Conversation of large utility coal–fired units to natural gas-fired units

THE 33TH ANNUAL SYMPOSIUM OF THE ISRAELI SECTION OF THE COMBUSTION INSTITUTE

Thursday, December 26, 2019

Case study of boiler conversion
Technical issues

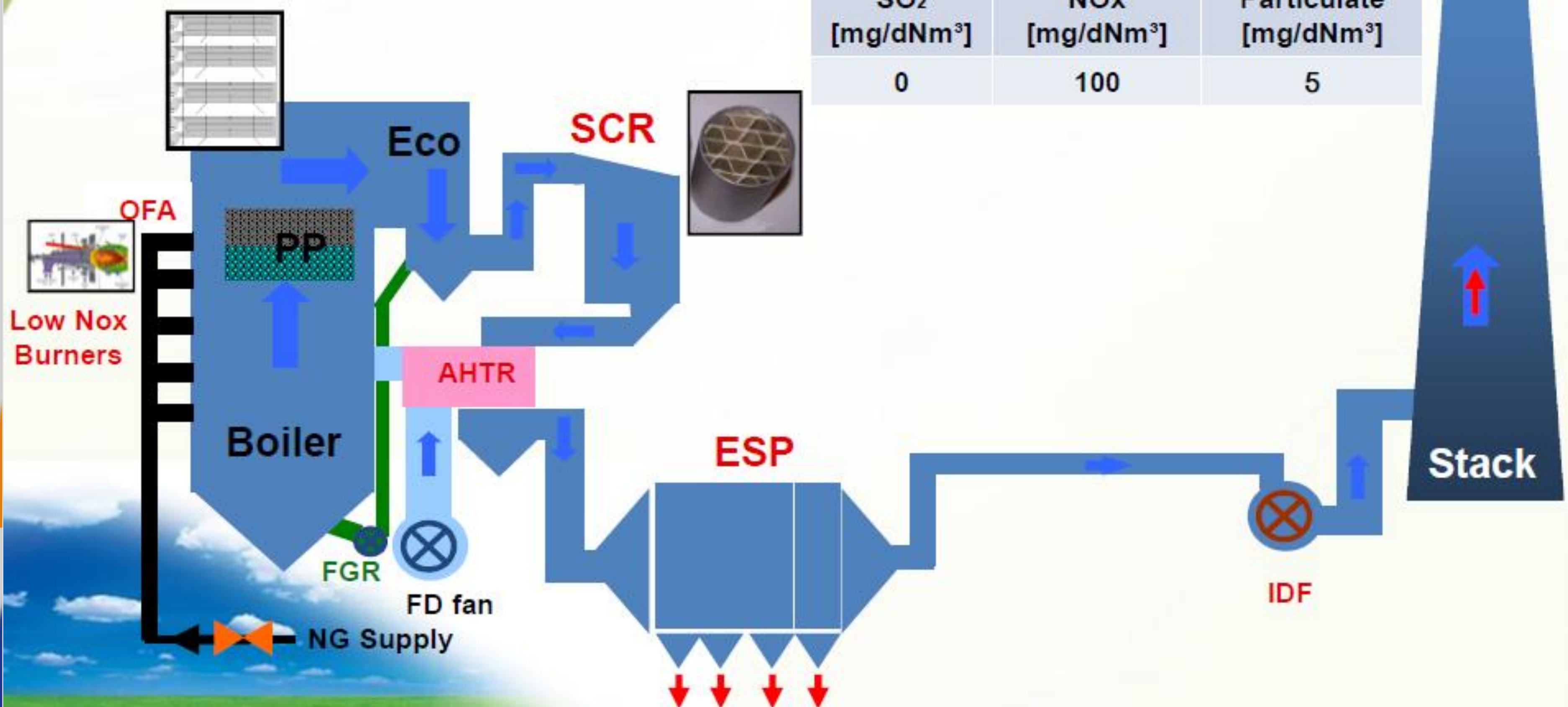
A plant study should evaluate the impact of the following technical issues:

- Characterize natural gas versus the original or current fuel.
- Estimate the impact on boiler design and capacity.
- Estimate the impact on cycle efficiency.
- Determine the boiler modifications required: burner modifications; convection pass modifications; attemperators and modifications to fans, ductwork, and flue ducts.
- Determine the boiler and environmental equipment modifications required.

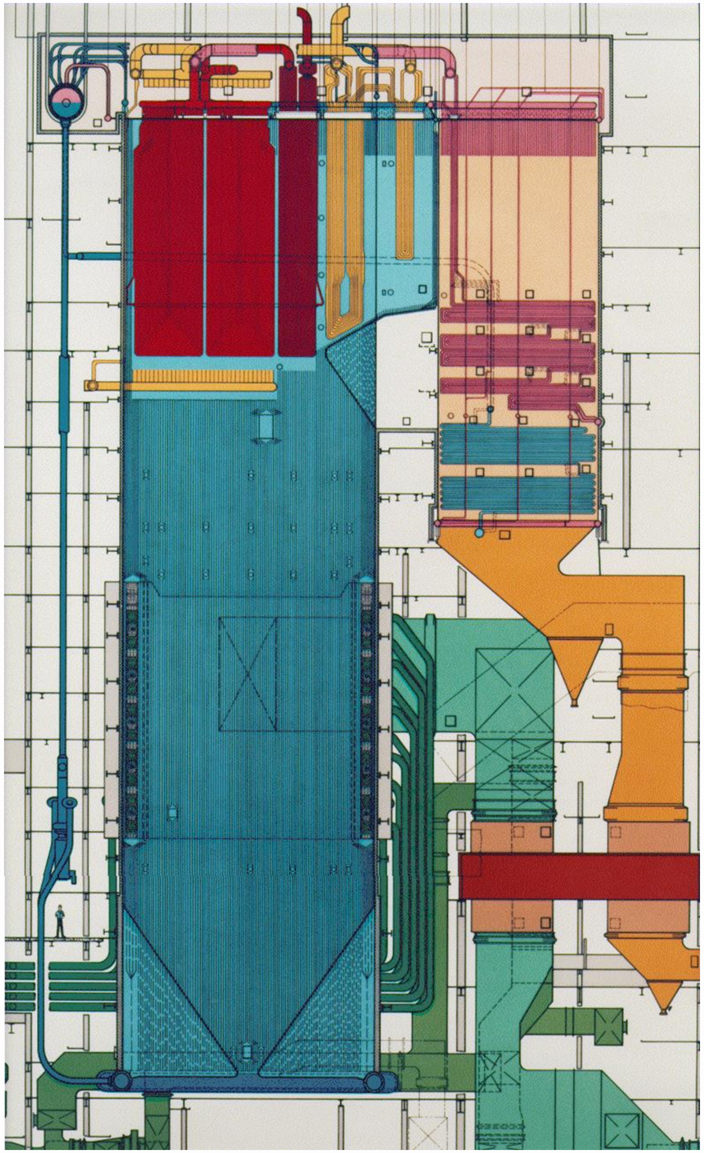
NG conversion plant configuration

Future Configuration and Emissions:

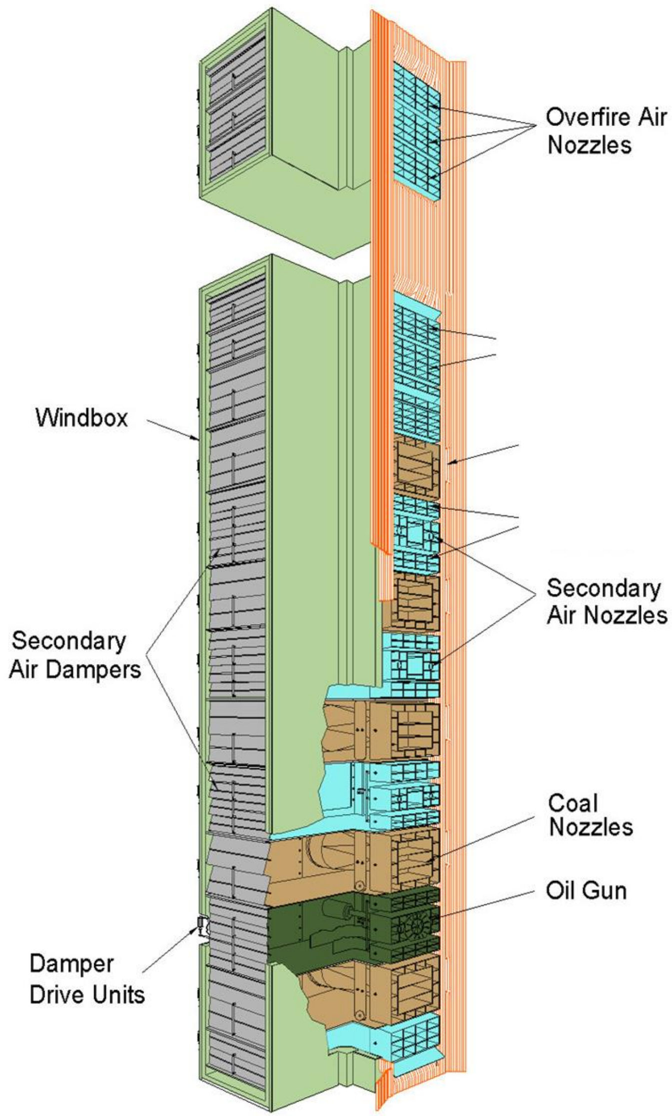
Target Emissions		
SO_2 [mg/dNm³]	NOx [mg/dNm³]	Particulate [mg/dNm³]
0	100	5

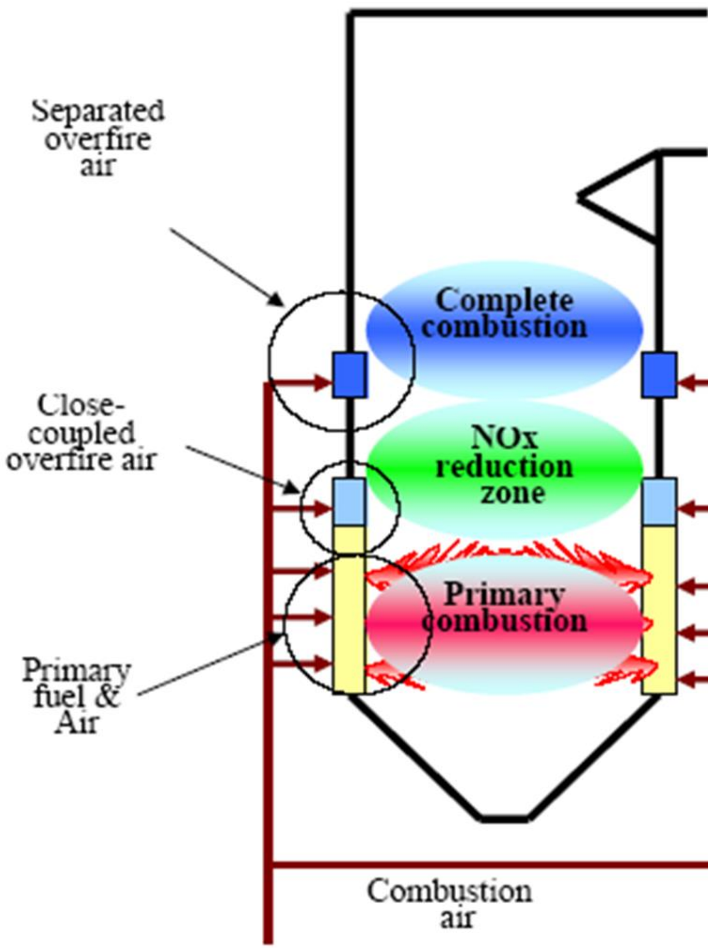


Tangential firing boiler design



Firing system design





< Schematic diagram of advanced overfiring system >

NG conversion simulation results

Boiler simulation methodology

Furnace Heat Transfer

Radiation heat transfer

$$Q_{Rad} = [\varepsilon_{Furn} * \sigma_0 * (T^4_{Flame}) - (T^4_{Foulwall})] * H_{Rad}$$

Incident heat flux

$$q_{in} = \varepsilon_{Flame} * \sigma_0 * (T^4_{Flame})$$

Furnace wall reflected heat flux

$$q_{reflect} = f(T^4_{Foulwall}, \varepsilon_{Foulwall}, d_{Tube}, pitch, T_{Fluid})$$

Absorbed (net) heat flux

$$q_{net} = q_{in} - q_{reflect}$$

Boiler simulation methodology

Furnace Heat Transfer (cont.)

Wall tubes effectiveness factor

$$\psi_{Furn} = \frac{q_{net}}{q_{in}}$$

Wall tubes fouling factor

$$\zeta = \frac{\psi_{Furn}}{x}$$

Where
x- water wall tube pitch factor

Emissivity characteristic of the flame

$$\varepsilon_{Flame} = 1 - e^{(-kps)}$$

Flame ray absorbed factor

$$k = k_{3atomgases} * r_{3atomgases} + k_{ash} * r_{ash} + k_{char}$$

Boiler simulation methodology

Pressure Parts Calculations

Heat transfer equation

$$q = \frac{A * U * \Delta T}{B_{Fuel}}$$

Flue gas heat balance equation

$$q = \varphi * (I^{in} - I^{out} + \delta\alpha * Ii^{0}_{\inf air}) + q^{pp}_{rad}$$

Steam (water) heat balance equation

$$q = \frac{D_{steam} * (i^{out} - i^{in})}{B_{Fuel}}$$

Heat transfer factor equation

$$U = \frac{1}{\frac{1}{\alpha_1} + \Sigma\frac{\delta}{\lambda} + \frac{1}{\alpha_2}}$$

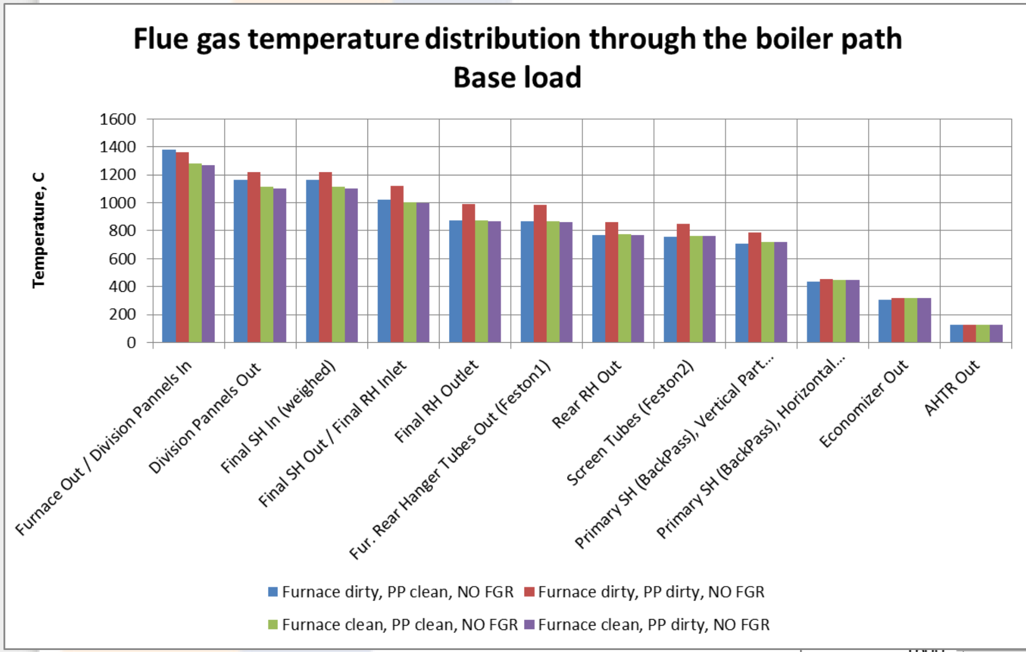
Where

$\alpha_1 = \alpha_{conv} + \alpha_{rad}$ - Flue gas to tube heat transfer coefficient

α_2 -Steam to tube heat transfer coefficient

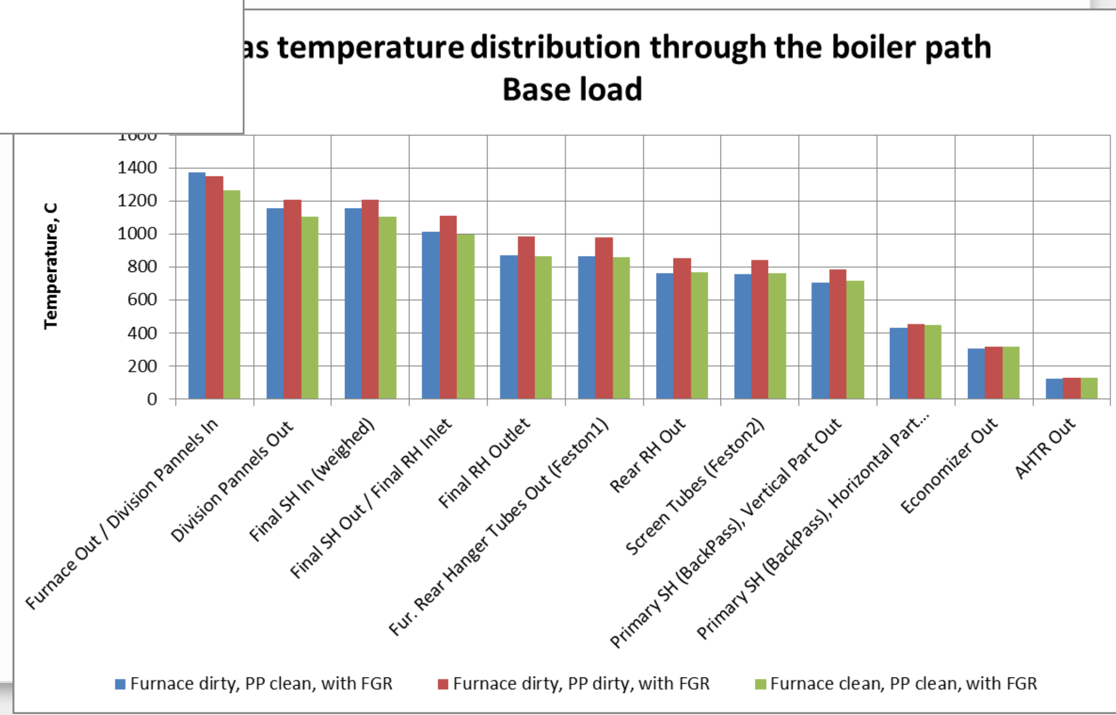
$\Sigma\frac{\delta}{\lambda} = \varepsilon$-Conductivity heat transfer coefficient

Boiler performance simulation results



NO FGR

With FGR



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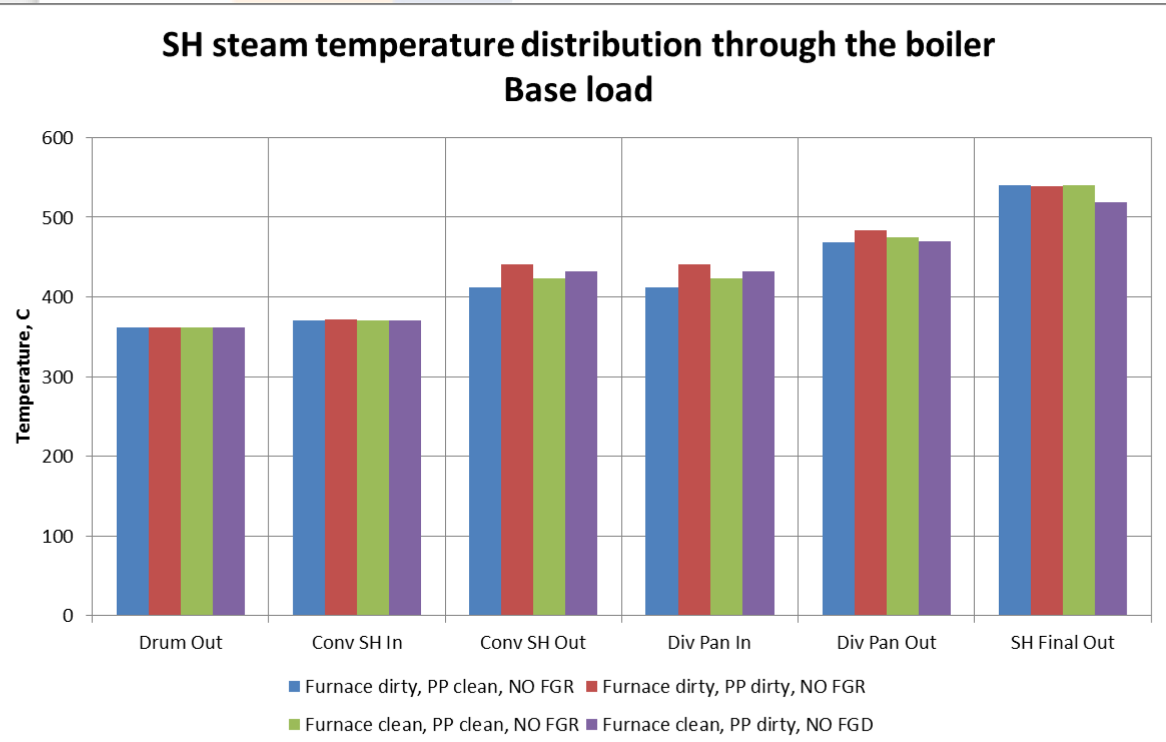

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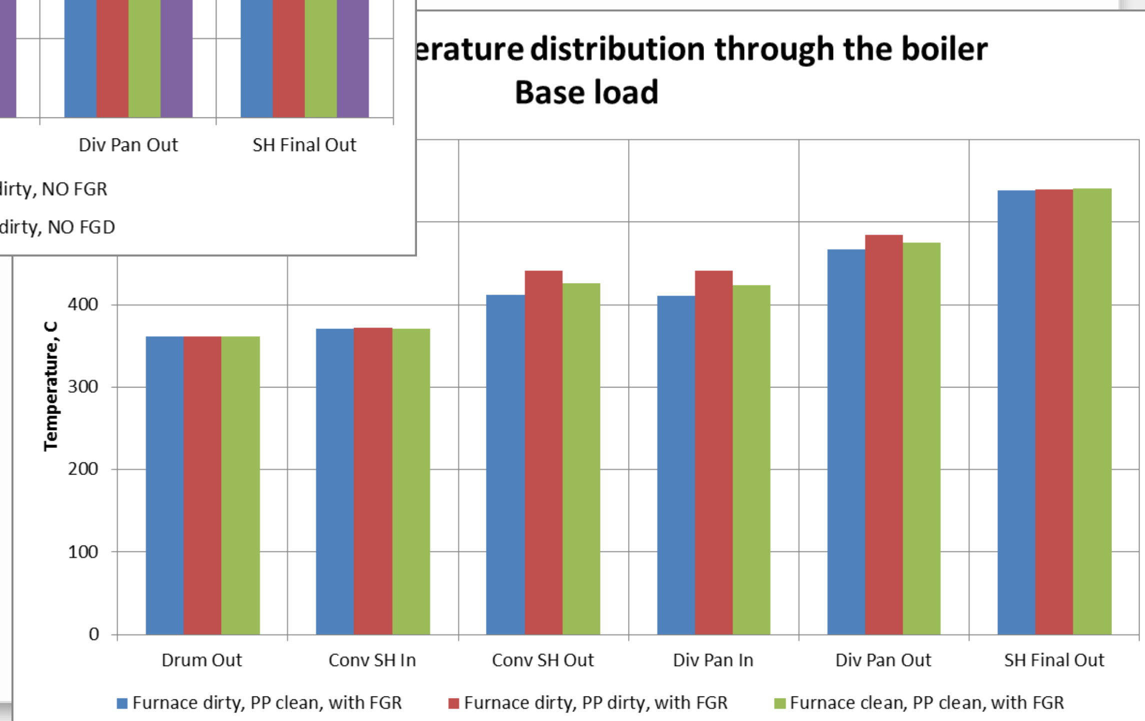

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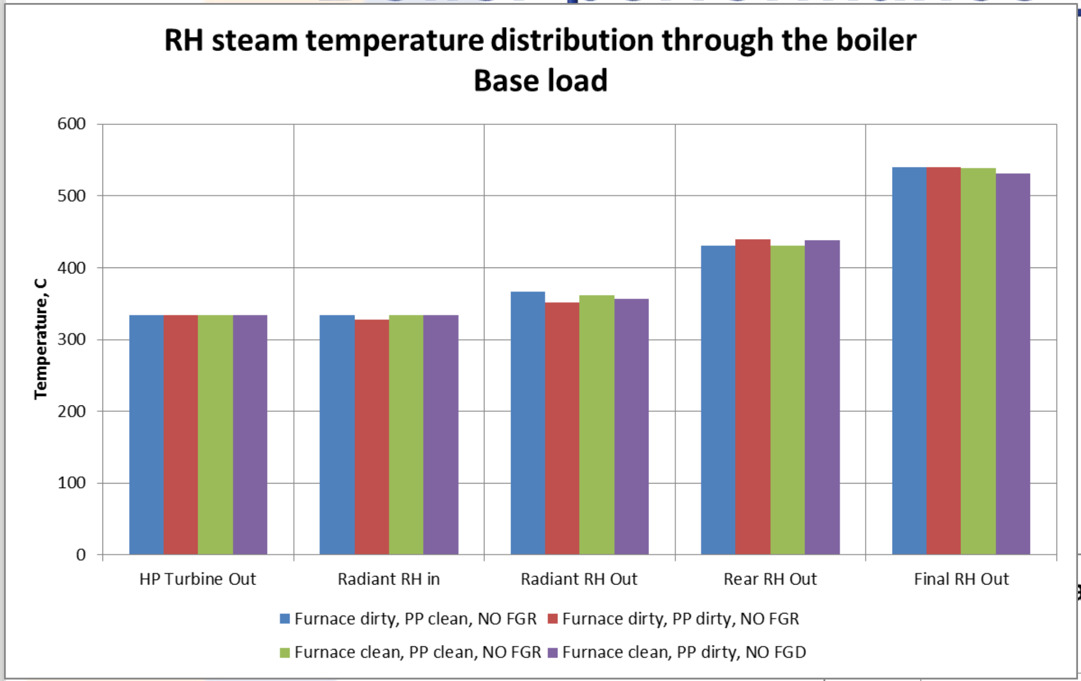

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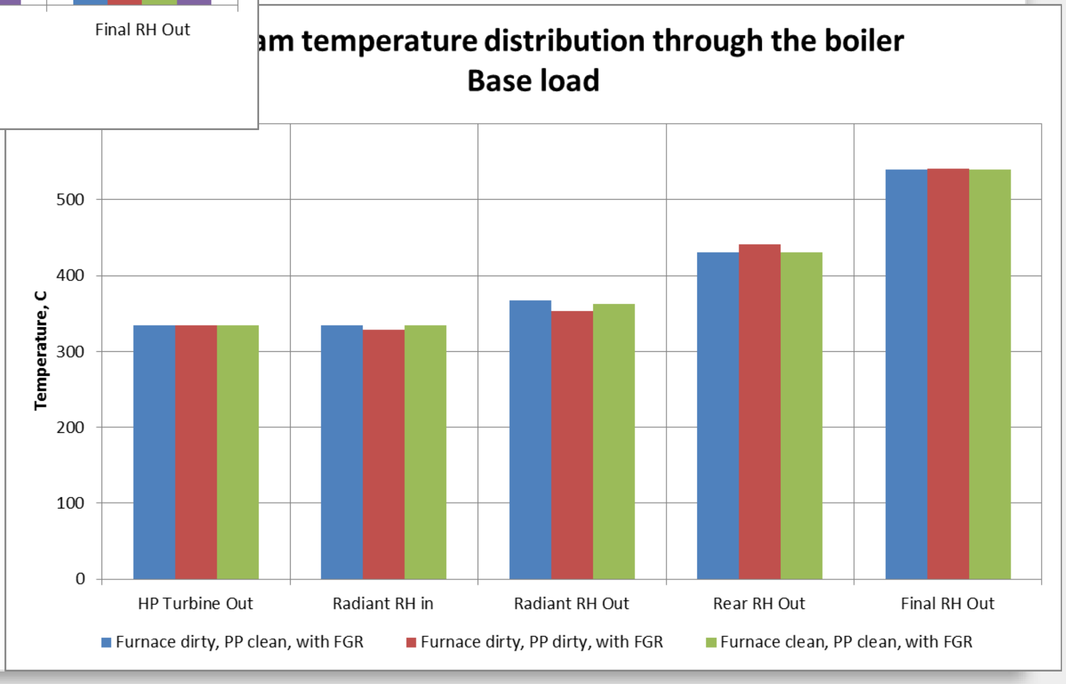

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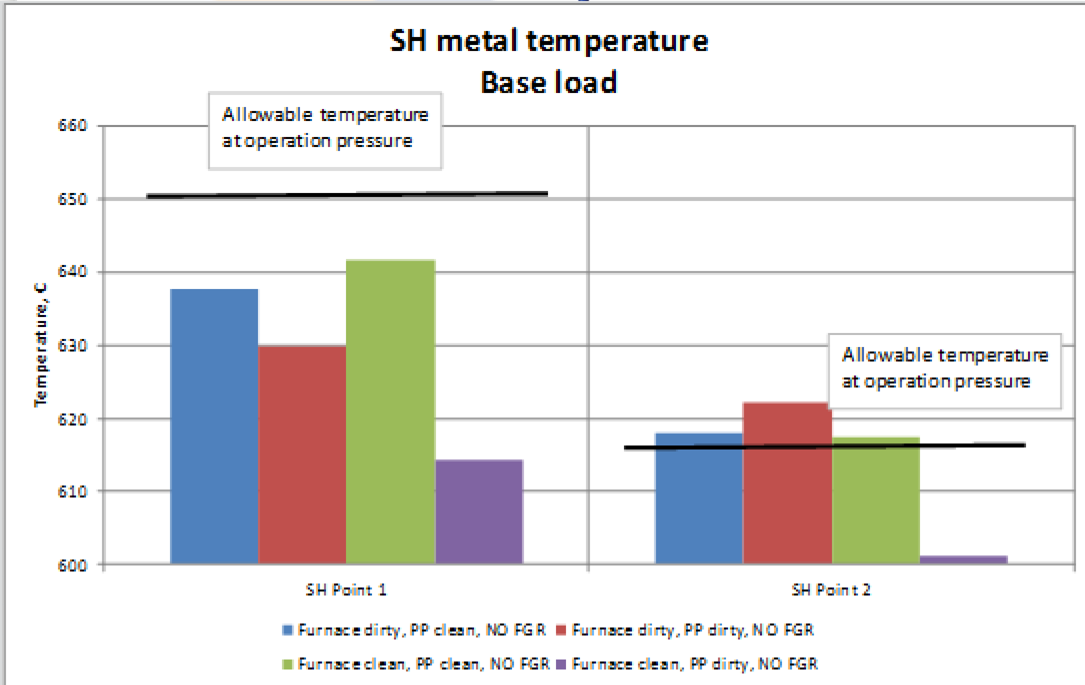

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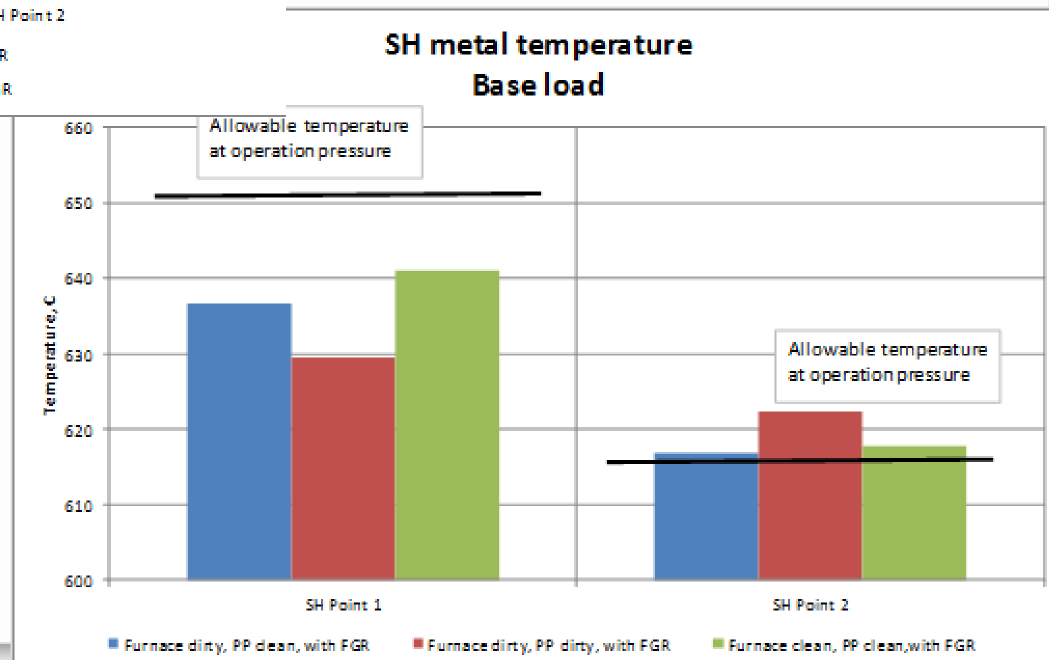

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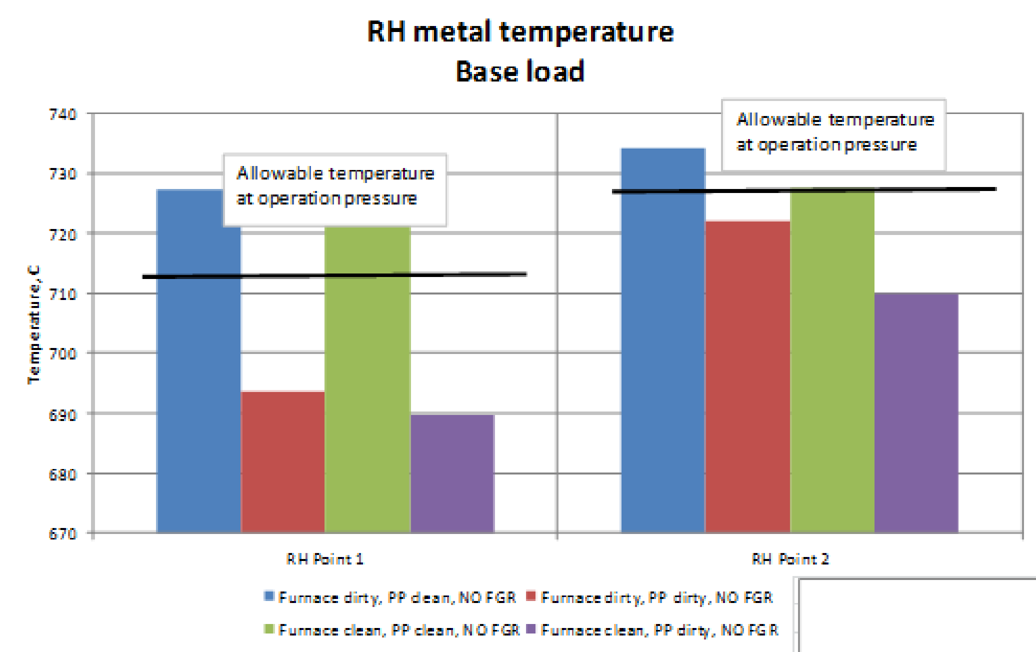

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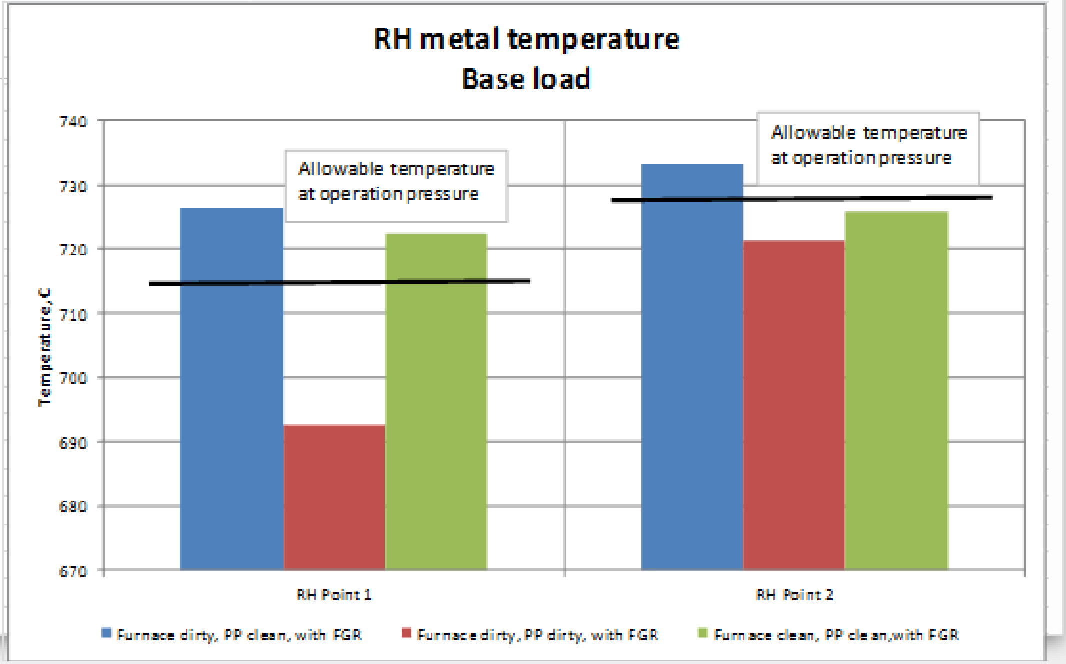

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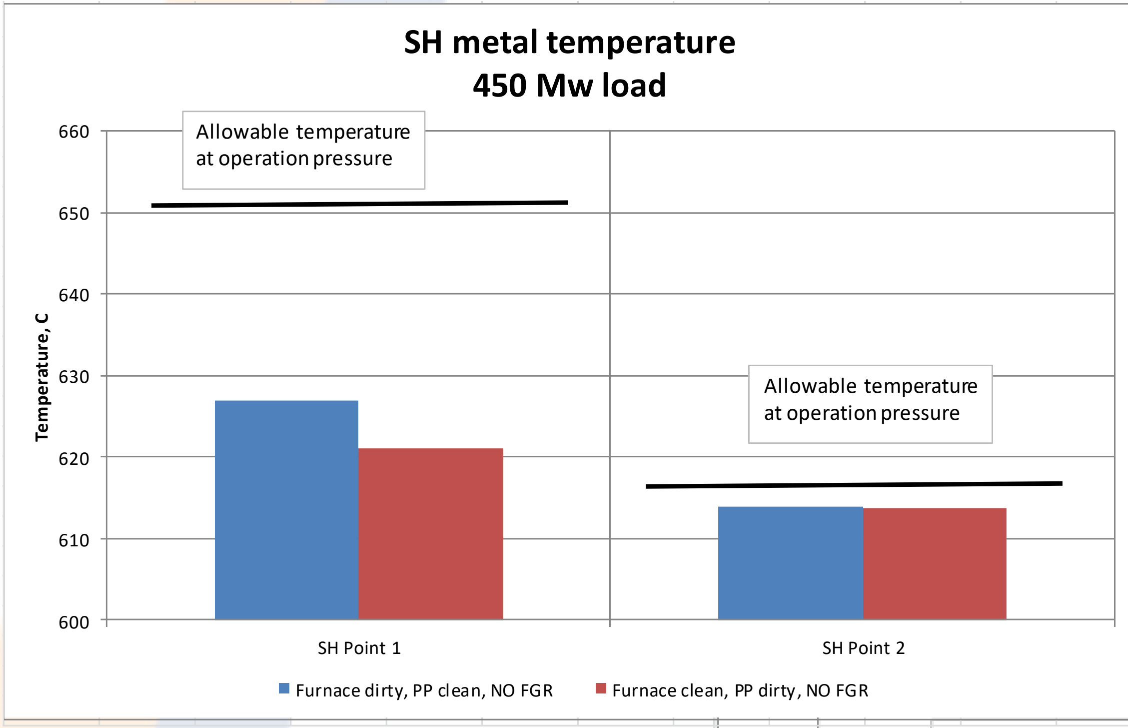
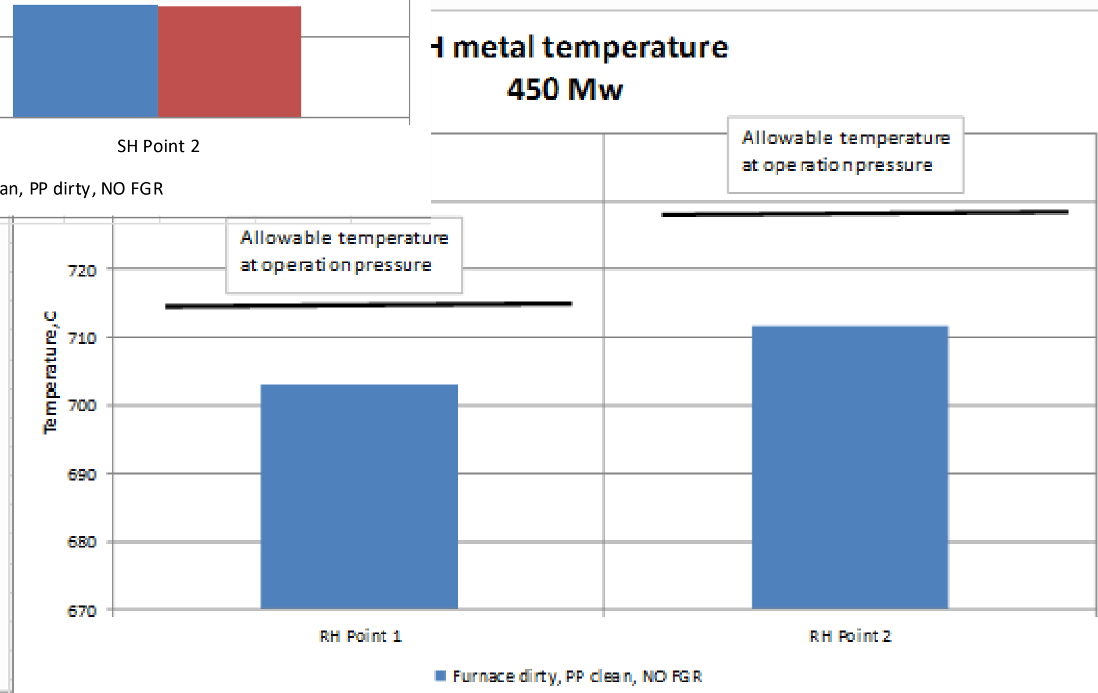


SH, NO FGR

RH, NO FGR



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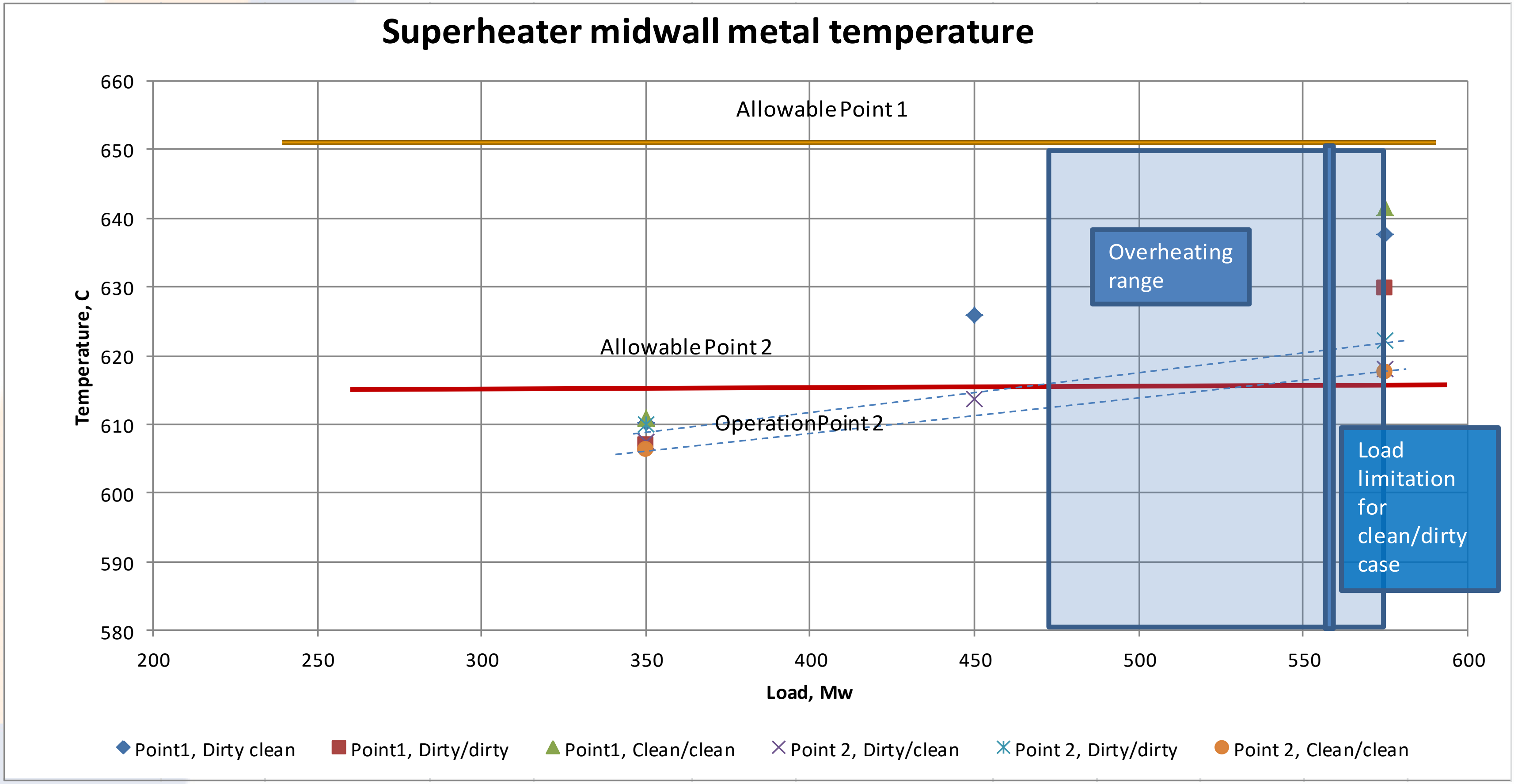

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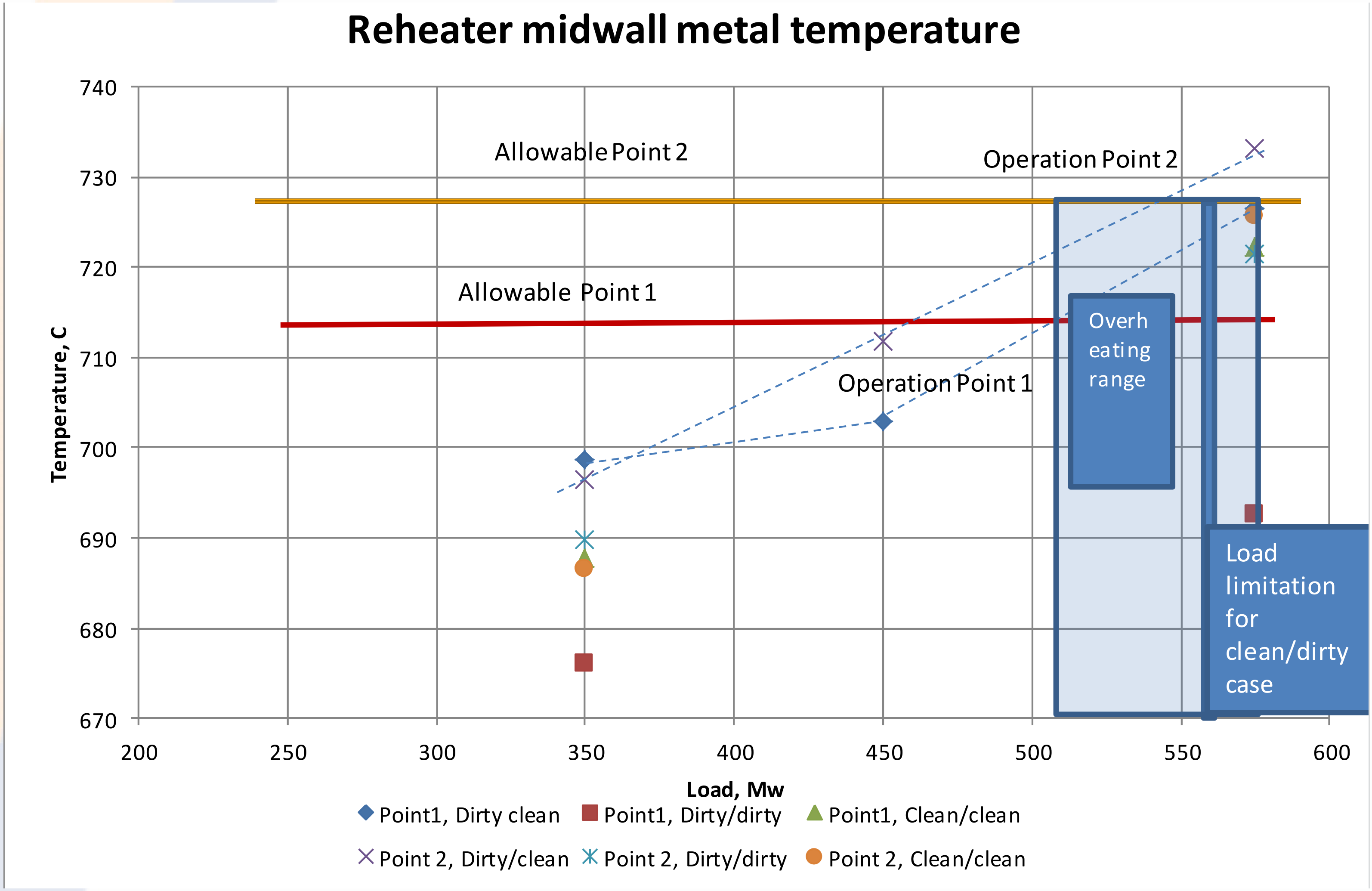

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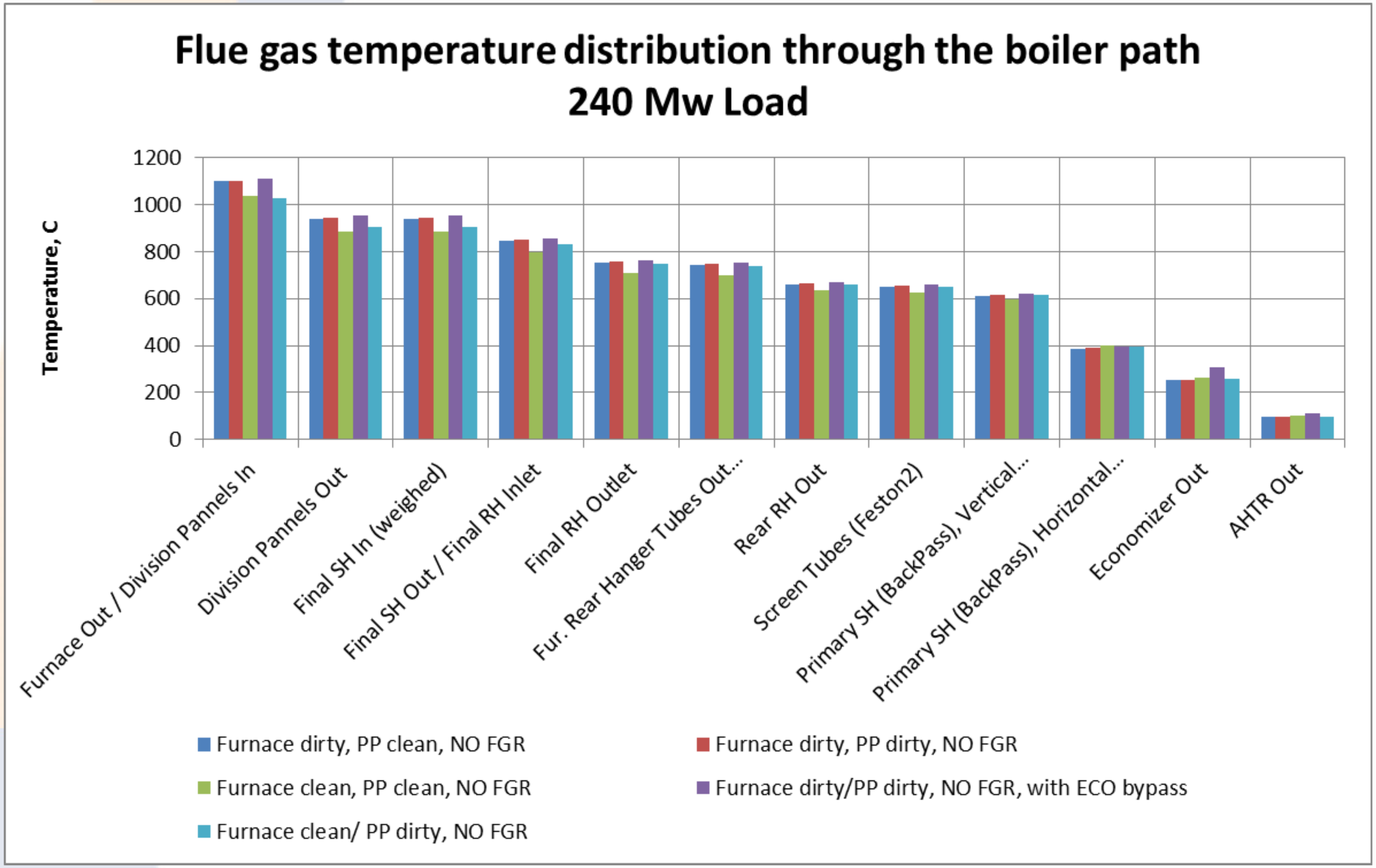

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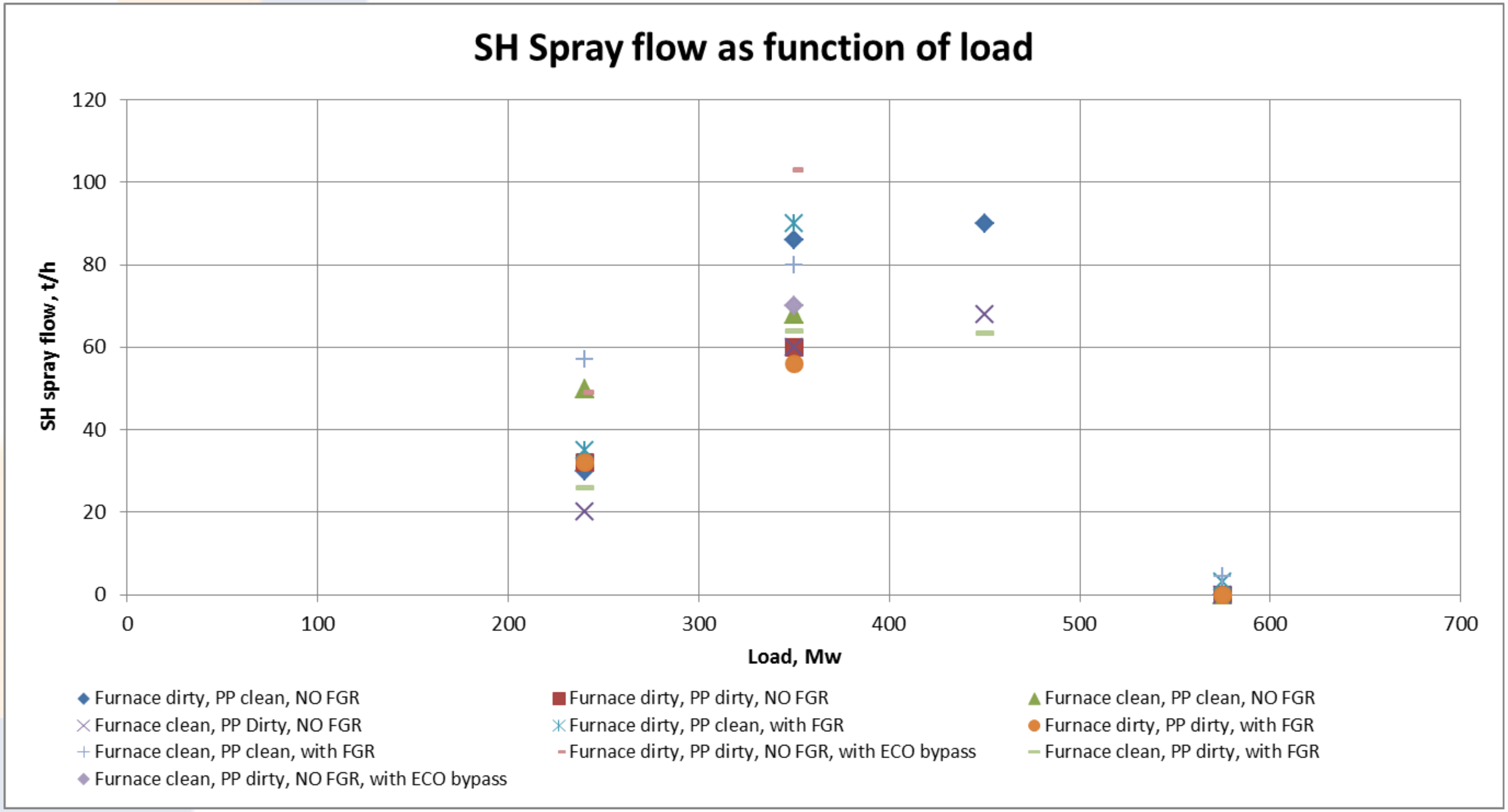

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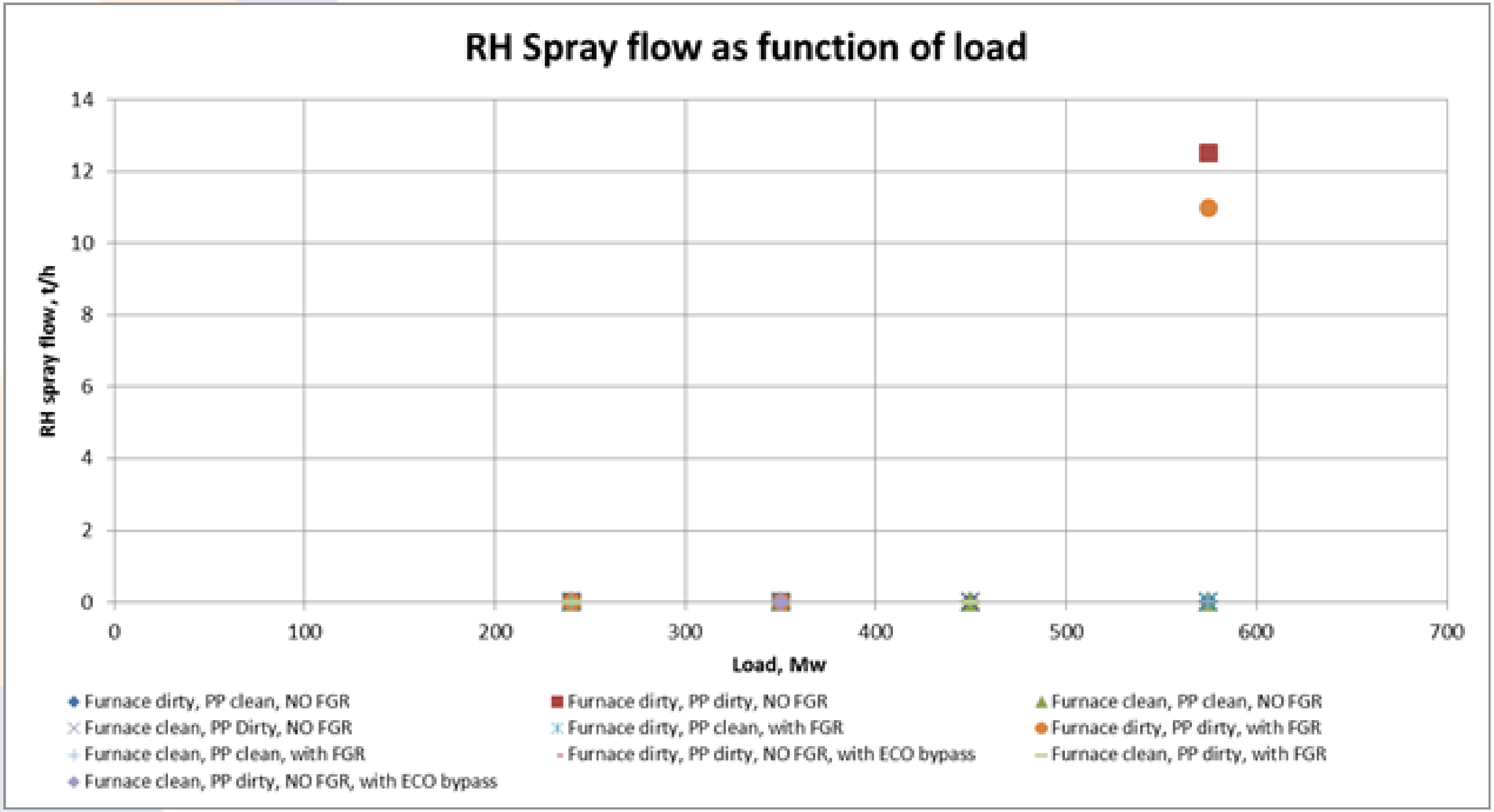

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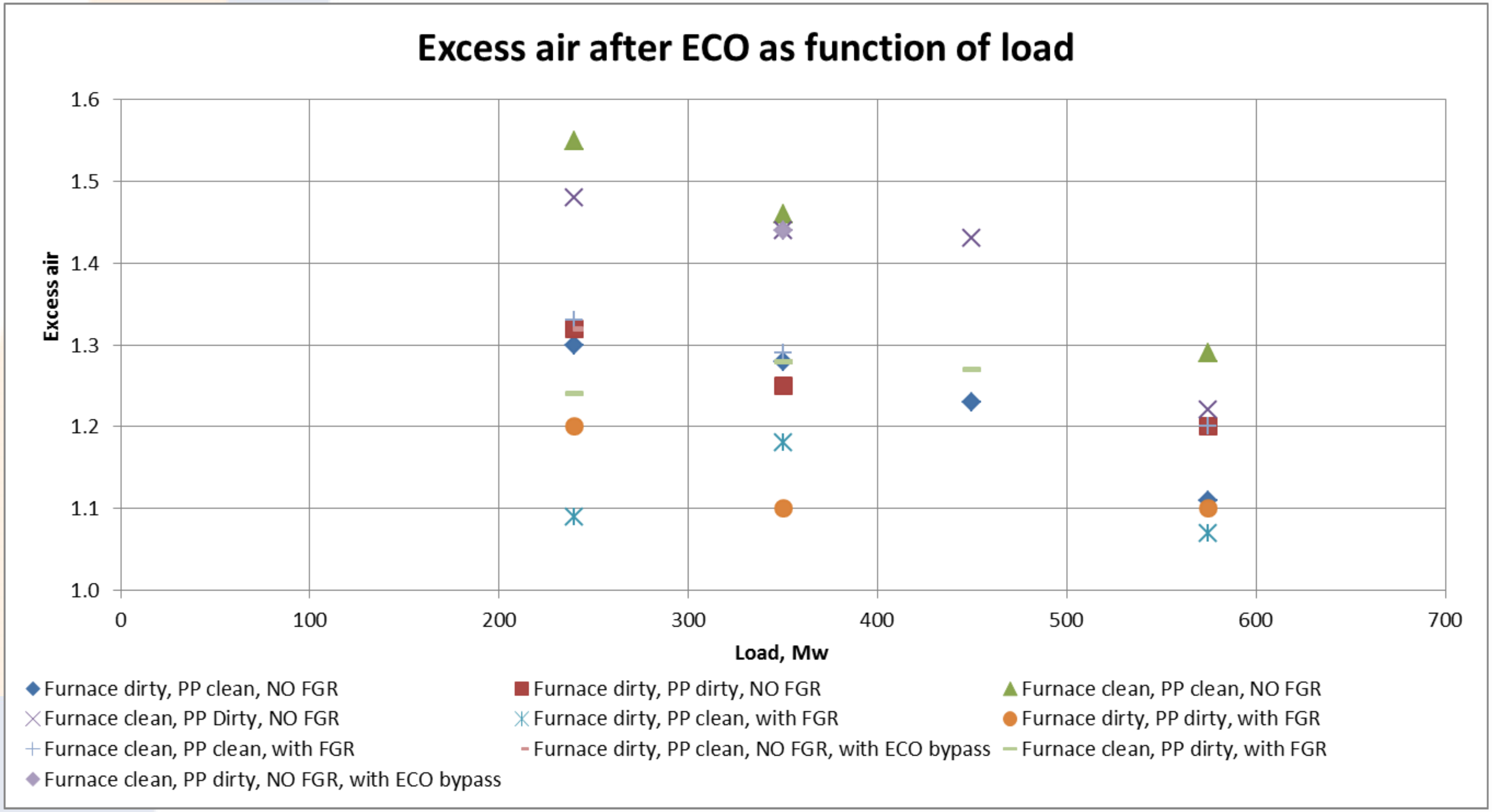

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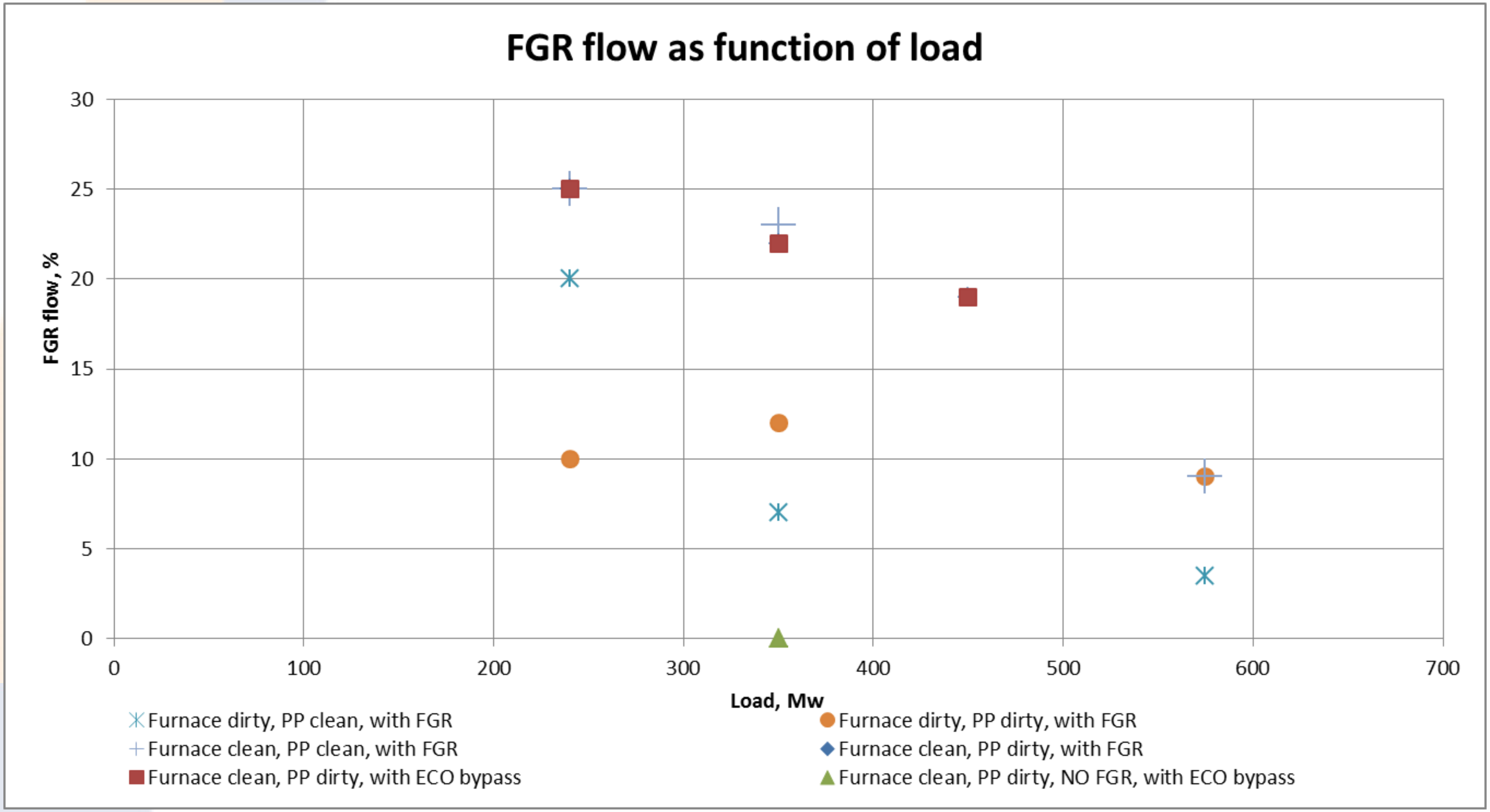

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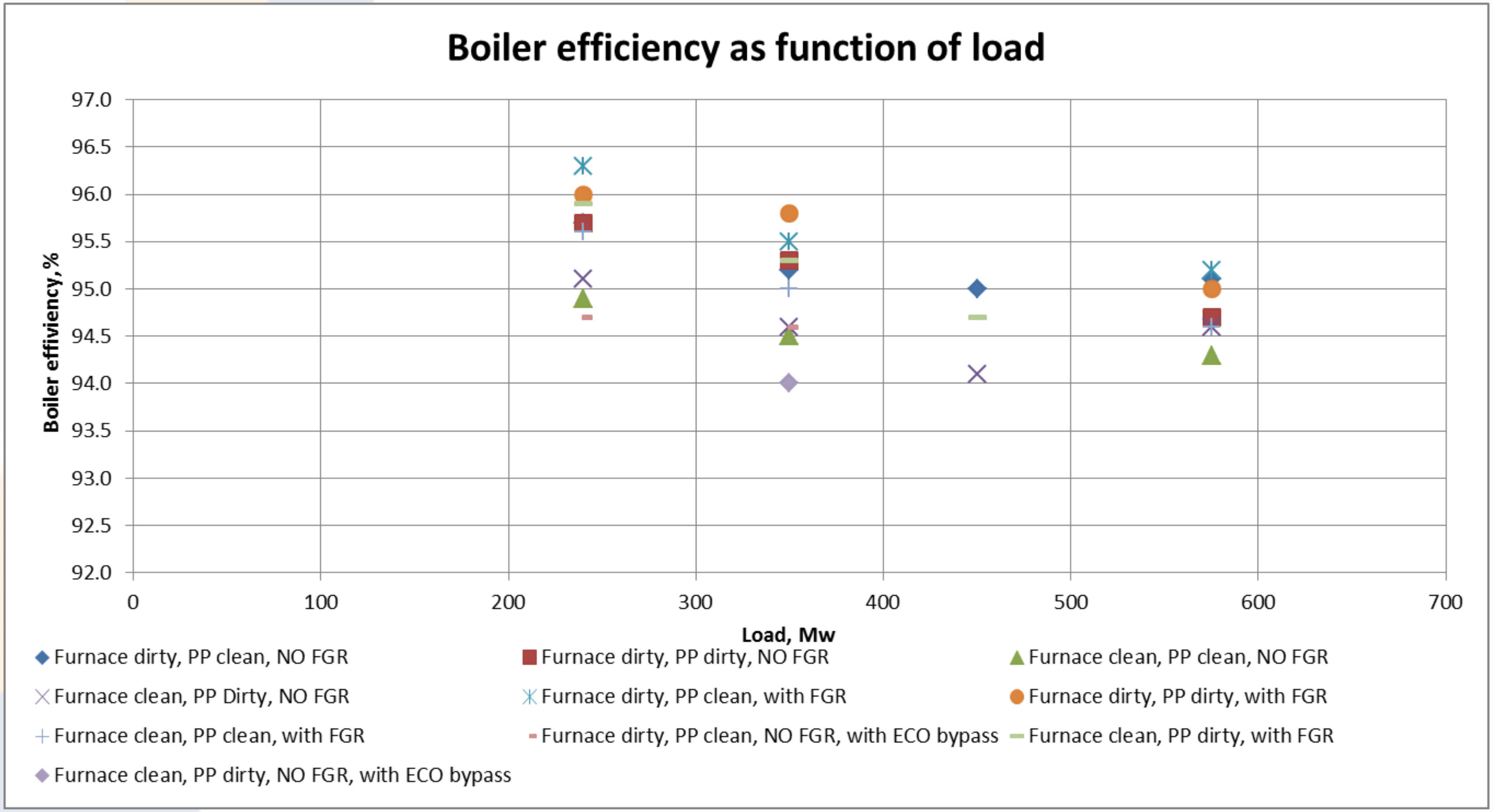

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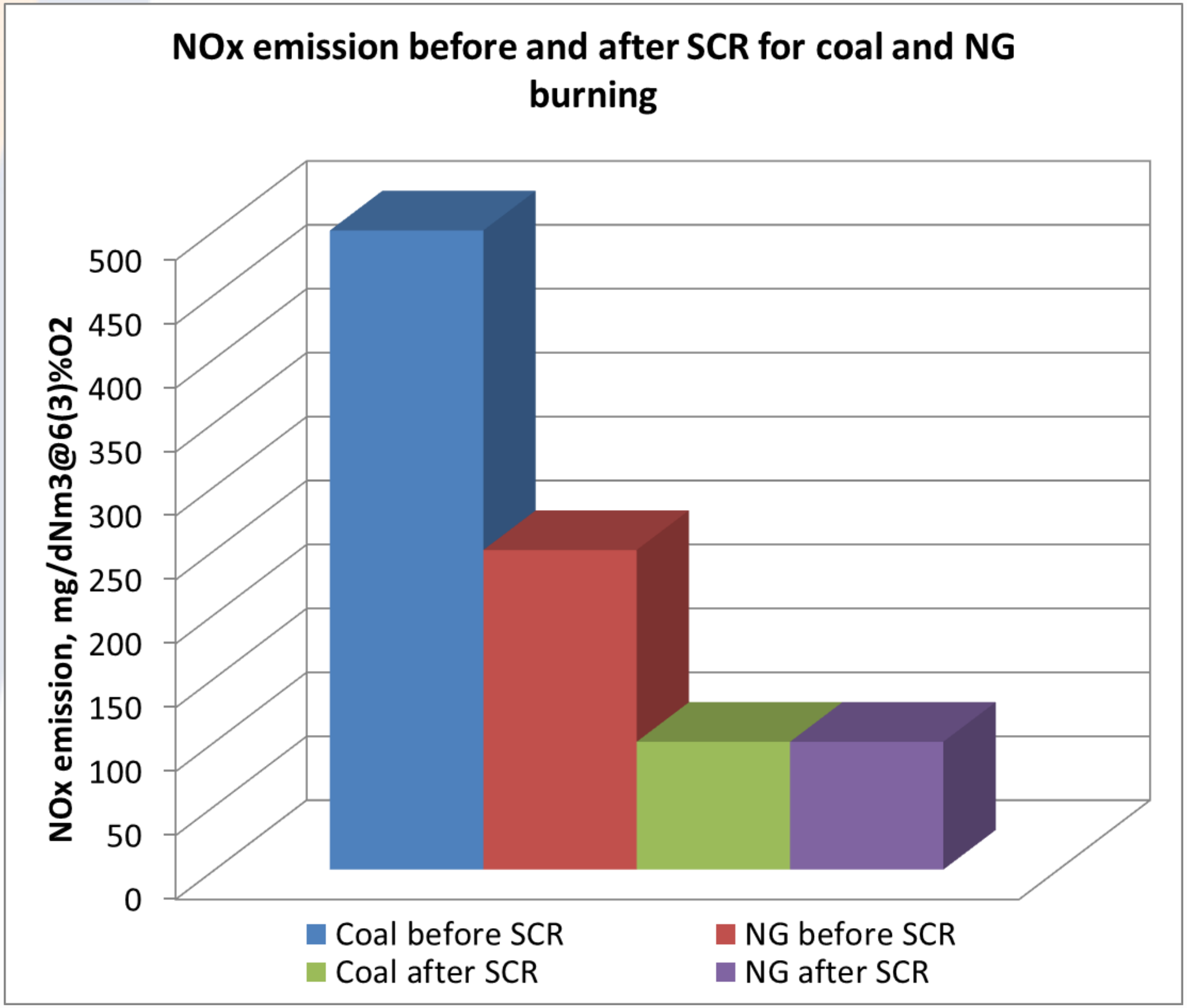
Boiler emission performance



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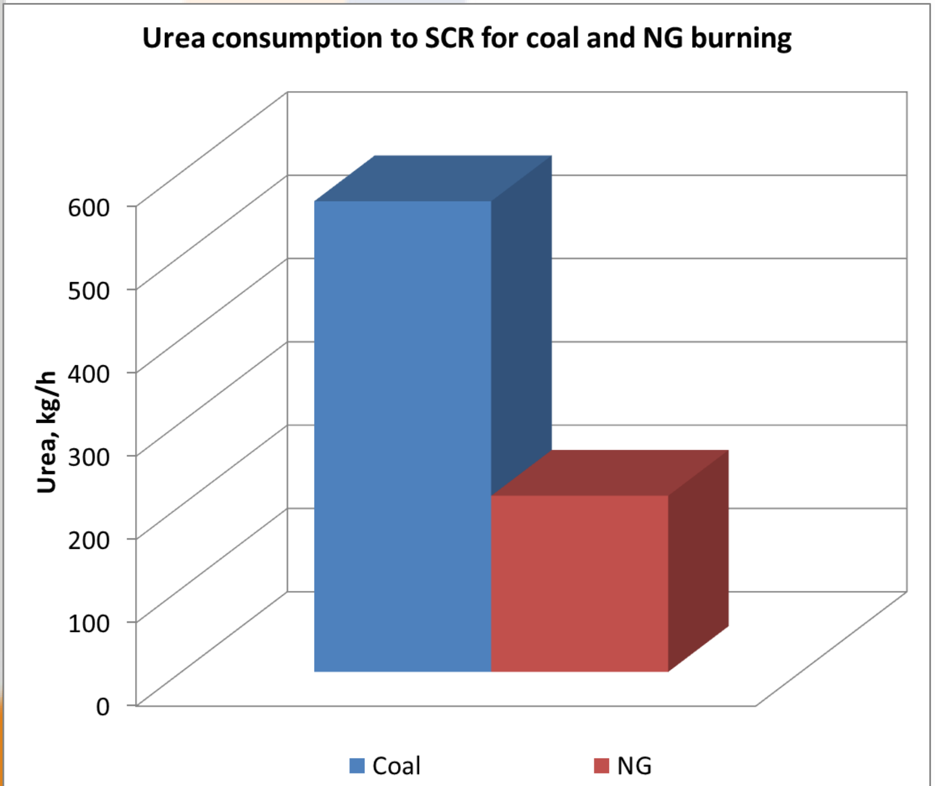

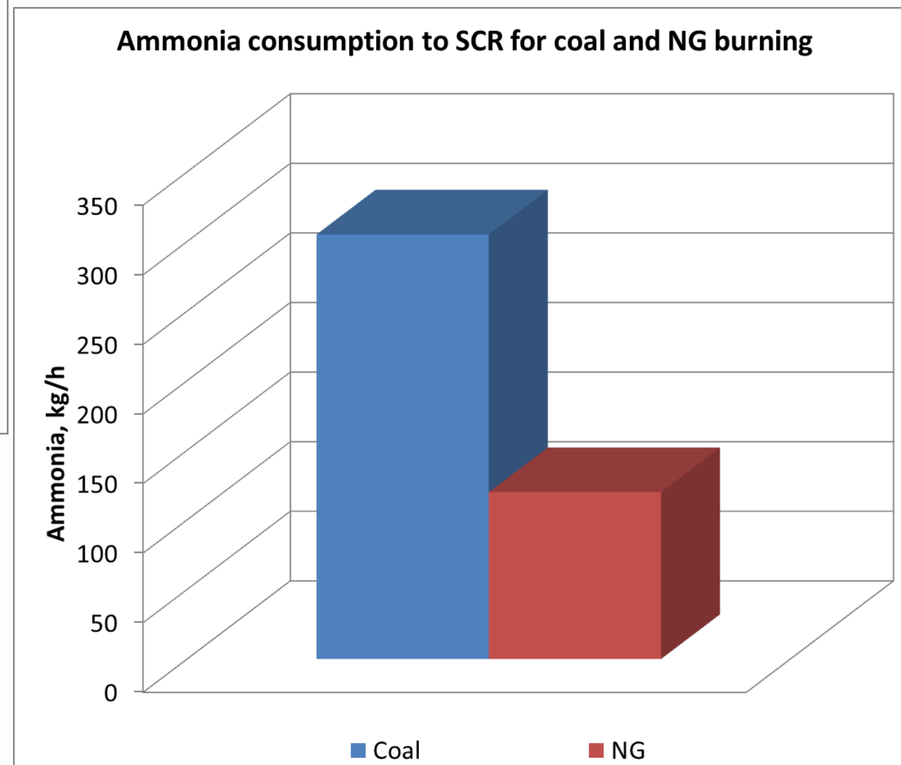

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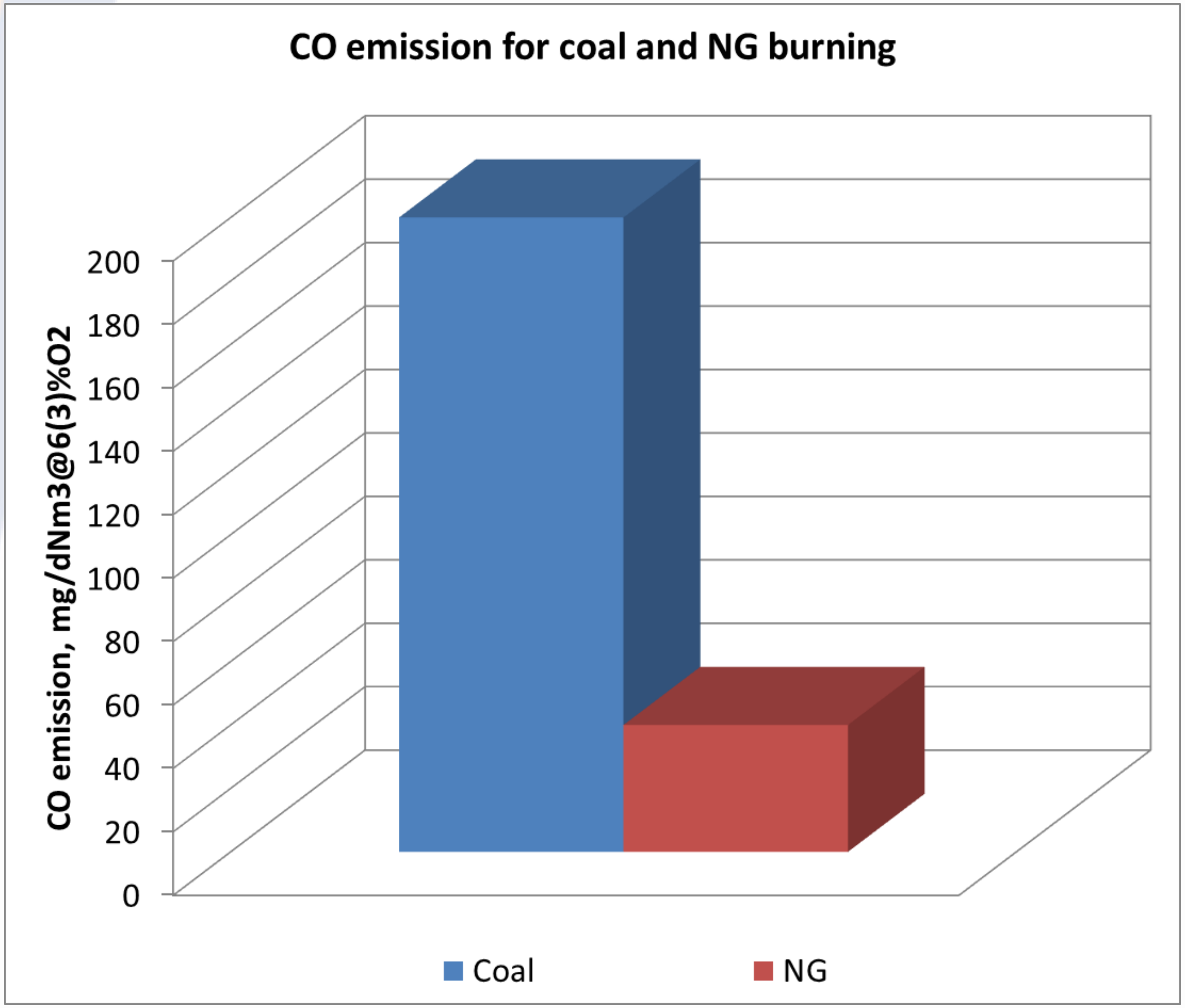

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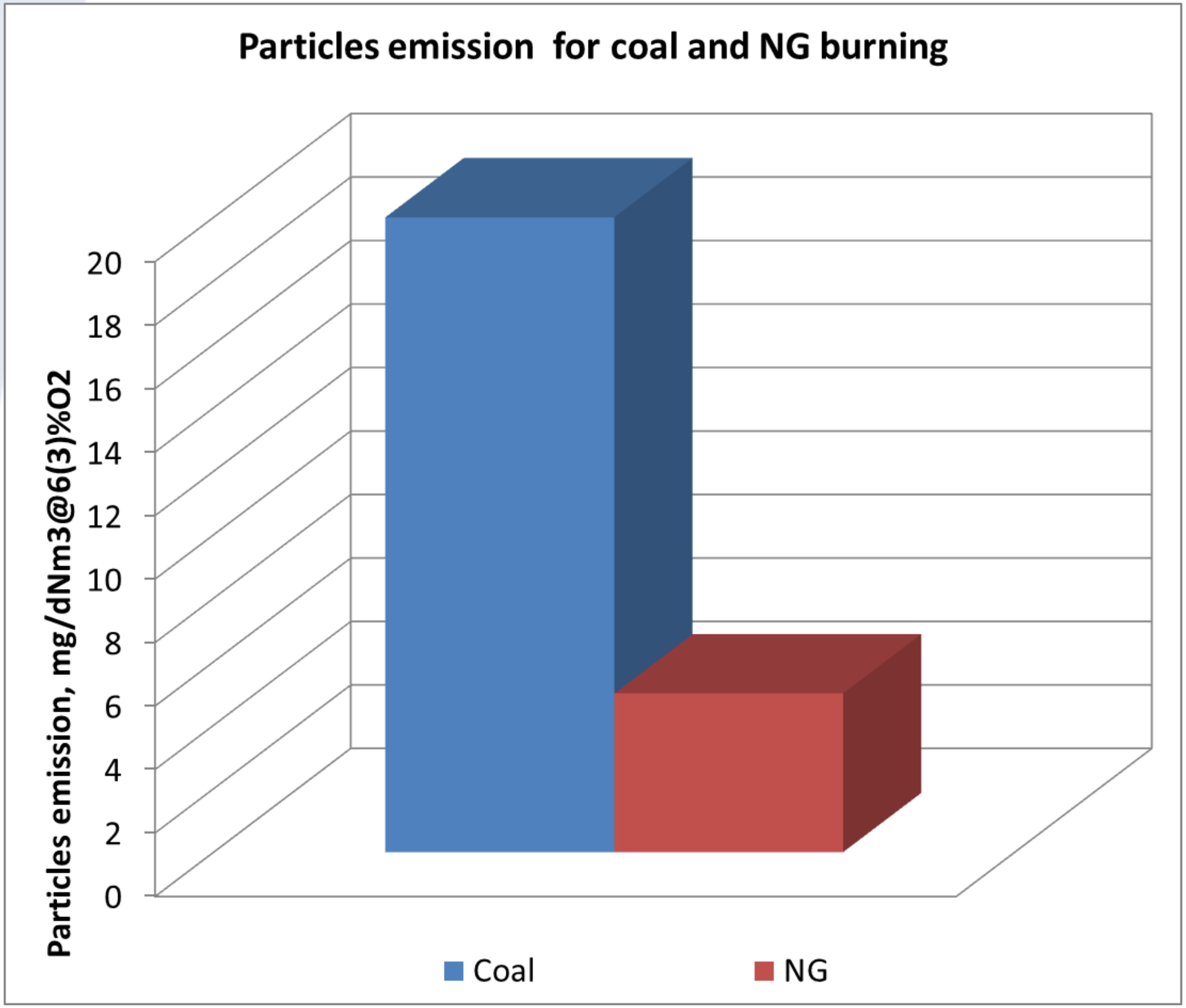

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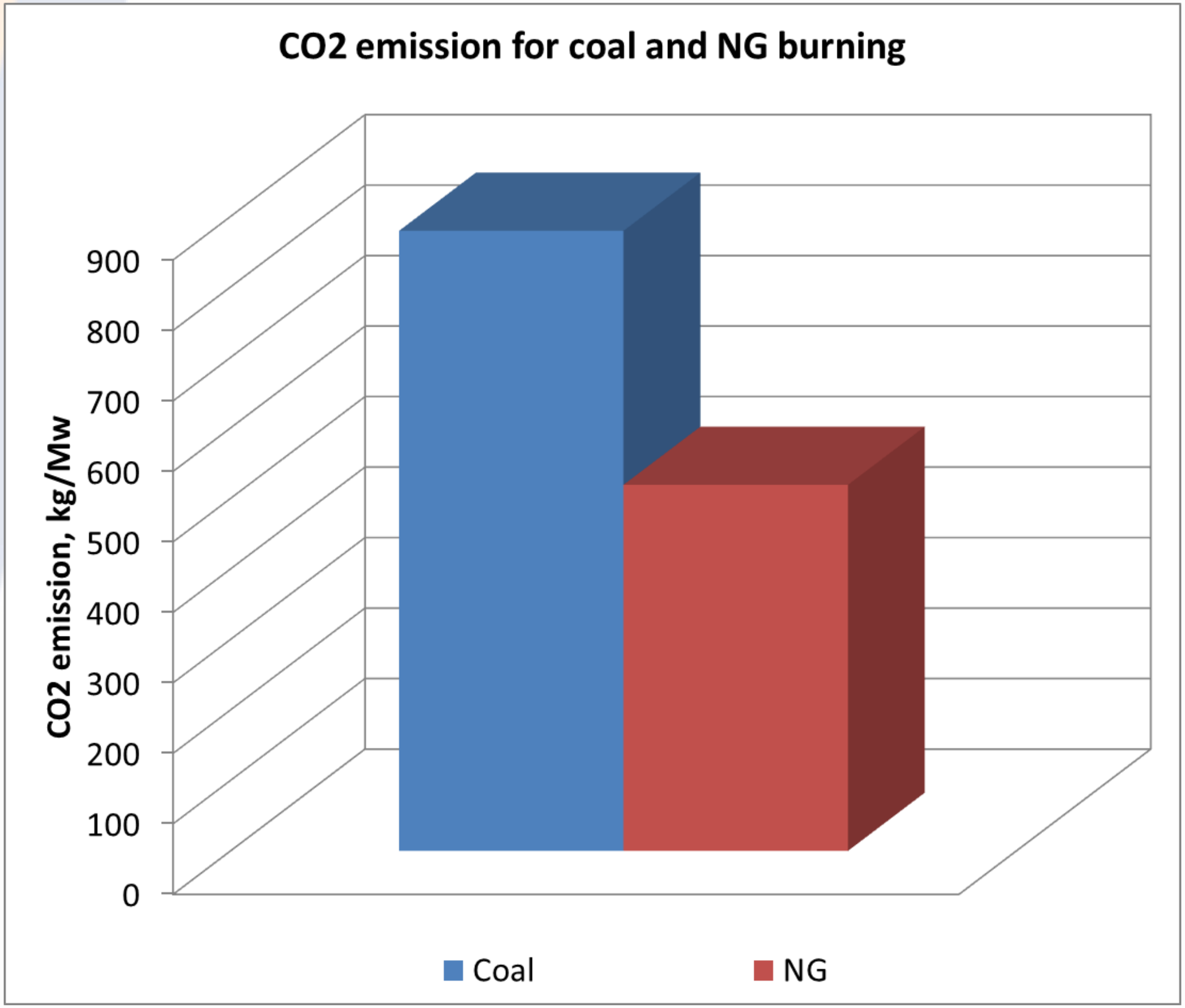

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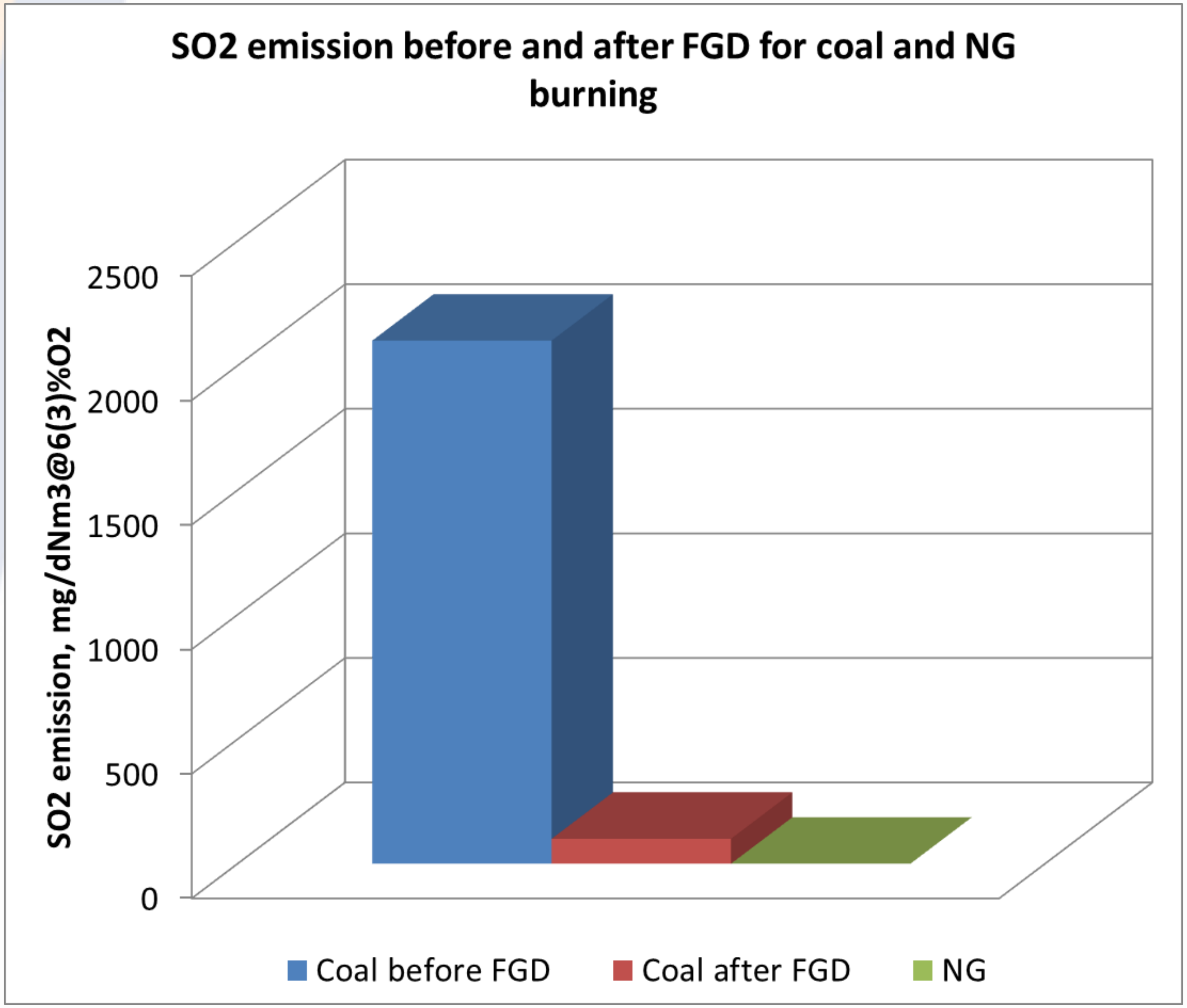

Conclusion

A case study which involved the conversion of existing industrial boilers from coal to NG burning shows:

- The existing boiler may be converted to NG burning
- The nominal operation condition may be achieved with some pressure parts modification
- Boiler efficiency will be increased
- Significant emission reduction will be achieved

Thank you