STERLING CHEMICALS

Waste Oxidizing Boiler Fuel Management

Jane Arnold
Senior Process Control Analyst

STERLING CHEMICALS

Waste Oxidizing Boiler Fuel Management

- Introduction – Natural gas price increase, NOx regulation changes
- Problem – Significant WOB trips
- Solution – Instrumentation, wiring, and controls
- WOB Control Background
- WOB Control Improvements
- Results of Control Improvements
- Conclusion

Introduction

In the manufacturing community there is a strong effort towards improving fuel efficiency and lowering emissions.

Natural gas prices have risen from approximately $2 per MMBTU in January of 2000 to $6 per MMBTU presently, with peaks up to $10 per MMBTU in 2001.

The federal and state environmental agencies are narrowing allowable emissions each year. The federal NOx reportable quantity (RQ) is now only 10 lbs over the permitted limit for each piece of equipment that emits NOx.

Following is a case study for efficiency improvement that resulted in increased on stream time, lowered natural gas usage, and lowered NOx without significant capital expenditure.

Problem – Significant WOB trips

In the year 2000, there were 27 trips on the 3 WOBs at Sterling Chemicals. With the new environmental regulations coming in 2002, it was imperative to correct the problems. The new, lower, allowable limits on NOx and other VOCs would have forced an immediate shutdown of the reactor train on a WOB trip that seriously cuts into production and increases costs.

The following chart shows 60 WOB trips from 1997 to 2000.

WOB trips			
	WOB-A	WOB-B	WOB-C
2000	17	7	5
1999	3	4	1
1998	6	2	2
1997	3	3	7

Root Cause Analysis:
50% - fuel management/level control
29% - instrument/equipment failure
11% - personnel errors / IFC errors
6% - reactor trips / column slump
2% - atomizing steam

Solution

- To solve the WOB trips, Sterling Chemicals initiated a program to recalibrate each instrument and check associated wiring, or replace the necessary instrumentation to improve field device reliability.

- Since the largest number of trips was a direct correlation to control, the WOB controls were evaluated for improvement.

WOB Control Background

- The control of A-WOB is much more complex than a typical utility boiler due to the burning of three different waste fuels, whereas a utility boiler is designed to just burn natural gas and produce steam. Also, the purpose of a utility boiler is to produce steam. Steam is a by-product of waste destruction in a WOB. Therefore, the WOB pressure just rides the plant 650 lb steam header and does not try to control it.
- In A-WOB there are three exothermic fuels including natural gas, and one large volume, endothermic fuel that is combusted. Waste fuel A (WF-A) has a high heating value (HHV) of 10000 BTU/lb and waste fuel B (WF-B) has a HHV of 6500 BTU/lb, compared to natural gas with a HHV of 23600 BTU/lb. Both WF-A and WF-B flow rates are rate dependent and vary significantly based on process conditions. The off-gas is a large volume gas that has a HHV of 300 BTU/lb.

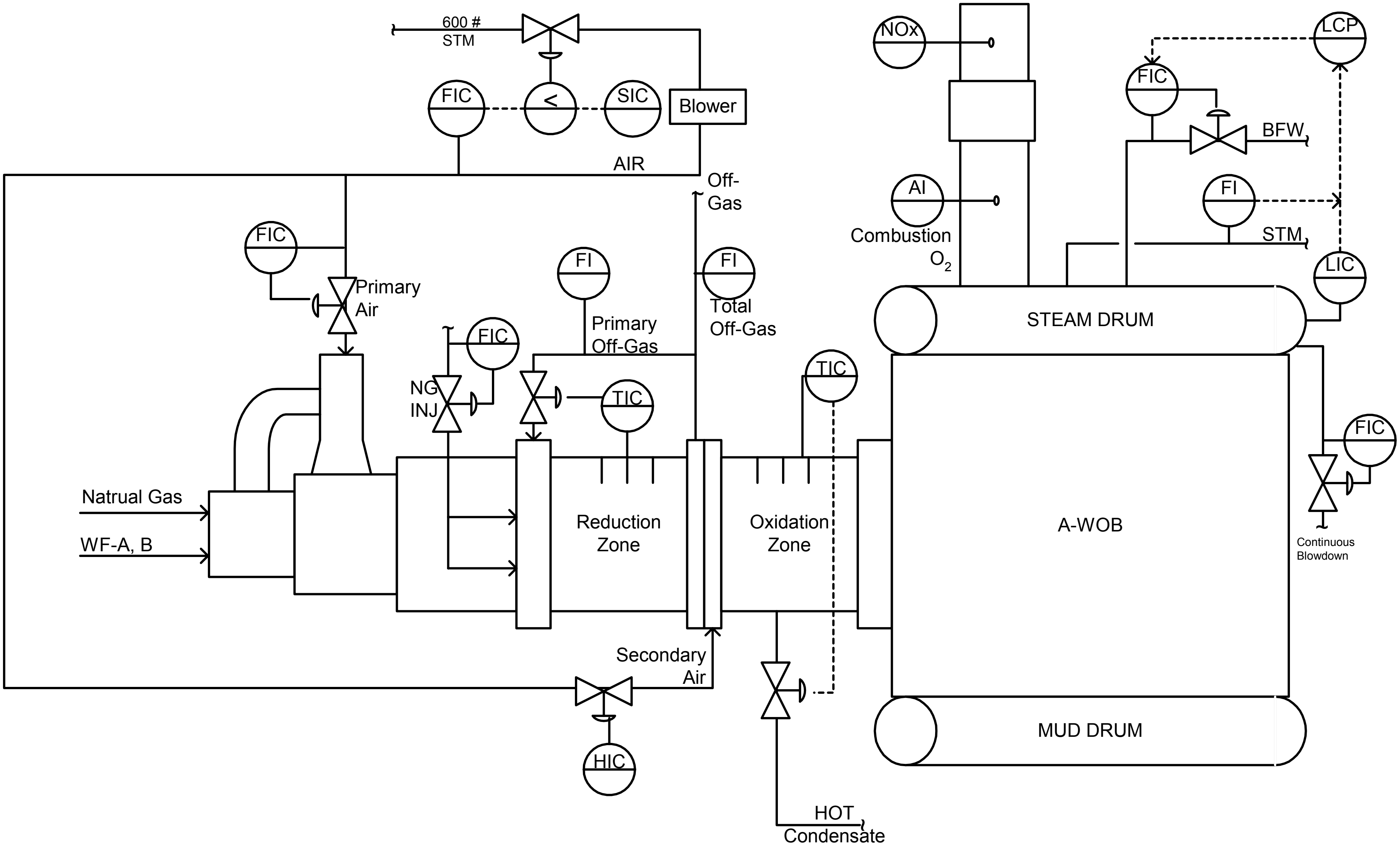


FIG.1 - A-WOB CONTROL

WOB Control Background – Operations

- Due to the multiple dynamic variables, the primary Waste Oxidizing Boiler (A-WOB) ran on local automatic or manual control. This mode required operations to pay close attention to the WOB at all times. Sudden adjustment in fuels sometimes caused the boilers' steam drum level to become unstable, resulting in drum level trips.
  - » Total Air and Natural Gas
  - » Reduction Zone vs. Oxidation Zone temperature
  - » Natural Gas Injection
  - » Primary and Secondary Air
  - » Hot Condensate
  - » Steam Drum Level

WOB Control – Improvements

- In order to minimize NOx formation and maximize hazardous waste destruction efficiency, the WOB is designed to operate in staged combustion. The first stage is the reduction zone and is operated fuel rich at about 85% stoichiometric air. The second stage is the oxidizing zone and is operated fuel lean. Managing the combustion process in multiple stages at a lower temperature minimizes the NOx formation compared to single stage oxidation.
  - » Fuel Management
  - » Level Control
  - » Excess O2 Control
  - » Total Air Control

Fuel Management

- Fuel Management is the automatic modulation of air and gas using high/low signal select control and stoichiometry to ensure the proper mix for optimum combustion.

- The primary control point for A-WOB fuel management is the oxidizing zone temperature. The temperature is run in automatic (Auto). It feeds a remote set point (RSP) to both the primary air and the natural gas loops.

- The calculations are performed in a Logic Control Point (LCP) on the Fisher Provox DCS system. The LCP allows for a Function Sequence Table (FST) for advanced programming.

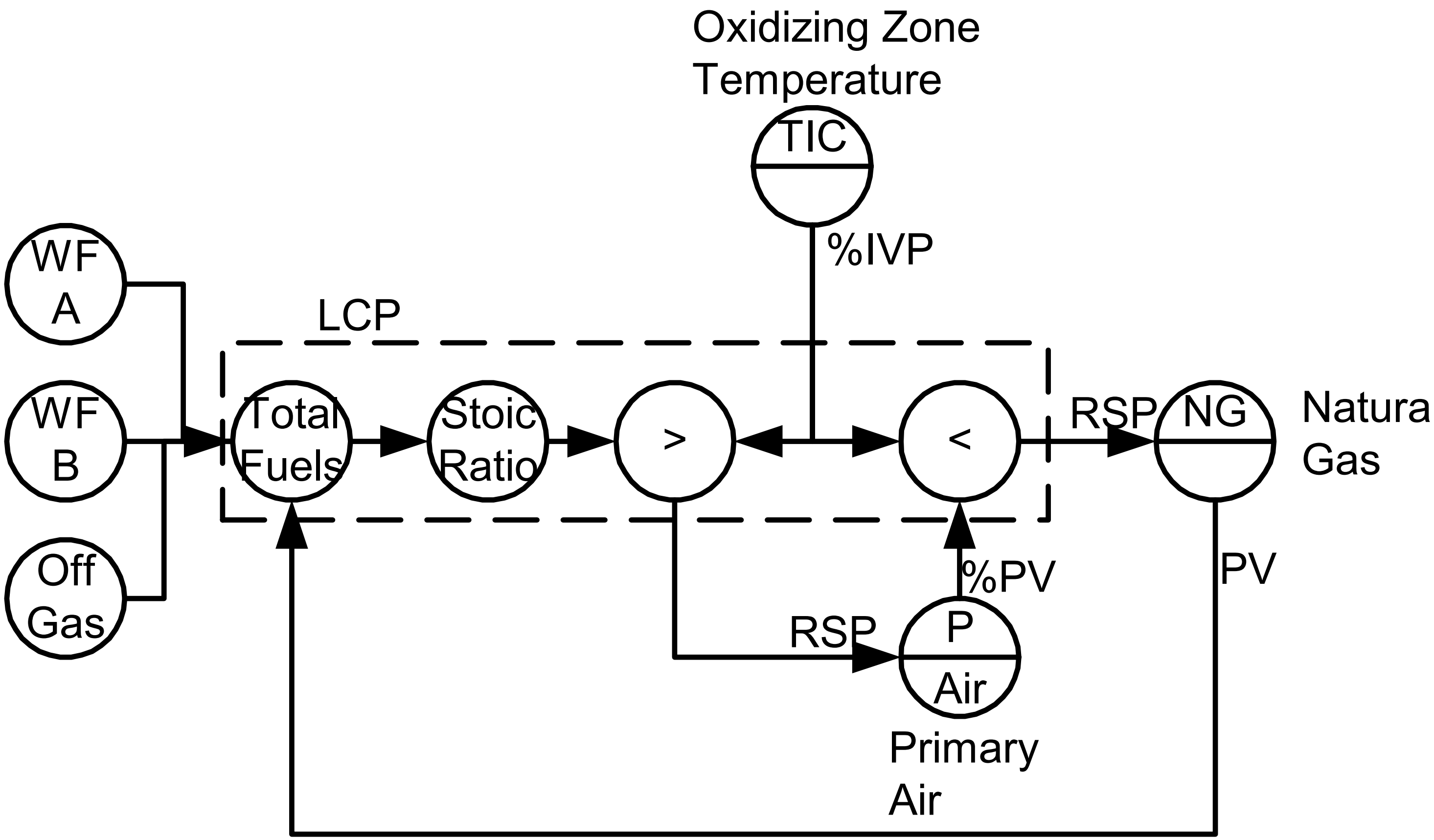


FIG. 2 - FUEL MANAGEMENT

Stoichiometry

- Total fuels are summed using stoichiometry which is the molecular weight calculation of fuels to ensure there is enough air for complete combustion.
- The calculation below shows how to determine the amount of air needed to combust natural gas at 85% stoic.

F1 = F2 / 17.337 * 2.050 * 0.85 / 0.21 * 28.930

Where:

F1	= Primary air to reduction zone in lb/hr
F2	= Natural gas flow to burner in lb/hr
17.337	= Molecular weight of natural gas
2.050	= Moles of O_2 required for every mole of natural gas
0.85	= Stoichiometric ratio.
0.21	= Percent of O_2 in air
28.930	= Molecular weight of air

Steam Drum Level Control

- The purpose of boiler feed water control is to maintain steam drum level at setpoint. Steam flow is a feed forward setpoint to boiler feed water adjusted by the drum level controller. The amount of Boiler Feed Water is dependent on the steam flow out of the boiler with the level controller working to correct any difference between the two transmitters.
- The Logic Control Point (LCP) shown in Figure 3 contains the following equation to calculate the Remote Set Point (RSP) to the BFW flow.

RSP BFW = (Level IVP – 50) / 100 * BFW Scale + STM

Where: RSP BFW = Remote Set Point to Boiler Feed water
IVP = Implied Valve Position in %
BFW Scale = Full range of the BFW transmitter
STM FLOW = Actual value of the steam flow

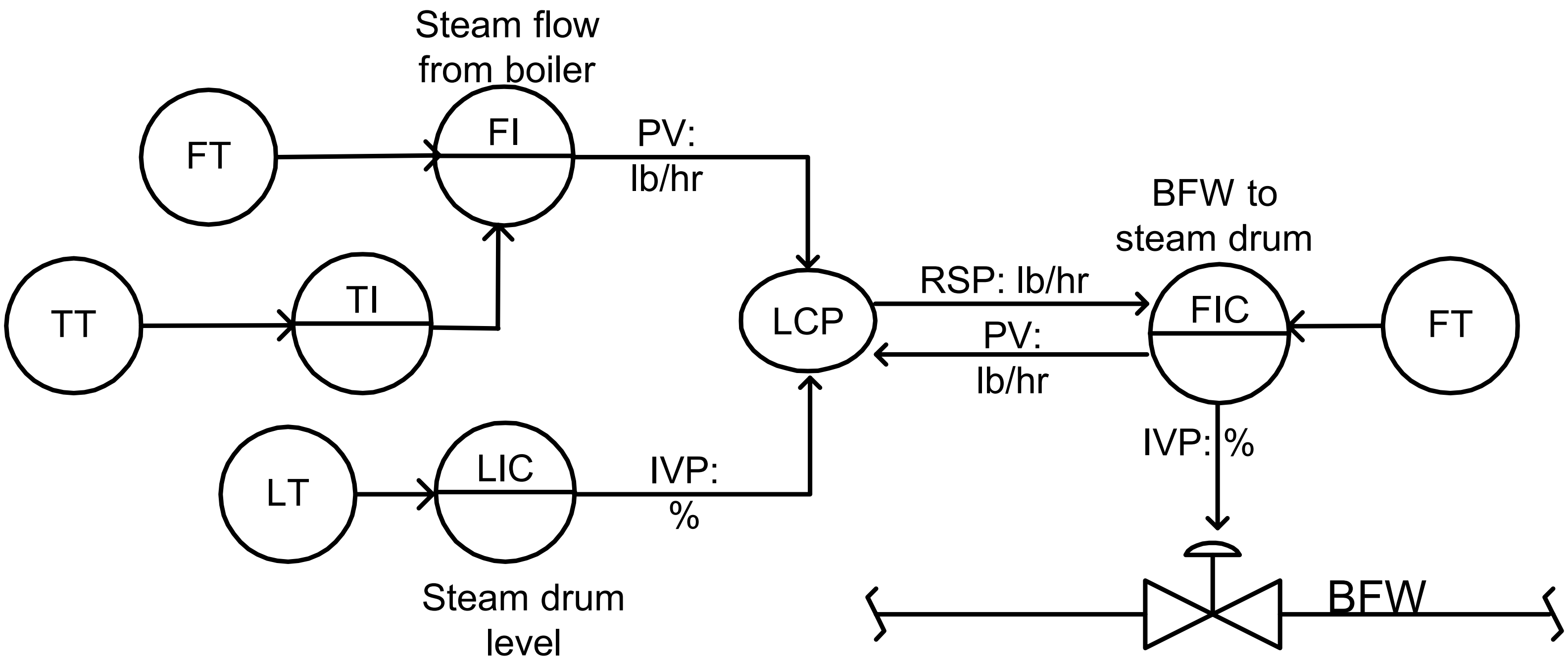


FIG. 3 - LEVEL CONTROL

Excess O_2 Control

The oxidation zone is the second of a two-staged combustion. More oxygen in the oxidation zone completes combustion and minimizes the amount of Carbon Monoxide (CO) out of the stack, which is also tightly regulated. Less oxygen minimizes the amount of NOx emitted in the stack. Therefore, it is imperative to maintain tight control on oxygen to keep down both CO and NOx.

The following control scheme helps to maintain the right amount of oxygen in the WOB at all times.

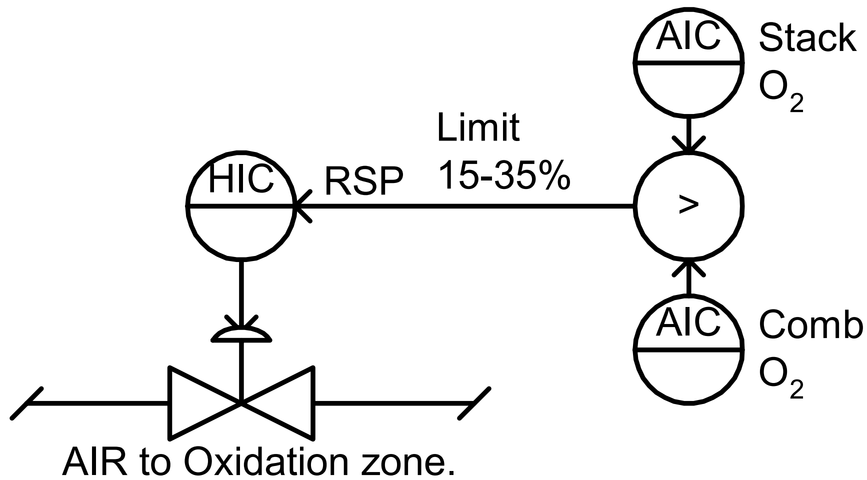


FIG. 4 - EXCESS O_2 CONTROL

There are two oxygen analyzers monitoring the condition of the WOB. The primary measurement for excess O2 is the combustion O2 analyzer. The stack analyzer acts as an override controller in the event of a problem. This high signal select will ensure that there is always enough air in the WOB for proper combustion. The signal select loop writes to the secondary air valve.

Total Air Control

- It is crucial to maintain enough oxygen to fully combust fuels. The following control scheme maintains a constant supply of air regardless of the amount of fuels present. As the primary and secondary air valves move, the discharge pressure on the blower changes. A pressure loop tied to total air with a speed safety override is shown in Figure 5.

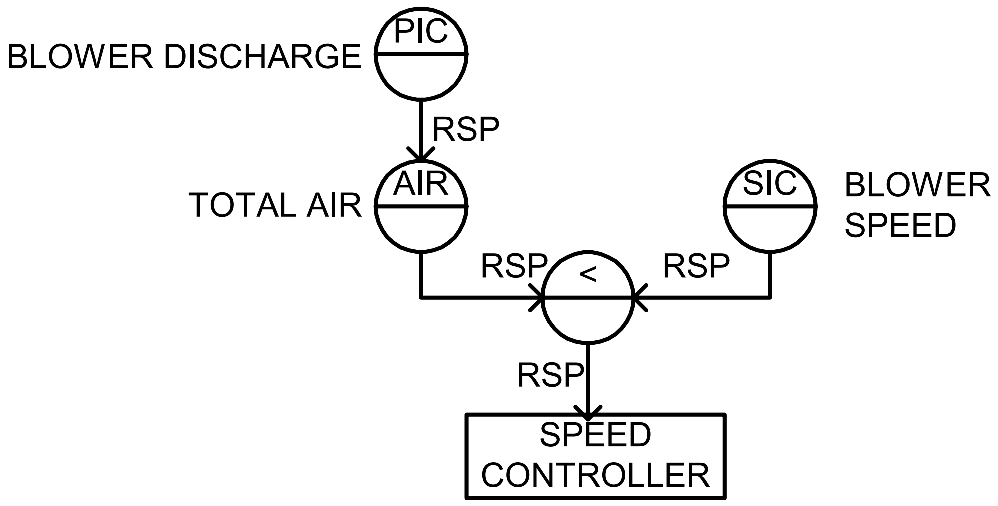


FIG. 5 - TOTAL AIR CONTROL

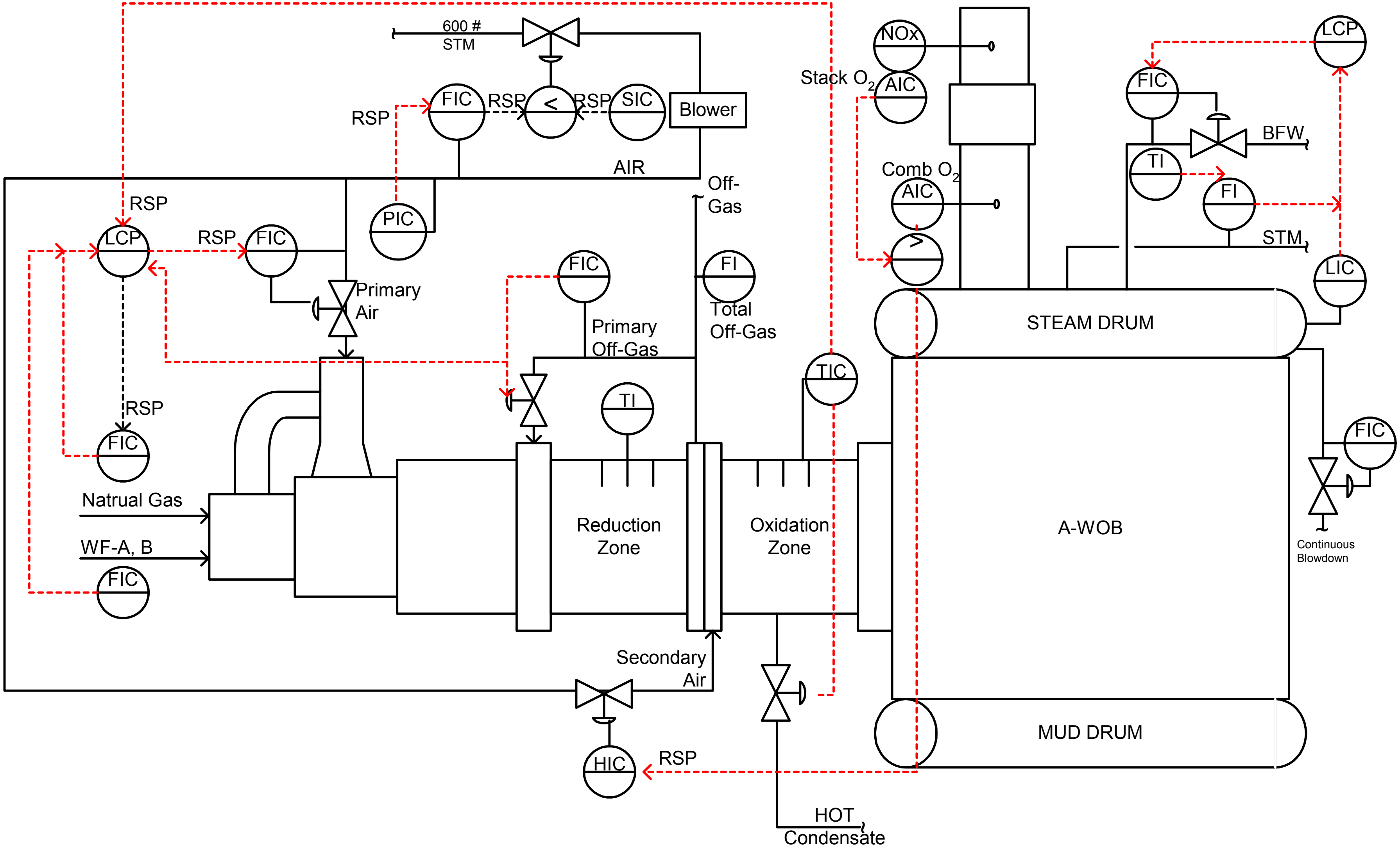
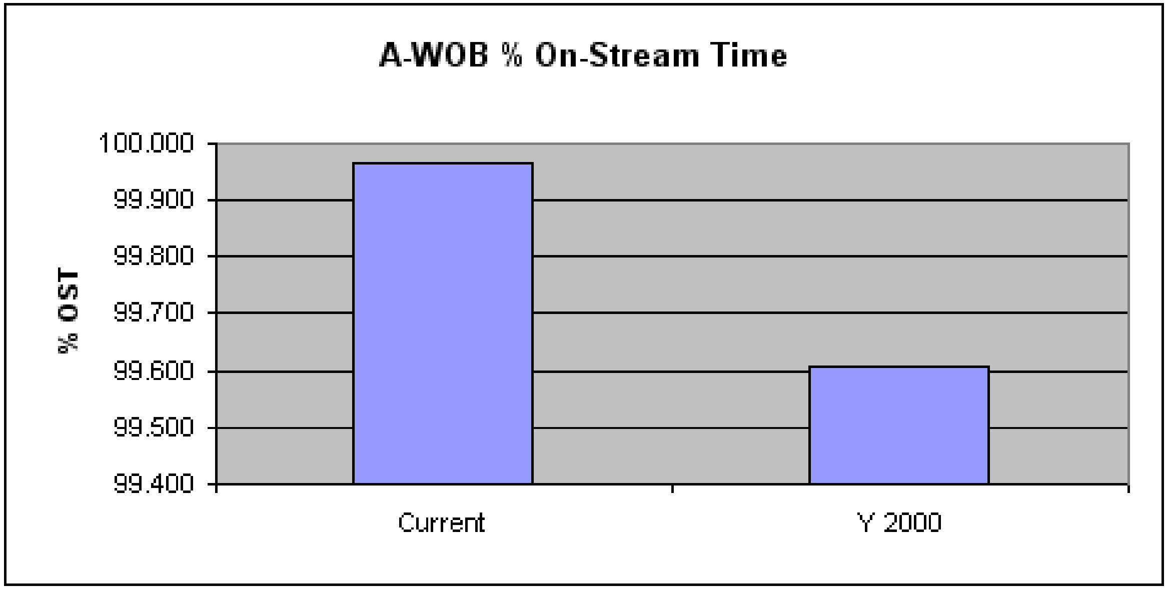


FIG.6 - IMPROVED A-WOB CONTROL

Results:
Improved On-Stream Time

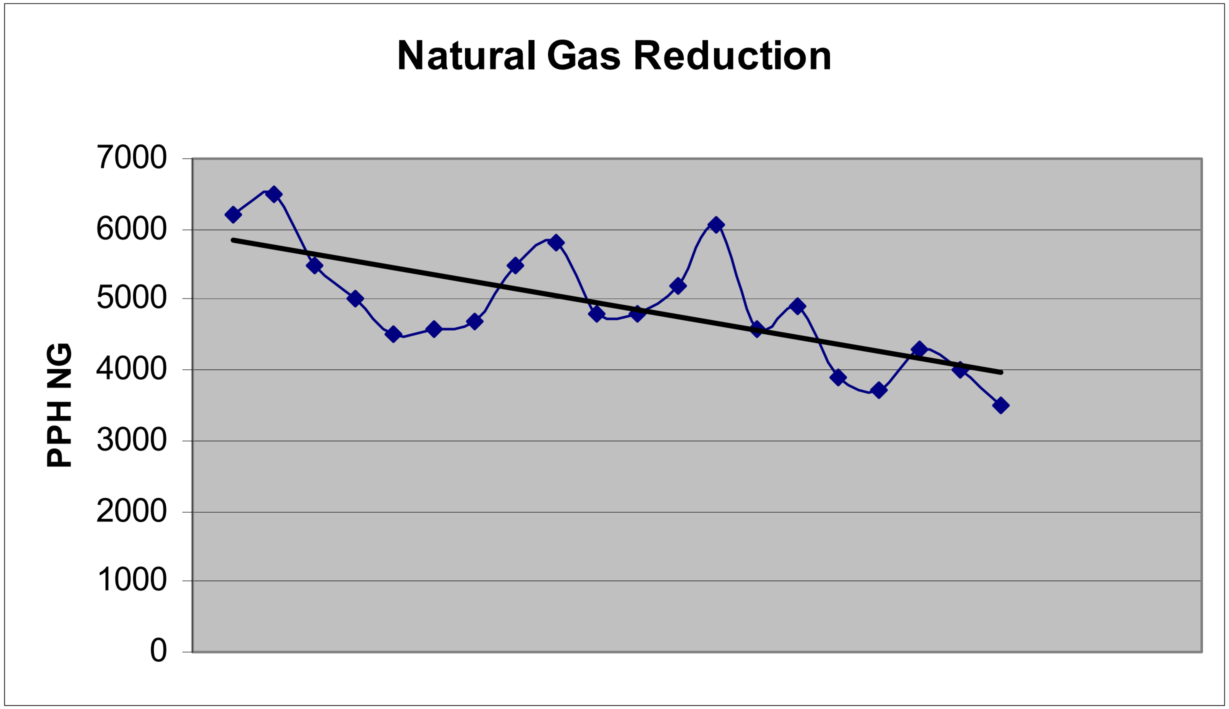
- The reduction of trips on A-WOB from 17 trips to 2 results in a savings of over $420,000 for lost production time.

	% OST	% OST	
Aug-03	100.00	99.73	Jan-00
Sep-03	100.00	100.00	Feb-00
Oct-03	100.00	100.00	Mar-00
Nov-03	100.00	99.72	Apr-00
Dec-03	99.73	100.00	May-00
Jan-04	99.87	99.17	Jun-00
Feb-04	100.00	100.00	Jul-00
Mar-04	100.00	99.17	Aug-00
Apr-04	100.00	98.06	Sep-00
May-04	100.00	99.87	Oct-00
Jun-04	100.00	99.86	Nov-00
Jul-04	100.00	99.73	Dec-00
	99.966	**99.608**	



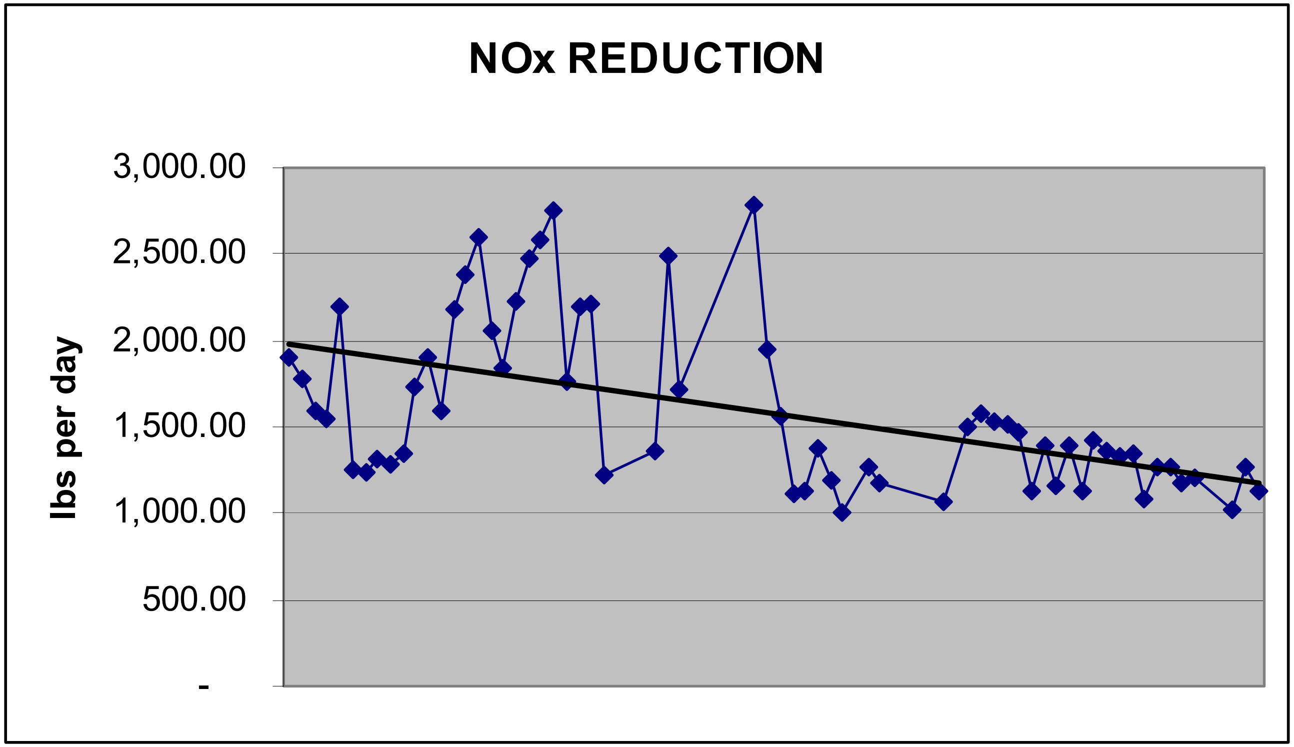
Results:
Lower Natural Gas Usage

- There is an approximate reduction of 2000 lbs per hour reduction of natural gas to A-WOB while not burning waste fuels. At $6 MMBTU this reduction is a savings of over $400,000 per year.



Results: NOx Reduction

- Lower temperature and oxygen setpoints also significantly reduced the amount of NOx emitted from A-WOB stack. NOx reduction was over 80 lbs per hour on A-WOB. This improvement allowed for a delay in purchasing an SCR or NSCR.



Conclusion

- Running the WOB on Fuel Management and closing all the loops allowed operations to run at a much lower temperature control setpoint and lower excess O2. The changes resulted in lower natural gas, lower NOx and increased on stream time (OST).

- Similar results were seen on B-WOB and C-WOB after the implementation of improved control. The total savings is well in excess of $1 million dollars a year in natural gas and lost production. NOx was also reduced by over 40% for the 3 WOBs. This savings was achieved without any significant capital expenditures.