

AN ADVANCED MSW INCINERATOR DESIGN AND FIRST OPERATIONAL EXPERIENCE

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ABSTRACT

The K + K grate technology represents 20 years of development by K + K of Zürich, Switzerland. In 1988 K + K became a part of NOELL GmbH. Since the acquisition of this technology by NOELL, major improvements have been incorporated into the design of the K + K grate. This paper summarizes the improvement and their impact on operation and performance.

Experiences from the Pinneberg plant in Germany, the Horgen plant in Switzerland and the Eindhoven plant in Holland show that the service life of the grates has been doubled and the costs of maintenance and spare parts have been halved by means of the improved design. Operating experience from the first train at the plant in Hamm also shows that, when the first boiler pass is designed in accordance with the design referenced in this paper, the new German regulations can be fulfilled and a low level of chlorinated aromatic hydrocarbons in the flue gas can be achieved.

INTRODUCTION

Waste incineration technology, which has been practiced for more than 90 years, has now reached the stage at which safe operation, high availability and effective use of the energy released can be ensured. Problems with corrosion and slag build-up, such as often occurred up to 10 years ago, can be considered as more or less solved. However, improvements can still be made to the design to decrease the costs of maintenance.

Current research programs emphasize the development of low-emission combustion systems. The objectives of these programs are to achieve the best

possible burn-up rates for flue gases and solids (fly ash and bottom ash), thus ensuring that existing organic compounds are destroyed and the formation of new noxious substances, such as PCDD and PCDF, are prevented. The achievement of these goals is the particular aim of the new German guidelines 17. BImSchV (1), which stipulate that there should be a retention period of a minimum of 2 sec at temperatures above 1560°F to ensure complete destruction of dioxins and their precursors. The first plant in Germany to be retrofitted in accordance with the new regulations is the incineration facility in Hamm. The first train has now been retrofitted and operational testing initiated as of February 1992.

WASTE COMBUSTION IN VIEW OF THE STRICTER REGULATORY REQUIREMENTS

Waste incineration is carried out in the following stages:

- (a) drying
- (b) gasification
- (c) incineration

Although these thermal processes take place one after the other, they cannot be separated due to the fluctuation of the waste composition on the grate. Fluctuations in the waste result in uneven burnup over the surface of the grate and variations in the composition and temperature of the flue gas.

In spite of this, stricter emission limits are now required for waste incinerators, requirements which can only be fulfilled by operating the waste combustion process within a narrow temperature range. The regulatory lower temperature limit is specified as 1560°F and the retention time specified is not less than 2 sec.

17.BImSchV = 17. Bundesimmissionsschutzverordnung: Regulations on environmental impact of waste incinerators, dated 23.11.1990.

To maintain temperatures above the lower temperature limit, various efforts are currently being made to provide better heat insulation for the furnace and parts of the first boiler pass by using new types of linings. This should reduce the heat losses, so that the aforementioned requirements can be fulfilled.

The upper temperature limit is established when increased NO_x formation occurs and there is a danger of fly ash fusion and melting. To preclude these detrimental effects, the upper furnace temperature is maintained below 2000°F .

Intensive mixing of the flue gases is also very significant, as the composition and temperature of these gases can differ due to a local lack or excess of air. Gas strands with reducing atmosphere cause corrosion at the boiler heating surfaces. To ensure good mixing and complete burnup of the gases, secondary air and recycled flue gas are normally injected before entry into the boiler. Cooling then takes place, the rate of which varies according to the amount of air or recycling gas injected. The main reason to use recycling gas instead of air for cooling purposes is that the recycling gas does not have to be taken through the entire flue gas cleanup train.

DESCRIPTION OF THE K + K COMBUSTION SYSTEM

The K + K system is based on controlled gasification on the grate with subsequent incineration of the gases in the furnace by means of an extremely flexible air supply system, which enables active intervention in the incinerating procedure.

The combustion air in a conventional combustion system for municipal solid waste is introduced into the furnace by undergrate air and secondary air nozzles. In the K + K system, air is also introduced through the side walls of the furnace, that is cross-wise to the direction of the flue gas (Fig. 1). Distribution of the air into separate air flows can be adjusted depending on the combustion behaviour. The velocity of side wall air into the furnace is in the order of 2000–5000 fpm.

The side air enters the furnace through a casing that works as a heat exchanger. This casing is heated by cast stainless steel plates which face the furnace. The system using side air has the following advantages:

(a) No slag or fly ash particles attach to the air-cooled side wall.

(b) The heat transferred to the side wall by radiation preheats the side wall air. Therefore there is no heat loss to the side wall (as to the wall of the boiler).

The side air and undergrate air enter the furnace through five individually adjustable sections over the length of the furnace. This results in air distribution which can be adapted to the incinerating process accordingly.

Layout of the Combustion System

The most important components of the combustion system are shown in simplified form in Fig. 2. The furnace is fed through a feed chute and a ram feeder below the chute.

The stoker is of the single reciprocating type, i.e., every second row of grate bars reciprocates. All movable rows reciprocate at the same time and in the same direction.

The waste, according to its composition, is transformed through the furnace within 30–60 min. The fuel drops from the second grate for postcombustion onto the third grate and from there as a burnt-up ash through a chute into the water bath of the ash extractor, where it is quenched. The drop from grate 2 to grate 3 improves the burn-up rate.

The incinerators at the plant in Hamm as originally installed in 1985 are shown in Fig. 3. Thermocouple elements measure the furnace temperature above each of the five undergrate air sections.

Combustion Control

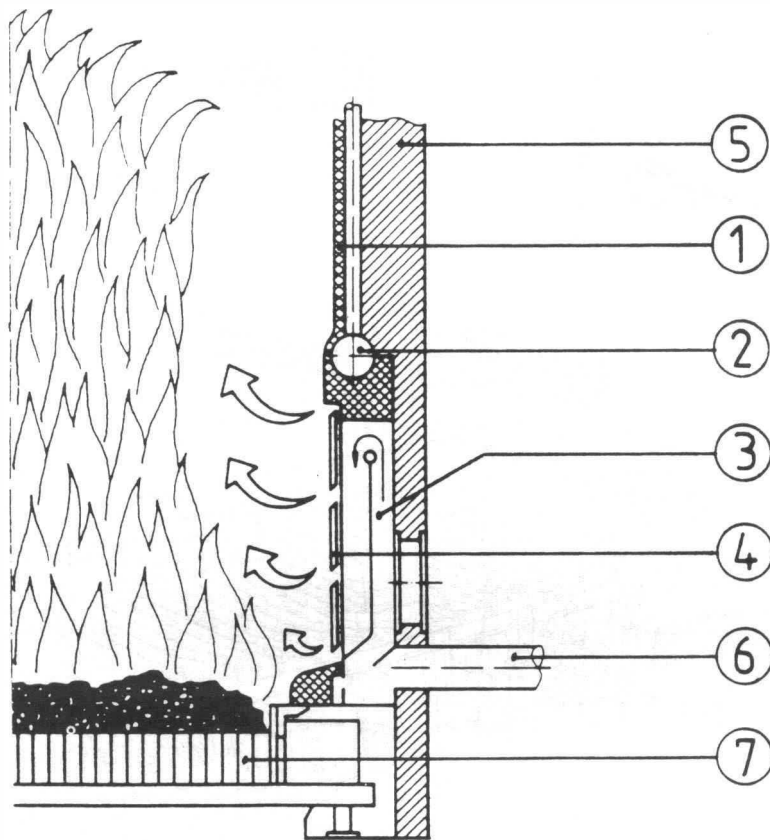
The combustion control basically does two things:

(a) It compares the actual steam production in the boiler with a preset value and adjusts the flow of waste and combustion air accordingly.

(b) It keeps an ideal temperature profile over the length of the furnace by adjusting the undergrate air flow in the five individual undergrate air sections. Changes in the total flow of undergrate air are compensated by the side air and secondary air.

ADVANCED DESIGN

Stricter regulatory requirements and expectations, particularly with regard to service life, availability and the best possible uniform utilization of the furnace, even when the quantities of waste and calorific values vary, made it necessary to improve individual components.



1. CASTABLE REFRACTORY
2. COLLECTOR
3. AIR BOX
4. AIR-COOLED PLATES
5. INSULATION
6. SIDEWALL AIR INJECTION
7. GRATE

FIGURE 1 SIDE WALL

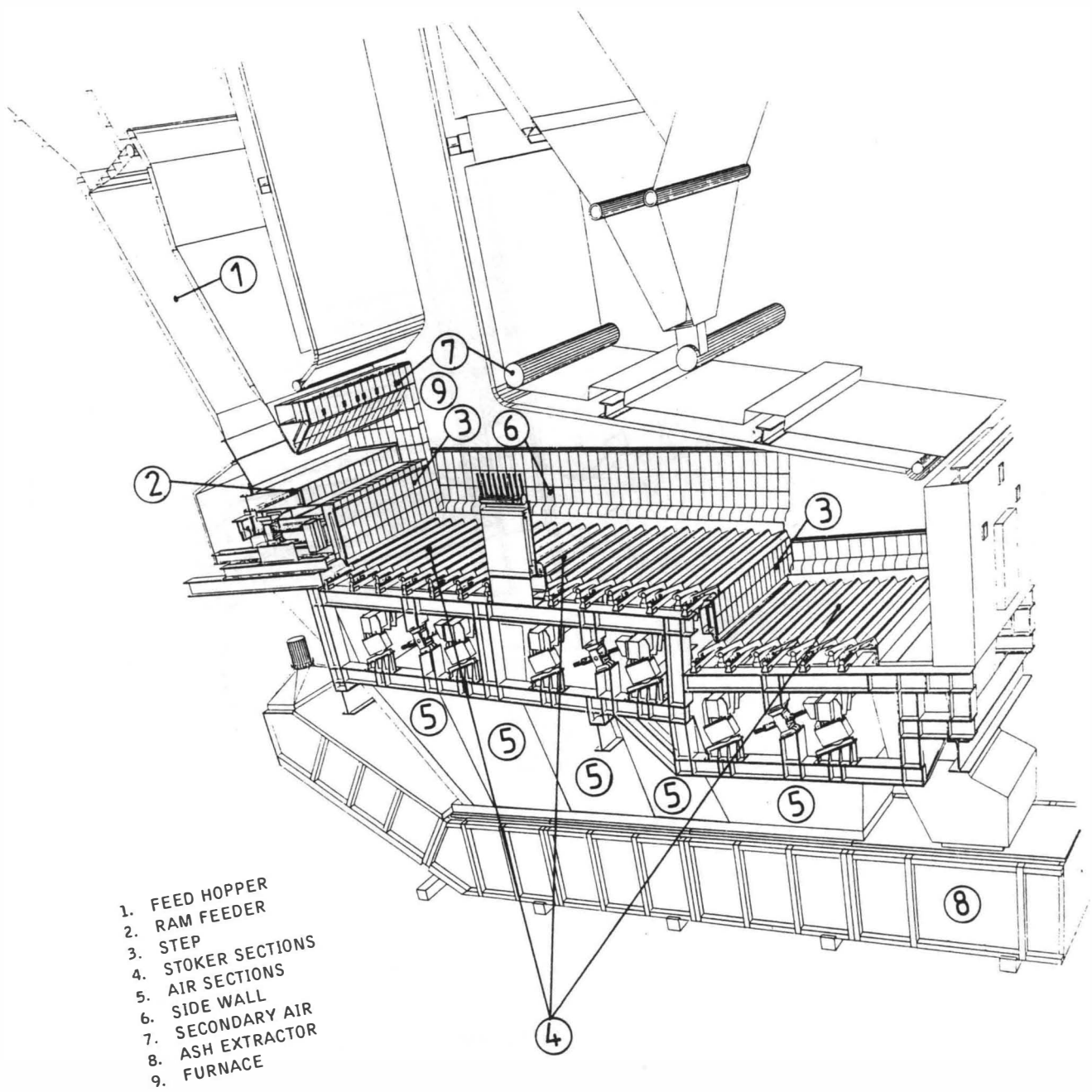


FIG. 2 LAYOUT OF THE COMBUSTION SYSTEM

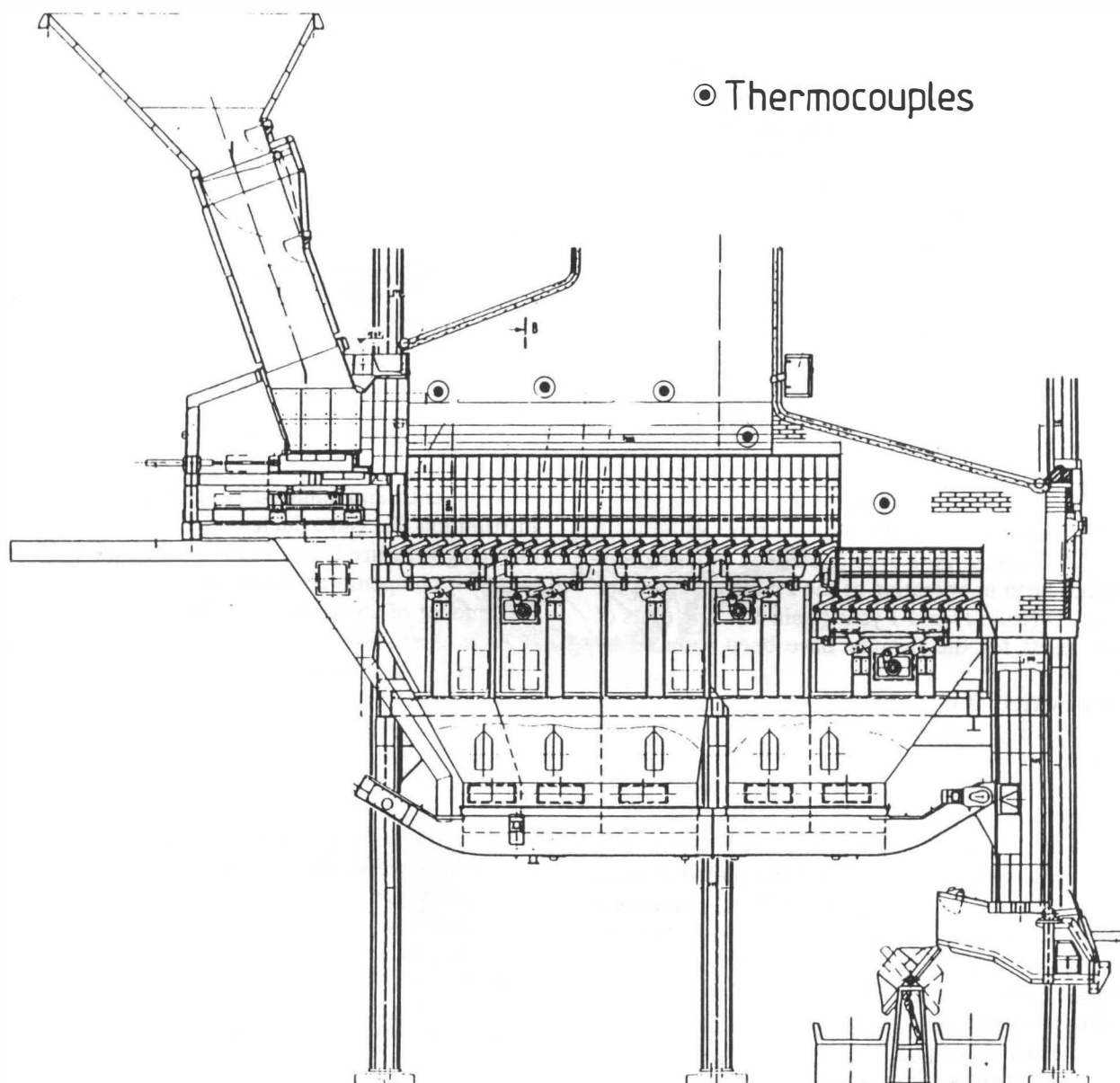


FIGURE 3

In the last years, the design and process used in the K+K combustion system has been revised and the following measures have systematically been put into practice.

The actuator and bearings of the grate slide system were improved. The actuator previously used (Fig. 4), vibrating shaft and connecting rods, was replaced by a linear drive (Fig. 5). This means that various components subjected to wear are no longer required and the whole design is simplified. The bearings, which support the weight of the grate bars and the waste, were removed from below the grate together with all other movable parts, and located below the side wall. They are, therefore, outside the area subjected to dust and high temperatures and facilitate inspection and maintenance (Fig. 6).

A top view shows clearly just how decisive an effect the mechanical simplification has had. If you observe the grate from above and imagine the grate and bar supports have been removed, Fig. 7 shows the previous design of the grate substructure and Fig. 8 shows the design now developed. The modified design has been in operation at the Pinneberg plant for 1½ years (train I) and 1 year (train II). The costs of spare parts for the furnace have been reduced by 50%.

A new type of side wall expansion was developed which reliably compensates for the expansion of the individual rows of grate bars. The expansion element slides on the fixed grate bar supports, which were extended to below the side wall. The expansion equipment is bolted to the fixed grate bars and is pressed outwards during heating and pulled inwards by the grate when cooling down, without requiring a large amount of energy (Fig. 9). The design was so flexible that various alterations in length within the various temperature sections along the grate do not lead to any jamming.

This expansion equipment makes the concept of a tight grate possible. Several grate bars are bolted together in bundles which are clamped together to form a compact surface.

The combustion air is then distributed evenly over the grate through partial slits, 8-mm wide in the bar heads. The free air cross section is about 2% of total grate surface.

Cooling ribs, bar width, size of slit, and machining of the grate bars are all improved to reduce the influence of the thermal load. Even distribution of air leads to even cooling, and therefore to avoidance of temperature peaks. Maximum temperatures of grate bars are below 900°F, while the bars metallurgical structure is stable up to 1250°F.

Fixed thermocouple elements in the grate section subjected to the greatest heat continuously measure the temperature of the grate bars to ensure that no temperature peaks occur.

The grate stroke has been extended by about 50% to a maximum of 1 ft 3 in. to reduce the mechanical wear and improve transport of the fuel. This improves transport considerably and decreases the number of strokes by a factor of 2. Taking an operating period of one year, this means a reduction of 1.3–1.7 million strokes for individual grate bars. The stroke is adjustable between 10 in. and 1 ft 3 in.

Due to the reduction in the thermal and mechanical load on the grate, the average service life of the grate has doubled. In the Eindhoven plant, not a single grate bar has been replaced in the first 10,700 hr of operation.

The air flow to the undergrate section, side wall sections, and secondary air is determined by Venturi measurements, and adjusted to achieve controlled air distribution. Pressure fluctuations in the air ducts or changing pressure losses in the waste bed are automatically compensated using butterfly valves, so that the amount of air demand can be kept constant.

At present, fast, wide-band electromagnetic sensors are being tested to determine the temperature in the separate incineration sections of the furnace. The sensors are similar to the flame eyes that are used for supervision of burners.

The following information has already been established.

At the Pinneberg plant, it was shown that by lengthening the stroke from 10 in. to 1 ft 2 in., humid waste which previously tended to form in piles could be transported without any problems. At the same time, the following improvements resulted:

- (a) The ash burn-up rate, which was previously up to 4%, improved to below 2% unburned carbon.
- (b) The average CO content was reduced from about 25 ppm to about 10 ppm (Fig. 10).
- (c) The dioxin content improved by a factor of 3.
- (d) Operation of the combustion system was more even, as shown in the curve for the amount of steam generation rate and the CO/O₂ content in Fig. 10.

IMPROVEMENTS IN THE PROCESS ENGINEERING WITH REGARD TO OBSERVANCE OF THE 17. BImSchV REGULATIONS

The plant in Hamm is the first in Germany to be retrofitted to fulfill the new German regulations (17. BImSchV) governing emissions. The plant in

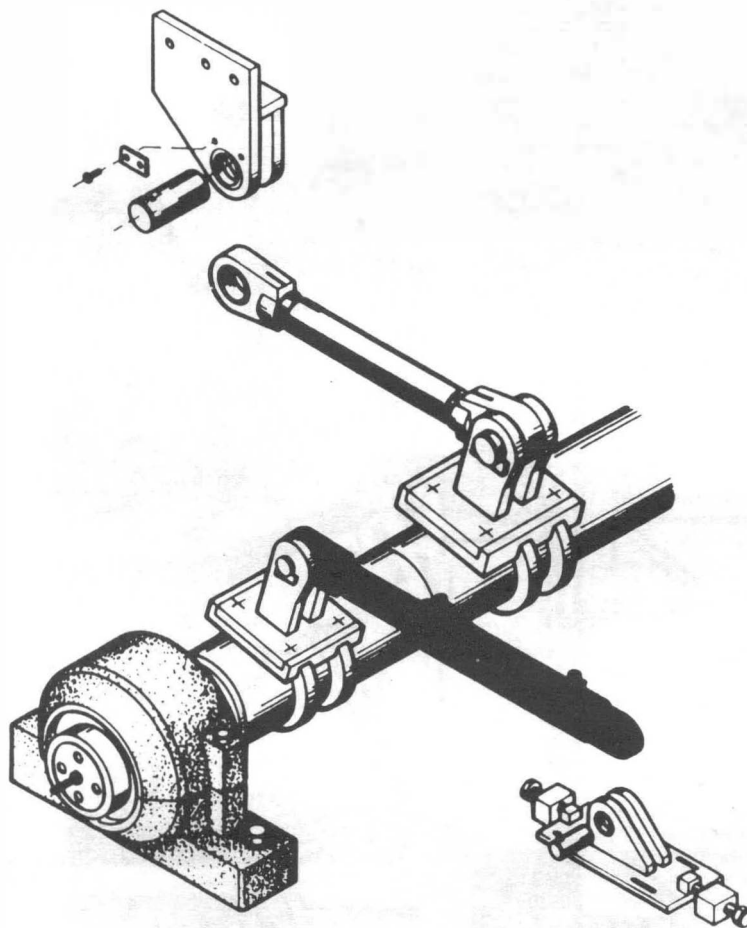


FIGURE 4 GRATE DRIVE, PREVIOUS SYSTEM

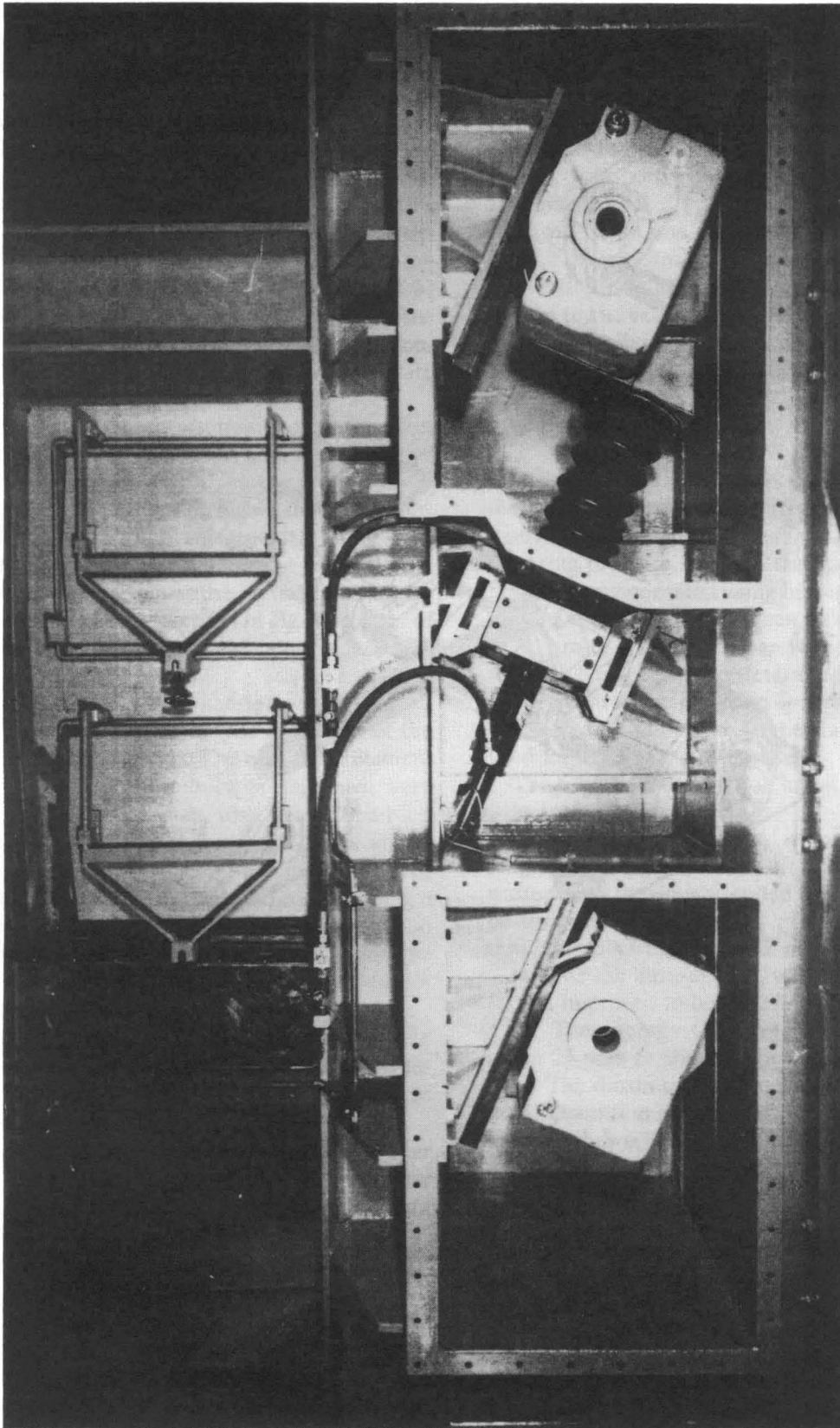


FIGURE 5 LINEAR STOKER ACTUATOR

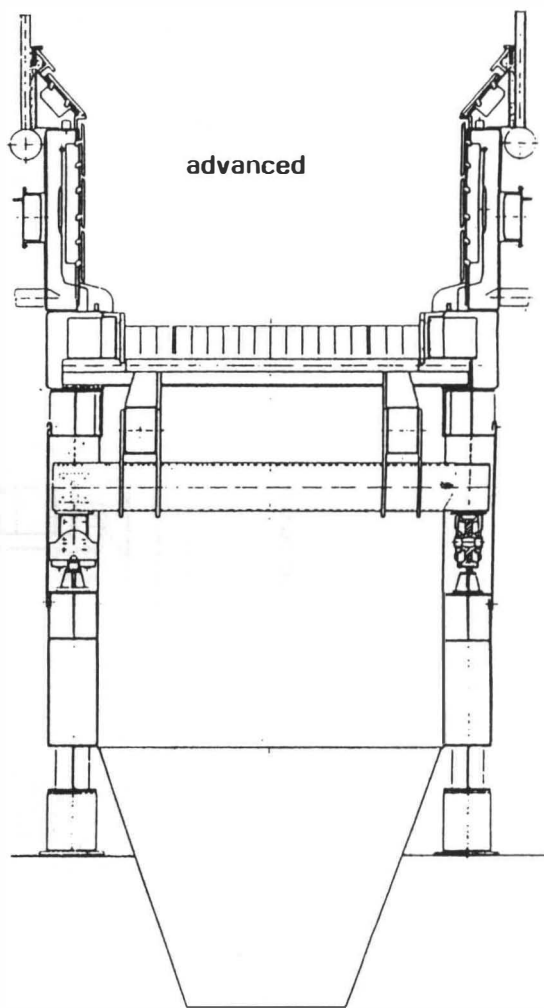
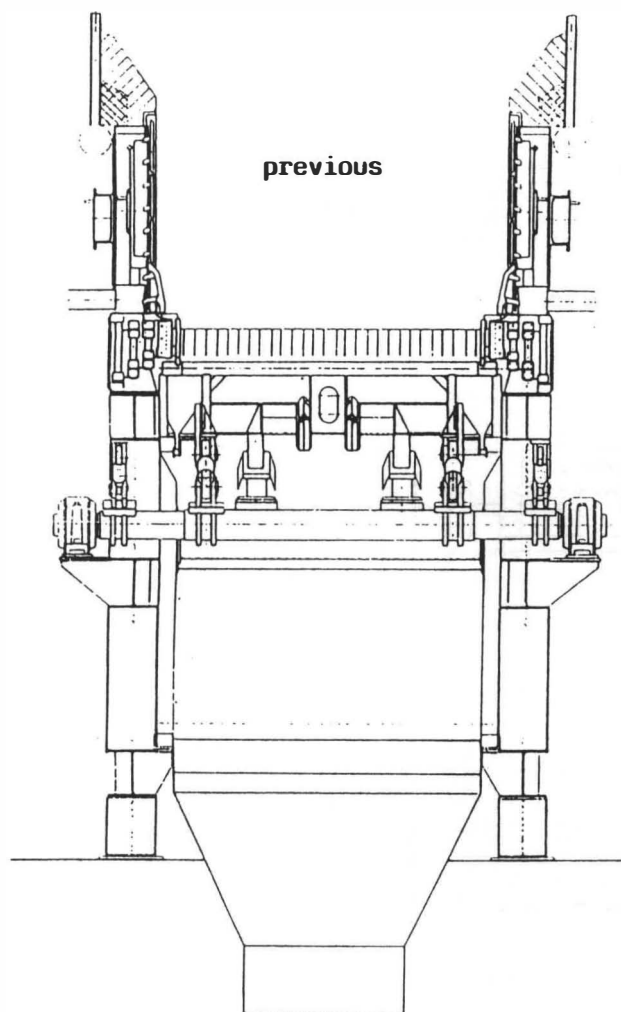


FIGURE 6

previous

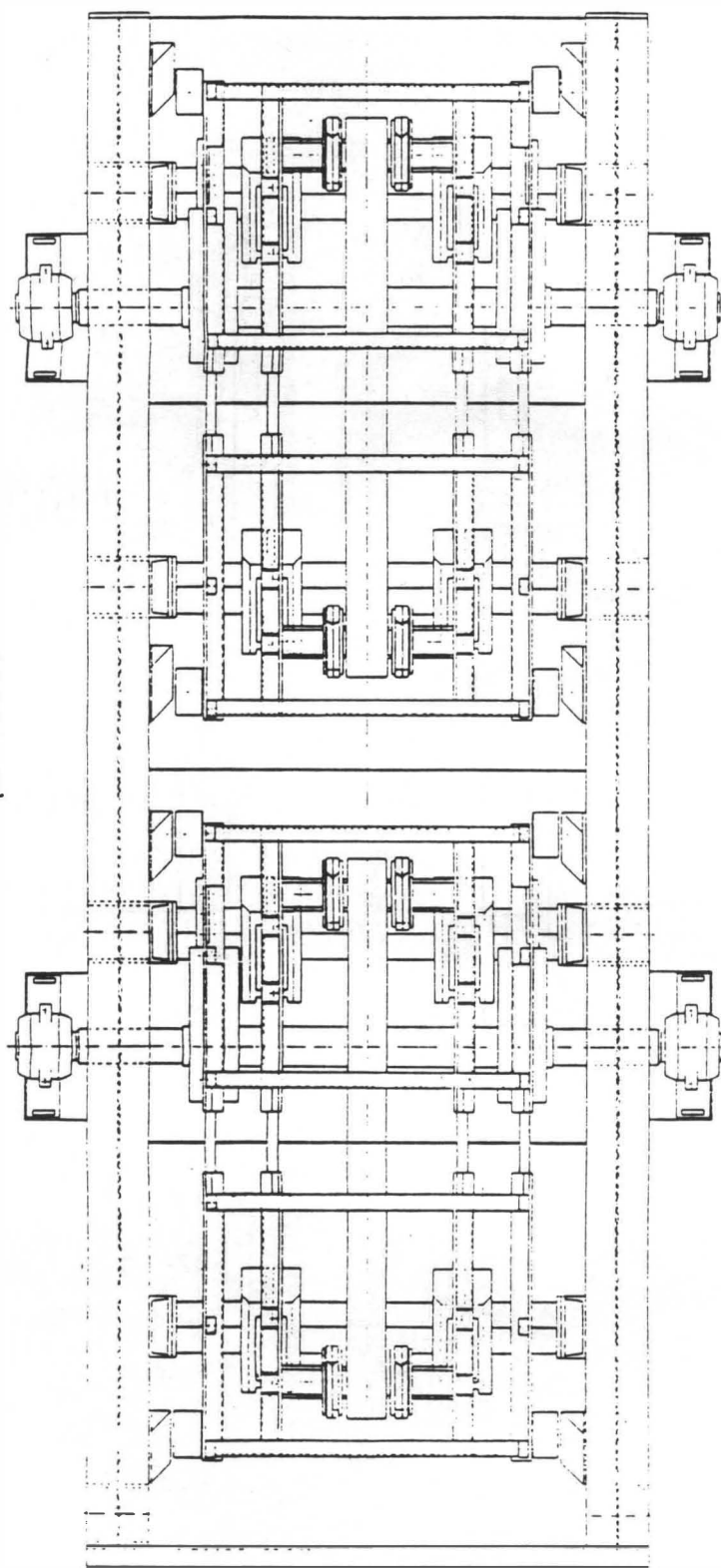


FIGURE 7

advanced

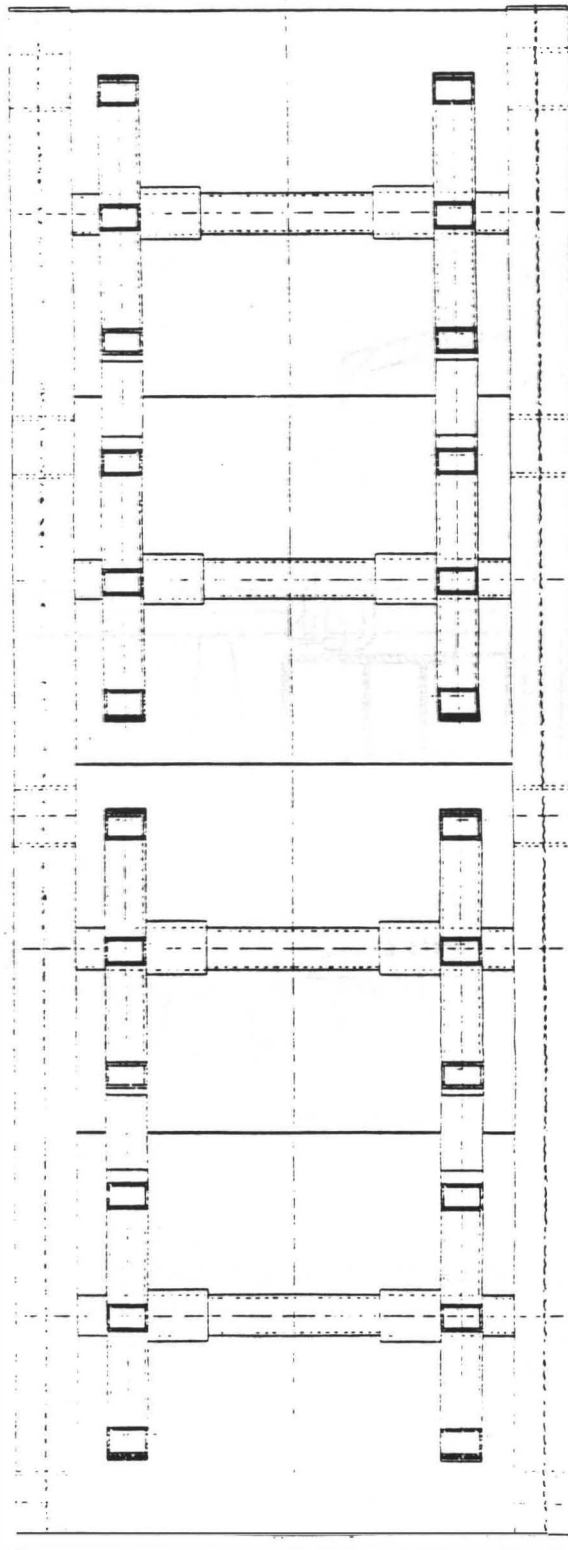


FIGURE 8

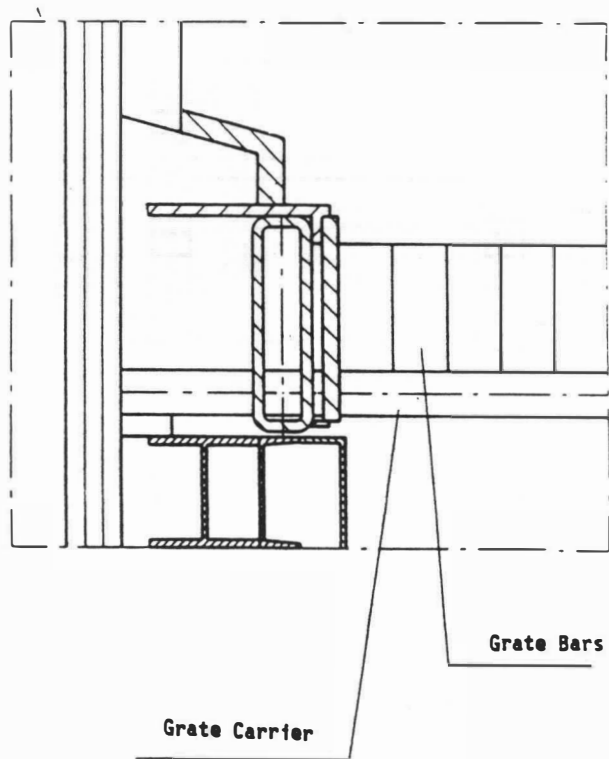


FIGURE 9 THERMAL EXPANSION

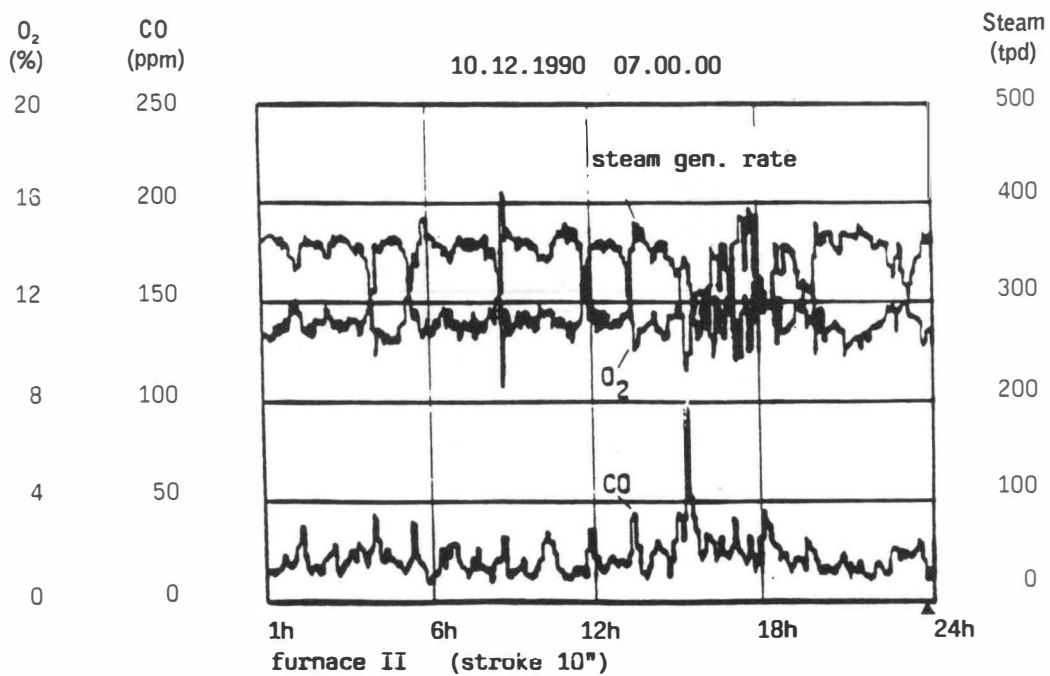
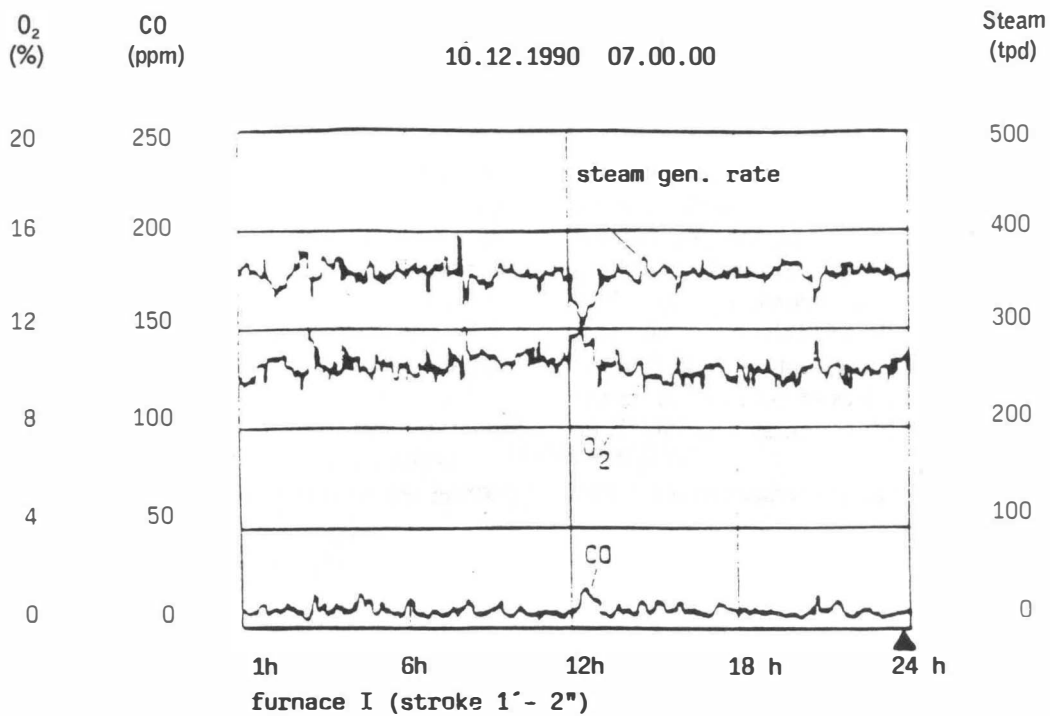


FIGURE 10 INFLUENCE OF THE STROKE LENGTH ON
OPERATION OF THE COMBUSTION SYSTEM

Hamm was previously equipped with four trains, the grate systems of which were supplied by NOELL and the boilers and flue gas cleaning systems by a different contractor.

The trains are presently being decommissioned one after the other and retrofitted with NOELL grates and boilers. The process and the mechanics of the stoker systems are being improved, as already described and tested at the Pinneberg plant. Furthermore, the refractory lining of the first boiler pass has been extended up to an elevation of 45 ft above the grate to minimize the loss of heat and to ensure that the flue gas temperature remains at 1560°F up to this height.

Due to the increased flue gas temperatures, a new

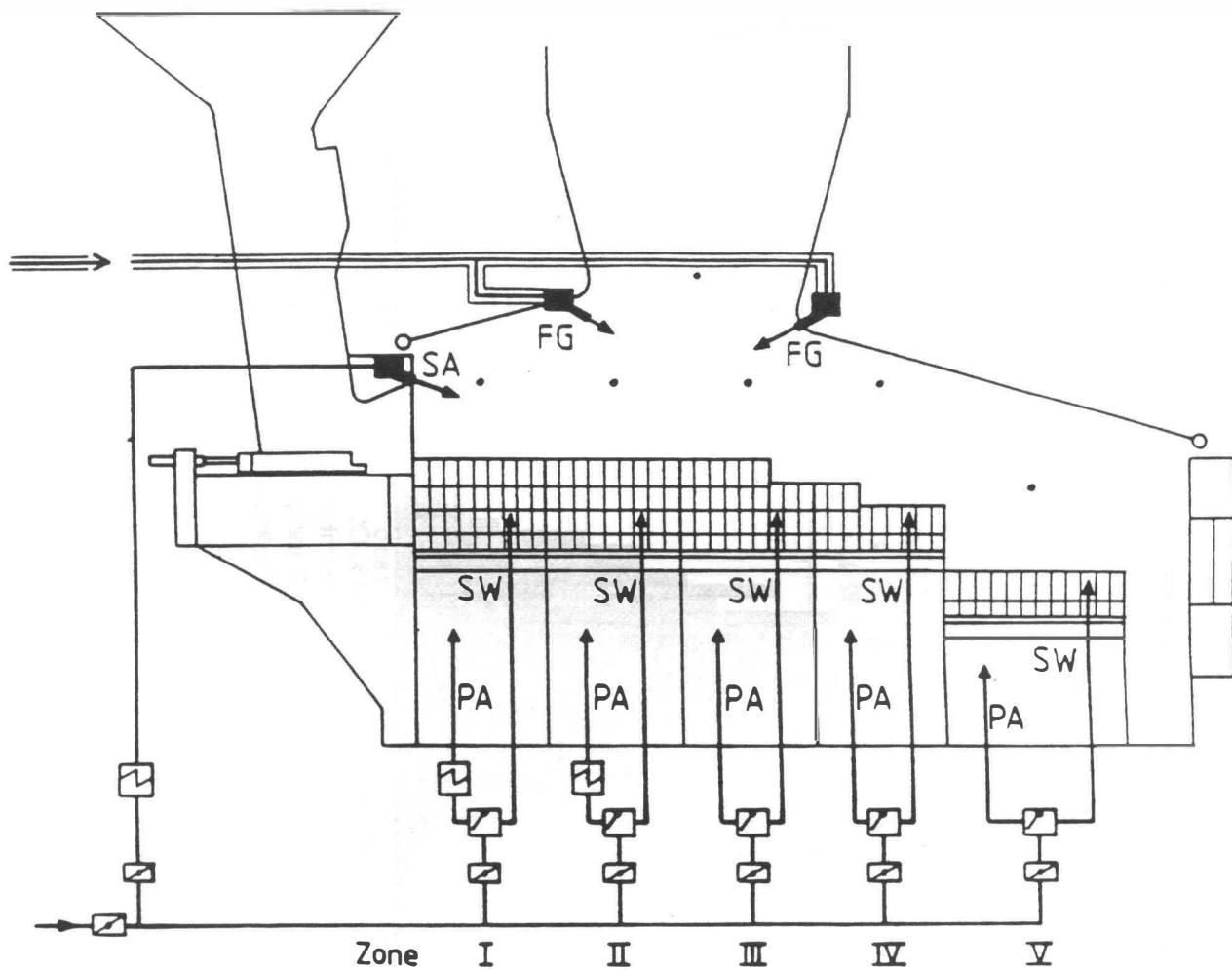
arrangement of the various heat exchange surfaces in the boiler was necessary. (The details of this boiler amendment are not the subject of this paper.)

Recirculated flue gases are introduced above the secondary air supply at the beginning of the first boiler pass to improve mixing and regulation of the flue gases from the combustion system. This makes it possible to lower the O₂ content of the flue gases further.

Figure 11 shows the improvements made to the air supply system.

The first retrofitted train at the Hamm waste incinerator was put into operation in February 1992.

Figures 12–15 show the CO and NO_x emissions during the testing of the Hamm, Train I incinerator.



PA - PRIMARY AIR
 SA - SECONDARY AIR
 SW - SIDEWALL AIR
 FG - FLUE GAS

FIGURE 11

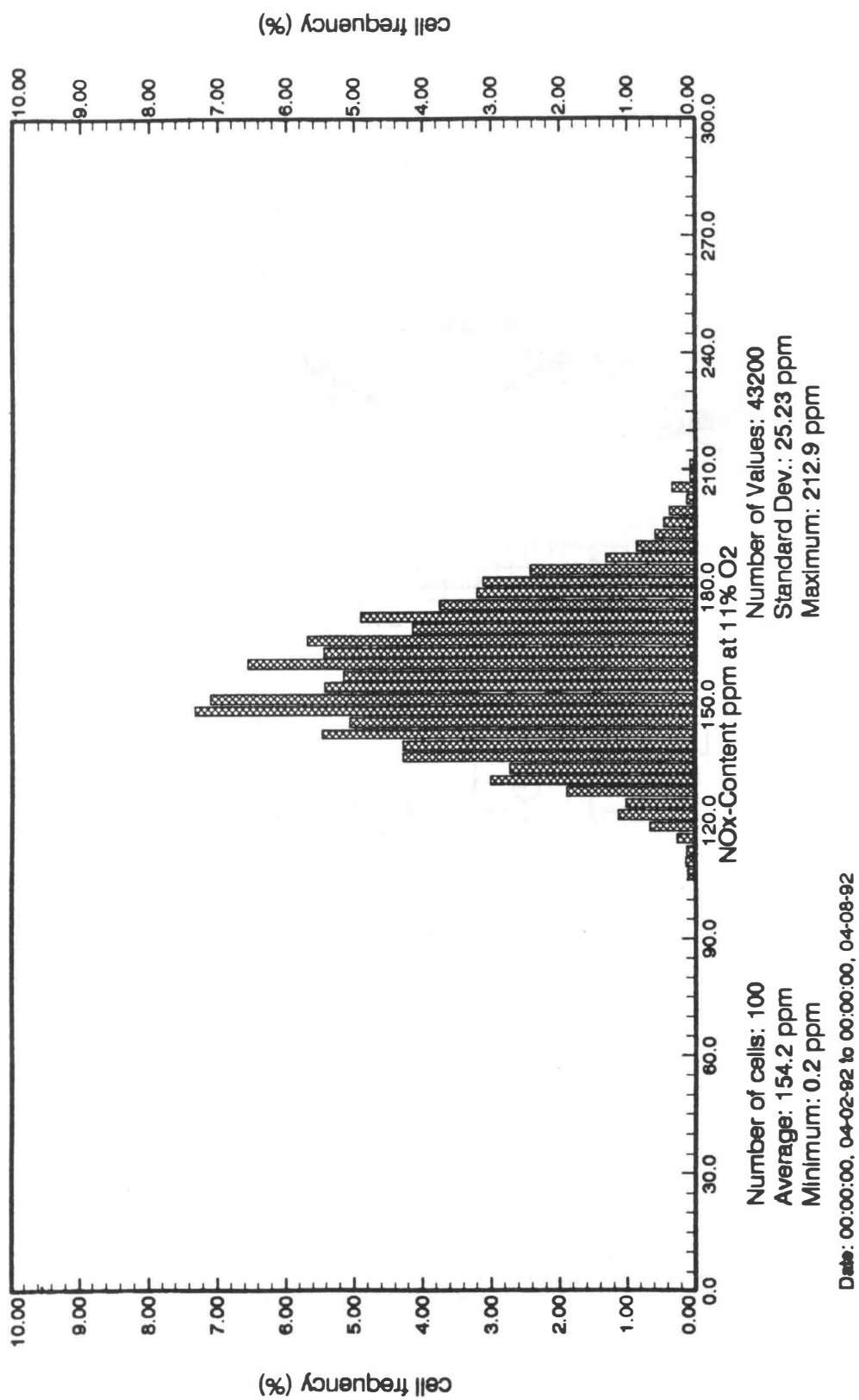


FIGURE 12 MSW INCINERATOR, HAMM, TRAIN 1
(NO_x Content in Flue Gas)

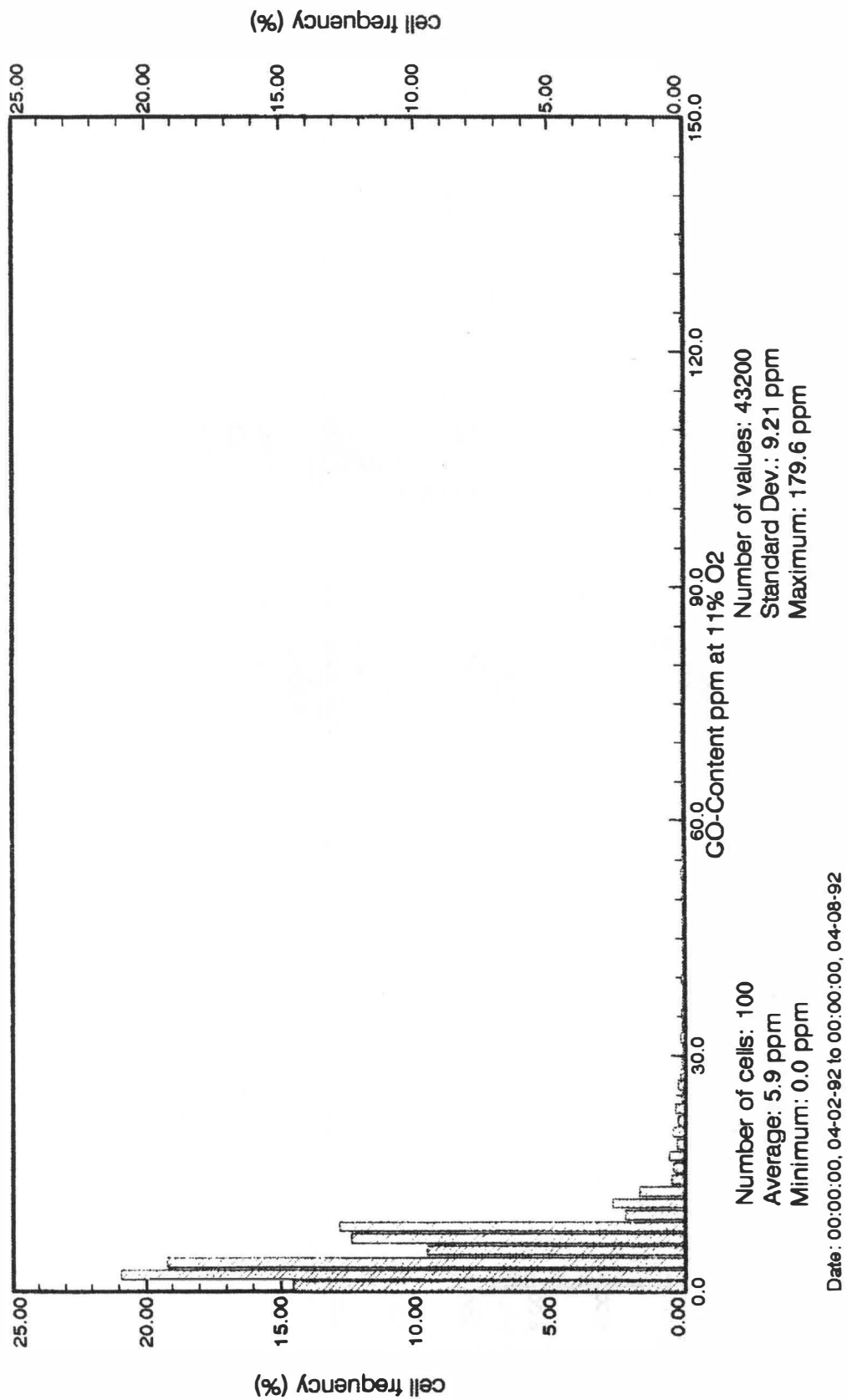


FIGURE 13 MSW INCINERATOR, HAMM, TRAIN 1
(CO Content in Flue Gas)

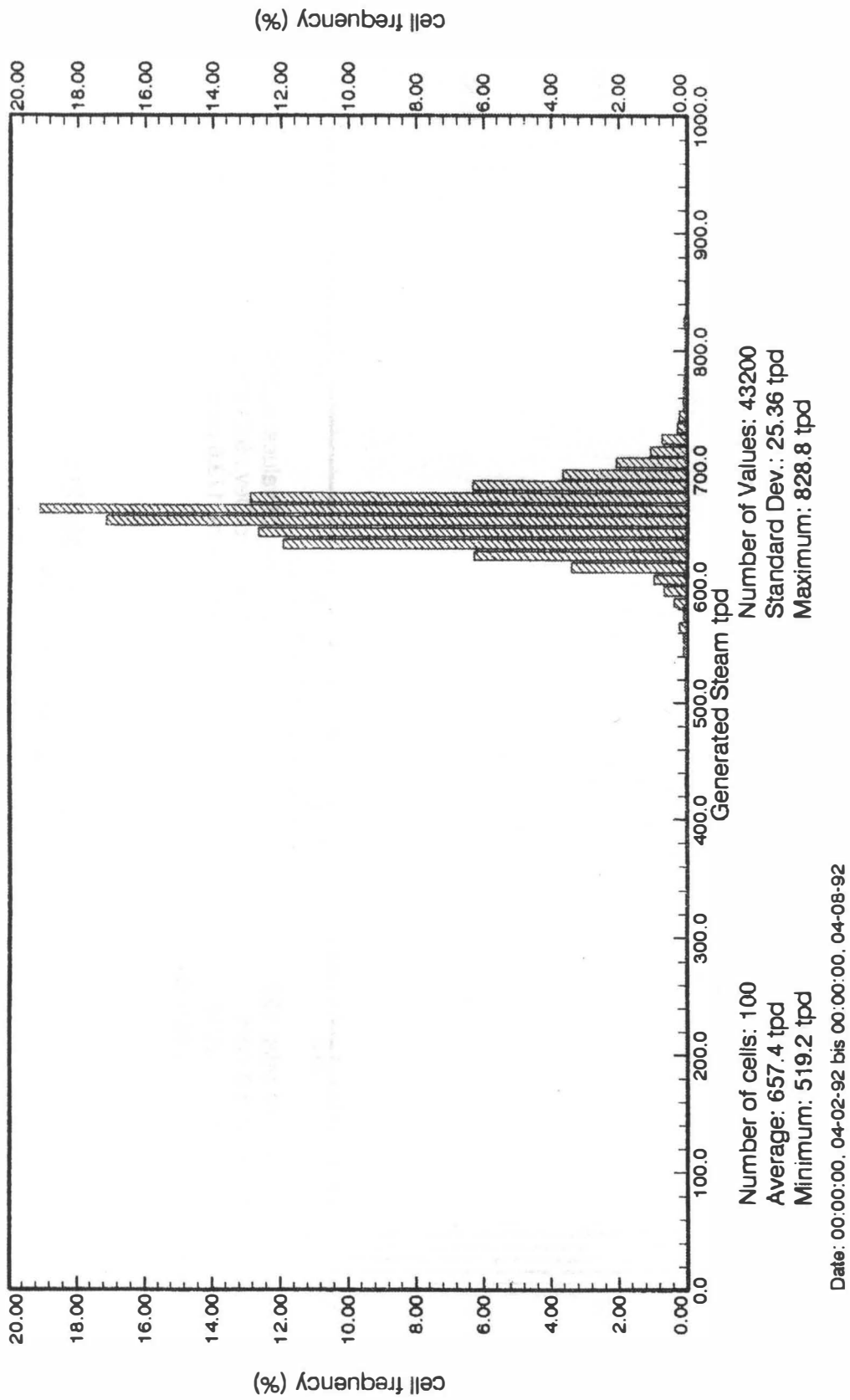
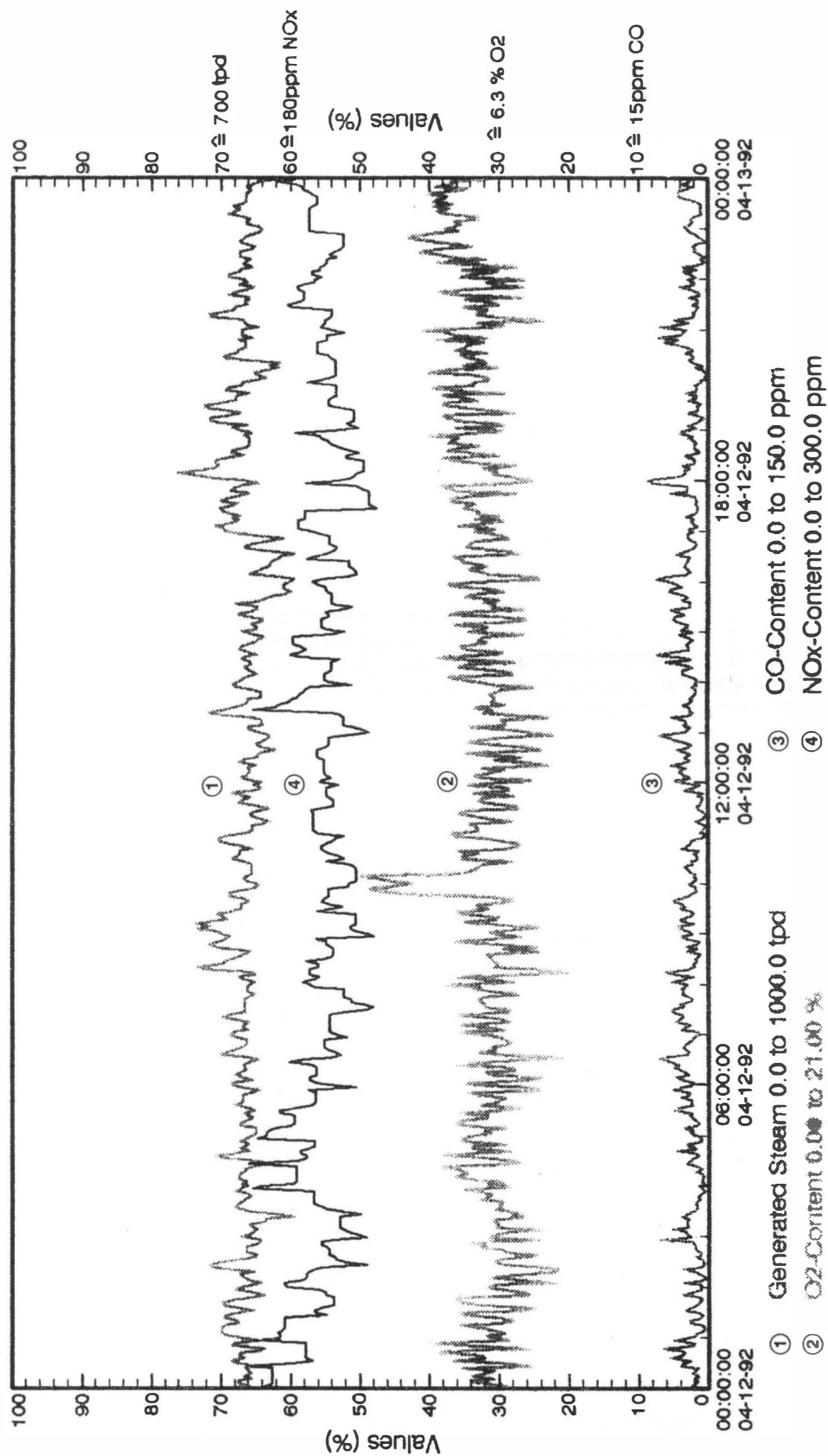


FIGURE 14 MSW INCINERATOR, HAMM, TRAIN 1
 (Generated Steam)



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FIGURE 15 MSW INCINERATOR, HAMM TRAIN 1
(Generated Steam and Emissions)