REINHOLD ENVIRONMENTAL Ltd.

2012 APC Round Table
& Expo Presentation

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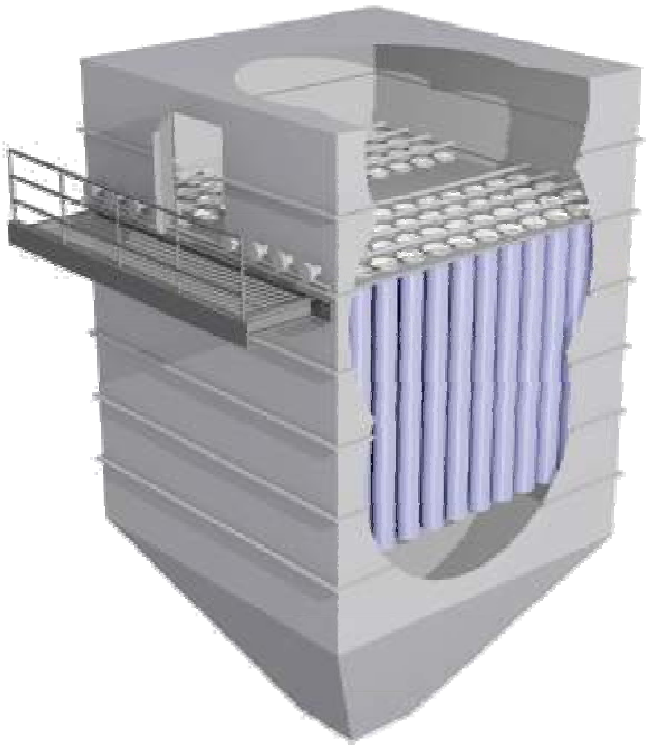
GE Energy
Air Filtration

Impact of Gas Fuel Conversion on PM Control Equipment



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imagination at work

Background

- The majority of domestic and global electricity is generated using coal as the fuel.
- In the US, natural gas (NG) enjoys almost a two to one cost advantage in terms of equivalent heating value
- Utility boiler NESHAP, CSPAR, and proposed CO_2 emission limitations are driving coal fired power generation costs higher
- Restrictions on reduced load operation limits dispatch
- These factors are fostering interest in conversion of coal fired boilers (CFB) to burn natural gas

What is the impact on existing PM control equipment?

Background

There are multiple approaches to converting a coal fired boiler to burn natural gas:

- *Replace* existing burners and *Modify* boiler systems to accommodate NG (Direct firing)
- *Modify* existing burners and boiler systems to accommodate NG (Direct firing)
- *Repower* utilizing a combination of gas turbine and existing boiler / steam turbine
- *Abandon* coal fired boiler and replace with combined cycle gas turbine or other approach.

This presentation considers the first two options

Background

Difference in products of combustion CFB vs NG:

Inputs	PRB	Ill	Nat Gas	
Heat input	2400	2400	2400	mmBTU/hr
Excess air	25.00%	25.00%	15.00%	%
In-leakage	10.00%	10.00%	10.00%	%
Air heater outlet	295	325	295	F
Air heater outlet	-10	-10	-10	inches WC
Actual volume	915,935	917,683	780,203	ACFM
Standard volume	558,882	550,738	444,756	DSCFM
Products of Combustion	**PRB**	**Ill**	**Nat Gas**	
H20	10.89%	8.87%	16.75%	%V, wet
O2	5.20%	5.34%	3.98%	%V, wet
CO2	12.31%	12.04%	7.56%	%V, wet
N2 Fuel	0.07%	0.07%	0.38%	%V, wet
N2 Air	71.51%	73.45%	71.33%	%V, wet
SO2	0.02%	0.22%	0.00%	%V, wet
PM*	3.94	7.38	0.00	lb/mmBTU
SO2	0.61	5.77	0.0028	lb/mmBTU

* Considers filterable particulate matter only, not condensable
Natural gas SO2 attributable to mercaptans

Impact of Conversion to Natural Gas

- For the same heat input at appropriate excess air, NG will produce ***comparable*** gas volume
- ***Moisture*** content of NG combustion products increase ***~30%+***
- ***No PM*** will be created during NG combustion (Condensable will be created)
- ***NOx*** levels comparable or lower
- ***~ 1/3 Less CO_2*** is created at the same heat input
- Trace amounts of sulfur in the NG create minimal amount of ***SO_2*** (Mercaptans)
- Furnace exit gas temperature ***(FEGT)*** may increase

Impact of Conversion to Natural Gas

Why does FEGT increase?

- Particulate "cloud" present in PC boiler is a major source of radiant heat transfer
- Without particulate, water wall heat absorption drops causing higher FEGT
- This increases heat transfer in convective passes
- May require more attemperation to compensate for increased convective pass heat transfer
- Ability to effectively compensate for increased convective pass temperatures will determine temperature at air heater hot gas inlet

Impact of Conversion to Natural Gas

After conversion to NG, existing PM control equipment not required

Approach to PM equipment moth balling is a function of duration – ***Short Term*** or ***Long Term***

And

Type of Equipment ***ESP*** vs. ***Fabric Filter***

ESP **-** Low inherent pressure drop, steel internal components, multiple casing penetrations, external power supplies and controls

Fabric Filter **-** Significant inherent pressure drop, fabric and steel internal components, minimal penetrations, external control and valves

Impact of Conversion to Natural Gas

Few units have *PM* equipment *by-pass*

As a result, PM equipment needs to accommodate continued gas flow

To meet today's conversion objectives, a unique approach is required:

Moth Ball – Previous approach when a boiler was taken out of service. Activities necessary to prepare PM equipment for extended period of inactivity, off-line.

Active Moth Ball – Current requirement to prepare PM equipment for inactivity, while remaining on-line. Long term goals affect Active Moth Ball approach.

Impact of Conversion to Natural Gas

What is the expected duration of *NG firing*?

Short Term – Supplement coal firing with NG or switch back to coal 6 to 18 months? (Rapid ability to restore operation of PM equipment)

Long Term – Burn only NG for foreseeable future or until boiler is decommissioned (PM equipment can be brought back on line with significant effort.)

The duration of NG firing determines the extent of the moth ball activities

Impact of Conversion to Natural Gas

What is basis for planning decisions?

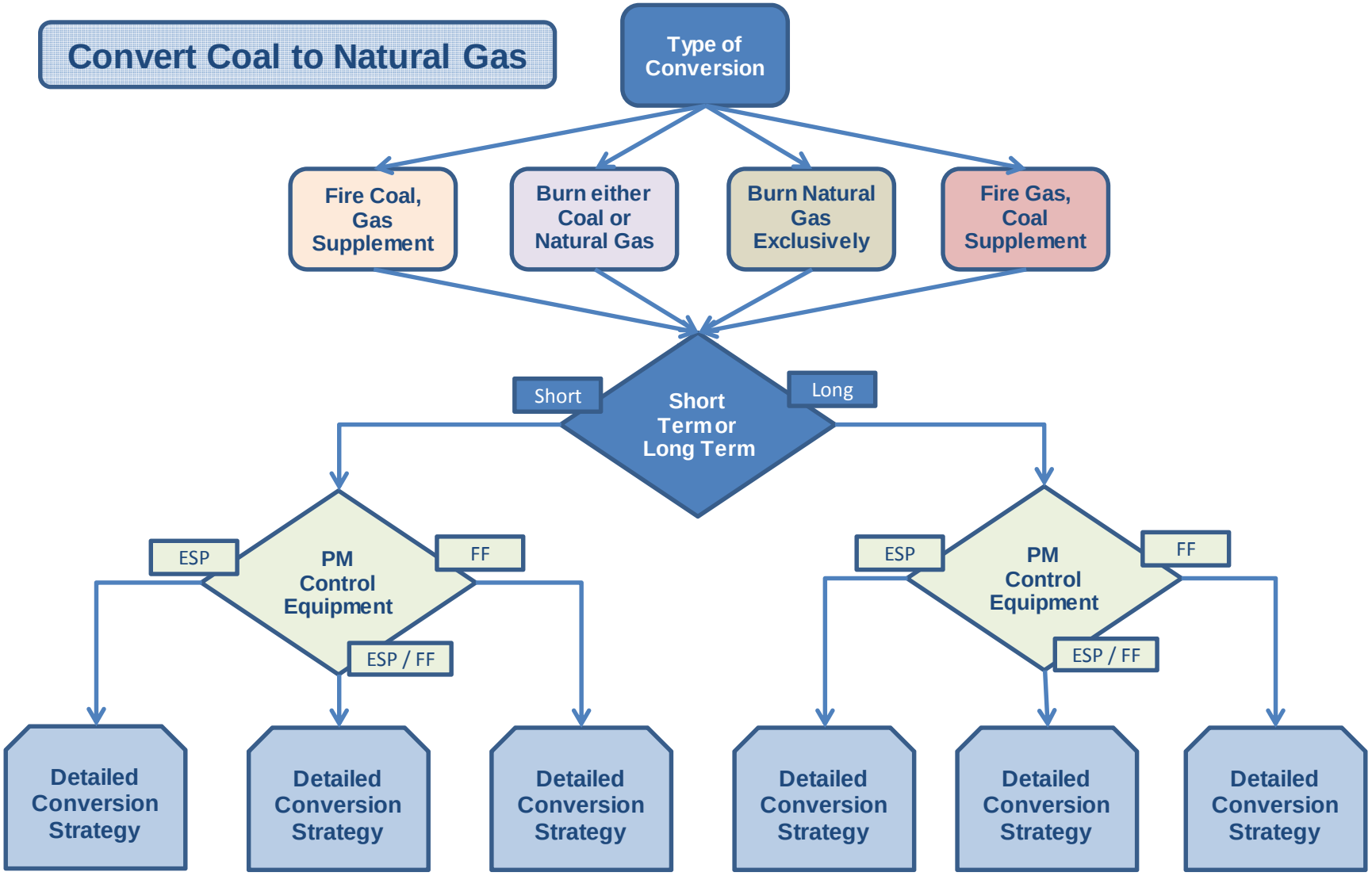
There are several "stages" of modification possible to accommodate natural gas conversion.

The final decision must be a result of comparing factors such as outage requirement, capital expenditure, and operating cost against the benefits derived from implementing the change.

Some changes in equipment configuration, although technically desirable, may not be economically justifiable.

In the end, the extent of modifications should be based on an economic evaluation

Impact of Conversion to Natural Gas



imagination at work

Impact of Conversion to Natural Gas

Short Term Active Moth Ball Approach – ESP

- Keep induced draft fan operating if possible
- Bring unit off-line with collecting plate and discharge electrode rappers operating
- Continue rapping after unit cools down to ambient temperature
- After several hours, shut down ID fan and rappers
- Create V-I curves for each power supply
- Electrically isolate power supplies and heating systems at main panel and locally at high voltage bus (LOTO)
- Remove lower frame stabilizer insulators (Replace with aluminum bars if desired)

Impact of Conversion to Natural Gas

Short Term Active Moth Ball Approach – ESP

- Grit blast or water wash interior of unit, including inlet gas distribution plates, and turning vanes
- Clean inside / outside of support insulators, outside of HV rapper and through put bushing insulators
- Fully evacuate hoppers, blank off ash evacuation flanges
- Vacuum casing, hoppers, ductwork and plenums ahead of stack
- Perform internal inspection documenting defects in internal systems, insulation, and casing
- Replace access door gaskets
- Document rapping and voltage control set up

Impact of Conversion to Natural Gas

Short Term Active Moth Ball Approach – ESP

Specific equipment configurations will require additional activity:

- FGC Equipment –SO_3 conditioning system must be moth balled according to manufacturers recommendation. Sulfur source must be emptied. Make storage provisions for pumps, blowers, sulfur storage, and injection lances
- PAC Equipment – Empty all storage and transportation lines of PAC. Utilize manufacturers recommendations for moth balling pumps, blowers, feeders and injection lances. Verify that no accumulations of PAC remain in equipment

Impact of Conversion to Natural Gas

Short Term Active Moth Ball Approach – ESP

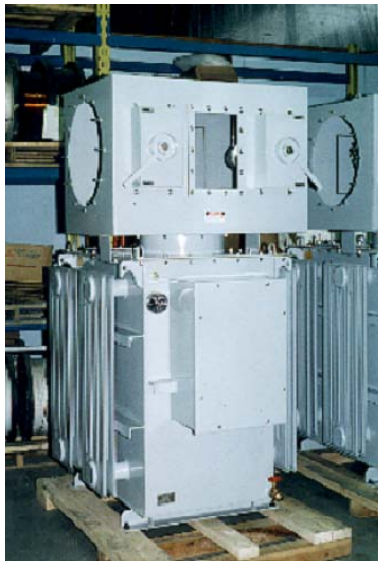
During operation in the Short Term:

- Continue to operate insulator compartment / penthouse insulator heaters.
- If a purge heater system is in place, continue to force filtered, and heated air into the insulator enclosures.
- If hopper heating is in place, continue to operate hopper heaters.
- Moth ball any hopper level indicators pressure taps
- De-energize any hopper vibrators or fluidizers

Impact of Conversion to Natural Gas

Long Term Active Moth Ball Approach – ESP

- Bring unit off-line with collecting plate and discharge electrode rappers operating
- Continue rapping as unit cools down to ambient temperature
- After several hours, shut down ID fan and rappers
- Create V-I curves for each power supply
- Remove power supplies and store in temperature controlled warehouse



- Grit blast / water wash unit, including inlet gas distribution plates, and turning vanes
- Remove lower frame stabilizer insulators

Impact of Conversion to Natural Gas

Long Term Active Moth Ball Approach – ESP

- Consider removal of inlet / outlet gas distribution devices
- Remove support and through put insulators - blank off openings.
- Remove gravity impact type rappers, palletize and store in warehouse
- Remove collecting plate rapper shafts and cap off penetrations
- Remove HV rapper shaft, cap insulator compartment / penthouse penetrations

Impact of Conversion to Natural Gas

Long Term Active Moth Ball Approach – ESP

- Vacuum casing, hoppers, ductwork and plenums ahead of stack
- Fully evacuate hoppers, blank off ash evacuation flanges
- Remove hopper evacuation equipment and level indicators
- Replace access door gaskets to ensure seal integrity
- If penthouse arrangement, insulate hot roof
- Verify integrity of expansion joints and duct penetrations

Impact of Conversion to Natural Gas

Long Term Moth Ball Approach – ESP

If the intent is to burn NG for the long term or until the coal fired unit is decommissioned, additional decisions are required:

- Remove inlet / outlet gas distribution devices? – Represent ¼ to ½ inch pressure drop, no longer required
- Remove internal collecting and high voltage system? – Represent ½ to 1 inch pressure drop, no longer required
- Deterioration of steel (Corrosion) overtime may result in PM emissions

Impact of Conversion to Natural Gas

Long Term Moth Ball Approach – ESP

It may be appropriate to permanently decommission ESP support equipment:

- FGC systems
- PAC injection systems
- Acid Gas control systems
- ESP fly ash handling systems

May be beneficial to continue operating hopper heating equipment based on high moisture content of NG flue gas

If it is never coming back on-line, gut it

Impact of Conversion to Natural Gas

Short Term Moth Ball Approach – Fabric Filter

- Keep induced draft fans running
- Bring FF off-line with pulse cleaning system active
- Continue pulsing after unit cools down to ambient temperature
- If reverse gas cleaning, operate system continuously while unit cools down
- After several hours of cleaning, shut down induced draft fan, stop cleaning system
- Evacuate hoppers using fly ash removal system
- Vacuum hoppers, inlet, outlet, clean gas plenum
- Plug magnehelic pressure taps, cap compressed air

Impact of Conversion to Natural Gas

Short Term Active Moth Ball Approach – Fabric Filter

Decision time – ***Leave*** filter bags in place or ***Remove***?

Leave in place –

- –High system pressure drop, ~4 to 6 inches
- –Possibility of blinding, loss of permeability
- –Save cost of replacement bags (?)

Remove –

- –Reduce system pressure loss, ~4 to 6 Inches
- –Removal process expensive probable damage
- –Need to purchase new set for coal start up

Unless operating period on NG is very short, removal of the filter bags is the best choice.

Impact of Conversion to Natural Gas

Short Term Active Moth Ball Approach – Fabric Filter

Possible Additional Activities:

- May be possible to remove bags from one or more compartments and isolate balance. (***Virtual by-pass***)
- Acid Plume Control – Empty silos, moth ball pumps blowers and injection lances
- PAC Equipment – Empty all storage and transportation lines of PAC. Utilize manufacturers recommendations for moth balling pumps, blowers, feeders and injection lances. Verify no accumulations of PAC remain in equipment
- May elect to operate hopper heating system to avoid hopper corrosion

Impact of Conversion to Natural Gas

Long Term Active Moth Ball Approach – Fabric Filter

- Keep induced draft fans running
- Bring FF off-line with pulse cleaning system active
- Continue pulsing after unit cools down to ambient temperature
- If reverse gas cleaning, operate system continuously while unit cools down
- After several hours of cleaning, shut down induced draft fan, stop cleaning system
- Remove bags, cages, tensioning equipment - ***waste***
- Evacuate hoppers using fly ash removal system

Impact of Conversion to Natural Gas

Long Term Active Moth Ball Approach – Fabric Filter

- Vacuum hoppers, inlet, outlet, clean gas plenum
- Plug magnehelic pressure taps, cap compressed air
- Remove ladder vanes and distribution vanes
- Remove blow pipes and headers, blank holes
- Remove reverse gas poppet valves and blank
- Consider removing tube sheet, ~ 1 to 2 inches WC

Impact of Conversion to Natural Gas

Long Term Active Moth Ball Approach – Fabric Filter

By-pass possibility on fabric filter:

Several fabric filter configurations have dirty and clean gas duct work that have a contiguous wall or are adjacent to one another.

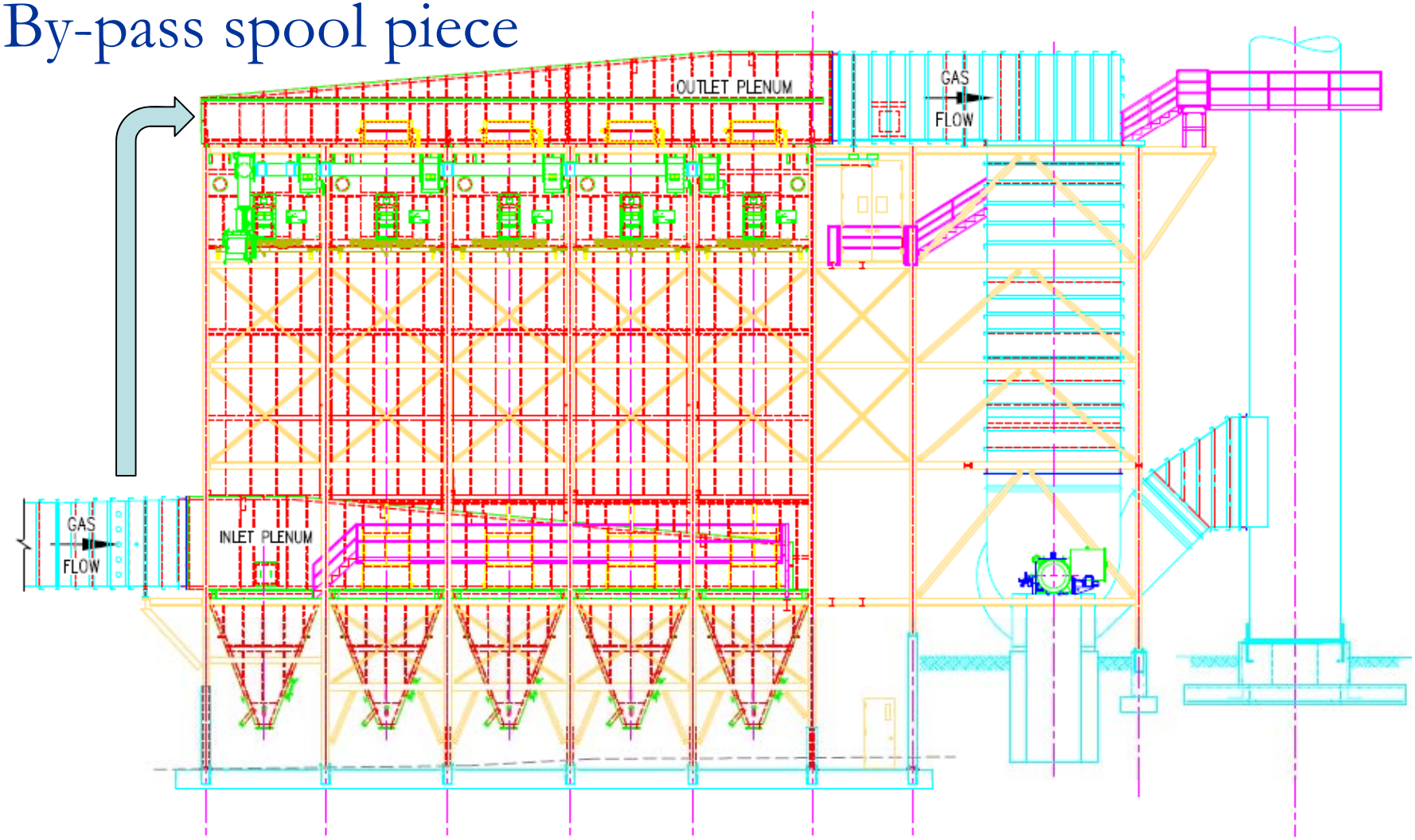
When this configuration exists, the inlets to the dirty gas plenum can be blanked off.

Next access between the dirty gas duct and clean gas duct can be created. (May require spool piece)

The ability to ***by-pass*** the fabric filter avoids the need to make structural changes to avoid pressure drop.

Impact of Conversion to Natural Gas

By-pass spool piece



Impact of Conversion to Natural Gas

Summary

In light of current natural gas pricing, it is wise to consider conversion of a coal fired boiler.

The existing PM control equipment can be modified to accommodate the fuel switch from coal to natural gas.

Modification of PM equipment to accommodate NG does not result in an ideal configuration

The modification does allow continued use of an existing asset

The performance and cost effectiveness of the conversion is a function of the initial assessment of the duration of the fuel switch.

Thank You