26) in service at Coal Creek since early spring 2006.*
  - *No operating issues*
  - *Nominal coal flow rate 75/t/hr.*
- *Inlet moisture level reduced by* ***8.25% Abs.***
- *Coal flow rate reduction:* ***2.0%***
- *Mill power reduction:* ***4.5%***
- *Boiler efficiency improvement:* ***0.27% Abs.***
- *Net unit heat rate improvement:* ***0.34%***
- *NO_x mass emissions reduction:* ***8.5%***
- *SO_x mass emissions reduction:* ***2.0%.***

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Future Work

- *Operate CD26 at maximum capacity.*
  - *Determine operating conditions required to reduce inlet moisture level by 8.5% Abs.*
- *Determine effect on unit performance*
- *Construct and install additional three dryers in Phase 2.*
  - *Test to determine effect on unit performance, emissions, and operation.*

Questions ?