Coking/Coal Gasification Using Indiana Coal for the Environmentally Clean Production of Metallurgical Coke, Liquid Transportation Fuels, Fertilizer, and Electric Power

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Goals

- Develop new technology that will provide new environmentally friendly methods to create value from coke oven gas and thereby enhance the capabilities and operations of existing and new coke production facilities.
- Develop multipurpose Heat Recovery coke plant that maximizes the use of non coking coals (up to 40%) from Indiana. This will significantly reduce coal costs.
- Combine the best of recovery and non recovery coke making technology to maximize the value of coke oven gas (COG).
- Assure acceptable CSR and other coke characteristics for large Blast Furnaces.
- Produce new value from methane as heating fuel or reducing agent for direct reduction, production of diesel oil, fertilizer, and hydrogen.
- Produce electric power from waste heat gas
- Reduce carbon footprint by converting CO_2 to a marketable chemical product using nano catalysis

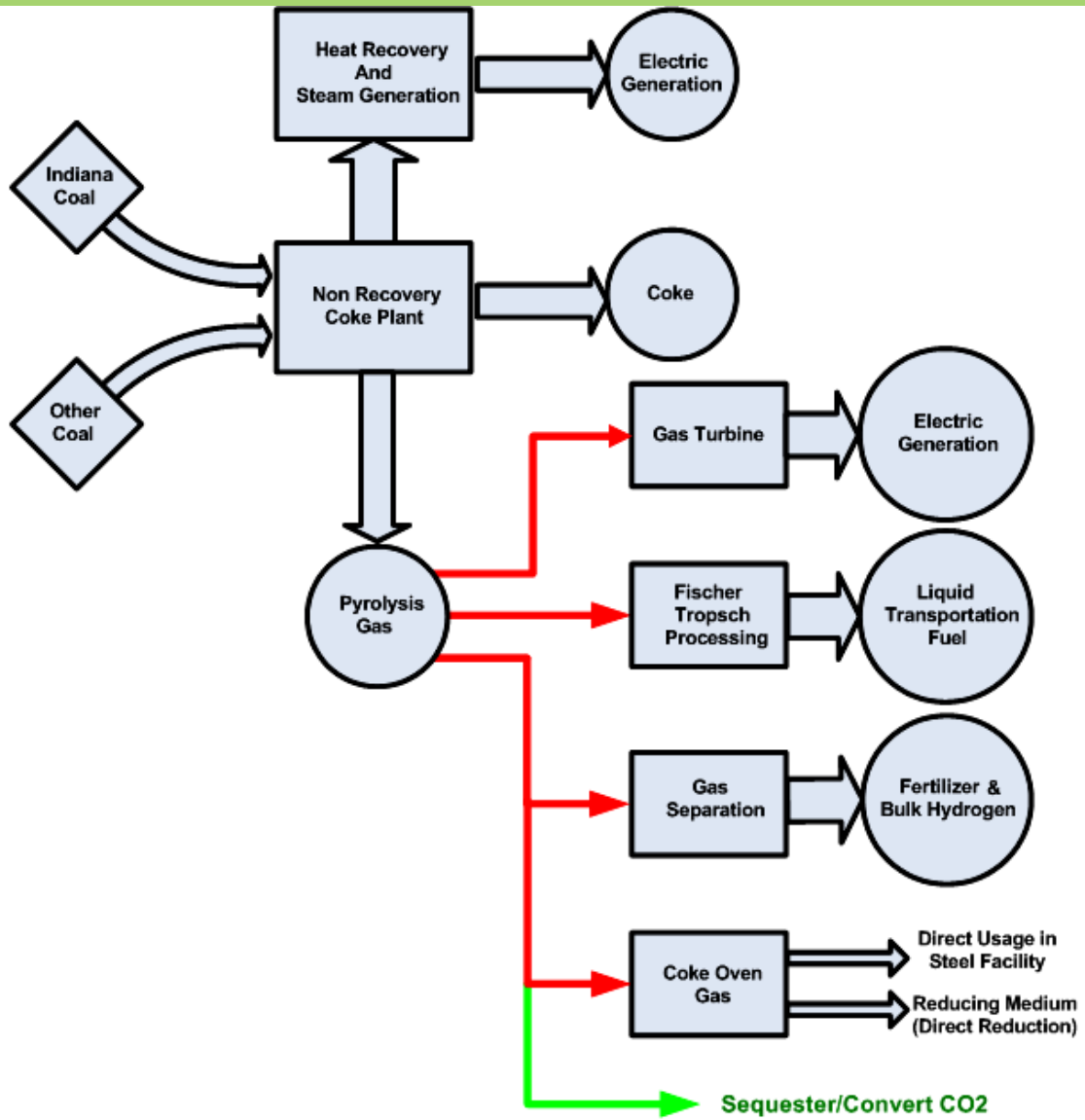
History

- Before the coke property called CSR (coke strength after reaction with CO2)was implemented in the USA during the 1970s, Illinois Basin coal was used extensively at a local steel company in blends as follows.
  - For wet charged coke batteries, a blend of 60% Illinois coal and 40% Eastern medium volatile coal was used.
  - For preheat coke batteries, a blend of 70% Illinois coal and 30% Eastern medium volatile coal was used.
- These blends produced coke with high cold strength properties (stability, hardness, impact resistance, and abrasion resistance). But, the hot strength property, CSR, was poor.
- For small blast furnaces, poor CSR values did not cause operating issues, but as furnace sizes increased dramatically in the late 1970s, issues started to arise with furnace component and wall integrity.

History

- To improve CSR, blends were modified
  - 30% Illinois coal, 30% Eastern high volatile coal, and 40% Eastern medium volatile coal for wet charged batteries
  - 43% Illinois coal, 25% western Canadian high/medium volatile coal, and 32% Eastern medium volatile coal for preheat charged batteries.
  - Optionally, for preheat charged batteries a blend of 43% Illinois coal, 25% western Canadian high/medium volatile coal, and 32% western Canadian medium volatile coal
- With increased emphasis on CSR as an operating parameter, the use of Illinois coal was discontinued for production of coke.

Multipurpose Coke Facility Is Under Development That Will Provide Clean Coal Technology and Multiple Products



Coke Production Level
Liquid Fuel Production Level
Electric Production Level
Liquid Fuel Production Level
Coke Production Level
Electric Production Level
Electric Production Level
Coke Production Level
Liquid Fuel Production Level
Increasing Liquid Fuel Price
Increasing Coke Price
Increasing Electricity Price

Indiana Coal Samples

Indiana Coal Samples

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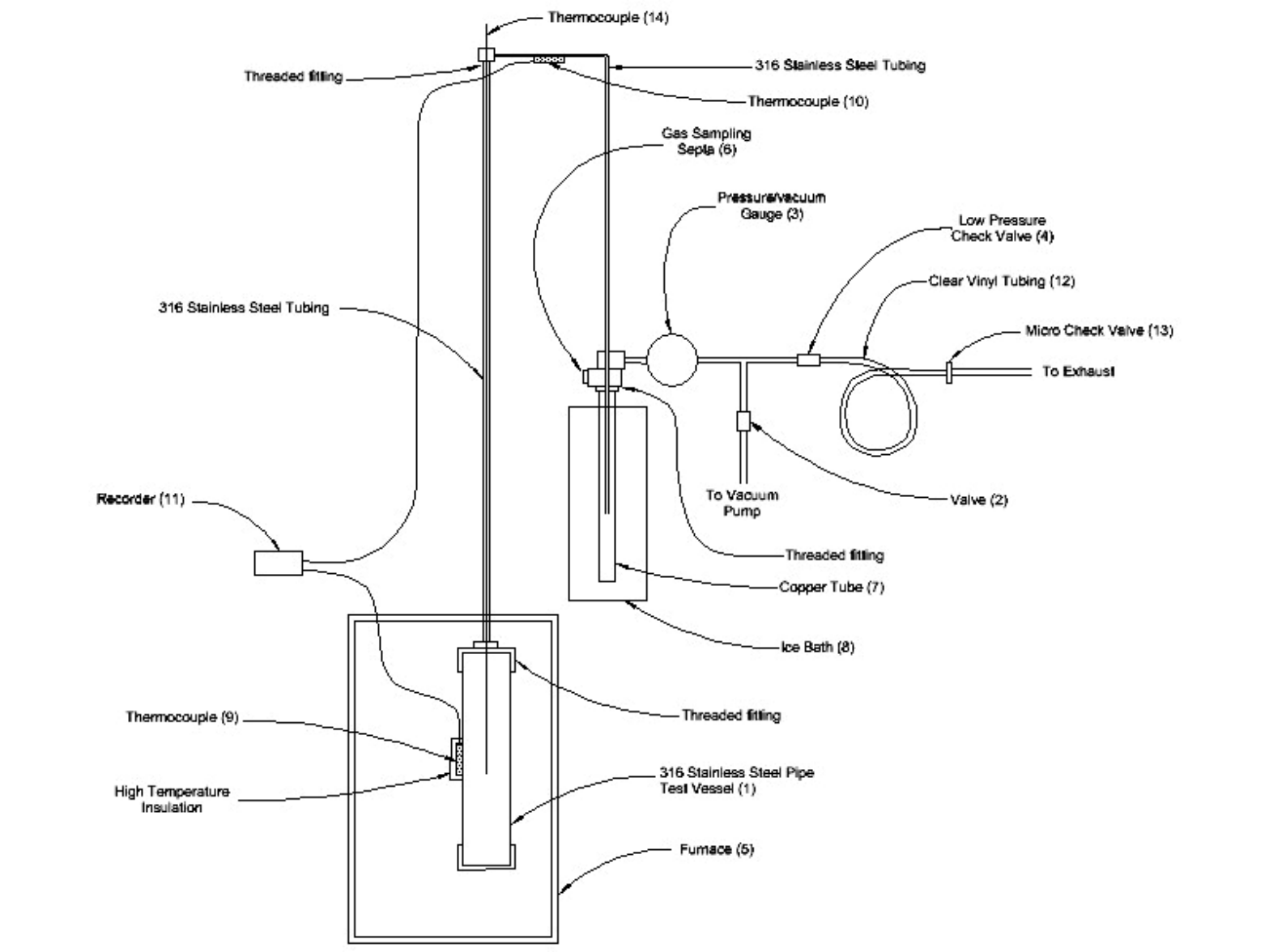
Indiana Coal Samples

Updated Testing Procedures

- New furnace and test system
- Pyrolysis gas is now transmitted directly to the gas chromatograph through tubing connected to a selector valve.
- This has improved the accuracy of the data.
- An expansion of the test system to have the capability of testing up to 5 samples of coal simultaneously is planned.

Updated Testing Apparatus

Purdue Coal Pyrolysis Testing Apparatus



New Coal Test Results from Indiana Coal Mines

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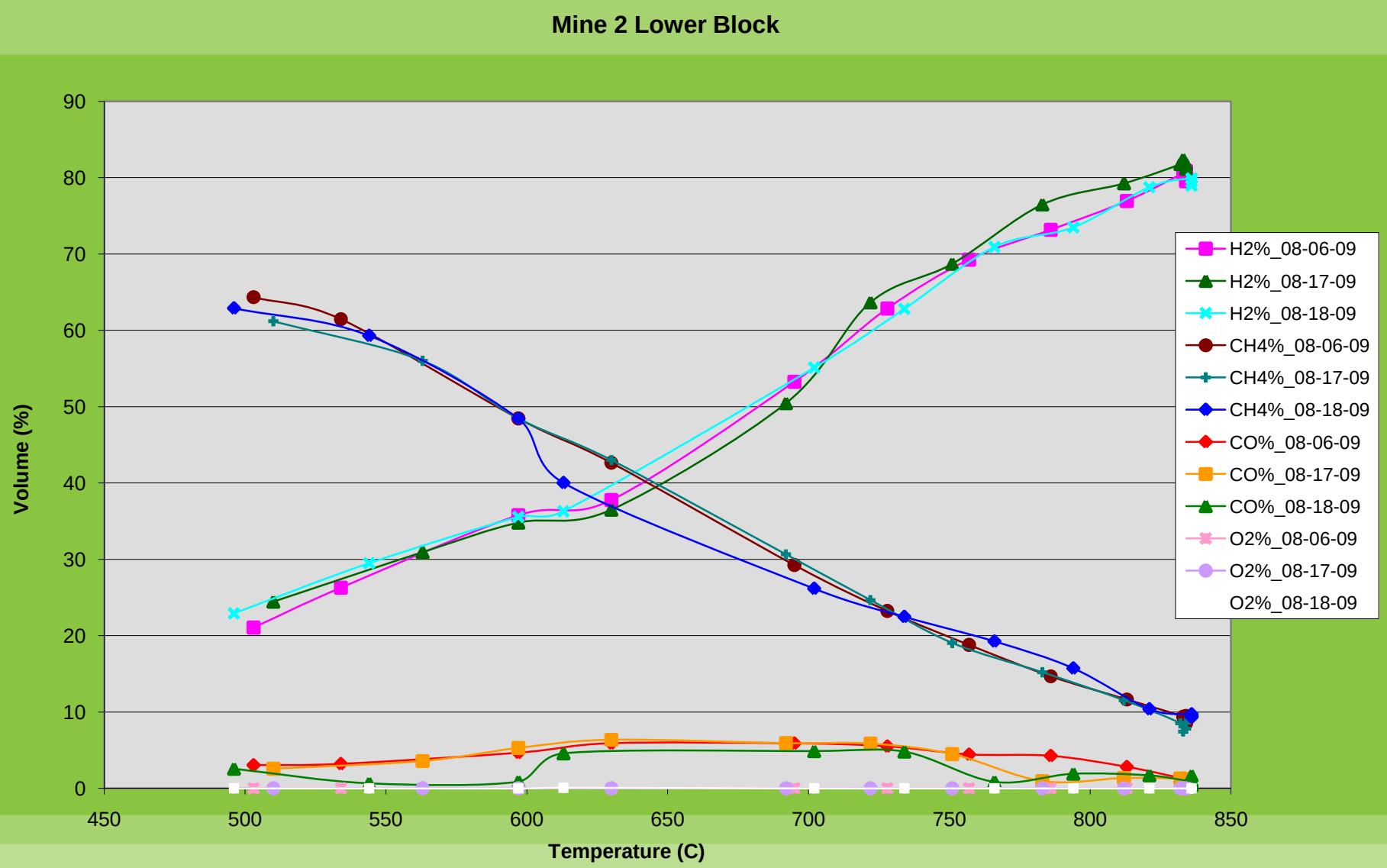

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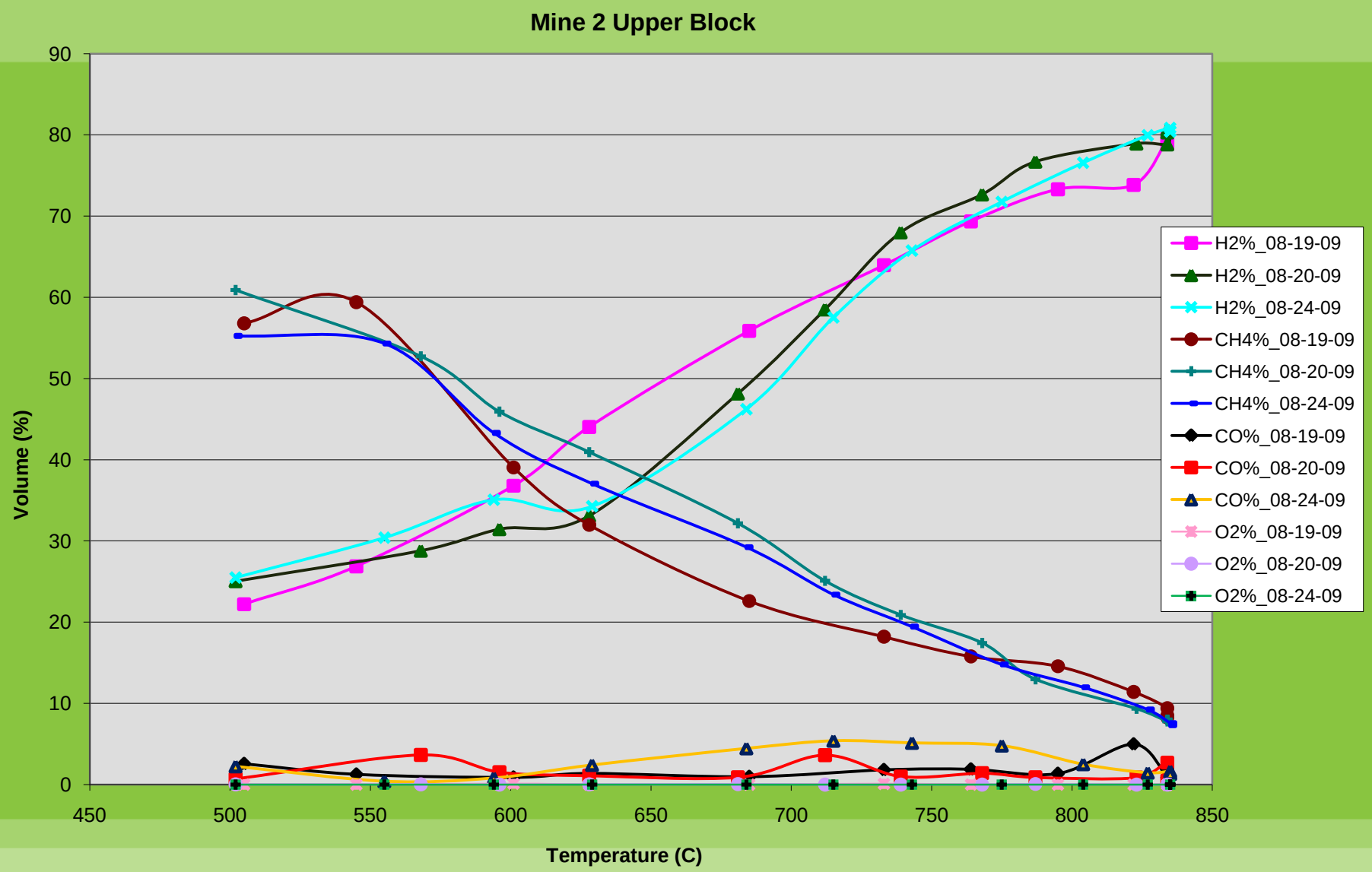

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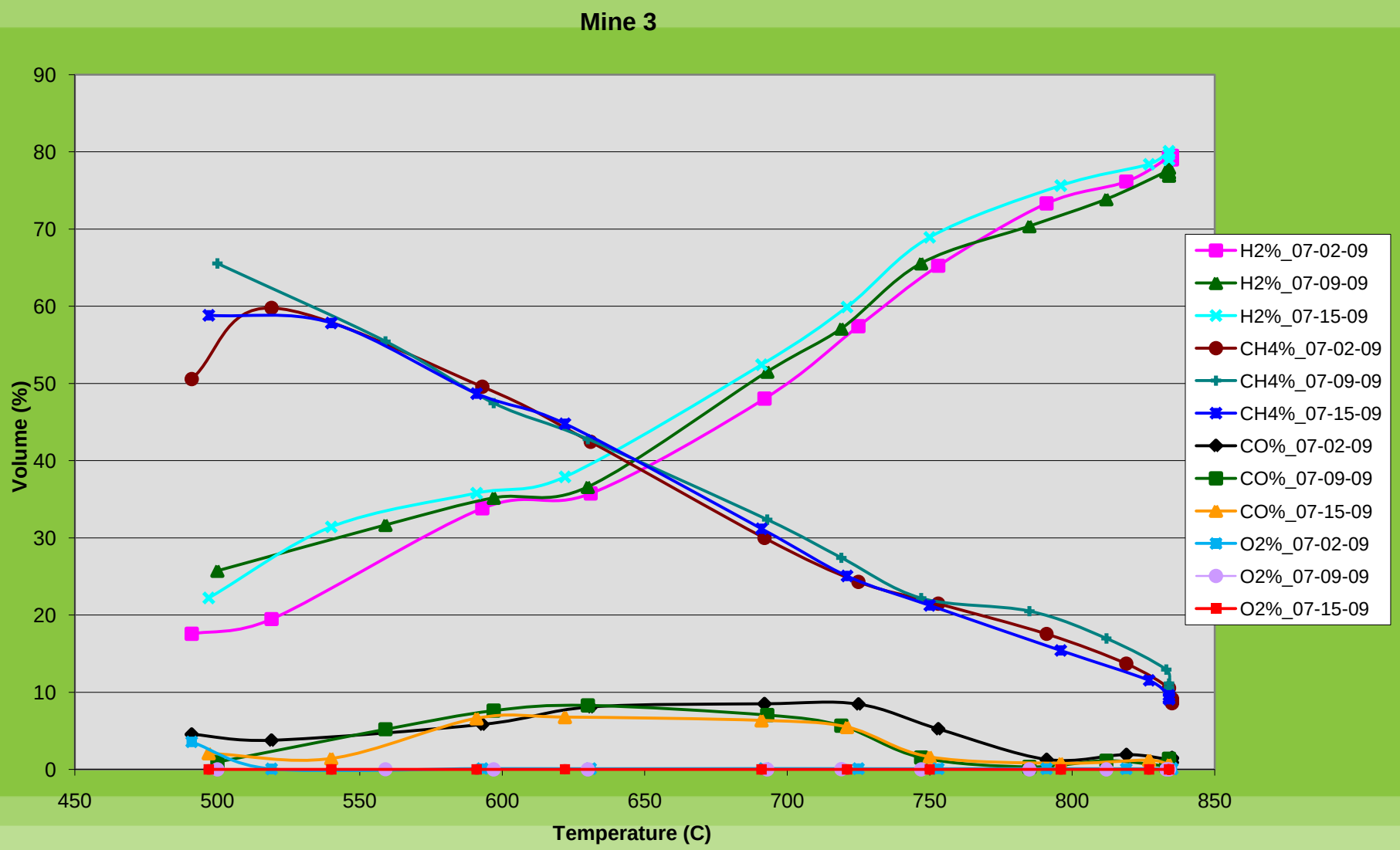
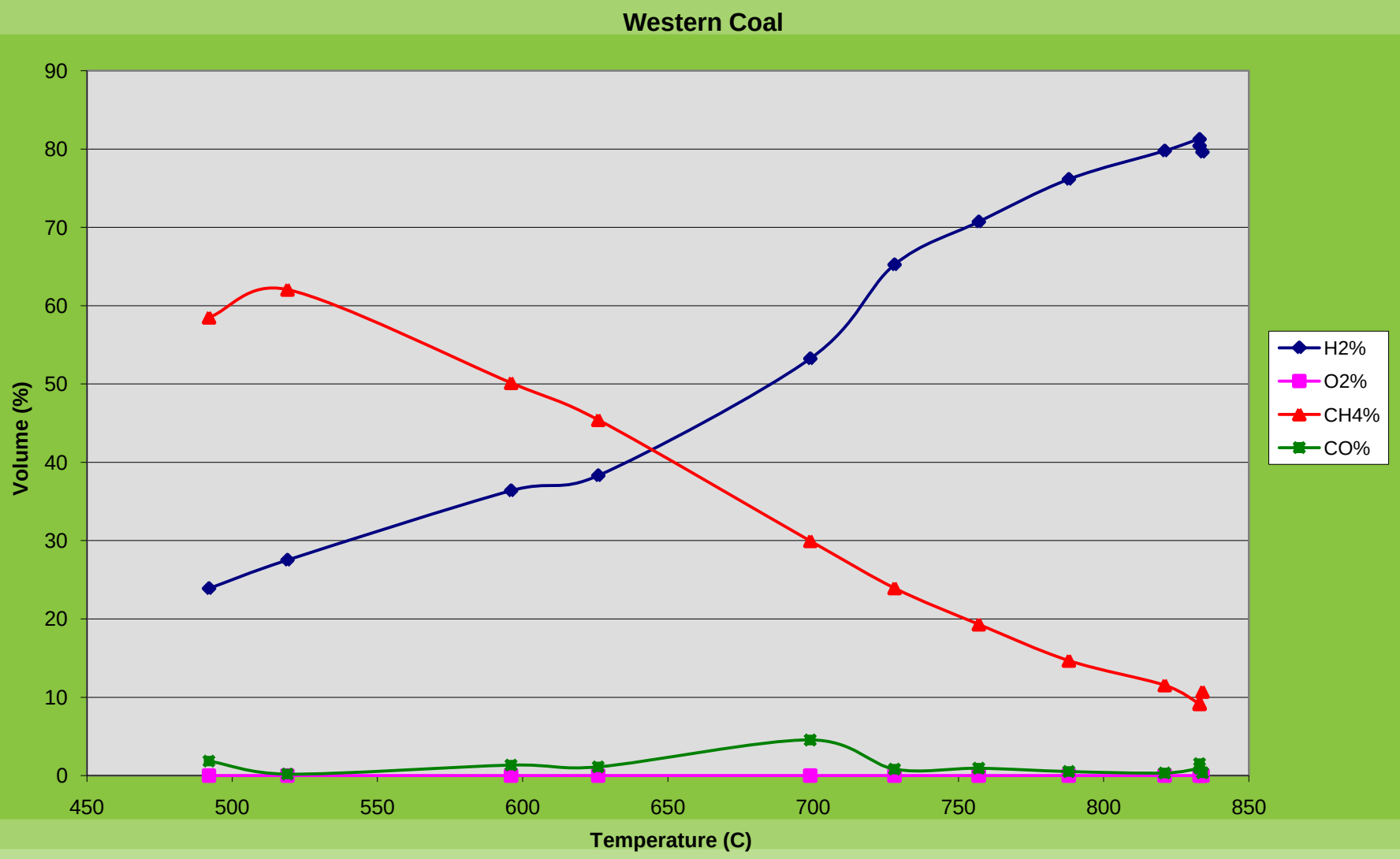
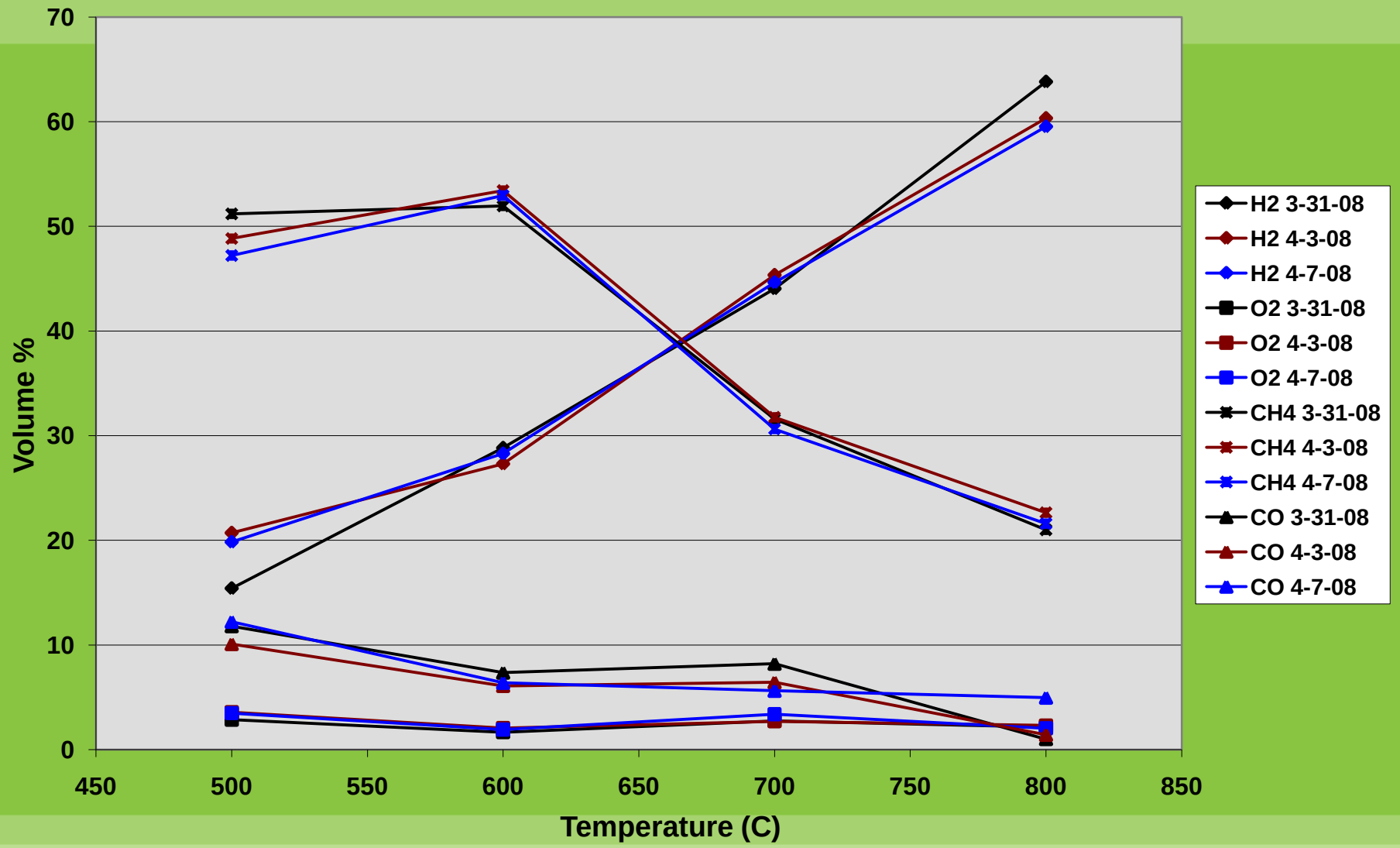


Test of Western Coal



IN Coal Blending Test Pyrolysis Data



Previous Coal Blending Test Results

	TC1931	TC1933	TC1935	TC1940	TC1941	TC1951	TC1952	TC1953	TC1954	TC1995
	30% Ill 30%EHV 40% EMV	30% Ind 30% EHV 40% EMV	80% Ind 20% PC	45% Ind 15% EHV 40% EM	45% Ind 15% EHV 40%WCM	30% Ind 30% EHV 40%WCM	30% Ill 30% EHV 40%WCM	20% Ind 10% PC 30% EHV 40%WCM	20% III 10% PC 30% EHV 40%WCM	50% Ind 50%LVM
Moisture (%)	2.94		2.5	4.98	5.15	4.48	4.03	3.29	3.24	3.4
Grind (%, -3.35mm)	97.1	93.3	87.6	90.7	91.1	91.9	92.7	94.6	96.9	91.0
Dry oven bulk density (kg/m^3)	792	816	754	801	788	801	804	804	805	794
Max oven wall pressure (kPa)	5.65	6.27	2.55	4.62		3.45	4.07	4.07	3.58	7.23
Coking time (h)	16.87	16.37	16.05	17.13	17.03	17.05	17	16.6	16.1	17.02
Stability	61	60	42	58	63	57	61.1	60.5	60.7	62
CSR	61	68	24	57	65	65	70	72	71	66
CRI	30	22	44	32	24		21	20		28
Hardness	70	70	51.3	70	68	70	70	69	68	72
Coke size (mm)	61.73	65.53	70.9	70.74	69.3	62.8	59	61.3	64.2	62.6
Coke yield (%)	73.58	70.15	69.6	73.39	74.6	74.9	76.3	78	76.9	74.9
SHO contraction %	-7.99	-9.57	-11.94	-11.13	-10.14	-12.82	-7.93	-10.59	-12.93	
Coke sulfur (%)						0.66		0.93		
Coke ash (%)						11.1		8.9		

Value Proposition

- Indiana's steel and foundry industries are major employers, as well as significant sources of revenue to the State in the form of taxes.
- This technology will help to assure the health of these vital industries, generate new jobs and revenue streams through the use of Indiana coal at a facility to be located in Indiana, and advance the technical state of the art by using Indiana coal and simultaneously enhancing coke oven operations and reducing environmental emissions.

Conclusion

- **Results indicate that it is highly likely that a coking/coal gasification process can be developed that would produce metallurgical grade coke using 20%+ Indiana coal.**
- **By using a new blending approach that optimizes coke properties and pyrolysis gas composition it is possible to use Indiana coal blended with other coals to enhance coke oven and modern blast furnace operations and reduce costs.**
- **This technology has the opportunity to develop a new market for Indiana Coal**
- **Results indicate that it is possible to use pyrolysis gas generated from a coke oven feed with a blend of Indiana and other coal to produce electricity, liquid transportation fuels by means of a Fischer-Tropsch process, fertilizer, electricity, and hydrogen.**
- **Methods to isolate carbon dioxide from the process and use it to produce a marketable chemical product with nano catalysis technology is being investigated.**

Next Steps

- Continue patent application process
- Complete pyrolysis testing of Indiana Coals
- Obtain washed coal samples, develop optimal blends of Indiana and conventional metallurgical coal, and perform pyrolysis and coke characteristic testing.
- Perform large scale testing at a one ton level and demonstrate feasibility of producing Fischer-Tropsch liquids and other value streams from pyrolysis gas.
- Perform testing at a commercial coke oven and demonstrate capability to enhance coke oven operations and to produce ancillary product value.
- Commercialize the process.

CSL Pilot Oven

Acknowledgement

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