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# IMPROVING RDF COMBUSTION: CASE HISTORIES

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## ABSTRACT

During the past ten years Ogden has acquired or took over operating of several waste-to-energy facilities using RDF technology. Based on our diversified design, construction, and operating experience, Ogden conducted a multifaceted program to understand and improve the general plant operation and in particular the combustion in these RDF plants. This program has resulted in improved combustion stability, reduced corrosion/erosion of boiler components, and lower air pollutant emission rates.

The program began with a detailed evaluation of furnace design parameters and historical operating and maintenance data. This evaluation identified specific areas of concern at each plant, such as equipment with high maintenance requirements, low reliability, or high operating costs. Design parameters at the various facilities were compared to each other and to Ogden's mass-burn plants to gain insight into combustion issues such as fuel feed, combustion air supply, flame stability, and boiler corrosion.

This was followed by detailed studies of the combustion process in the plants, including furnace air flow modeling and corrosion and erosion processes in the boilers. This generated an understanding of many of the processes taking place in the furnace, and suggested opportunities for improvement.

The knowledge gained was used to determine appropriate improvements for each facility, in the form of equipment modifications and changes to operating and maintenance procedures. Finally, field testing was conducted after all modifications had been made to evaluate performance at each facility. Minor adjustments and fine-tuning were performed to optimize operations.

The RDF facilities are now operating at higher reliability and efficiency, with lower air emissions and improved combustion stability. These facilities are now fully integrated into Ogden's waste-to-energy operations with their own optimized preventive maintenance programs and improved training.

## INTRODUCTION

This two-case presentation includes the RDF facilities in Lawrence, Massachusetts and Honolulu, Hawaii. There are interesting differences between these two projects, including the fact that Lawrence is among of the older RDF plants, and the two utilize somewhat different technologies and boiler design. However, both have suffered from considerable corrosion of the furnace and superheater tubes and heavy fouling in the convection tube sections.

## CASE ONE: LAWRENCE

In 1986, Ogden acquired the RDF facility from the original developer and operator, Refuse Fuels, Inc. (RFI). During the initial two years of operation, from 1984 to 1986, the facility encountered numerous operating difficulties. Technical problems included malfunctions and breakdowns of the front-end processing equipment used to make the shredded fuel; low operating availability due to boiler corrosion, erosion and fouling; and major air emission problems that caused the facility to exceed its permissible limits. These technical failings kept the facility from meeting its economic goals.

### Description

The Haverhill/Lawrence RDF facility is designed to handle 1300 tons-per-day (TPD) of refuse. The front-end RDF preparation plant is located in Haverhill, Massachusetts and the combustion and power generation plant is located in Lawrence, Massachusetts.

The RDF preparation plant is comprised of refuse receiving area, in-feed conveyors, 1000 horsepower shredders, transfer conveyors, two-stage magnetic separators, 60-feet long trommels with two- and four-inch diameter holes, various product conveyors (i.e., feed, RDF, undersized and oversized rejects, ferrous materials), numerous transfer and loadout chutes, the RDF storage area and a dust control system. It is a complicated system and, as is customary in these plants, there is redundancy of all equipment to improve operating availability. To increase the yield of the RDF, secondary shredders were added to handle the oversized rejects, which are mostly combustible materials.

Processed RDF is hauled by trucks to the Lawrence facility, which is comprised of an RDF storage area, horizontal and inclined in-feed conveyors, distribution augers, return conveyors, various transfer chutes and a dust control system. As in the RDF preparation plant, all RDF handling equipment was virtually duplicated for redundancy in an attempt to provide a minimum operating availability of 85 percent.

RDF is fed into a single dedicated boiler, shown in Figure 1, via hydraulic rams, inclined feeders, air-swept chutes and fuel distributors, as illustrated in Figures 2 and 3. It is then combusted on a catenary type traveling grate, where the primary combustion air is supplied from an undergrate air plenum and distributed via 1/4 inch diameter holes.

The boiler is a conventional "two-drum Stirling" unit with an integrated spreader stoker combustion system designed to burn 950 TPD of 4800 Btu/lb RDF to produce 250,000 lbs/hr of superheated steam at 750 °F and 650 psig. It is equipped with a regenerative airheater for preheating the combustion air to 350 °F, and a four-field electrostatic precipitator (ESP) for particulate control.

## Initial Investigation and Corrective Measures

After the plant started-up in 1984, it was soon discovered that the RDF boiler, as built, could not meet its performance requirements without excessive downtime. Major operating problems included the following:

- Poor combustion conditions which caused the flame to extend into the superheater and boiler bank zone.
- High superheated steam and superheater tube metal temperatures.
- Severe furnace tube-wall corrosion.
- Actual availability was lower than 85 percent.

In trying to resolve these serious operating problems, the boiler vendor undertook the following corrective measures:

- Modified the overfire air (OFA) system, using three-inch diameter nozzles, consisting of 17 in the front wall and 16 in the rear wall, in addition to the original one-inch diameter nozzles.
- Installed furnace exit platen type screens, arranged at 18 inches lateral spacing, in an attempt to control the extremely high flue gas temperatures at the superheater inlet.
- Reduced the superheater heating surface by approximately 22 percent.
- Weld overlayed the furnace tube walls with Alloy 625, up to a level of approximately seven feet above the lower side wall headers.

Although these corrections and modifications were partially successful, they did not allow the unit to meet its design load and availability.

## Operating Experience After Boiler Vendor Retrofits

During the next operating period, the condition of the unit deteriorated rapidly with the following major problems encountered:

- Furnace tube wastage and failures of the tube walls above the newly installed Alloy 625 overlay, the new furnace exit platen type screens, the superheaters and boiler bank.
- Chain grate stoker problems, including excessive wear, warping, uneven enlargement of the air distribution hole sizes, blocking of air holes and grate sections with aluminum, and various stoker air sealing problems.
- Fuel maldistribution across the grate width affected by the fuel feeding system, where the incoming inclined conveyors feed the unit from the right side, resulting in biased fuel distribution with heavy fractions fed to the right side and the light fractions to the left side of the furnace.
- Heavy unburned particulate carry-over from the furnace into the convection zone due to poor combustion, undergrate air distribution and localized high-velocity zones in the furnace.
- Fuel piling on the grate.
- Heavy fouling of all the convection sections (heating surfaces).
- Inability to operate at the design excess air of 42 percent.
- Decrease of the RDF boiler's operating availability.
- Dioxin and furan emissions, which were several orders of magnitude above the limits permitted by the Massachusetts Department of Environmental Quality Engineering.

During this period, Ogden and RFI performed numerous combustion and other performance tests at 100, 90, 75 and 60 percent load to evaluate boiler performance at various loads. Additional steps included a furnace flue gas temperature survey, video filming of furnace conditions to monitor fuel distribution, observation of slagging patterns and flame development, including high velocity and particulate carry-over zones.

The test results, together with operator observations and experiences and several metallurgical reports, were evaluated to establish potential causes for these operating problems. More important, all of this data was used to determine necessary corrective measures to be taken.

The most likely causes of the tube wastage and failures were attributed to reducing furnace atmosphere conditions, high flue gas temperatures (2000 °F at the furnace exit was recorded), high flue gas velocities, corrosion caused by fuel and ash constituents mainly attributed to chloride, sulfate, zinc and lead, high particulate carry-over, and insufficient clearances between the sootblowers and the tube banks.

The boiler was originally built without any furnace tube wall protection and also without any tube shields, both with destructive results.

## Corrective Measures to Improve Operating Ability

The pressure of cumulative tube failures forced two major boiler shutdowns, during which several hundred furnace exit platen type screens, superheater and boiler bank tubes were replaced. Additional steps that were also taken to improve boiler operating availability included:

- Increasing the amount of Alloy 625 weld overlay by approximately 20 feet, from 7 feet to a total height of 27 feet above the lower sidewall headers.
- Replacing and modifying the lower return superheater bends.
- Extensively shielding sections of the furnace exit platen type screens, superheaters and boiler bank tubes and all tubes in the vicinity of the sootblowers.
- Changing the tube size in several rows of the boiler bank as a measure to control the flue gas velocities.
- Installing new thermal drain valves for the sootblowing system.
- Rebuilding the stoker, replacing all grate bars, front and rear seals, grate support rails, fuel distributors, etc.
- Derating the boiler to 75 percent load.

We believe that the fix, using Alloy 625 weld overlay, was the first one applied to refuse burning boiler.

## Furnace Air-Flow Model Study

To establish potential improvements in combustion performance, which was needed to minimize the corrosion as well as for reduction of dioxin and furan emissions, it was decided to proceed with a furnace air flow model study. A three-dimensional plexiglass model was constructed at one-sixth scale to conduct isothermal flow tests. A series of tests was conducted using various OFA configurations in an effort to achieve better mixing patterns and flue gas distribution in the furnace.

During these tests the gas flow patterns in the furnace were distinguished by injecting smoke into the various manifolds and also sequentially through the individual air ports. This was done to identify jet penetrations and localized circulation patterns. In addition, sawdust was used to simulate injection of the RDF through the fuel distributors into the lower furnace. All of these gas flow patterns were recorded on videotape and summarized on simple sketches.

The velocity distributions at the test locations within the boiler furnace were measured, using a hot wire anemometer, at a number of discrete points (in this case 77), located at the centers of equal areas. The velocity vectors were normalized and evaluated both graphically and numerically.

The model tests confirmed the site observations, that the OFA system, as modified by the boiler vendor, was still performing poorly. They demonstrated that the one-inch OFA nozzles were ineffective and the three-inch nozzles, because of their location, provided a "blanket" effect with mid-furnace clash and resulting poor penetration and velocity distribution. In addition, the RDF fuel injected into the lower furnace had a tendency to pile in localized areas.

Based on the results of the flow model study, it was decided to completely change the OFA system including installing new nozzles of different sizes, numbers and locations and adding a separate OFA fan using cold air, as indicated in Figure 4. In addition, the fuel distributors were altered in order to improve fuel distribution on the grate surface.

Following all modifications, the RDF boiler was officially tested in September 1987 for particulate emissions, dioxins, furans and nitrogen oxides. These tests confirmed that the unit had successfully been brought into conformance with the State of Massachusetts dioxin and furan emission guidelines.

## Present Situation - Update

Because of the ever changing environmental regulations and the variations in refuse fuel quality, it is necessary to keep the system up-to-date and in top combustion condition to meet all the requirements. For example, since 1987, the dioxin and furan emissions were further reduced by approximately 50 percent and we have successfully demonstrated continuous compliance through periodic testing. This, of course, means frequent review and update of key elements of the combustion system, including the following:

- Installation of a furnace dry lime injection system, to reduce acid gas concentration in the flue gas.
- Update the stoker grate system with improved seals, aluminum trays, better drives for improved speed control, and improved grate metallurgy.
- Change the manner of distributing RDF to the individual feeders, using both distributing augers. This is to minimize the fuel segregation right-to-left.
- Further modification of the fuel distributors to improve the fuel feed.
- Improve the fuel distribution air damper control.

## CASE TWO: HONOLULU

In 1993, Ogden acquired this RDF facility, together with those in Detroit and Hartford, from the original developer and operator, ABB/CE. Like Lawrence, these facilities have encountered numerous operating difficulties during the initial years in operation. Early technical problems included malfunctions and breakdowns of the front-end processing equipment used to make the shredded fuel, low operating availability due to boiler and superheater corrosion, erosion and fouling. Also like Lawrence, these technical failures kept the facility from meeting its economic goals.

The Hartford plant has been in commercial operation since 1987, Honolulu since 1990 and the Detroit facility since 1991.

## Description

The Honolulu RDF preparation system was designed to handle 2160 tons-per-day (TPD) of refuse. It is comprised of a refuse receiving area, horizontal and in-feed conveyors, primary and secondary shredders, transfer conveyors, two-stage magnetic separators, primary and secondary trommels, various product conveyors (i.e., feed, RDF, fines/rejects, ferrous materials), numerous transfer and loadout chutes, the RDF storage area and a dust control system. It is a complicated system and, as is customary in these plants, there is redundancy of all equipment to improve operating availability.

Processed RDF is transferred via conveyor belt to the power block, which has horizontal and inclined in-feed conveyors, transport belt conveyors, distribution chutes and metering bins, also various transfer chutes and a dust control system. As in the RDF preparation plant, all RDF handling equipment was virtually duplicated for redundancy in an attempt to ensure a minimum operating availability of 85 percent. The RDF is fed into dedicated boilers, shown in Figure 5, using rotary augers, vibrating pan feeders, air-swept chutes and fuel distributors as indicated in Figure 6. It is then combusted on a catenary type traveling grate, where the primary combustion air is supplied from an undergrate air plenum and distributed via five independently controlled underfire air (UFA) zones, as illustrated in Figure 7.

The RDF boilers are of conventional design with CE's designation of VU-40. This multi-fuel type boiler is primarily used for cellulose and fossil fuels, and is not specifically designed for refuse burning. It comprises a single pass furnace, followed by a pendant, semi-radiant type superheater and a two-drum boiler generating bank. The boiler is designed to burn 854 TPD of 5137 Btu/lb RDF to produce 244,000 lbs/hr of superheated steam at 830 °F and 900 psig. It is equipped with a tubular airheater for preheating of the combustion air to 450 °F and a semi-dry scrubber and electrostatic precipitator (ESP) for air pollution control.

The Hartford boilers have, in addition, platen type furnace exit screens for superheater protection. The Detroit boilers have also partial furnace exit screens installed. Honolulu boilers have no screens.

All of these boilers have also a tangential overfire air (TOFA) system which is an ABB/CE trademark, as seen in Figure 8. The units at Honolulu and Hartford are arranged with a single TOFA firing circle, the Detroit boilers, which are approximately 50 percent larger, use a double circle.

All of these boilers were originally designed without any furnace waterwall tube protection.

## Initial Investigation and Corrective Measures

After the Hartford plant started-up in 1988, it was soon discovered that the RDF boilers developed catastrophic furnace gas-side waterwall tube wastage within a very short operating period. ABB/CE conducted a comprehensive investigation including furnace flow model testing in an effort to establish reasons for this wastage. Detroit boilers were also model tested, however, to a much lesser degree. Honolulu boilers were not tested as part of this study.

The following sections summarize their investigations, findings and opinions of how the combustion and corrosion issues should be addressed.

**ABB/CE Cold Flow Furnace Modeling.** In an attempt to analyze and resolve the serious problems facing these boilers a flow model was built and tested. The major conclusions, mainly from the Hartford model testing, were as follows:

- Based solely upon the OFA mixing results at the design operating conditions, there was no evidence to support the hypothesis that localized concentrations of flue gas constituents were accelerating the corrosion process.
- There were several TOFA nozzle angle configurations tested, but the level of "mixedness" above the TOFA nozzle elevation (designated as "Plane 4") did not change appreciably when the OFA mass flow was equal to 40% of the total gas flow. The mixing results were far more sensitive to the quantity of air introduced through the TOFA system than to the particular horizontal angle settings for the nozzles. Based strictly on these results, no significant differences in mixing existed at the full load conditions tested.
- The rate of mixing is highly dependent upon the amount of TOFA introduced. Model results show that the distribution of OFA at Plane 4 was nearly uniform when the OFA mass flow rate was 40% of the total gas flow rate. "Mixedness" decreased as the mass flow ratio of TOFA decreased.
- The rapid mixing of the TOFA in the flow model correlated with the elevated heat fluxes at the TOFA windbox elevation as determined from field thermocouple readings in both Units 11 and 12. This is indicative of the high rate of combustion that accompanies the rapid mixing of the TOFA with the "fuel-rich" flue gas flowing from the grate zone.
- The "As Found" condition, defined as the orientation of the nozzle tips during the pressure part failure, was used

as the baseline condition. Velocity traverses at Plane 4 for the "As Found" and the "Inverted Cone" TOFA configurations yielded similar flow fields/velocity vectors. Although these two configurations represented the extremes of the TOFA nozzle settings tested, there were no obvious differences between the respective flow fields that would indicate that jet impingement would be more of a problem with one configuration than the other.

- The normalized velocity components perpendicular to the wall surfaces were combined with the corresponding normalized flux to the wall. The results of this analysis were inconclusive and could neither support nor deny the contention that jet impingement is accelerating the corrosion.
- Field observation of changes in emissions with changes in TOFA nozzle setting are more likely related to TOFA/grate interaction than to mixing. Flow visualization tests using smoke injection through the TOFA nozzles showed that some nozzle configurations, in particular those which have relatively tight firing circles, seem to have minimal effect on the lower furnace while the wider type configurations penetrated through the fuel injection air stream to the grate surface and consequently were likely to increase the carry-over of particulate.
- The addition of Upper Rear Wall OFA (URWOFA) did not significantly improve the mixing higher in the furnace. The flow visualization tests showed that the URWOFA intersected the PDA flow stream. It appears that this would serve to increase carry-over and promote suspension burning. Operators report that the URWOFA is only used when the fuel is wet which would minimize these effects.

**ABB/CE Field Studies - Optimization of Overfire Air.** It was found that the OFA configuration had a measurable impact on the boiler exit CO emissions and CO concentrations at the right furnace waterwall.

Lowest CO emissions and therefore the optimum OFA arrangement was achieved with the three elevations of the TOFA in an inverted conical configuration. The lowest elevation was directed 4° right of the design firing circle, the middle elevation was aimed directly at the firing circle, and the top elevation was directed 4° left of the design firing circle. No front or rear OFA was utilized. It must be stated, however, that for the entire duration of testing, the RDF was relatively dry. When the RDF contains high moisture, it necessitates the use of the URWOFA. This is based on day-to-day operation and plant operator observations.

Approximately 40% of the total combustion air flow was introduced as OFA for these tests. With the optimized OFA arrangement, there were very consistently low CO values from both the CEM and the plant monitor. The CEM value varied between 25 and 94 ppm and averaged 46 ppm over the duration of the test period. The baseline condition contained numerous CO spikes exceeding 500 ppm, and averaged 148 ppm.

The gas sampling results along the right wall were just as dramatic. In the horizontal plane, the baseline condition CO gas concentrations had recorded values up to 65,000 ppm (close to the wall) compared to 100 ppm for the optimized arrangement.

The $NO_x$ values were slightly higher in the optimized configuration. The optimized arrangement had values between 0.22 and 0.24 lb $NO_x$/MBtu. The baseline condition was 0.155 to 0.19 lb $NO_x$/MBtu. Both arrangements were well within the 0.6 lb $NO_x$/MBtu permit.

The calculated heat flux values showed that "As Found" condition also had the highest peak heat flux of all tests performed at approximately 67,000 Btu/hr-ft$^2$.

There was no conclusive opinion drawn from the HCl concentrations.

Visually, the furnace conditions were considerably more stable and brighter with the optimum (inverted cone) configuration than during the other tests.

**ABB/CE Corrosion Studies.** These studies addressed several major topics as follows:

**(A) Deposit/Scale Analysis** - Significant amounts of zinc, lead and chloride, as well as measurable amounts of sulfur and potassium have been found in tube wall deposits. All of these substances are known to be instrumental in the corrosion of boiler tubes. A reducing gas environment or alternating reducing and oxidizing conditions are often linked to fireside tube wastage. The continuing presence of a hydrogen chloride rich gas phase has been shown to undermine the formation of a normally protective oxide layer on tube surfaces.

**(B) Integral Test Panels** - After 122 days of 100% RDF firing closely monitored integral waterwall test panels showed carbon steel to be wasting at up to 0.60 mil/day or approximately 35% of the rate prior to adjustment of optimum OFA, while Alloy 625 showed less than 0.01 mil/day loss. Other high nickel alloys and coatings showed losses from 0.03 to 0.6 mil/day and the austenitic alloys have shown an increase in wastage from 0.08 mil/day after 51 days to 0.19 mil/day after 122 days.

**(C) Corrosion Probe Studies** - Deposit probe analysis indicated a continuing increase in concentration of certain constituents (lead, zinc, sulfate and chloride) with time. A somewhat cyclic buildup of these constituents on the probes in the corrosion zone when associated with low melting fluxes may reflect a contribution to the observed wastage.

Alloy 625 performed very well on corrosion probes in all locations on both side and rear wall corrosion areas showing less than 0.1 mil loss in 1000 hours. Carbon steel lost up to

5 mils during the 1000 hour exposure, while nickel alloys performed better showing losses from 0.1 to 0.3 mils.

**(D) Tube Metal Temperature and Heat Flux** - Heat flux, as well as crown skin metal temperatures were shown to increase markedly above the TOFA elevation.

Review of the data supports the observation that most accelerated wastage occurs in waterwall regions with higher heat flux. The analysis also supports the contention that optimum steady state combustion corresponds to a measurable reduction in average heat flux in the region of higher waterwall distress.

**(E) Furnace Gas Analysis** - As expected CO is relatively high along the walls prior to the introduction of OFA and decreases markedly after.

While the optimized tight concentric OFA arrangement results in improved combustion (lower CO), there was no indication of a statistically significant variation in HCl regardless of OFA configuration.

**(F) Bench Studies** - Addition of zinc chloride and/or lead chloride particularly in the presence of alkali salts can increase tube wastage from double to tenfold depending on local concentrations.

**(G) Superheater Inspection** - The chromized finishing superheater is more resistant to general wastage during operation. Down time pitting and localized sootblower erosion may require additional maintenance and/or use of protective shields on leading tubes in those regions near the sootblowers.

**ABB/CE Conclusions.** These are the major conclusions reached by ABB/CE following the described studies and investigations:

- It was proven that the tube wastage could be controlled by combined use of wastage resistance material (Alloy 625) and control of furnace operation to provide steady state combustion with minimum oxidation/reduction fluctuations.
- The "optimized" TOFA system, the inverted cone configuration, has a measurable impact on boiler exit CO emissions as well as on CO concentrations at the right waterwall.
- To achieve best possible furnace flue gas mixing, the TOFA mass flow needs to be at least 40% of the total combustion air flow.
- The current TOFA nozzle design, incorporating 10° and 15° downtilt, promotes penetration of the OFA jet flow into the lower furnace. Penetration to the surface of the grate was observed and it is expected it increases the particulate carry-over and suspension burning.

  Emission levels can be expected to be high and the probability of fuel piling on the grate and a pluggage in the rear of the furnace will be increased.
- Based on the mixing test data, the disturbance of the lower furnace by the TOFA jet penetration was reduced as the TOFA "Firing Circle" was made smaller.
- The undergrate geometry forces the incoming grate air flow to be biased to the center of the furnace. Low flows up the left and right walls were observed. In these locations, the TOFA jets from corners 2 and 5 (Detroit) can traverse the furnace and impinge on the front wall, each on their respective sides, just above the TOFA windboxes.
- The maldistribution in the undergrate air may result in burnout of the grate keys in those sections along the walls if there is an insufficient quantity of air to cool them. Redistribution of the undergrate air would promote equal cooling of the grate and would minimize columnar flow up the center of the furnace.
- The localized sootblower erosion experienced at the tube banks requires frequent maintenance and/or use of protective shields.

## Ogden Investigation and Evaluation

Ogden's early operating experience showed that even the major ABB/CE efforts were not sufficient to resolve the combustion related problems facing all three RDF burning facilities. As operation continued, it become increasingly clear that we must consider fundamental changes in the combustion and/or OFA systems.

It was decided that an airflow model study was an essential part of the ongoing investigation to resolve the furnace flow problems as quickly as possible. The main objectives of the study were:

1. To establish the influence of the existing TOFA configuration on the gas-flow patterns in the boiler furnace.
2. To determine potential improvements using a multi-level front and rear OFA nozzle arrangement.
3. To optimize the gas-flow patterns and to produce a sensitivity analysis with the most promising OFA arrangement.

## Model Testing

Similar to the Lawrence model testing, the flow patterns, for different OFA configurations and a range of overfire/underfire ratios, were identified by measuring air velocities within the furnace, across a matrix of points at selected elevations in the model. The flow patterns were also studied by injecting smoke through all the air ports. In addition, the effect of a specific OFA nozzle arrangement on gas-mixing was determined by injecting tracer gas (CO) into the OFA nozzles. The degree to which the OFA mixed with the rising grate flow was measured by sampling the CO concentrations, again, across a matrix of points at selected elevations in the model.

This required that the test program determine the configuration of the OFA ports to achieve optimum gas-flow patterns in the furnace, defined as follows:

(A) High turbulence level in all sections of the furnace,
(B) Long retention time in the furnace,
(C) Even gas distribution in the upper furnace,
(D) Minimum scouring of the grate surface
(E) Minimum impingement of the gas-flow on the walls.

Again, based on the results of the flow model study, it was decided to completely change the OFA system including installing new nozzles of different sizes, numbers and location. In addition, the fuel distributors were also modified.

Following all modifications, both RDF boilers were officially tested in May 1994 for CO, particulate emissions, dioxins, furans and nitrogen oxides. These tests confirmed that both units were in conformance with the State of Hawaii air emission guidelines. In particular the CO emissions were the lowest ever achieved during the emission testing and about one half of the previous results.

## Present Situation - Update

For the last two years we have been monitoring the combustion conditions and the rate of corrosion in the boilers. The furnace corrosion has considerably decreased and is not presently posing any operating problem. The superheater wastage, although lower than before, is still present in the secondary superheater and we are continuously evaluating further steps to minimize it.

Again, because of the ever changing environmental regulations and also of the refuse fuel quality, it is necessary to keep the system up-to-date, in top combustion condition to meet all the operating and environmental requirements.

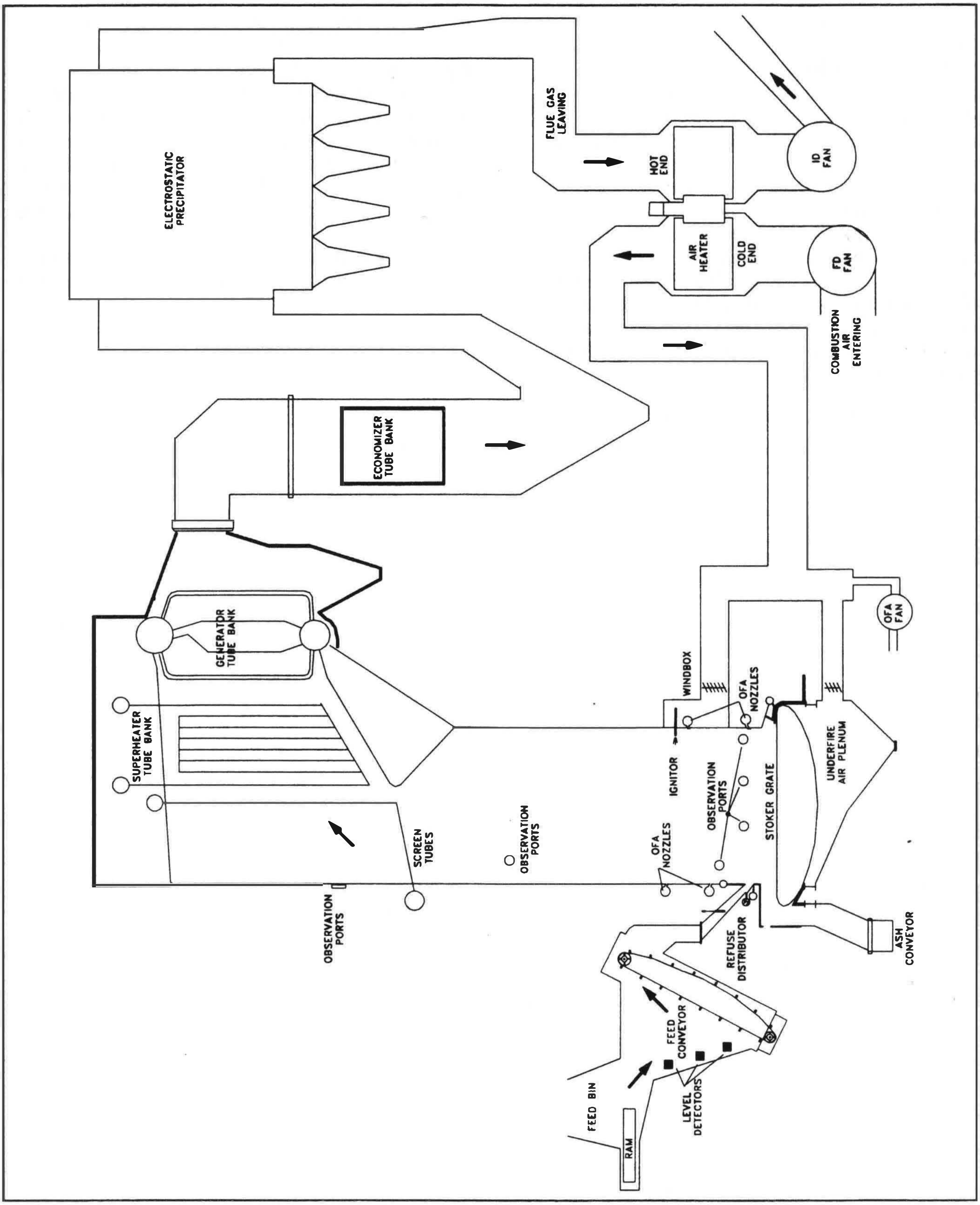

Figure 1: Lawrence RDF Boiler System

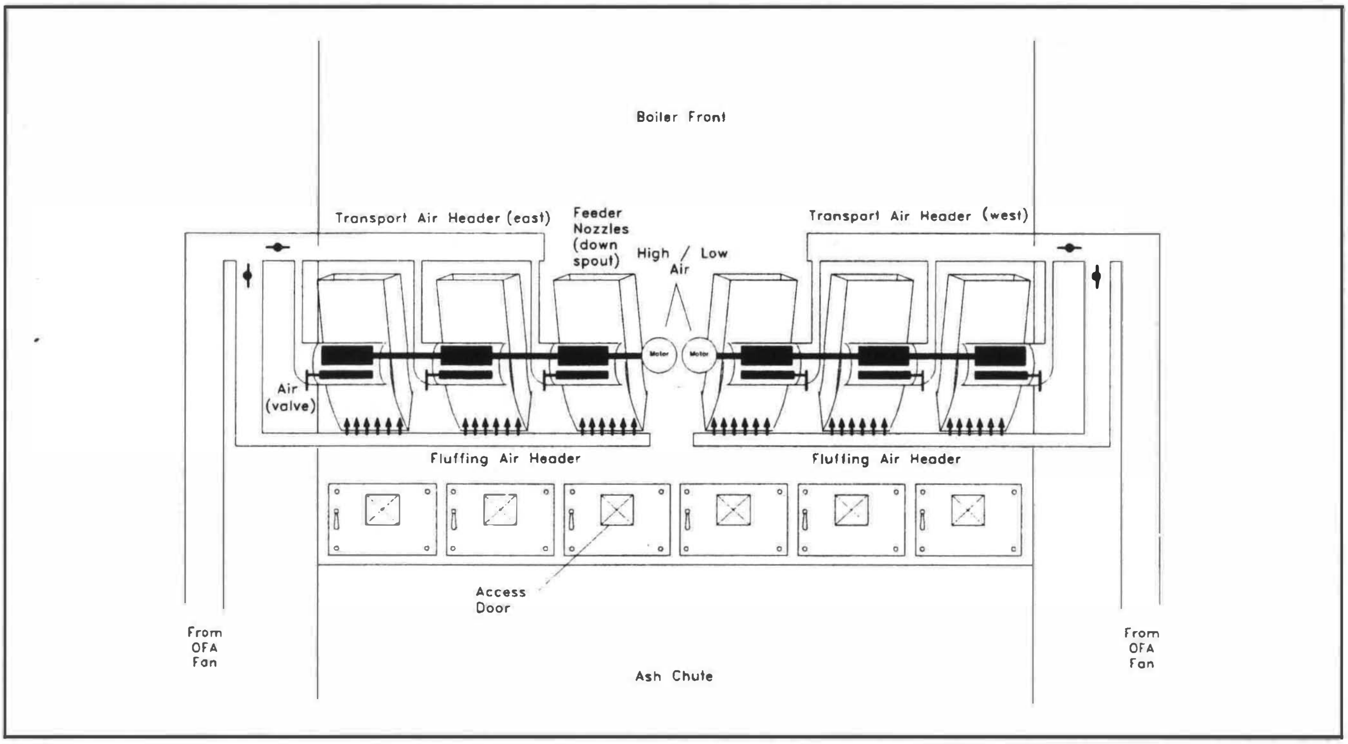

Figure 2: Lawrence RDF Distributors (Arrangement)

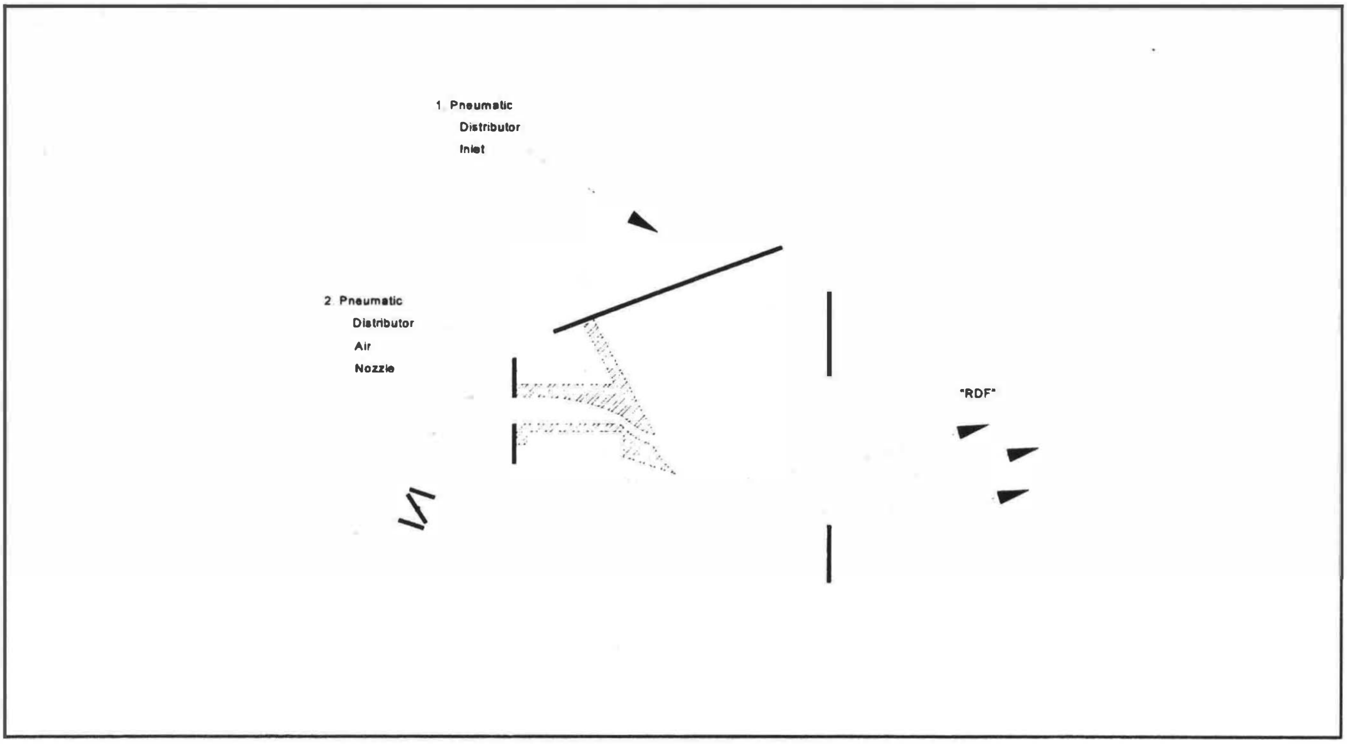

Figure 3: Pneumatic Distributor (Detail)

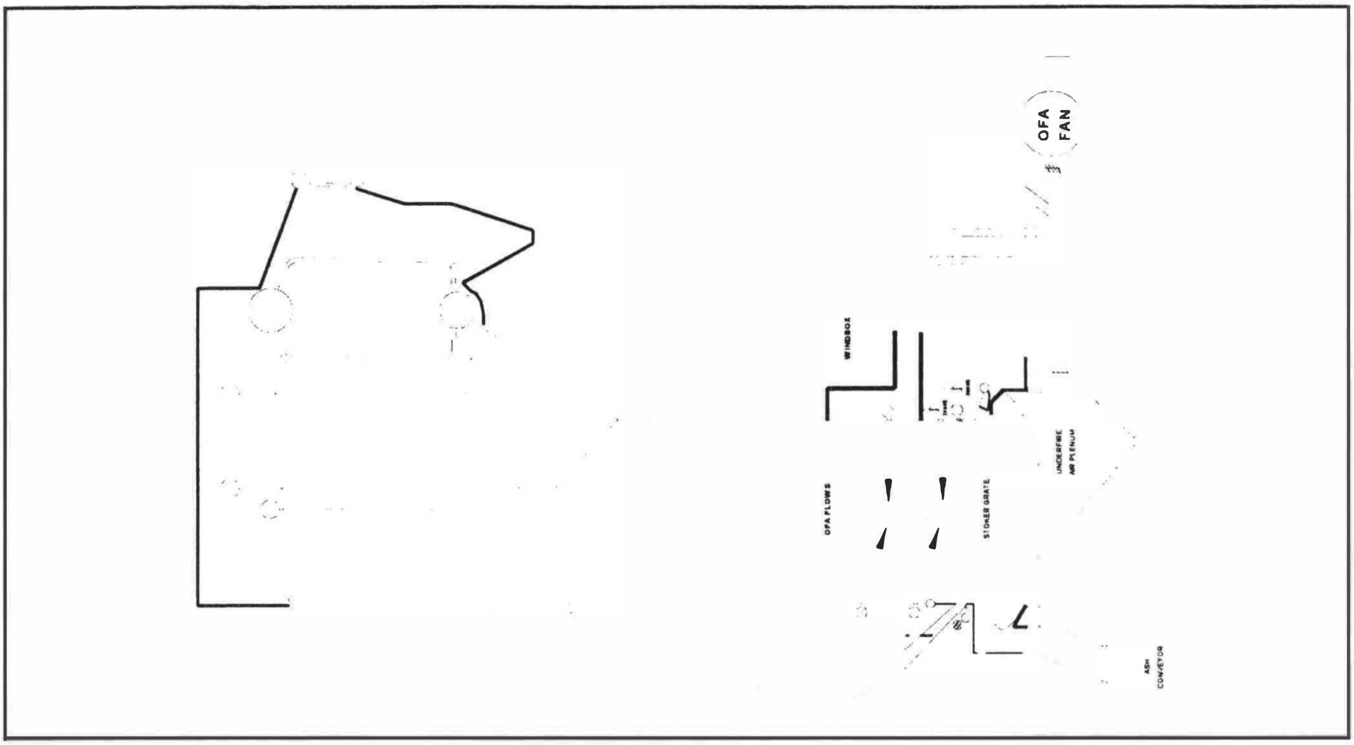

Figure 4: Lawrence RDF Boiler and OFA Arrangement

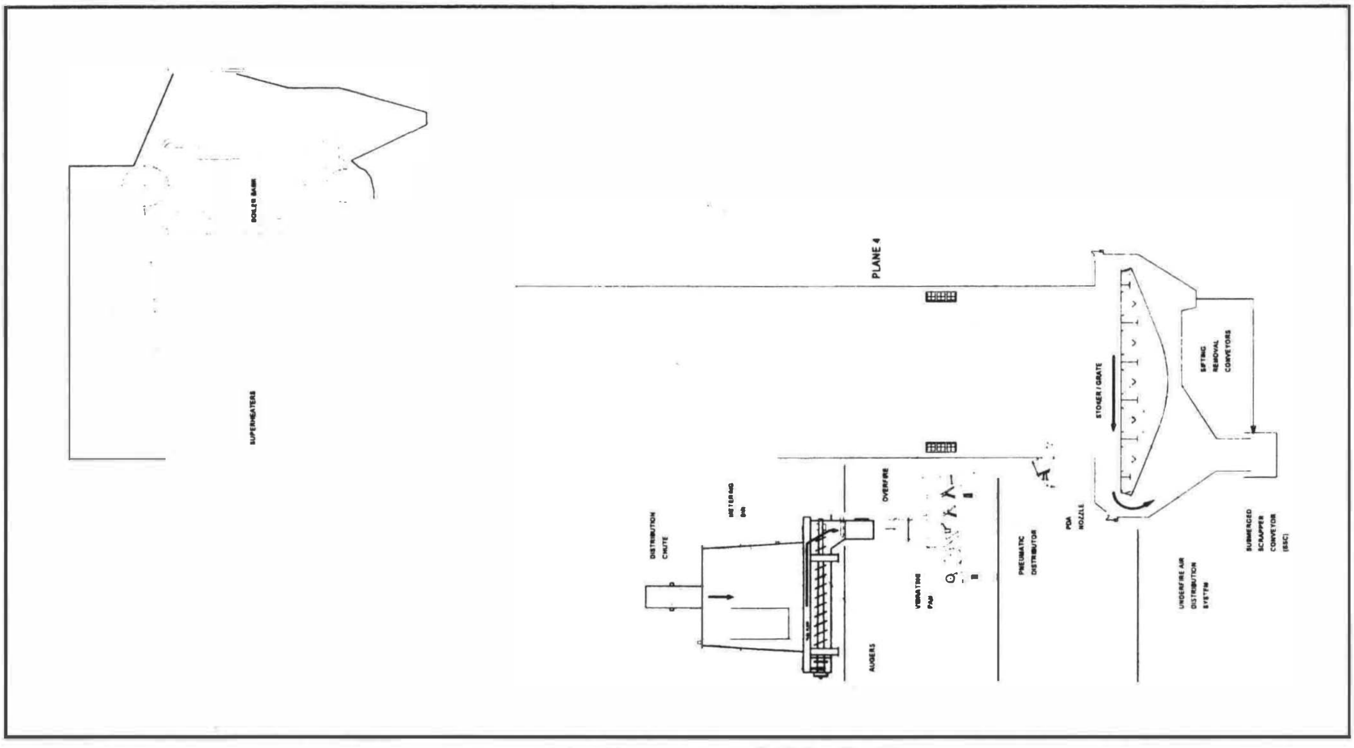

Figure 5: Honolulu RDF Boiler

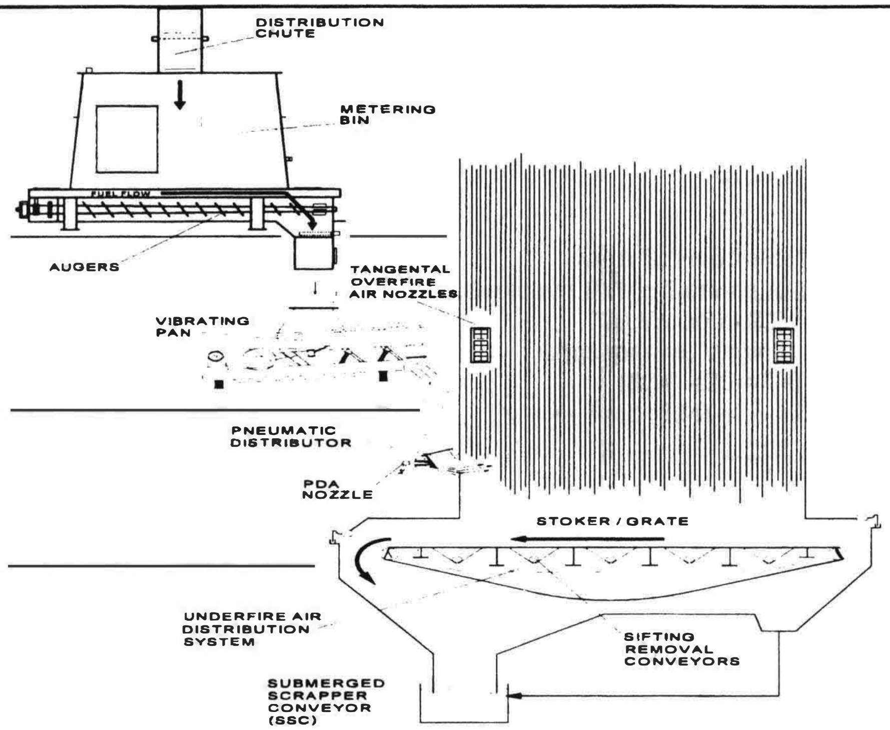

Figure 6: Honolulu RDF Fuel Feed System

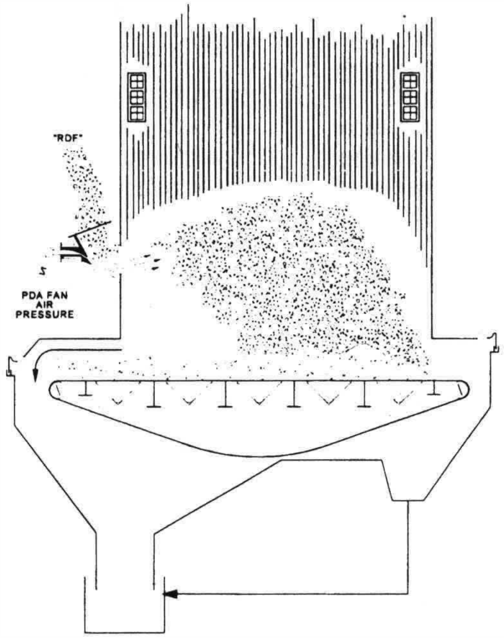

Figure 7: RDF Fuel Distribution and Combustion

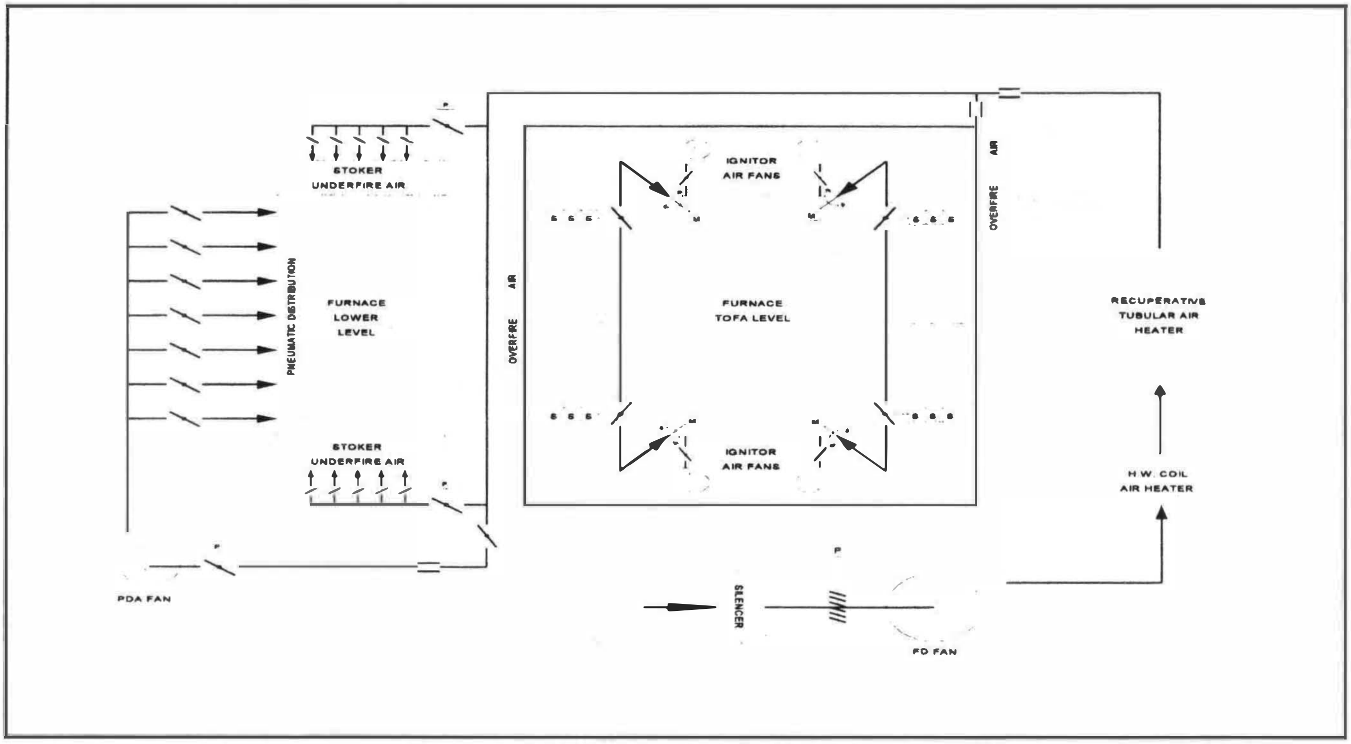

Figure 8: Tangential OFA System