

REINHOLD ENVIRONMENTAL Ltd.



2011 NO_x-Combustion Round Table & Expo Presentation

February 7-8, 2011, in Birmingham, AL / Hosted by Southern Company

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Integrating NOx Control Combustion and Equipment Optimization

Reinhold Environmental Conference

Pat Jennings

Birmingham AL, 7 Feb 2011

POWER

ALSTOM

Reducing Reagent Usage - Tuning

Gas Inlet Control Options for SCR

Surface Changes

Gas Path

Water Path

Reducing NOx from furnace

- New low NOx system on unit with existing SCR
- Using existing low NOx system to its best advantage
- Simple Spreadsheet to calculate reagent usage and cost savings

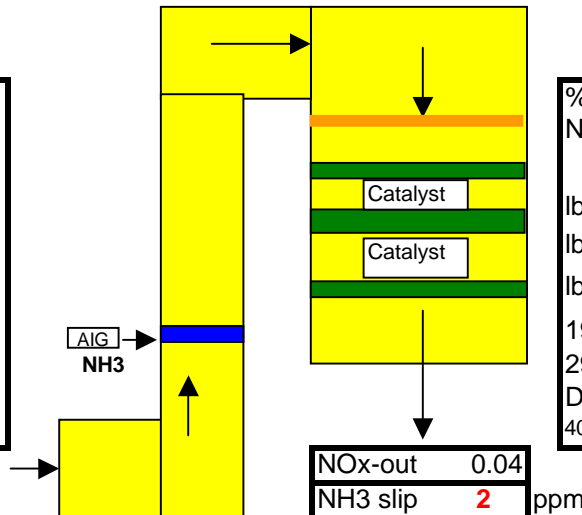
Red - Input
Blue - Calculated

Project/Proposal: **xyz**
Ammonia System: **Anhydrous / Method _____**

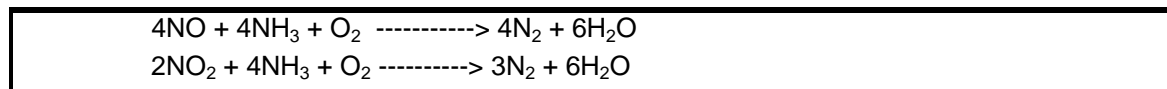
Method: **1 1A**
NO, % 95 90
NO₂, % 5 10

SCR Design for:

| | |
|-----------------------------------|-------------------------------------|
| | Input |
| Q _f x10 ⁶ = | 6828 x10 ⁶ Btu/hr |
| NOx-in | 0.13 lb/Mbtu |
| NOx-out | 0.04 lb/Mbtu |
| NOx-in | 95 ppm |
| NOx-out | 29 ppm |



| | | |
|-----------------------------------|--------------|--------------|
| % Reduction | 69.2 | 69.2 |
| NH ₃ /NOx mole ratio | 0.748 | 0.783 |
| lb/hr NH ₃ (stoich) | 245.8 | 257.2 |
| lb/hr NH ₃ (operating) | 258.1 | 270.0 |
| lb/hr NH ₃ (design) | 295 | 309 |
| 19% Aqueous | 1552 | 1624 |
| 29% Aqueous | 1017 | 1064 |
| Dry Urea, lb/hr | 520 | 545 |
| 40% Urea Soln. lb/hr | 1301 | 1361 |



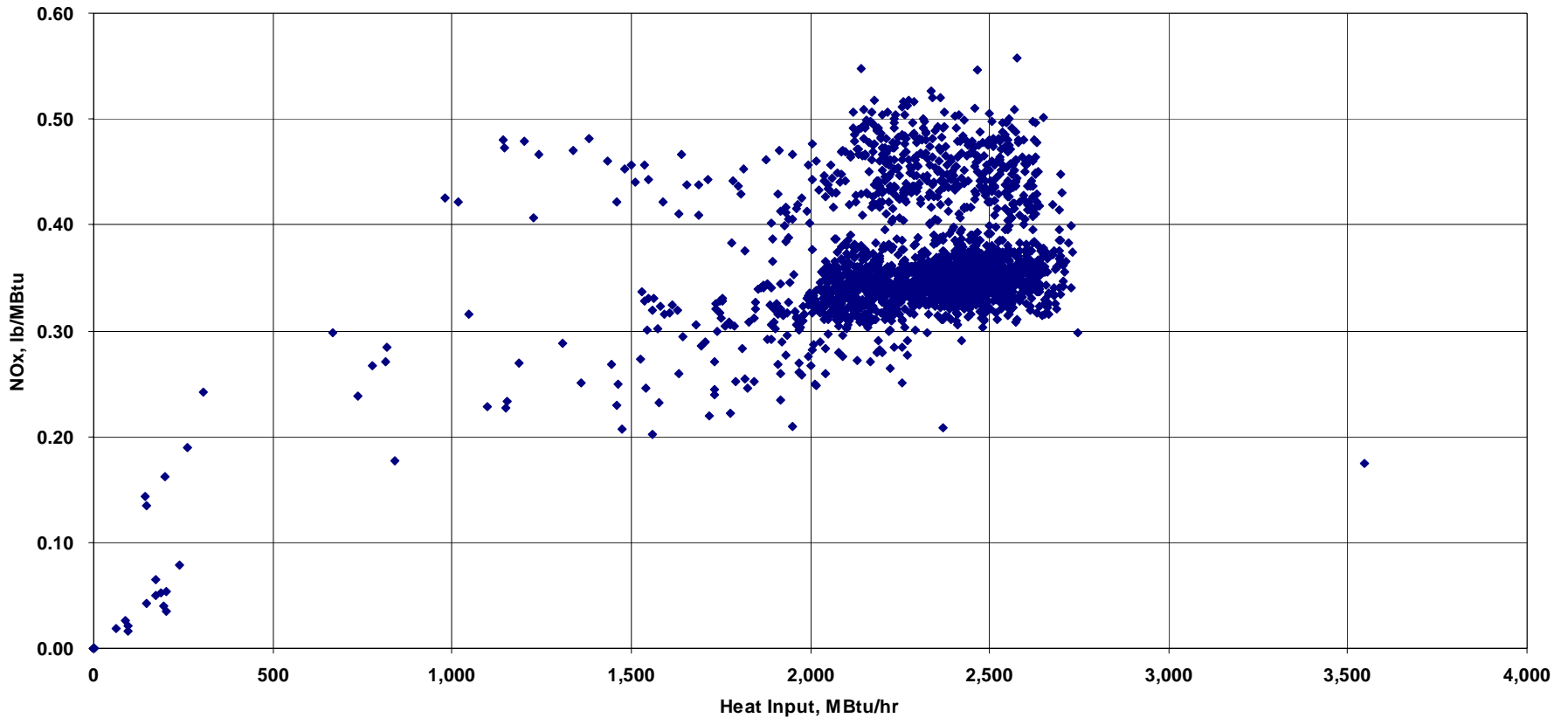
- Factors Affecting NOx Emissions
 - OFA Quantity
 - Excess Air
 - Fuel Type
 - Biasing Fuel and or Air (Generally lower {fuel} and higher {air})
 - Mills in service
 - Quantity
 - Location
 - Balancing
 - Generally little to no effect on Tangentially fired if well tuned
 - Wall Fired – More Likely

- Typical Limitations
 - CO
 - UBC
 - Steam Temperatures
 - Slagging or fouling
 - Controls
 - Concern over waterwall wastage

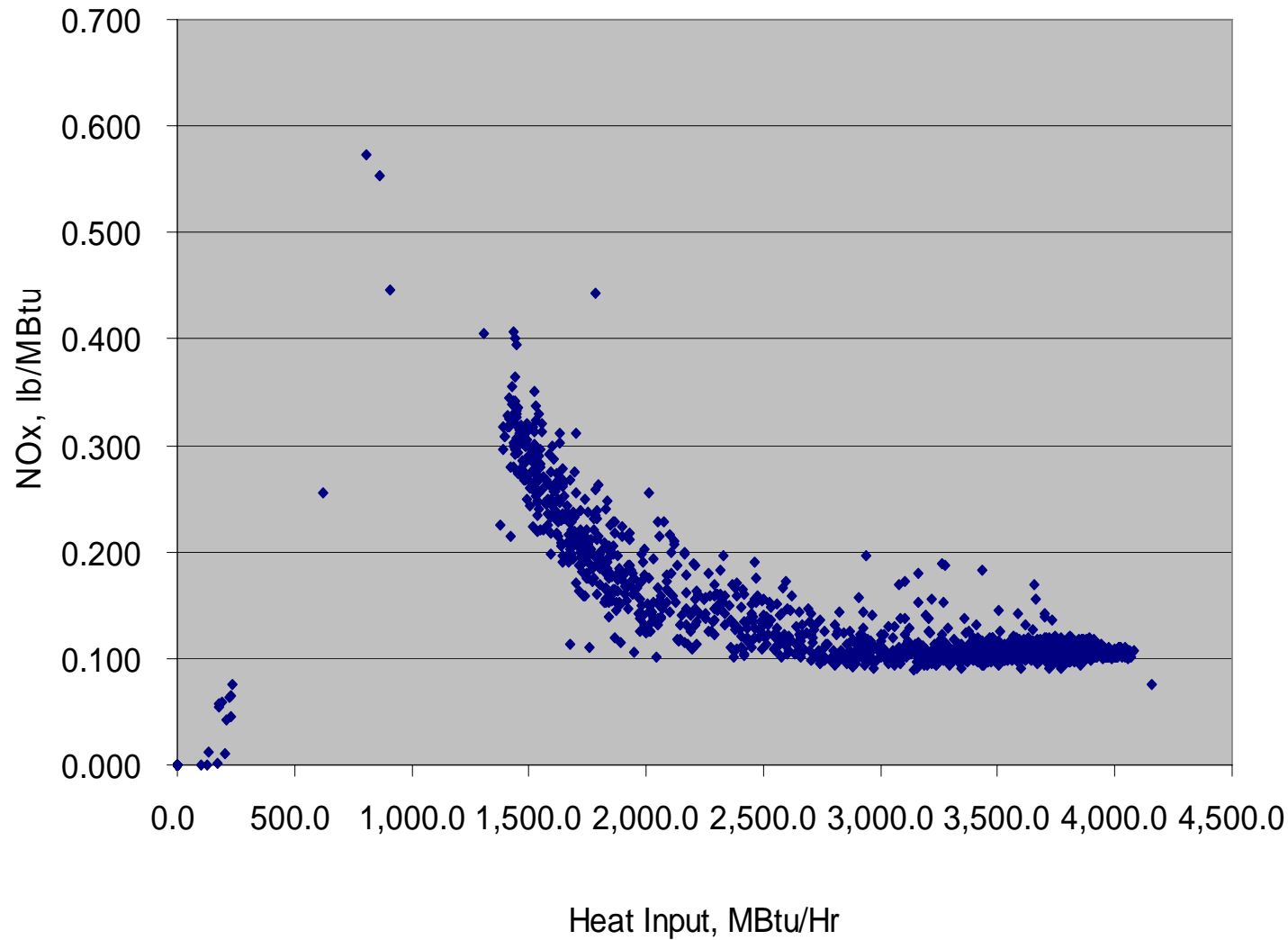
Tuning Examples



Unit 1 One Quarter
Hourly Averaged Data as Reported by the EPA



Tuning Examples



Reducing Reagent Usage - Tuning

Gas Inlet Control Options for SCR

Surface Changes

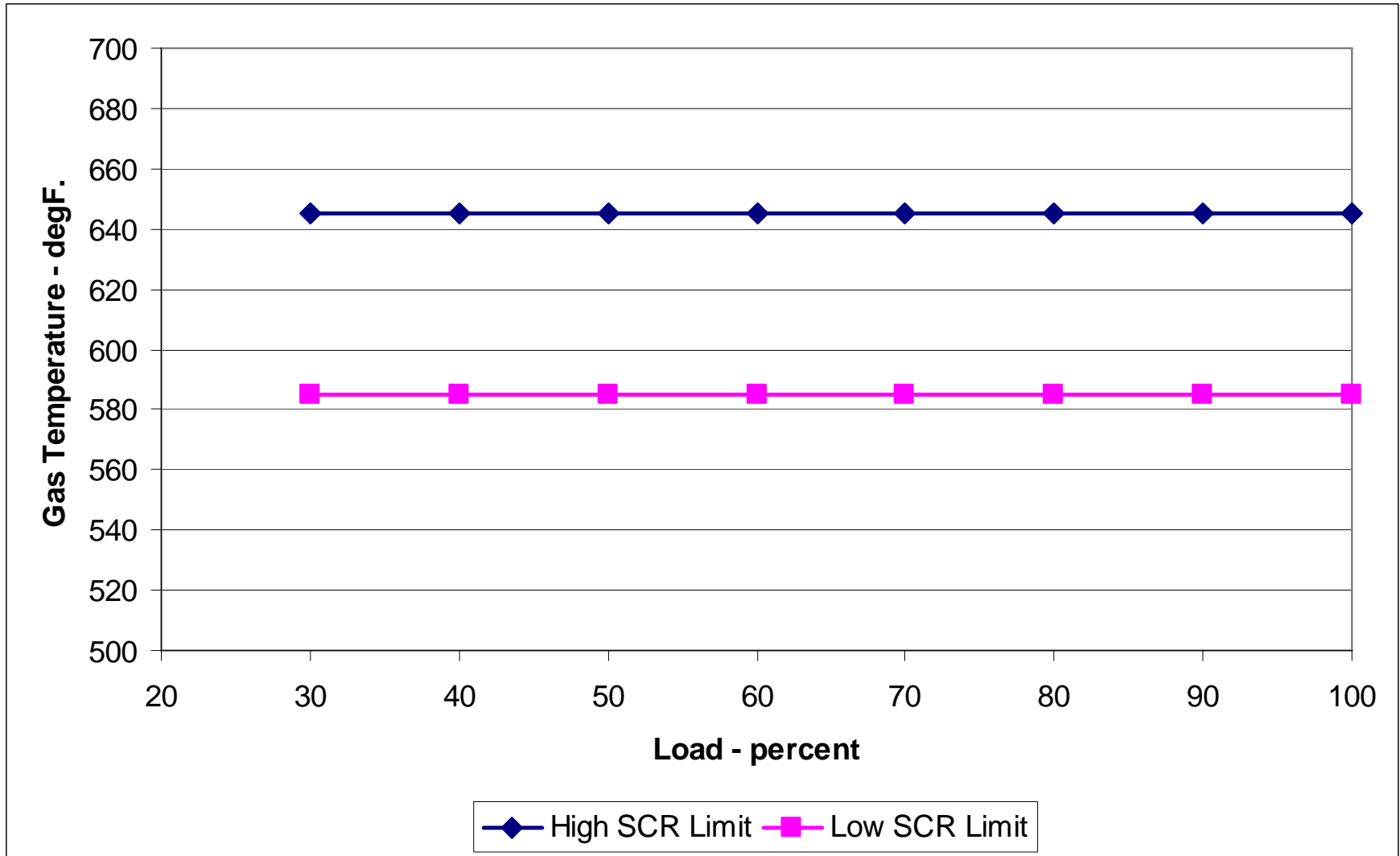
Gas Path

Water Path

What are the limits on SCR temperature?

- High temperature
 - Surface may sinter
 - Pore structure changes
 - Decrease in efficiency, more ammonia slip
- Low temperature fouling
 - Ammonium Bisulfate
 - Short term reversible
 - SO₃, ammonia and moisture in flue gas

SCR Inlet Gas Temperatures



Selective Catalytic Reduction System Gas Temperature Control Options



- Surface Changes
 - Install or remove economizer surface.
 - Split economizer arrangement.
- Economizer gas bypass system.
- Economizer water bypass system.
- Hot water recirculation.

Reducing Reagent Usage - Tuning

Gas Inlet Control Options for SCR

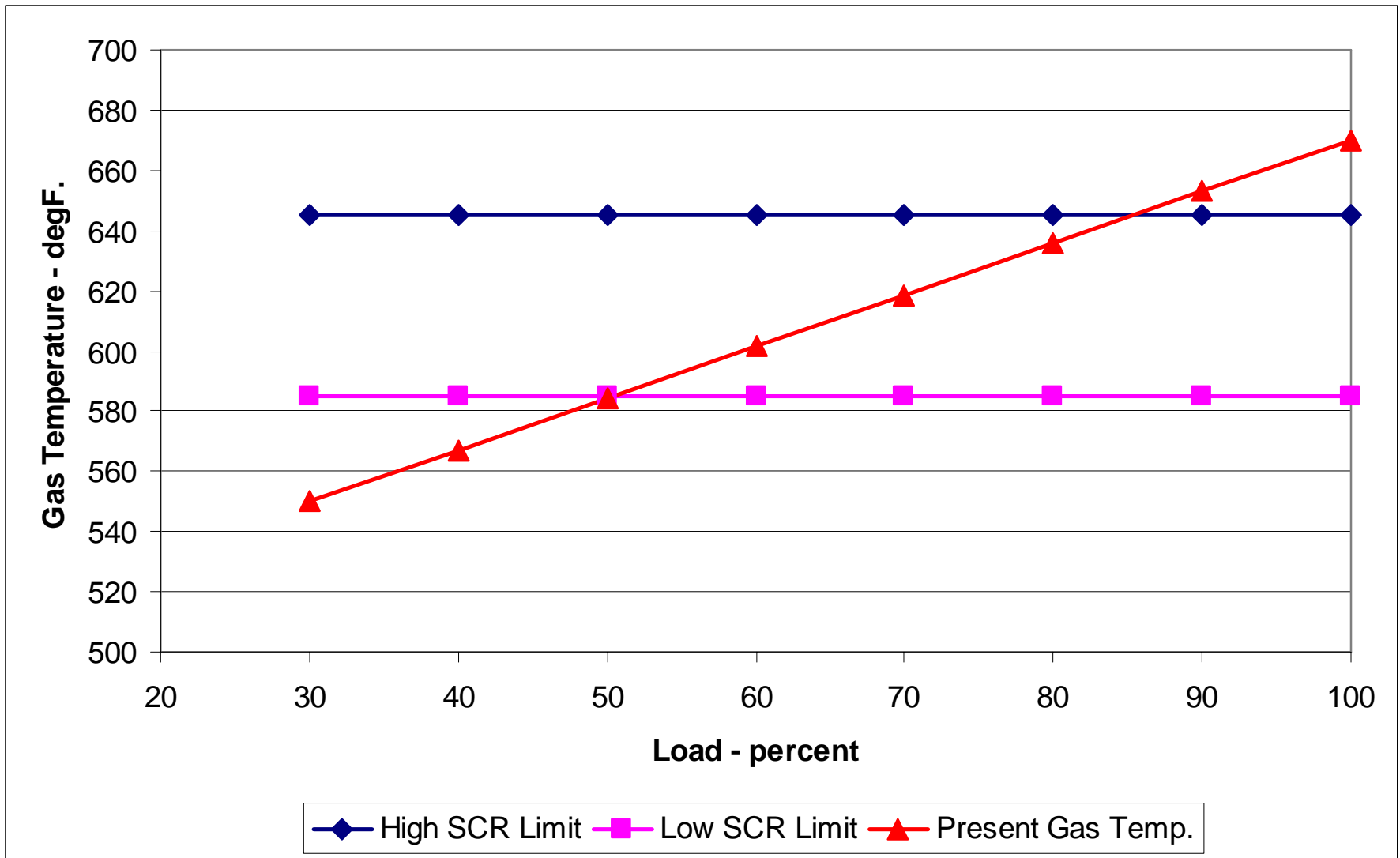
Surface Changes

Gas Path

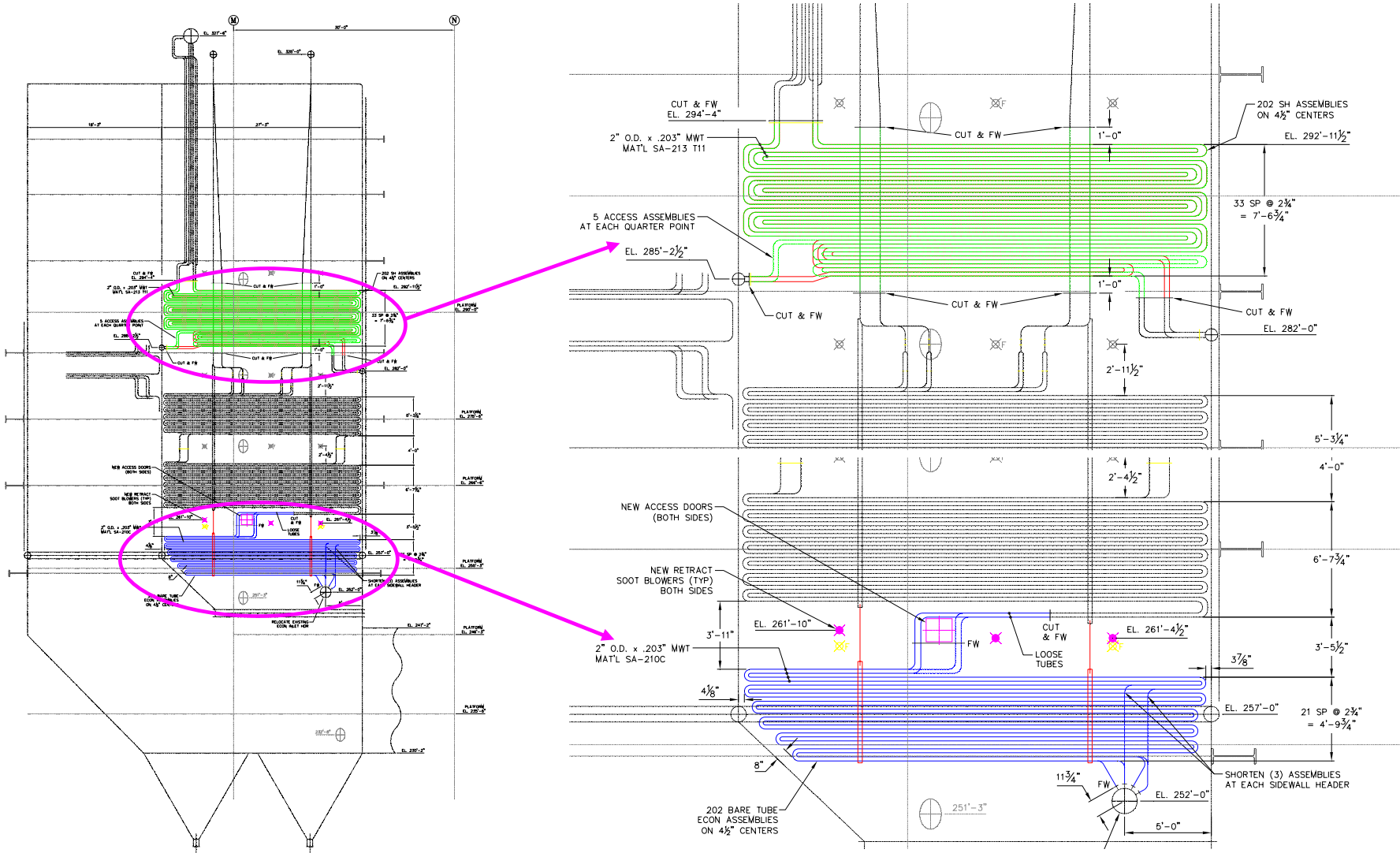
Water Path

Surface Changes Install Additional Economizer Surface

Install Additional Economizer Surface



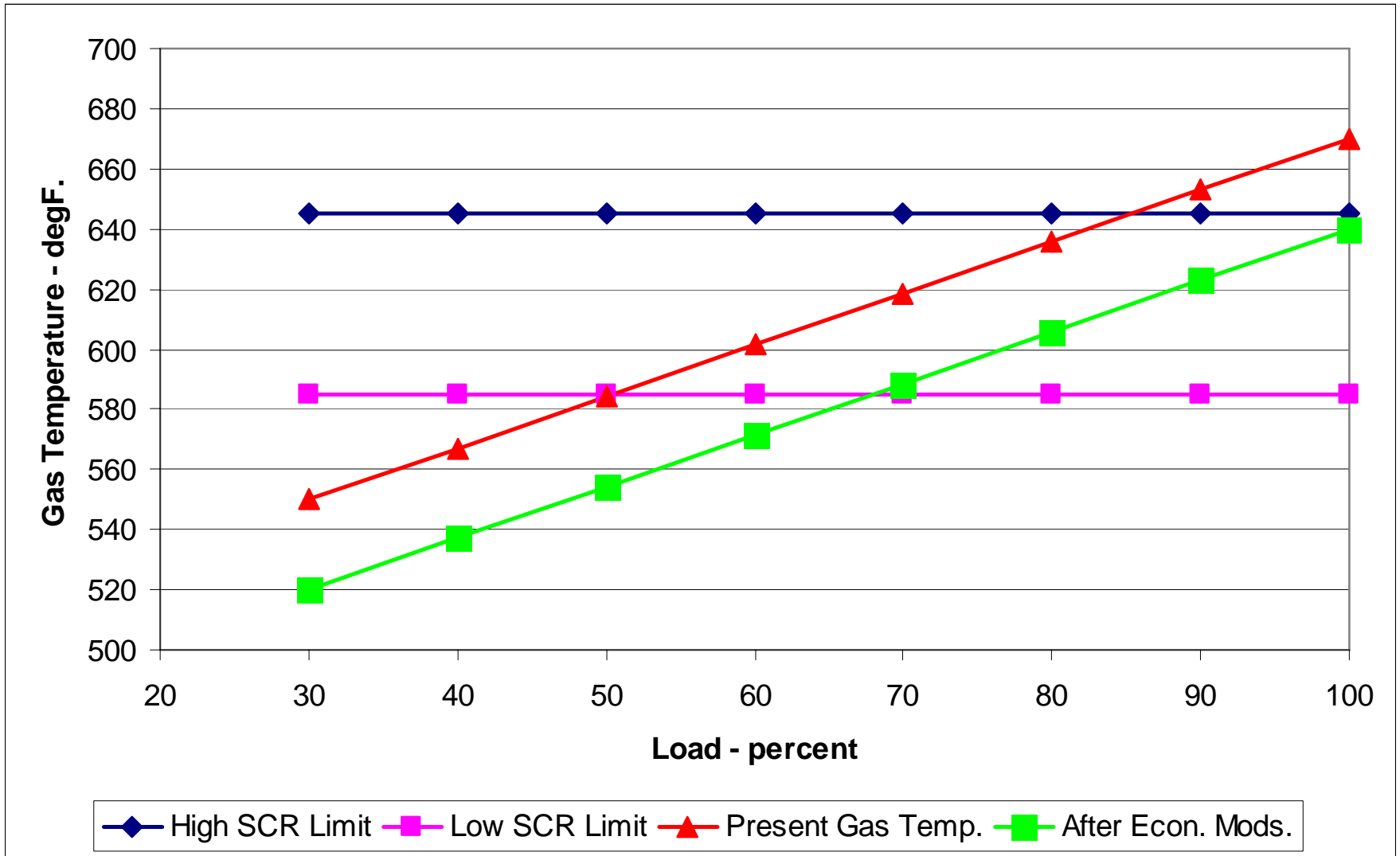
Install Additional Economizer Surface



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Install Additional Economizer Surface

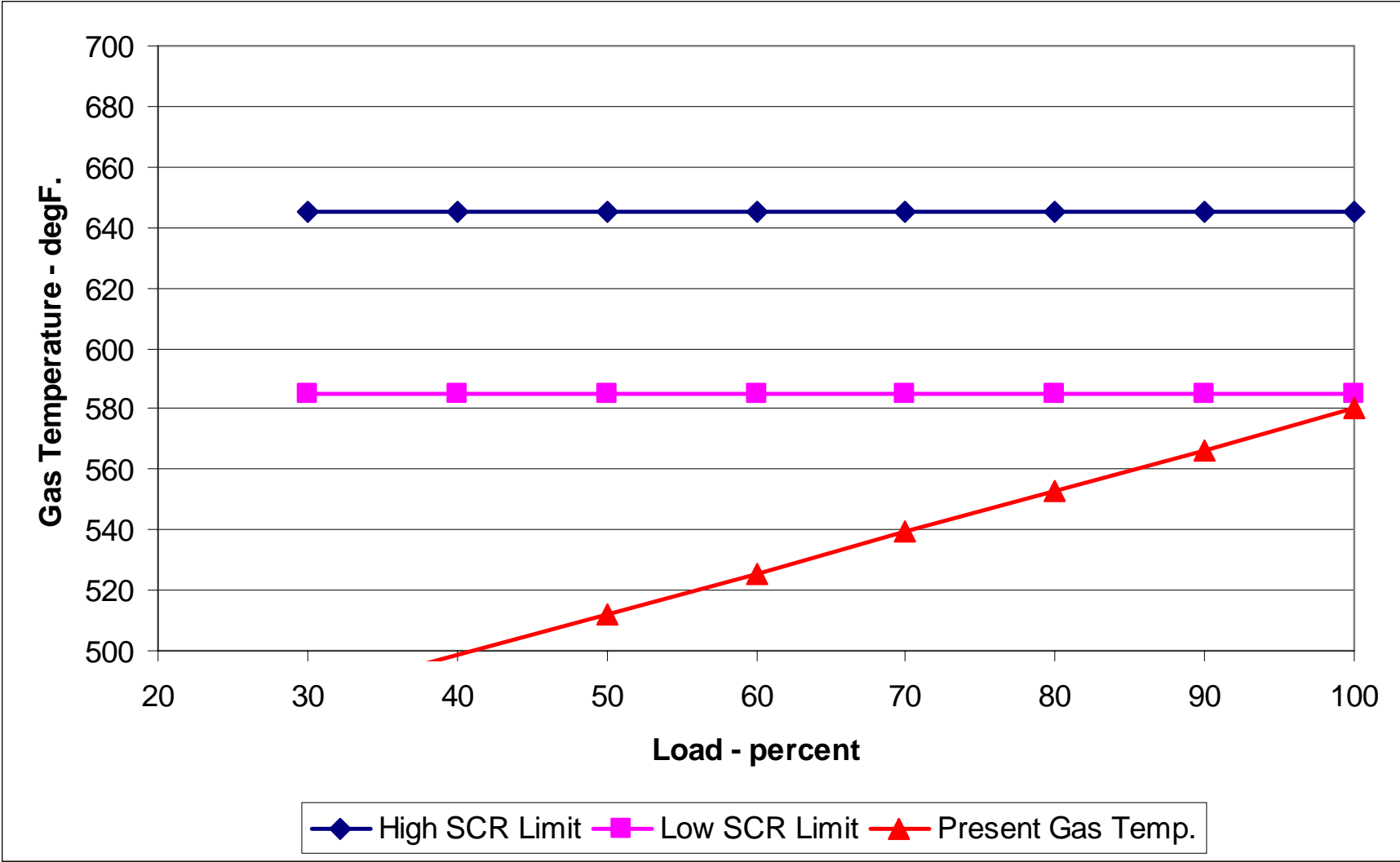


- Pros:
 - Should be resurfaced for 20 - 30 deg.F below maximum SCR operating gas temperature.
 - Improves boiler efficiency.
 - Good solution for base load boiler.

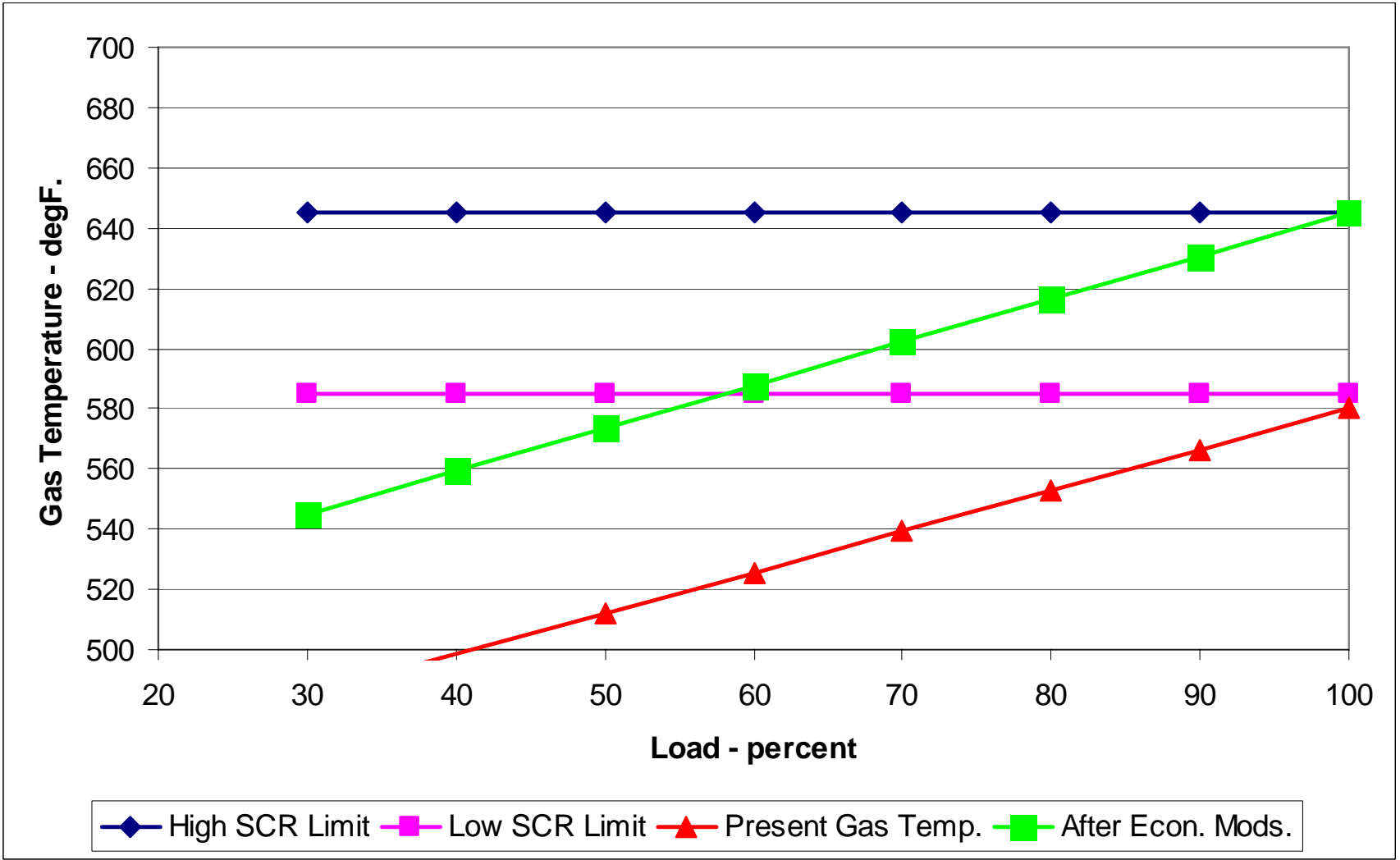
- Cons:
 - May provide a very limited control range.
 - If low load operation is required, SCR inlet temp may be too low and fouling in SCR may occur.
 - On subcritical boilers, steaming of the economizer may be an issue.

Surface Changes Remove Economizer Surface

Remove Economizer Surface



Remove Economizer Surface

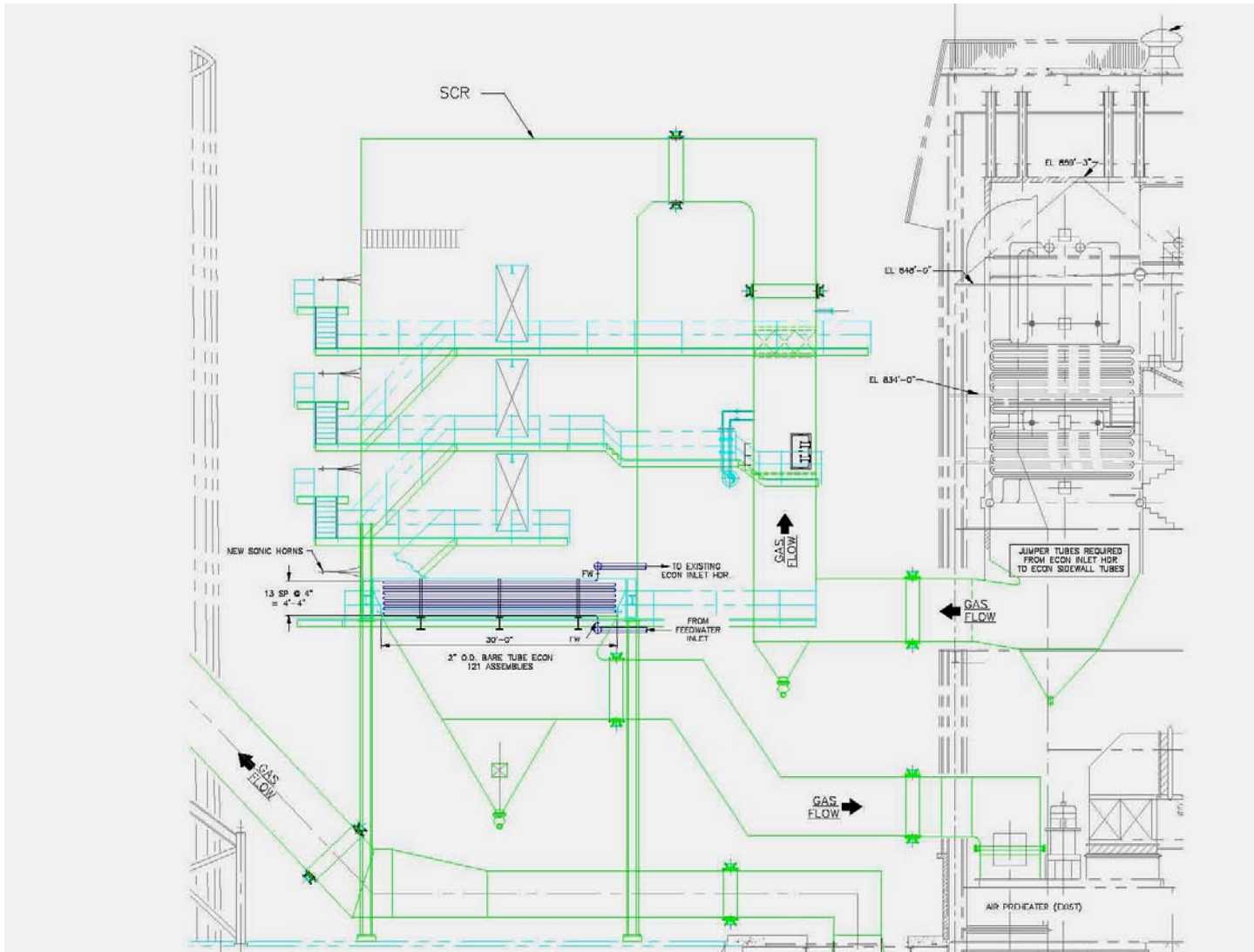


- Pros:
 - Should be able to obtain the desire gas temperature to SCR at full load.
 - Resurface for 20 - 30 deg.F below maximum SCR operating gas temperature.

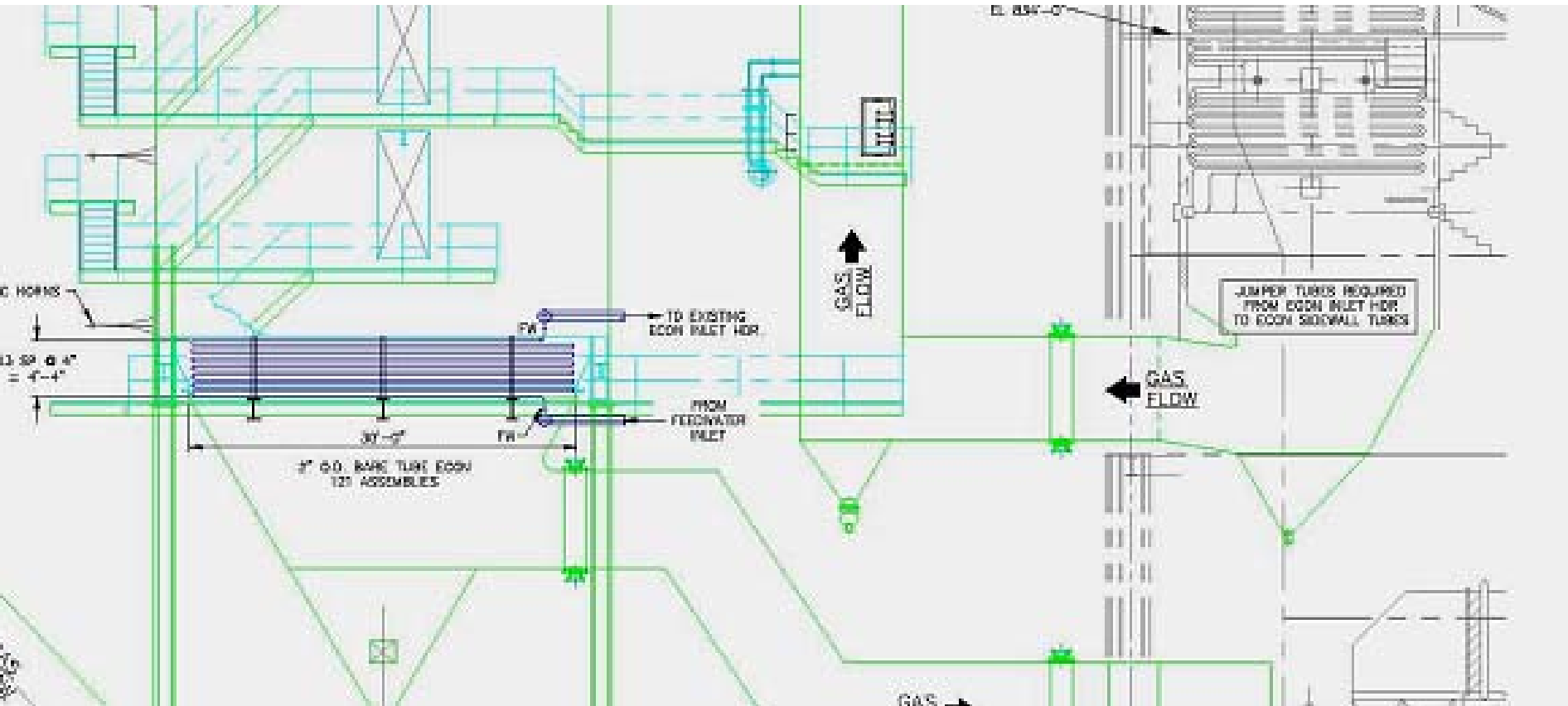
- Cons:
 - Decreases boiler efficiency at all load ranges.
 - May provide a very limited control range.

Surface Changes Split Economizer Arrangement

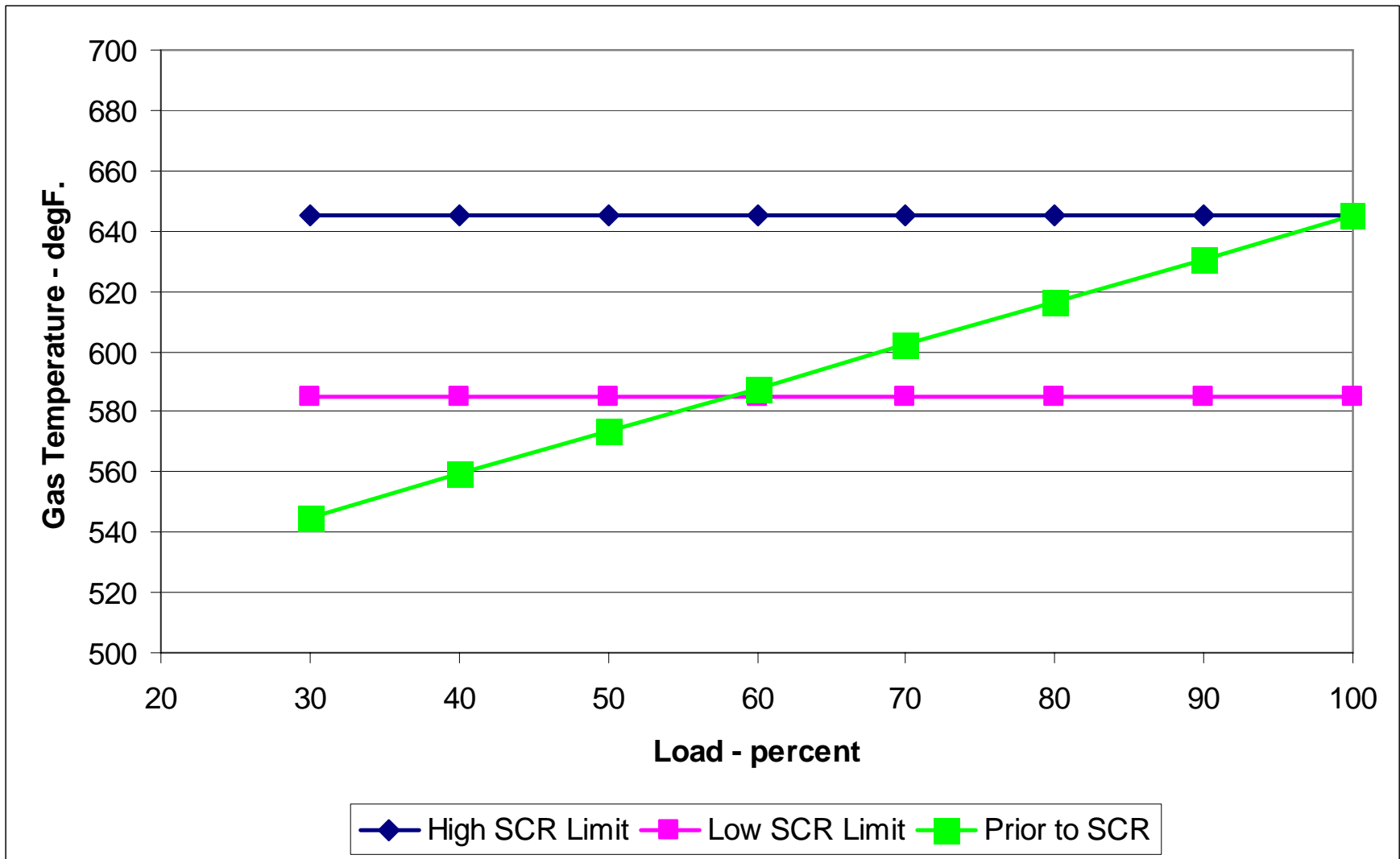
Split Economizer Arrangement



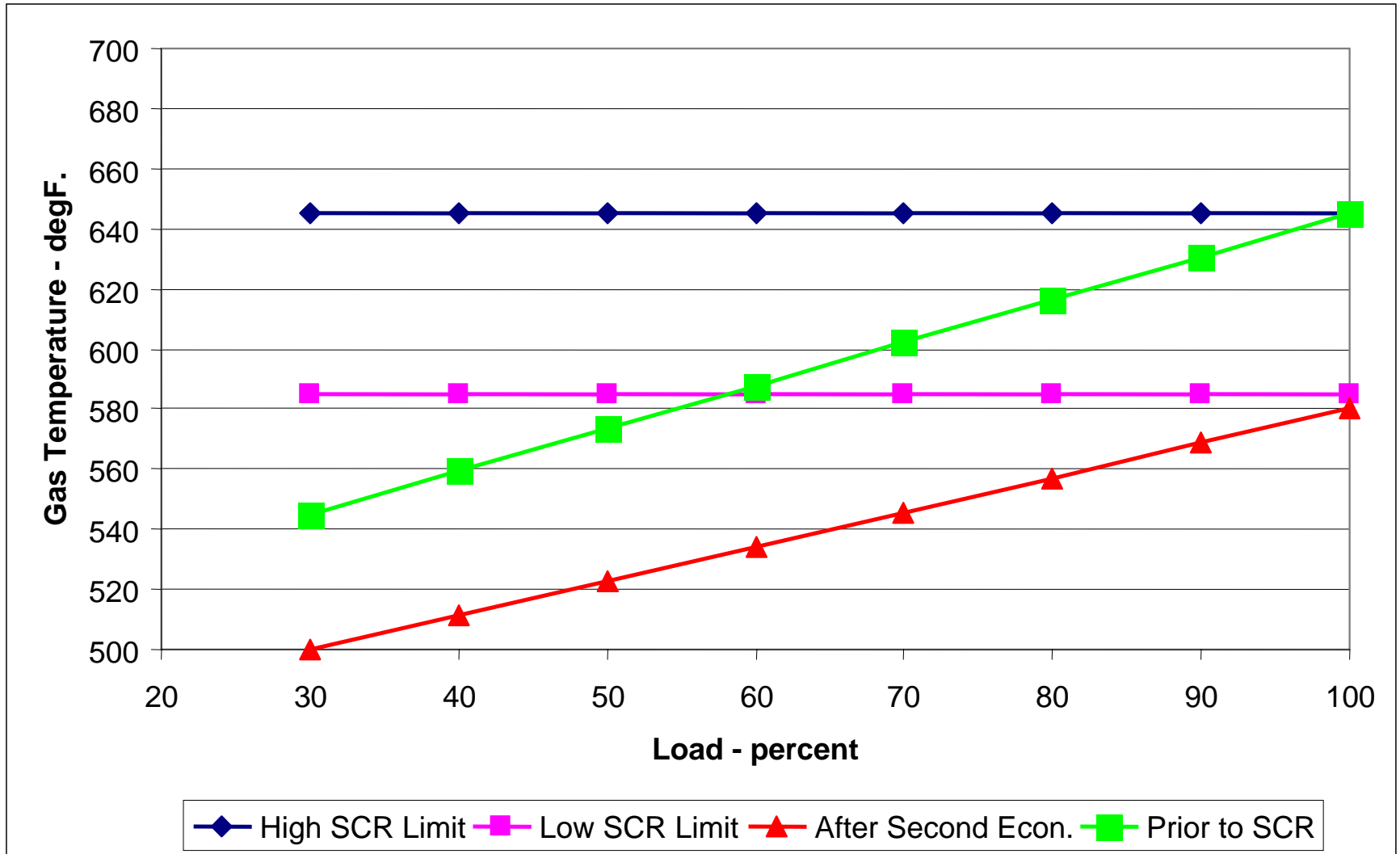
Split Economizer Arrangement



Split Economizor Arrangement



Split Economizer Arrangement



- Pros:
 - Should be able to obtain the desire gas temperature to SCR at full load.
 - Resurfaced for 20 - 30 deg.F below maximum SCR operating gas temperature.
 - Very little change to boiler efficiency at all load points but air preheater fouling may be an issue.

- Cons:
 - May provide a very limited control range depending on SCR design.

Reducing Reagent Usage - Tuning

Gas Inlet Control Options for SCR

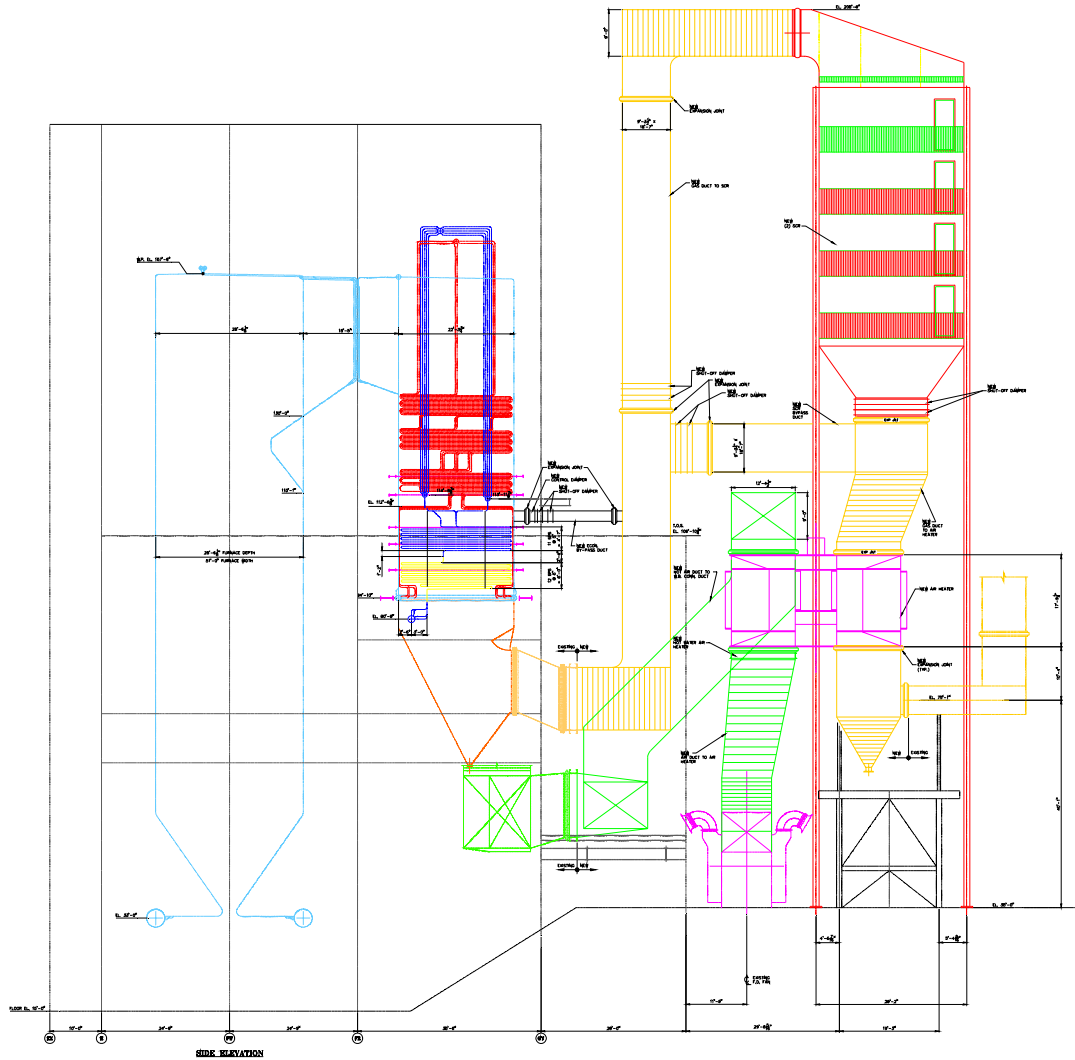
Surface Changes

Gas Path

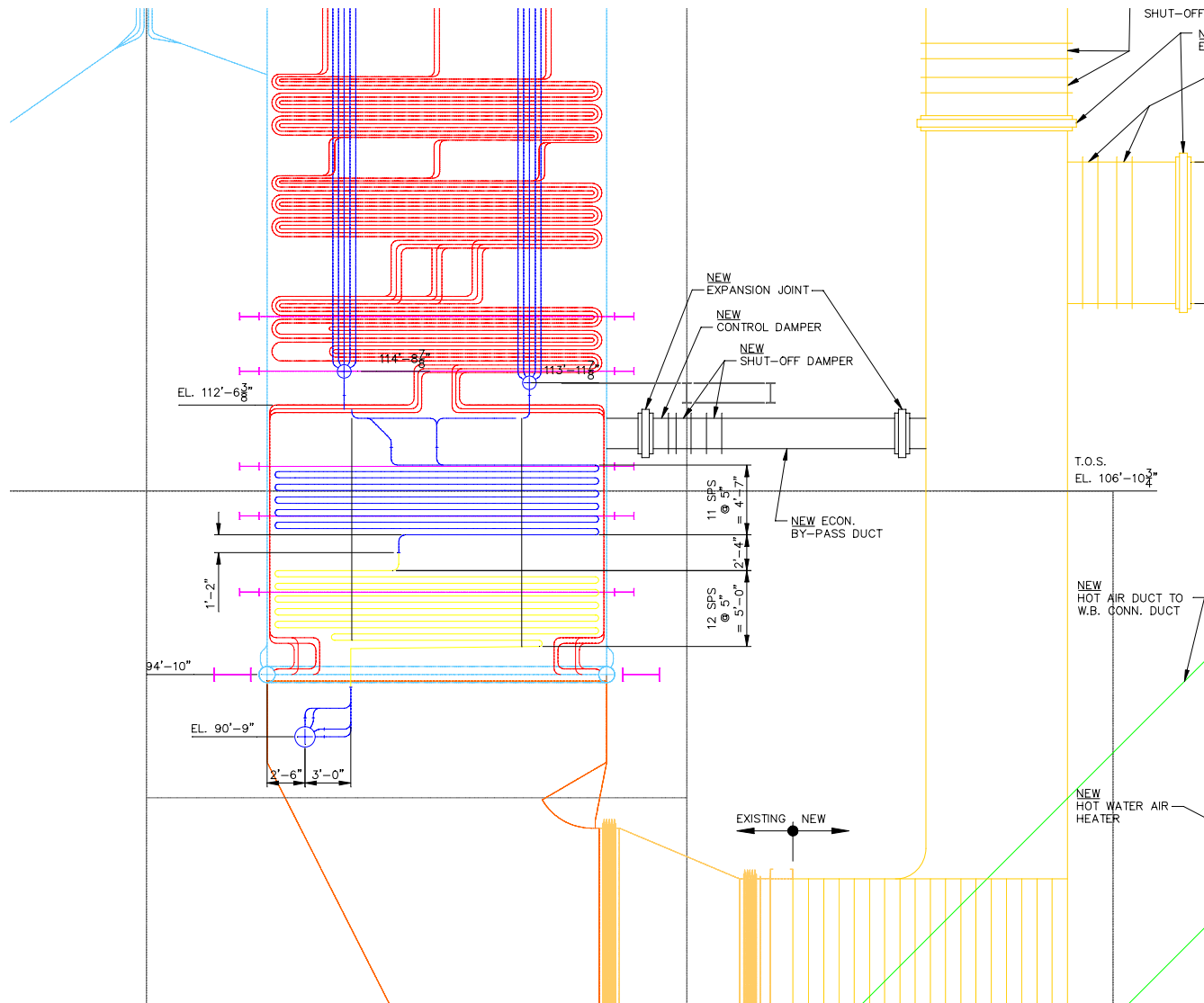
Water Path

Economizer Gas Bypass System

Economizer Gas Bypass System for SCR



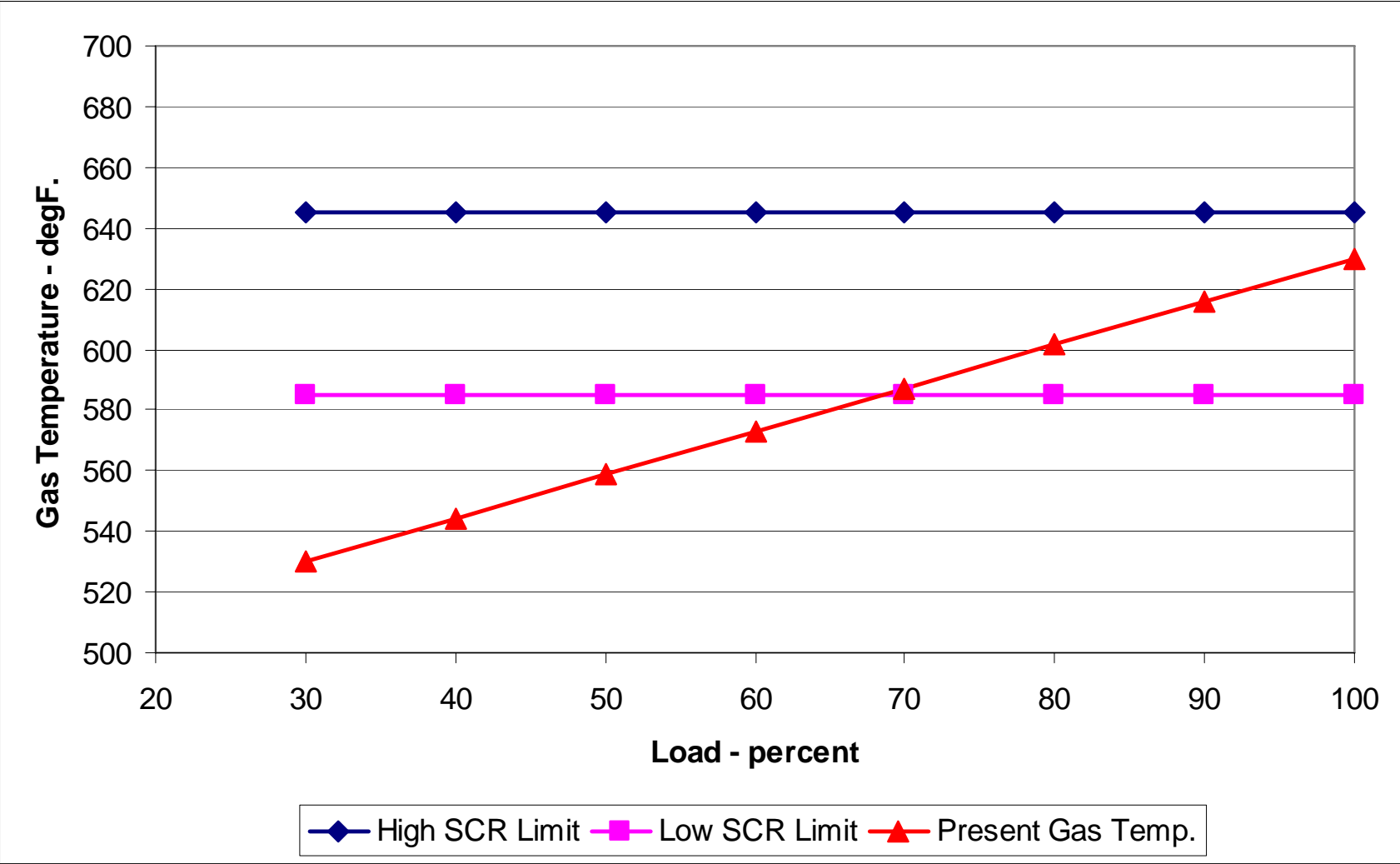
Economizer Gas Bypass System for SCR



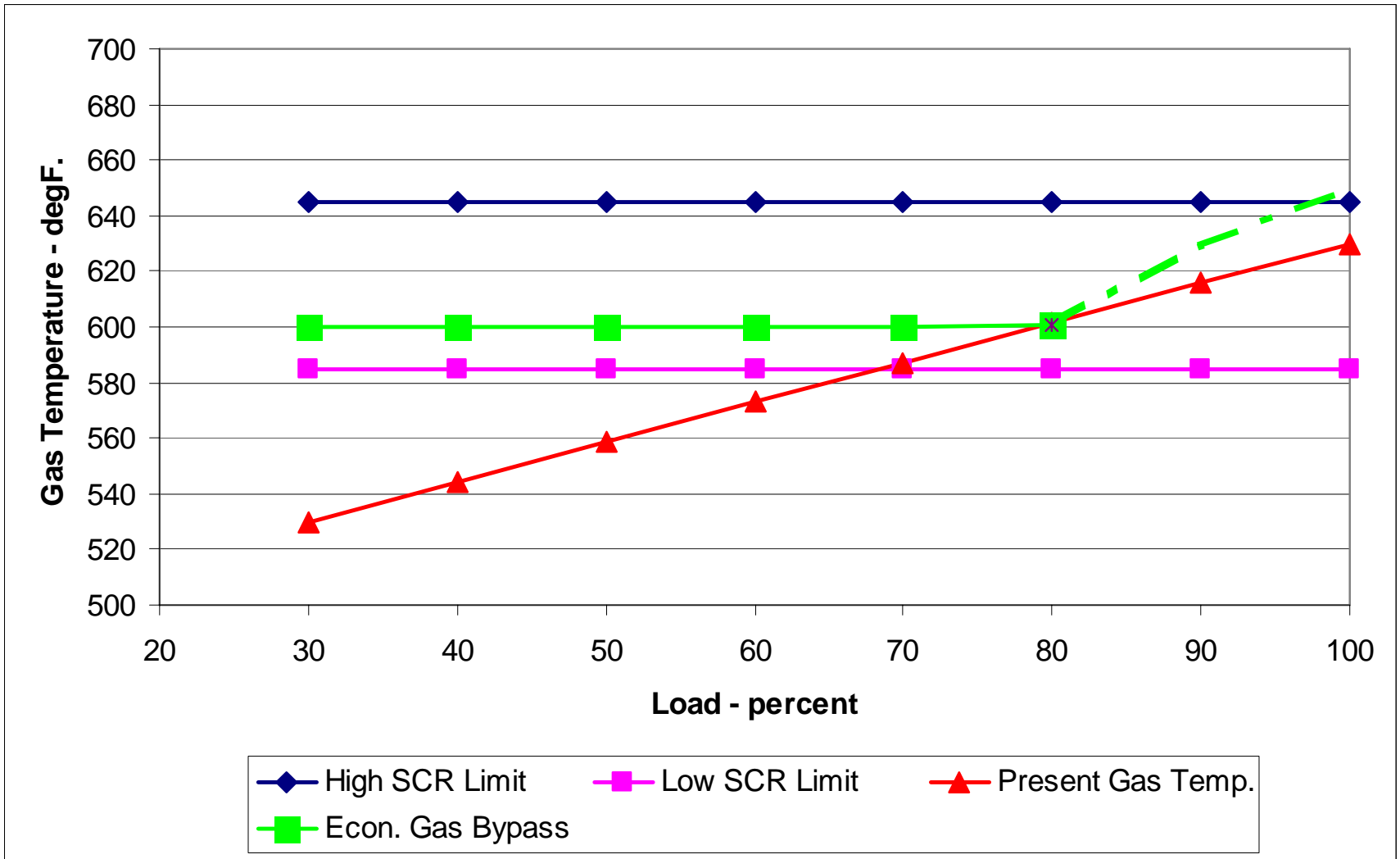
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Economizer Gas Bypass Duct



Economizer Gas Bypass Duct



- Pros:
 - Can provide a wide control range.
 - Normally closed at MCR so no decrease in boiler efficiency

- Cons:
 - Could experience high temperature in ducts.
 - Requires shut-off gates.
 - Requires control and resistance dampers.
 - Ash buildup and potential duct plugging.
 - High duct metal temperatures.
 - Damper and shut-off gate maintenance and possible leakage or failure.
 - May need to route duct to SCR inlet mixing device or may need provisions for prevention of ash build up
 - Can be very expensive if gas temperature source (economizer inlet or LTSH/ PSH) is high (+ 1300 degF.)

Economizer Water Bypass System

Reducing Reagent Usage - Tuning

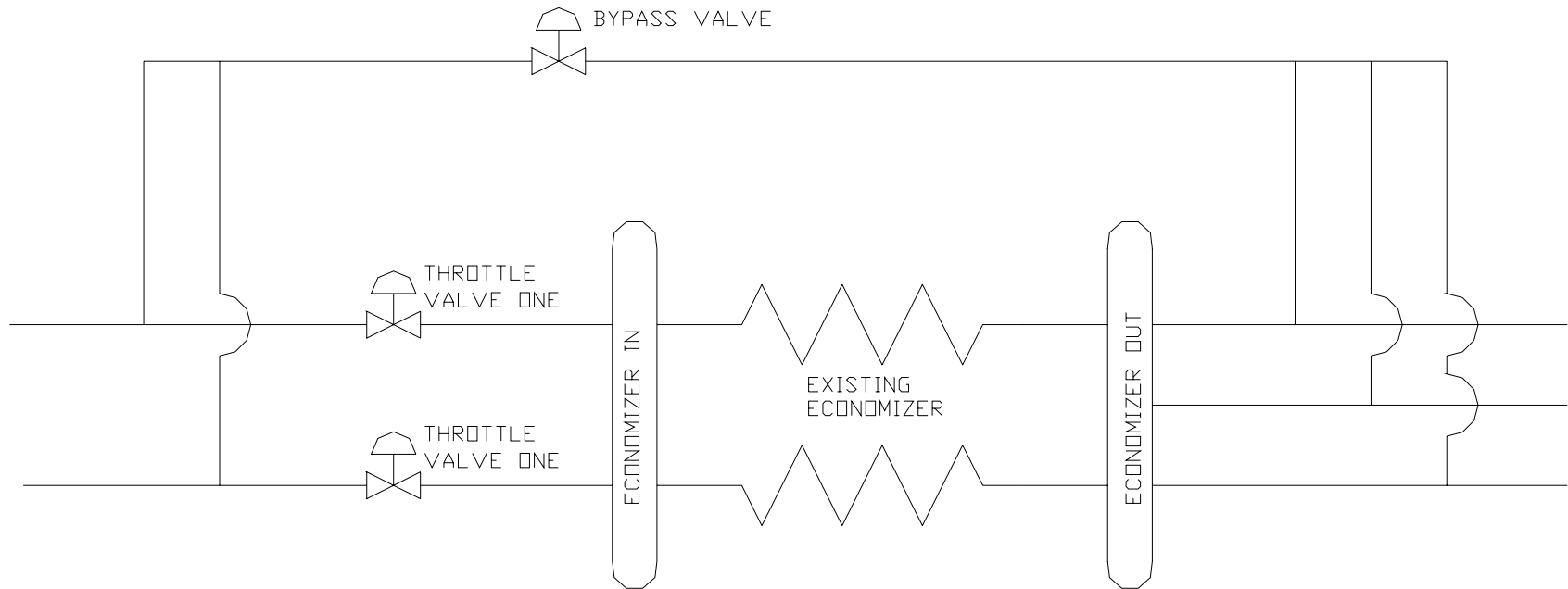
Gas Inlet Control Options for SCR

Surface Changes

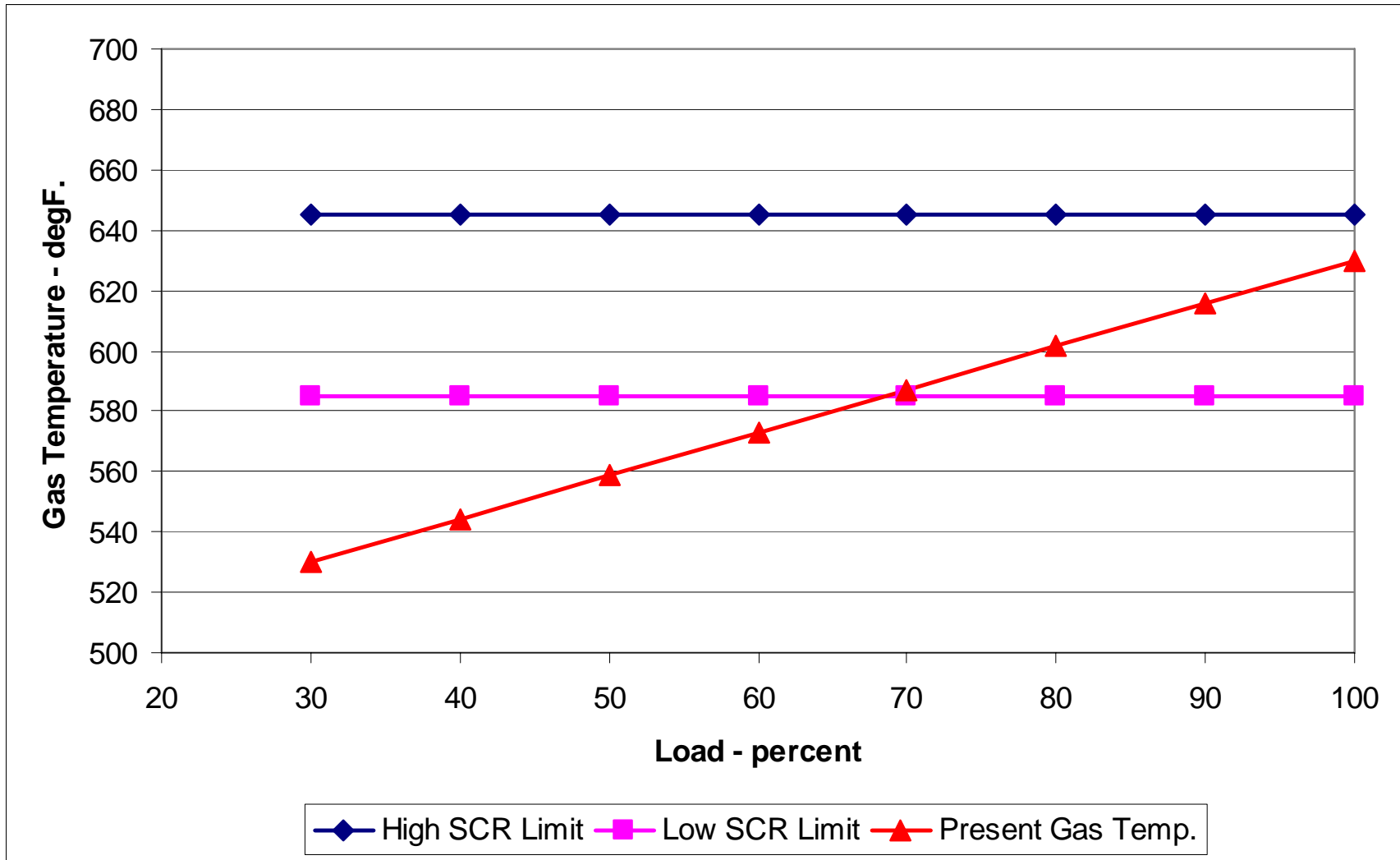
Gas Path

Water Path

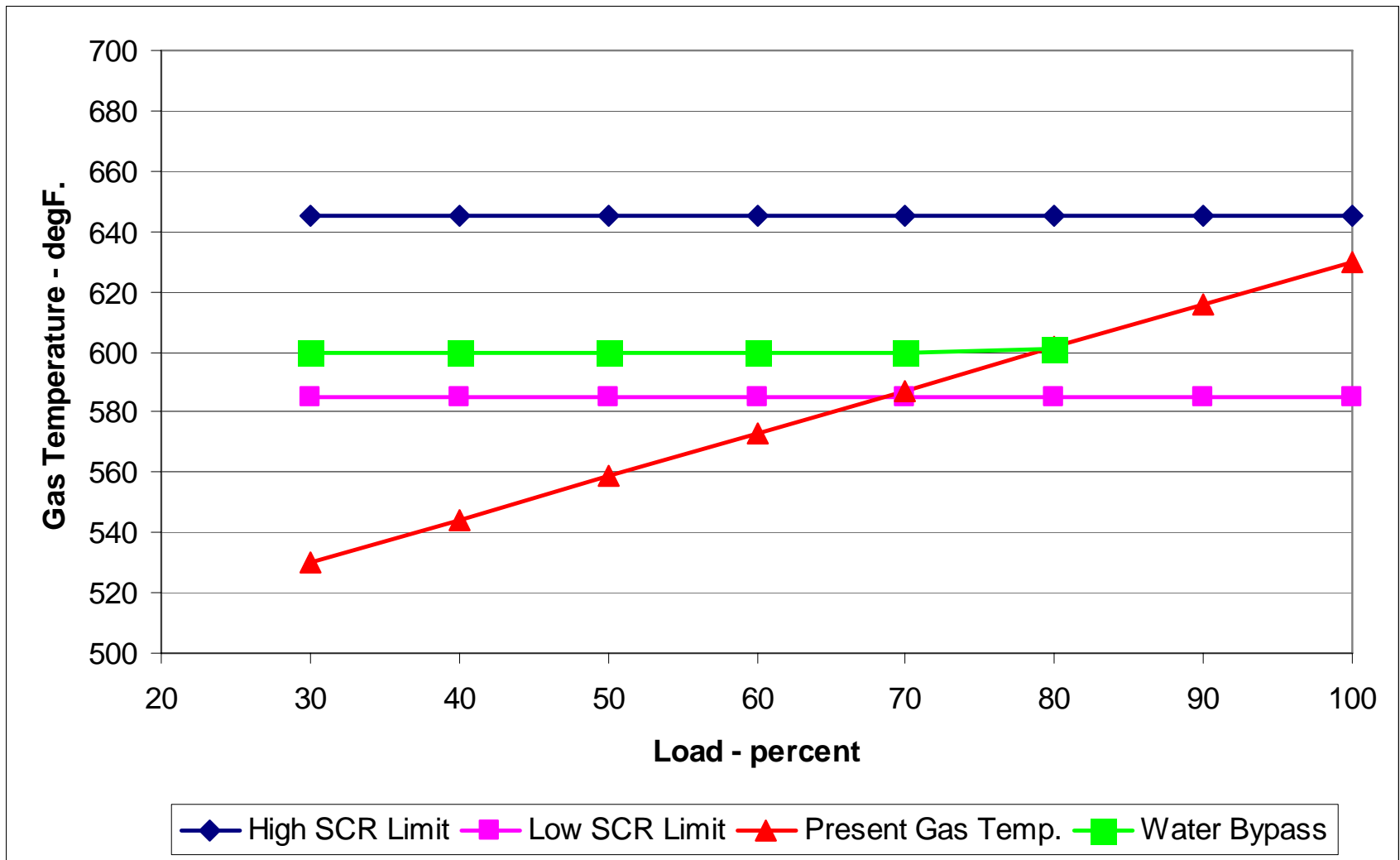
Economizer Water Bypass System for SCR



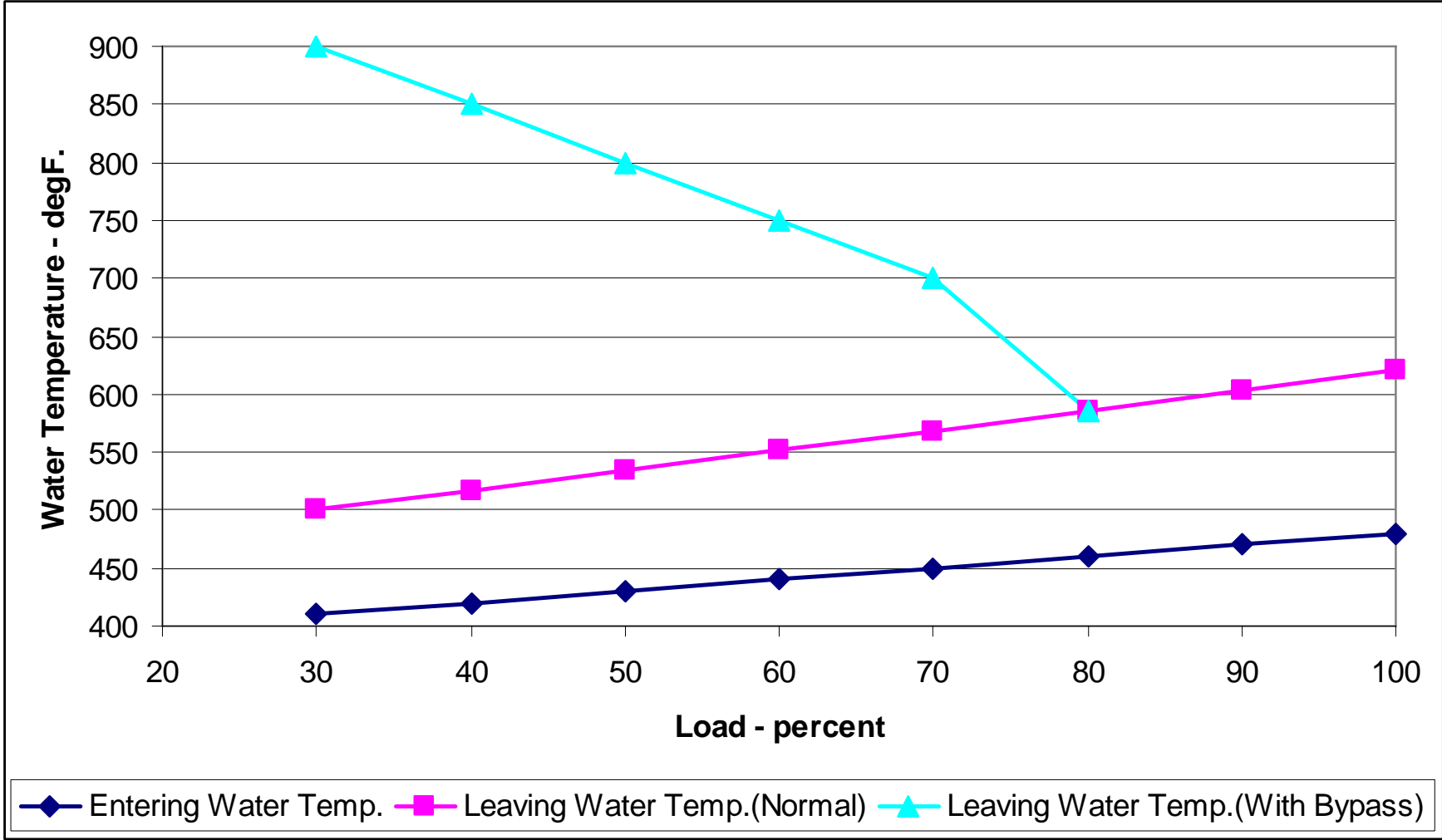
Economizer Water Bypass System



Economizer Water Bypass System



Economizer Water Bypass System

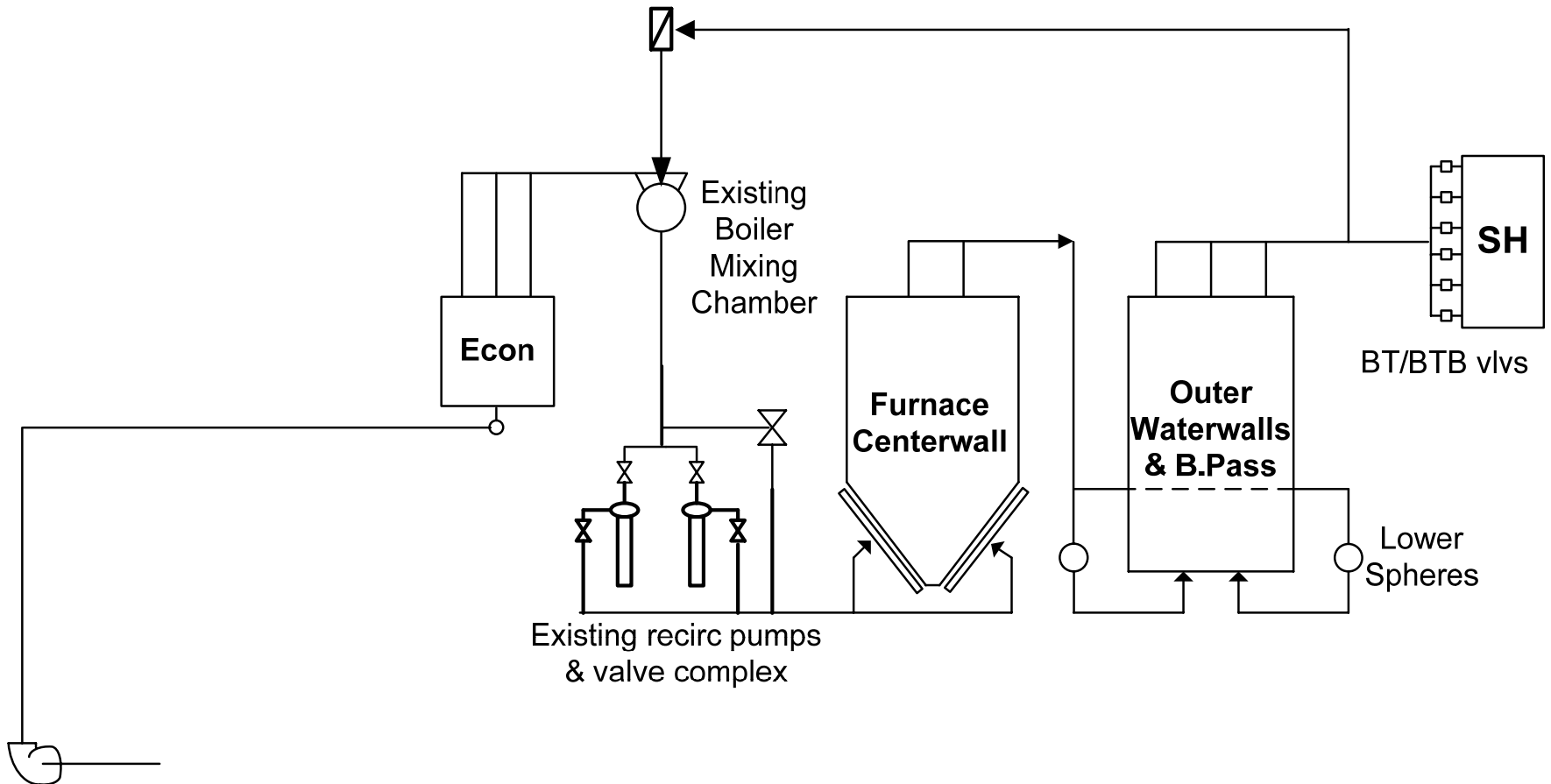


- Pros:
 - Works on supercritical (Combined Circulation) boilers if required gas temperature change is only 30 to 60 degF.
 - Lower maintenance than gas bypass system.
 - Lower installed cost.

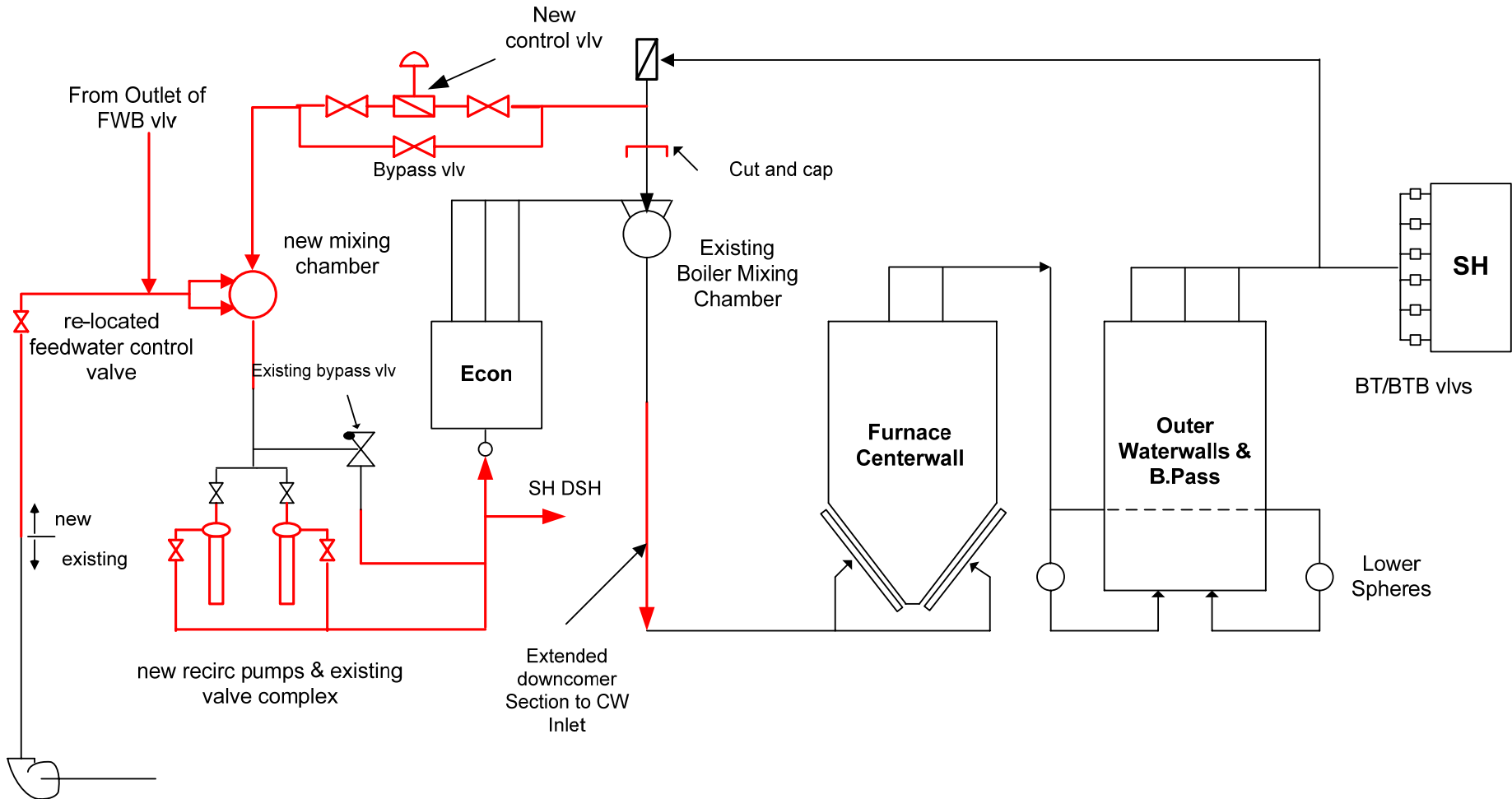
- Cons:
 - Limited control range.
 - May require economizer modifications such as hanger tubes, junction headers, etc.
 - On subcritical boilers, steaming of the economizer may be an issue so water bypass systems are not normally used.

Hot Water Recirculation System

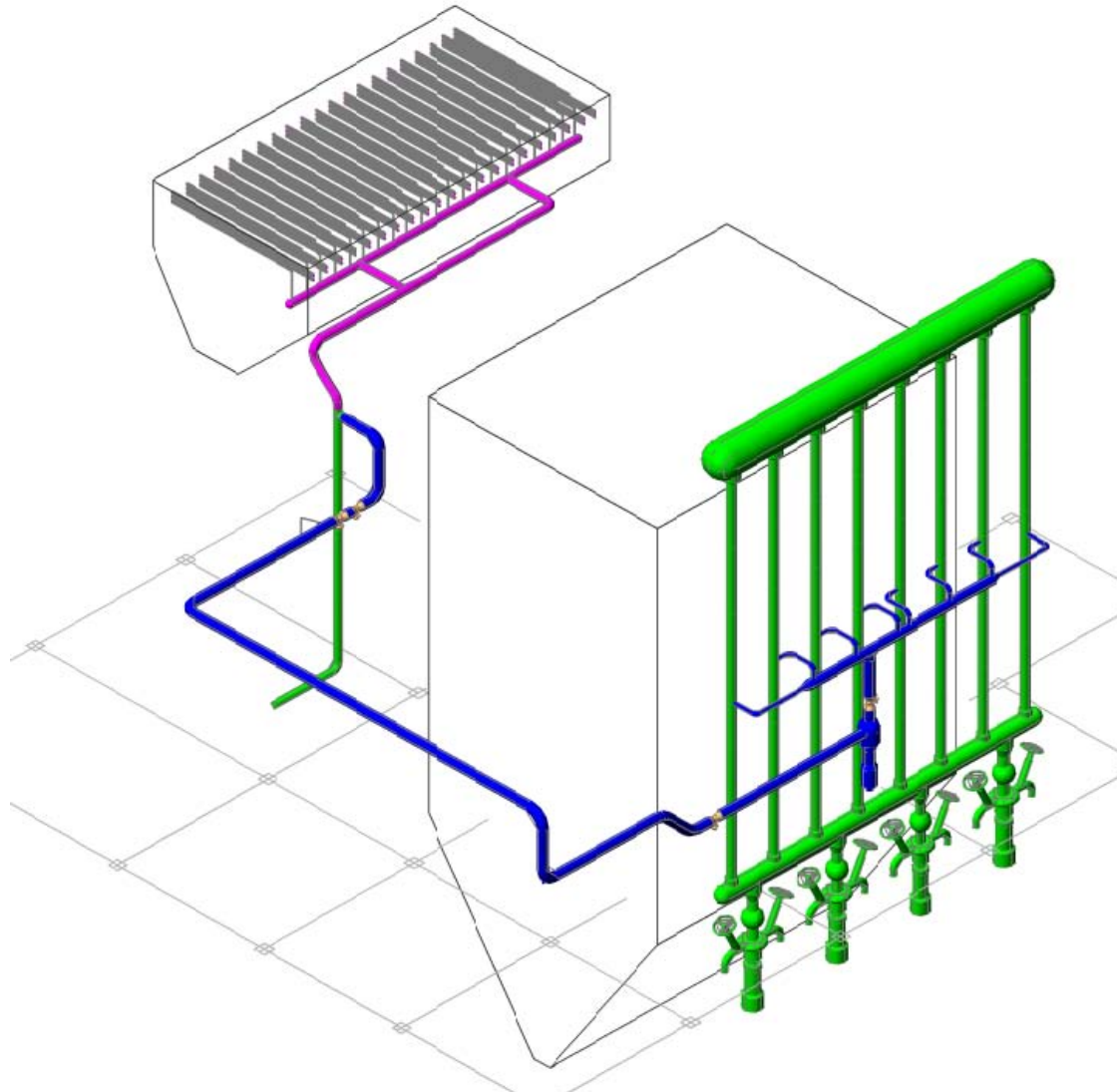
Hot Water Recirculation System - Supercritical



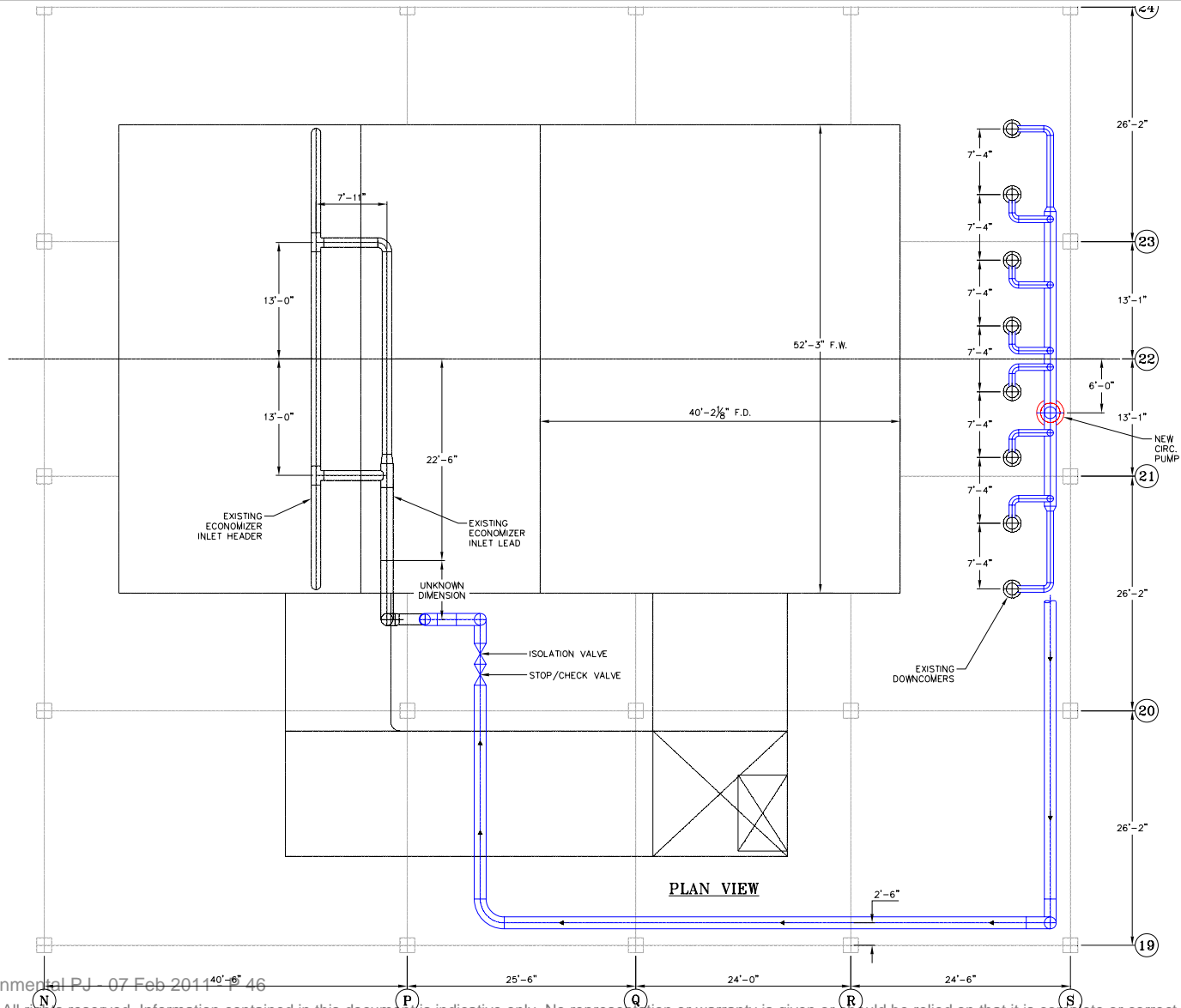
Hot Water Recirculation System - Supercritical



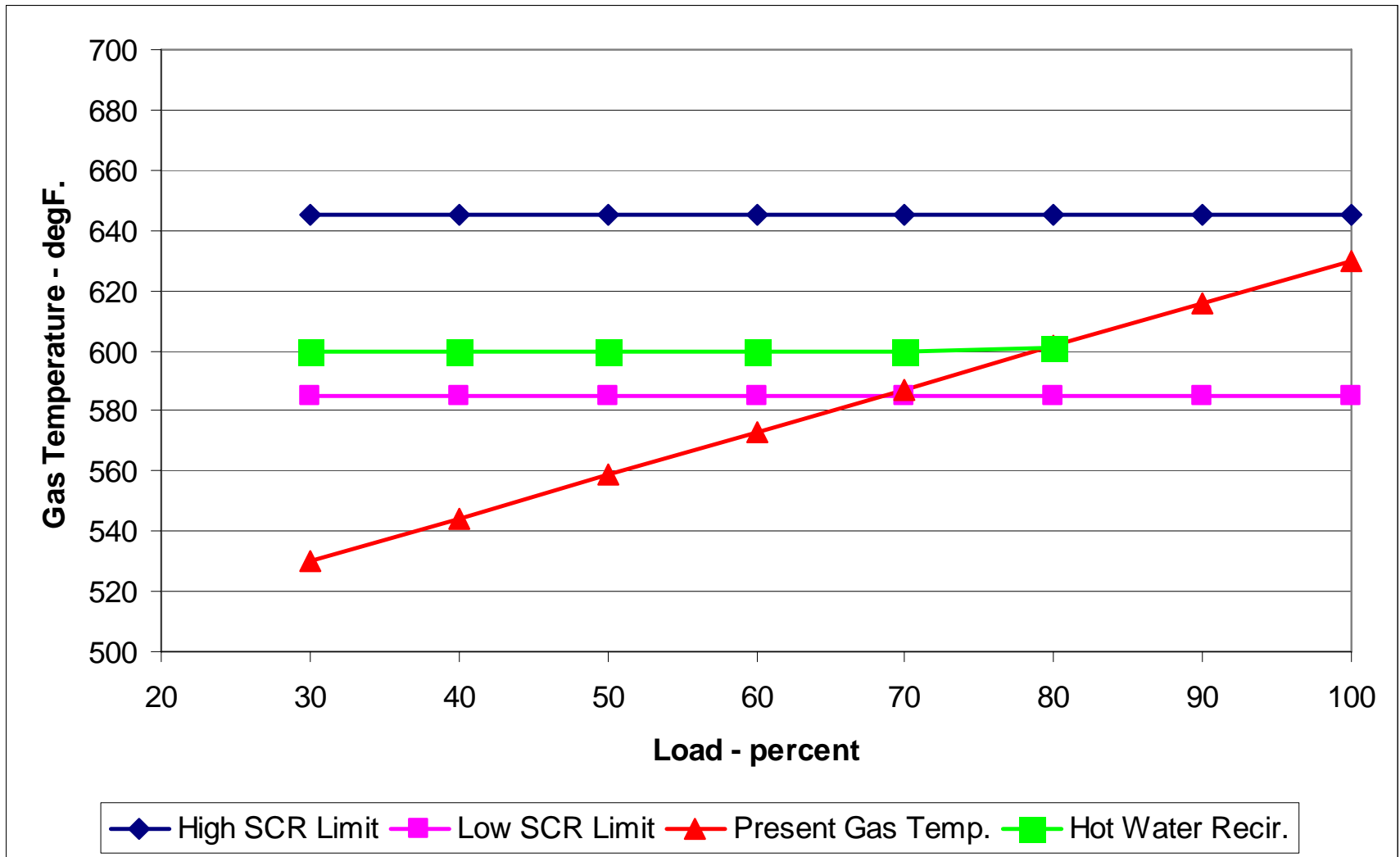
Hot Water Recirculation System - Subcritical



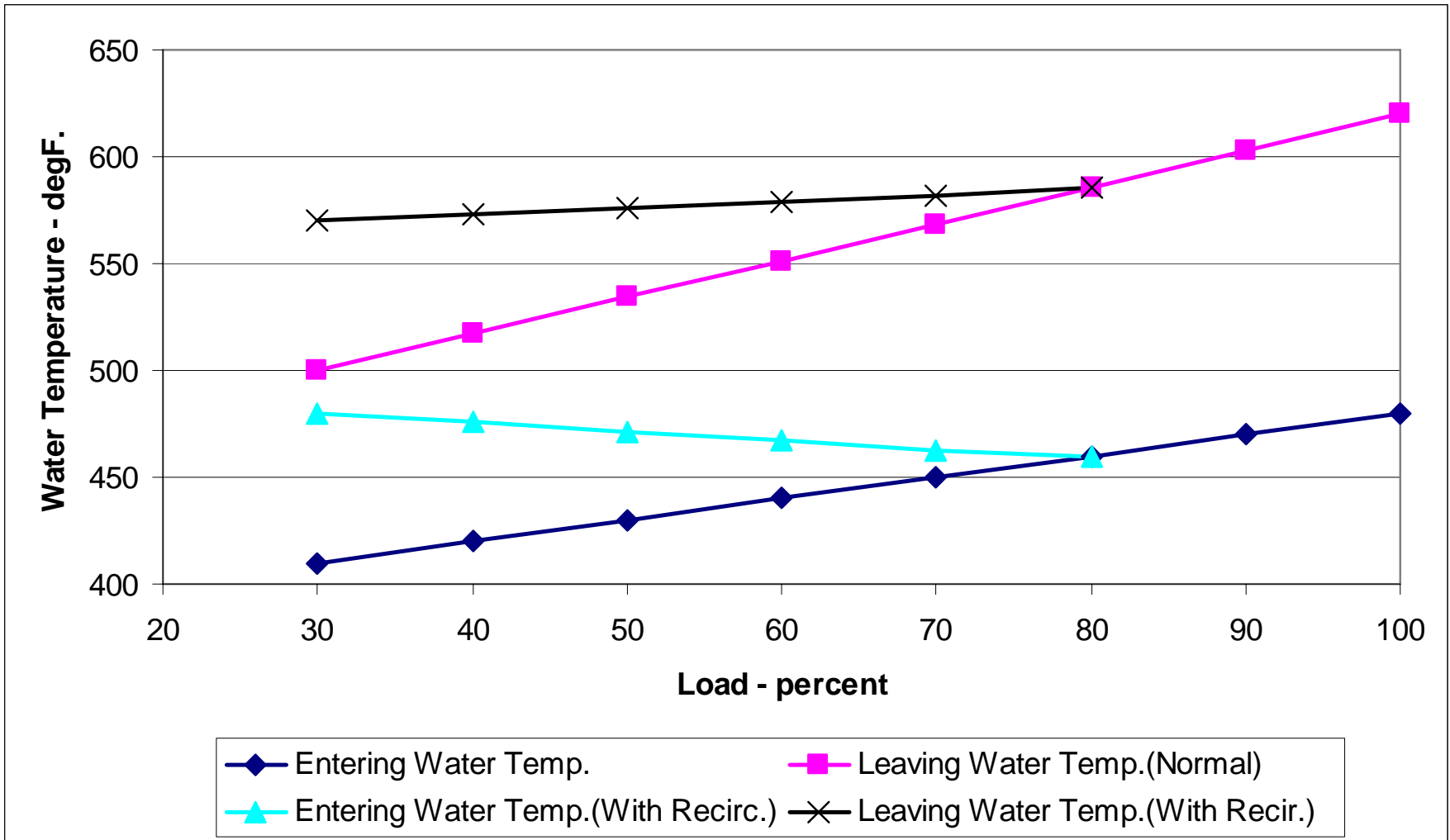
Hot Water Recirculation System – Subcritical – Plan view



Hot Water Recirculation System



Hot Water Recirculation System



- Pros:
 - Can provide a wide control range.
 - Normally not used at high loads so no decrease in boiler efficiency.
 - Very easy to control gas temperature to SCR at low loads.
 - Technology can be applied to supercritical and subcritical boilers.

- Cons:
 - Can be more expensive (capital) but it depends whether comparing total costs (maintenances costs and other control options).
 - Recirculation pump horsepower will increase but will be offset some FW pump horsepower on supercritical boilers.
 - On subcritical boilers, economizer outlet water temperature must be sufficiently below saturation at all loads.

- There are multiple methods to control gas temperature entering the SCR over the load range
- Options have to be evaluated
 - Compliance goals
 - Flexibility
 - Load range requirements
 - Fuel type
 - Capital cost
 - O&M cost
 - Complexity

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