Abstract

The boiler generating bank (convective) sections of waste to energy boilers are commonly found to be very limited in regards to personnel access. The Miami-Dade County Resources Recovery Facility has had a challenge in the past to effectively clean this section of the boiler either on line or within a timely manner during outages.

In 2003 the company used a new innovative method for cleaning this section off line. The boilers were 100% clean in 1/2 to 1/3 the usual time. The new method involved high-pressure industrial water blasting as typically used, with the exception of the water delivery device/system.

Normally the water delivery method involves personnel placed in the boiler with hand held high-pressure water lances. They require confined space monitoring, lighting, scaffolding, proper air supply, frequent breaks, rain suits, full face shields and other PPE for safety inside the boiler. These factors combined with the limited space severely constrain the personnel and their effectiveness when using the water lances. Cleaning is compromised and has led to poor effectiveness and long duration cleanings. Explosives have also been tried to help augment cleaning.

The new method used in 2003 involved no personnel in the boiler. Instead, for the water delivery system, a support cable is erected across the boiler upon which a rotary cable swivel tool (CST) is mounted. The tool has connections for high-pressure water and plant air and a simple winch for traversing the tool across the furnace.

Very effective cleaning was accomplished from drum to drum, a distance of 20 feet (6.1 m). Depending on the application, the water pressure can be adjusted for maximum effectiveness. The air pressure is also adjusted to control the speed at which the rotary nozzles spin to best match the fouled conditions. The orientation and number of nozzles is also optimized for each application.
This paper details the results of using the rotary Cable Swivel Tool (CST) in the generating bank section of the boilers and discusses related operational and maintenance benefits.

Introduction

The Miami-Dade County Resources Recovery Facility is 4,200 tons (3,810 tonnes) per day combined waste to energy and waste processing plant. The plant services the greater Miami-Dade County Florida area by processing approximately one third of the 3.5 million tons (3.2 million tonnes) of waste generated.

The 40-acre (16.2 hectares) site began operations in 1979 and has been retrofitted three times. The first retrofit was completed in 1989, which involved changing the waste processing system from a wet to a dry process. This retrofit also included a total rebuild of all 4 boilers, re-using only the existing steam and mud drums and most of the existing structural steel. [1]

The second retrofit completed in 1997 involved upgrading the trash processing system. This retrofit allowed commercial and wood waste including yard waste to be processed into a biomass fuel and a high-grade soil for recycling. This retrofit boosted the facility processing capabilities to over 1.2 million tons (1.1 million tonnes) per year, making it the largest in the world. [2]

The third retrofit completed in 2000 involved complying with the Clean Air Act Amendments (CAAA) of 1990 and meeting more stringent air emissions limits. It involved upgrading the air quality control system by replacing the existing Electro Static Precipitators (ESP’s) with Spray Dryer Absorbers (SDA’s) and Fabric Filters (FF) as well as retrofitting the boilers. The boiler retrofit work included a new Over Fire Air (OFA) system, a new Selective Non Catalytic Reduction (SNCR) DeNOx system, and new propane gas startup burners. See Fig. 1 for a site plan.

The boilers have experienced a change with regards to boiler fouling since being retrofitted. Prior to 1997 the boilers ran fairly clean and no outside additional cleaning methods were required. Although some fouling caused minimal gas flow channeling and increased flue gas flow velocities, it was sporadic and no immediate impact on operations was perceived.

After the trash processing system retrofit, the boilers began experiencing more frequent more severe fouling to the point that operations could not maintain a balanced draft furnace without reductions in load. Outside assistance was then sought for cleaning. Several methods were tried with varying but mostly limited success prior to the use of a new method, the rotary Cable Swivel Tool (CST).

Boiler Description

The facility has 4 identical boilers, originally supplied by Fives-Cail Babcock in 1977. They were demolished, re-designed and rebuilt by Zurn Industries during the first retrofit in 1989[1]. They are Refuse Derived Fuel (RDF) fired, balanced draft, natural circulation boilers. They incorporate a welded membrane waterwall construction, screen tubes, generating bank section and two stage pendant type superheaters. They are top supported, two-drum, bent tube, single gas
pass boilers with a two-section bare tube economizer and a tubular air heater.

The original stoker supplied by Detroit Stoker Company was replaced with a Zurn Industry traveling grate stoker during the 1989 boiler rebuild. The maximum continuous rating is 28 tph (25.4 tonnes per hour) per unit producing 180,000 PPH (81,648-kg/hr) steam at 732 Psig (50.5 bar) and 721 °F (383 Deg C) outlet conditions. For a boiler side view section see Fig. 2.

Generating Bank Details

The generating bank or evaporator section utilizes 1248 2.5" (63.5 mm) O.D. x 0.165 (4.2 mm) MWT, SA 210 A1 tubing swaged to 2" (50.8 mm) at the ends to fit the old Fives-Cail Babcock Steam and Mud Drums. The section is divided up into 48 rows wide of which the two outer rows are incorporated into the walls. The generating bank is 26 tubes deep in the direction of gas flow. There are two built in sootblower/ manway access lanes included in the design with the first one occurring between tubes 6 and 7 from the front and the second one between tube rows 18 and 19 from the front counting in the direction of gas flow.

These sootblower / manway access lanes are only 15.5" (395 mm) wide and are typical of most boiler designs of this size and rating. The tubes at the bottom of the manway form a V shape with one tube less than vertical and one tube at 45 degrees, making walking in the lane difficult without scaffolding.

Tubes are spaced on 5 1/16" (127 mm) from left to right on center, leaving gas pass lanes when clean at roughly 2.5" (63.5 mm). Spacing in the direction of gas flow is 4 1/2" (114 mm) on center leaving 2" (50.8 mm) spacing between the tubes from front to back. See Fig. 3 for a generating bank cross section.

Fouling Patterns

Earlier History/Experience

The tube and membrane water walls typically see only a small light coating of ash on the surfaces with no action required other than cleaning for specific outage work (Ultrasonic thickness (UT) testing or Inconel 625 maintenance). The spacing on the screen tubes and superheater (6 inches or 152 mm) together with the temperature prevent any real accumulation or fouling in this section. Again a light coating of ash typically develops with no action required unless maintenance is planned in those areas at scheduled outages. Occasionally a small build up may accumulate on the top surface of the upper furnace arch (Bull nose) underneath the superheaters which is easily removed.

The economizer as well has had a history of remaining fairly clean through the section unless an economizer tube leak develops. The added moisture from tube leaks generally leads to infrequent but severe fouling.

Inspections as well as draft loss data in the mid to late 1990’s showed only sporadic minimal fouling in the generating bank section. No real impact on operations was noted so no action was taken.

Recent History/Experience

Operational concerns about the ability to maintain furnace pressure with the ID fans surfaced in the late 1990’s. Boiler load
was being reduced, so the whole system was tracked initially to verify / locate the source of the worst fouling and cause for ID fan limitations. Although some draft loss was experienced in the SDA, the SDA and FF were found to have minimal impact and are exempted from discussions in this paper.

Through frequent inspections and monitoring the fouling patterns remained the same as in the past in all the other boiler sections but became much more severe in the generating bank section. The new extra fouling was seen to always occur in the first section of the generating bank. At times, depending on conditions, heavy fouling would also be noted in the second, middle section of the generating bank up to the boiler vertical centerline (in the direction of gas flow). The third section of the generating bank continued to remain typically free from fouling.

Figure 4 gives an example of the draft monitoring data sheet that was developed to pin point problem areas. Values for the various sections were established for clean conditions and then tracked, as the ID fan capacity became more and more limited. The main sections monitored were the Superheater, the Generating bank, the Economizer and the Tubular Air heater.

Figure 5 is a sample picture of typical fouling seen in the first section of the generating bank. This section reached a high of 17 inches of water column (432 Kg/m²) differential pressure as the most severe fouling reading seen to date. Under these conditions, boiler load is limited due to ID fan Amps and potential overheating of the motor, loss of draft control in the boiler, and Baghouse temperatures approaching or exceeding permit levels.

Sootblower locations and a sketch of the typical fouling locations are indicated in Fig. 6. Maintaining reliability of old chain driven steam soot blowers has proved challenging and the existing sootblowers were not able to maintain gas flow lanes clear. At this point outside help for cleaning was sought. The need to take action was reemphasized when the severe fouling was found to hinder planned outage maintenance activities, (specifically generating bank tube change outs).

Past Cleaning Methods

In an effort to clear the boilers of the fouling several methods were attempted at the facility.

On-Line Water Blasting

The boilers were fitted with on-line cleaning ports in the form of 4" (102 mm) pipe nipples with caps in key areas around the generating bank section, see Fig. 6. On line cleaning was carried out by the use of high pressure water blasting delivered through a simple pipe with a ‘T’ fitting at the end. The cleaning personnel would rotate the pipe during cleaning to sweep areas from top to bottom while slowly, manually indexing across the width of the section. Nozzle selection varied but was eventually optimized. Too much water would cause problems with the operating unit such as fouling downstream sections, or plugging adjacent hoppers. Too small of a nozzle was found not to be effective enough to remove deposits.

This method was used for some time but eventually abandoned. When working through a 4" (102 mm) pipe the effectiveness was difficult to determine as
no other view ports were available in the sections needing attention. Several openings would need to be accessed to attempt to make a measurable difference on draft and ID fan loading. Ash left behind from partial cleaning combined with moisture was leading to accelerated corrosion rates in some areas. This ash was also found set up hard in some areas after going back in service and firing the boiler. This proved even more difficult to remove during subsequent outages.

Thermal fatigue and stress cracking although not observed at the Miami-Dade Facility was a concern since it had been seen in other units due to the cold shock on the operating tubes. [3] This method was also incompatible with experimental ceramic shields being tried in various areas of the boiler at the time.

Explosive Cleaning

This method usually involved registered plastic explosives attached to sacrificial wooden broom stick handles fastened to aluminum poles. The charges were placed in position through an opening and detonated either on line or off. Either an access door or the same 4” (102 mm) on-line cleaning ports were used. This method was being used to help loosen up fouling before the water blaster with hand held lances would enter. This cleaning method was phased out when the rotary Cable Swivel Tool (CST) cleaning was shown to be very effective without the need to augment with explosive blasting. This method even when supervised closely was still found to damage furnace refractory in proximity to the blasting.

Some subsequent inspections also found damage to boiler tubes. See Fig. 7 for a picture of damaged tubes, found in generating bank no 1. The tubes have physical evidence of dimples at the point of detonation; however, they did not fail, and remained in service for some time after.

Other Cleaning Methods

Some of the other Waste to Energy plants within the Montenay-Onyx Power Corp. umbrella have been using a ‘mini cannon’. This is essentially a large shotgun device that blasts fouling with shot. A low velocity, 3-oz (85 g) Zinc, flat nose 8-gauge shell was used to help remove clinkers while on line. This method has not been tried at the Miami-Dade Facility.

Another one of the Waste to Energy plants under the Montenay-Onyx Power Corp. umbrella uses another form of high-pressure water blasting regularly that involves equipment similar to a portable soot blower. It uses high-pressure water instead of steam or air. This operation for cleaning the boiler is carried out just as the unit is coming off line. Due to the high volume (400-gpm or 25 l/s) wash and the limited wastewater handling capability at the facility, this method has not been tried to date.

Sonic horns are another method used with some success at various facilities but have not been tried at the Miami-Dade facility. Maximum efficiency comes with the use of horns when the ash and or fouling remain dry. Inspections have shown some of the fouling to be wet or moist and or hardened in place adhering aggressively to the tube and the thought is that sonic horns would not be effective on this type of deposit.
Off-Line Water Blasting

This is the area the facility had been using for the most part with difficulty. A trailer mounted diesel driven high pressure, high volume pump(s) is normally located near the boiler. The plant supplies clean water. The pump supplies the 8,000 to 10,000 psi (552-689 bar) water pressure at a 100 to 200 gpm (6.3-12.6 l/s) flow rate.

Normally the delivery method involved personnel placed in the boiler with hand held water washing lances. Due to the limited space, various lengths of lances were tried, depending on the section of the boiler being cleaned.

Since the personnel are in the boiler, they require confined space monitoring, lighting, scaffolding, proper air supply, frequent breaks, rain suits and other PPE for inside the boiler. The scaffolding would have to be minimal so as not to hinder the work area attempted to be cleaned. Scaffolding consisted of brackets attached directly to the boiler tubes supporting minimal planking. As one area was finished, cleaning operations would have to stop to allow support personnel, usually boiler makers to relocate scaffold higher or lower in the generating bank section to allow for the cleaning personnel to reach the next area.

The personnel worked from the soot blower lanes, which are only 15” (381 mm) wide and have a V shaped bottom in the walkway making standing or walking difficult without additional scaffold planking. All these factors especially the limited space severely constrains the personnel and their effectiveness when using the water lances. Typically 24 to 36 hours of front-end outage time would need to be allocated for the cleaning of this type, and not all the fouling would be removed.

Rotary Cable Swivel Tool

The current method used for the first time in 2003 involves no personnel in the boiler other than for initial set up of the CST and minor touch up at the end of cleaning. Instead, a support cable is erected across the boiler upon which a rotary cable swivel tool (CST) is mounted.

The water pressure and flow source, remain essentially the same as the off line cleaning used before. The source consists of 2 diesel driven pumps mounted on a flat bed 40-foot (12.2 m) trailer with a reservoir/surge tank at the pump suction for protecting the pumps in the event of a loss of water supply. It is transported in and out of the job site for scheduled cleanings.

The CST unit is walked into the soot blower lane through the existing access door once the boiler is cool enough. On several occasions the fouling is so severe, that cleaning personnel need to dig out the ash near the door just to gain entry and set up the tool.

The primary cable that supports the CST is fed through one of the existing 4” (102 mm) on line cleaning pipe nipples on one wall of the boiler. It is then threaded through the CST unit and then through a 4” (102 mm) on line cleaning port on the opposite wall of the boiler.

After air and water supply hose connections are made, one end of a secondary cable is attached to the unit. The primary cable is then pulled taught lifting the unit into position. Note no scaffold is required in the boiler to get the
The primary cable ends are secured to the structure, outside of the boiler at an elevation, which it is most effective, typically 3 to 4 feet (0.9-1.2 m) above the horizontal centerline. This is the same elevation of the 4” (102 mm) on line cleaning ports used. See Fig. 8 for a sketch of the CST set up.

The secondary cable is attached to a simple winch for traversing the tool across the furnace. The unit is pushed or positioned as close to the starting wall as possible to begin cleaning. The supply lines attached to the opposite side from where the winch cable is attached create enough drag to keep tension on the winch cable and keep the unit in position while operating. Due to the air and water supply lines hooked to the one side of the unit, cleaning for the first few lanes is not possible with the CST under the current boiler configuration.

These lanes need manual touch up with the hand held lances once the CST work is complete. Also the last one to two lanes are not able to be cleaned with the tool due to the nozzle location on the CST and the width of the unit itself.

The air pressure supplied by the plant through a drier is adjusted by hand with a simple ball valve on the supply to control the speed at which the rotary nozzles spin. Typical rotation speeds run at 10 to 15 rpm. The orientation and number of nozzles is also optimized for each application. See Fig. 9 for a picture of the CST in operation.

At Miami-Dade the adjustable water washing is accomplished set at 6,000 to 8,000-psi (414-552 bar) pressures and 110-gpm (7 l/s) flow through 2 nozzles. The nozzles on the CST are 180 degrees opposed with the resultant force from the nozzles canceling each other. This minimizes the force on the primary cable, leaving only the weight of the unit to support.

Cleaning effectiveness during the cleaning operation is judged by a number of methods. First, when available, upstream and/or downstream access doors are opened. The water spray coming through the whole bundle or the lack of it, can be an indicator of whether gas pass lanes are getting cleared or not.

Second and perhaps more telling is the sound. When initially started, the sound of high-pressure wash water digging through ash is discernable when compared to the sound after a number of minutes running, and the water goes through a clear gas pass lane. Also noticeable by sound differences is the proper lateral positioning of the CST whether the nozzles are spraying directly on the face of the tubes or in the gas pass lanes between tubes.

Based on the sound, cleaning and traversing the unit from one gas pass lane to the next can be customized each time to match the fouling conditions. The operator uses the hand winch to hasten through the lighter fouled areas that clear more quickly and slows cleaning in the areas with heavier, harder deposits. The tube spacing is known and coordinated with the number of turns on the winch to match nozzle position to be in the gas pass lane.
Results

Operational Impacts

Follow up boiler crawl through inspections show that CST to be nearly 100% effective from drum to drum, a height of 20 feet (6.1 m). Tube cleaning is completed between the tubes (in front of and behind subsequent tubes in the direction of gas flow) as well as clearing the gas pass lanes. Only minor touch up is required in the gas pass lanes adjacent the walls. With a generating bank section clean several improved operating conditions are noted.

Probably best illustrated by Table 1 for ID fan conditions before and after, ID fan operating parameters improve greatly. ID fan amps, ID fan positioner on the fluid drive, and ID fan RPM are all illustrated in the table. A reduction of approximately 400 Horsepower (71 Kcal/sec) is seen calculated from the before and after motor amps data. This is equivalent to approximately 0.3 more MW’s available for export.

<table>
<thead>
<tr>
<th>Boiler</th>
<th>Date Cleaned</th>
<th>Amps Before</th>
<th>Amps After</th>
<th>Control % Before</th>
<th>Control % After</th>
<th>RPM Before</th>
<th>RPM After</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>8/22</td>
<td>96</td>
<td>66</td>
<td>86</td>
<td>56</td>
<td>972</td>
<td>742</td>
</tr>
<tr>
<td>2</td>
<td>9/18</td>
<td>111</td>
<td>52e</td>
<td>78</td>
<td>40e</td>
<td>1103</td>
<td>600e</td>
</tr>
<tr>
<td>3</td>
<td>11/17*</td>
<td>66</td>
<td>54</td>
<td>55</td>
<td>44</td>
<td>762</td>
<td>636</td>
</tr>
<tr>
<td>1</td>
<td>1/7/04</td>
<td>114</td>
<td>55</td>
<td>98</td>
<td>37</td>
<td>1134</td>
<td>623</td>
</tr>
</tbody>
</table>

* - Cleaned for maintenance purposes at the front end of an outage, not needed for operations and draft control. e = estimated values

Table 1 – ID Fan Condition

Furnace draft readings also show marked improvement as would be expected. By helping maintain furnace draft and the ID fan within control range, minor positive pressure excursions from the balanced draft furnace are minimized. Table 2 illustrates some before and after readings for draft data with units in inches of water (kg/sq. m).

<table>
<thead>
<tr>
<th>Boiler No</th>
<th>Date Cleaned</th>
<th>Draft DP Before</th>
<th>Draft DP After</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>8/22</td>
<td>6.6 (168)</td>
<td>0.2 (5)</td>
</tr>
<tr>
<td>2</td>
<td>9/18</td>
<td>11.3 (287)</td>
<td>0.3 (8)</td>
</tr>
<tr>
<td>1</td>
<td>1/7/04</td>
<td>17.5 (445)</td>
<td>0.1 (3)</td>
</tr>
</tbody>
</table>

Table 2 – Furnace Draft Data Table

The frequency of cleaning using the CST to date illustrated in Table 3 shows the average length of boiler run time to be 6 months between cleaning. On occasion, as noted, the cleaning was completed prior to the 6-month cycle in order to accomplish more maintenance work during outages.
Table 3 - Frequency of cleaning using the CST

<table>
<thead>
<tr>
<th>Date of Cleaning with CST, 2003</th>
<th>Months Between Cleanings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Month</td>
<td>1</td>
</tr>
<tr>
<td>Boiler 1</td>
<td>10th</td>
</tr>
<tr>
<td>Boiler 2</td>
<td>17th</td>
</tr>
<tr>
<td>Boiler 3</td>
<td>4th</td>
</tr>
<tr>
<td>Boiler 4</td>
<td>3rd</td>
</tr>
</tbody>
</table>

Foot notes: x = cleaned in advance of superheater change out and not needed for boiler operational purposes, y = cleaned again prior to outage for maintenance purposes, z = not typical, short time between cleanings attributed to loss of soot blower nozzle head on a new soot blower in a critical area.

Although not as well documented, with clean boiler surfaces, better temperatures overall allow reduced spray flow in the SDA for maintaining the bag house temperature inlet conditions. This tends to save on water consumption. Because this is sometimes affected by many factors, the water savings was not determined strictly from the boiler cleaning aspect.

Outage Time Savings

This CST method of cleaning was found to save outage downtime in 2 ways. First less actual downtime is spent cleaning. The conventional way used prior with personnel in the boiler was taking between 24 to 36 hours at the start of the outage with some of the ash or fouling still left in the generating bank. Using the CST reduced this time to 8 to 12 hours including the minor touch up needed after the CST work is complete.

Another outage time saver was seen through increased maintenance efficiency on a clean boiler. Specifically, generating bank tube change outs are greatly enhanced. In past outages, boiler generating bank tubes were planned to be changes as part of an optimization plan. [4] Boiler 3 was scheduled for change out of between 156 and 208 tubes in a 5-day outage. In fact due to lack of cleaning efficiency, only 91 tubes were changed. In Boiler 2, again only 108 tubes were changed in the normal outage time frame.

Once cleaning efficiency picked up through the use of the CST, 372 tubes were changed in one outage in Boiler 1, and 202 tubes were changed in Boiler 2. Also any visual inspections needed in the section can be conducted more thoroughly on clean boiler tubes.

Practical considerations

Hoppers in the area do have trouble handling the large volumes of ash and fouling that’s broken loose by the CST. If the hoppers are not clear it is believed best to get them clear first and then keep them monitored and clear during cleaning operations.

In the case of the Miami Dade facility, it is also best to keep the stoker grate and ash system running when possible to move ash out. As the material is moved off the tubes a good portion of it falls to the stoker. Keeping the stoker running prevents a large pile, which is then 1) handled by the normal ash removal conveyors, and 2) prevents much more difficult handling later in the outage. It also prevents conflicts with other work...
such as stoker or ash conveyor maintenance.

Future planned improvements to the process involve adding access doors. In other facilities, cleaning is done while the boiler is cooling. When two doors large enough to fit the CST are located on opposite walls, and at the proper elevation for cleaning, the tool can be set without any access to the boiler at all and prior to the unit fully cooling. In addition, cleaning while the unit cools offers the potential to save even more outage down time.

Typically now the boilers are required to cool for 12 hours first, before personnel can enter, then the next 12 hours are set aside for cleaning. The potential there is to overlap the cooling and cleaning activities. The cable can be stretched across the hot unit with the use of a long pole. In some cases for the wider larger utility boilers, a crossbow with a leader is shot across the unit. The leader is then used to get the support cable in position.

Another goal of mounting permanent piping will also save on set up. Currently the cleaning contractor hoists high-pressure hoses to the cleaning elevation each time, approximately 70 feet (21 m) from ground level.

**Sootblower optimization plan**

Mentioned only briefly, in an effort to further lengthen the time between cleanings, the sootblower program and frequency is being examined for optimization. Programming to run soot blowers more frequently in the key areas, No 3 and No 4, where heavy fouling is developing, and less frequently in other areas not typically showing fouling history. Shields will be installed to protect the tubes from increased sootblower erosion, and wear should decrease where soot blower frequency is extended.

Some of the old chain driven soot blowers that have proven to be more challenging to maintain from a reliability standpoint are being replaced with new gear and sprocket driven models. Soot blower nozzle types and sizes as well as blowing pressures are also being investigated for optimization.

**Summary**

By using the rotary CST to clean the boilers at the Miami-Dade facility, outage time is reduced, both by less time required to get the boiler clean (8 to 12 hours vs. 24 to 36 hours) and by improved maintenance work efficiencies on a clean boiler. The unit is effectively cleaned 100% from drum to drum a height of 20 feet (6.1 m). The generating bank tube gas pass lanes as well as spaces between the tubes are cleaned with no ash remaining. This restores heat transfer and makes visual inspections much more effective.

For the same outage time given, roughly double the amount of generating bank tubes can be changed when the boiler has had all the fouling removed. Work progresses more efficiently with more tubes changed inside the same outage time frame.

ID fan operating parameters are returned to normal, and the boilers stay cleaner longer, when starting with a clean boiler.
Safety of personnel is improved because cleaning is done remotely with the help of the CST, keeping the need to put personnel in the confined space of a boiler to a minimum.

The facility is planning improvements to further streamline/ accommodate the use of the CST for boiler generating bank section cleaning.

Acknowledgments
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References


Figure 1 - Site Plan
For: Dade County Resources Recovery
Miami, Florida

Rating .......................... 180,000 lbs/hr. (675 tpd)
Fuel ................................ Refuse Derived Fuel
Design Pressure .................... 732 PSIG
Steam Temperature .................. 721°F

Figure 2 – Boiler Side View Section
Figure 3 – Gen Bank Side View section
Figure 4 - Draft Monitoring sheet
Figure 5 - Picture of typical fouling in generating bank
Figure 6 - Soot blower, cleaning ports and fouling locations
Figure 8 - Sketch of CST set up