ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF ENFORCEMENT
EPA-330/2-77-005-B

IMPACT OF PARTICULATE MATTER EMISSIONS ON AMBIENT AIR QUALITY

United States Steel Corporation - Geneva Works

Appendix II - Source Identification

(JULY—AUGUST 1976)

NATIONAL ENFORCEMENT INVESTIGATIONS CENTER
DENVER, COLORADO

FEBRUARY 1977

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I. INTRODUCTION

BACKGROUND

In May 1972, EPA disapproved the control strategy for particulate matter for the Wasatch Front Intrastate Air Quality Control Region (AQCR) in Utah. On May 14, 1973, EPA promulgated particulate matter control regulations applicable to, among other things, several of the process and fugitive sources at United States Steel Corporation (USSC) - Geneva Works, Orem, Utah. USSC, in turn, filed a "Petition for Reconsideration."

Following meetings with USSC and several plant visits, EPA proposed amendments to those regulations and held a public hearing. On September 5, 1974, EPA promulgated final particulate matter regulations for USSC in the Utah State Implementation Plan (SIP), including:

a. 45 seconds visible emissions allowed for coke pushing

b. 35 seconds visible emissions allowed for coke charging

c. 5% of the coke oven doors, charging hole covers, and standpipes allowed any visible emissions

d. 10% of the chuckdoors and elbow covers allowed any visible emissions

e. 0.027 gr/scf allowed from open hearth furnaces (8-hr avg)

f. 0.035 gr/scf allowed from sintering plants (2-hr avg)

On October 4, 1974, USSC filed a second petition challenging certain aspects of the revised regulations.

The EPA Region VIII office developed and in December 1975 submitted a revised set of regulations through the EPA concurrence route. These proposed regulations:

a. acknowledged that the Utah visible emissions regulation is not applicable to coke pushing operations

b. allowed 10% of the coke oven doors to produce visible emissions

c. required the Geneva Works power plant to meet 0.1 lb particulate/10^6 Btu. (Other power plants in the AQCR are required to meet 0.34 lb/10^6 Btu.) The Region also provided a technical summary to justify their actions; the justification focuses on a revised emissions inventory and current air quality data.

On March 12, 1976, the EPA Division of Stationary Source Enforcement (DSSE) expressed concern with the Region VIII technical justification underlying their regulation package and asked the National Enforcement Investigations Center (NEIC) to gather additional data (emissions and air quality) to evaluate the adequacy of the existing set of regulations for the control of particulate matter from USSC Geneva Works.

The report evaluating the adequacy of the Utah SIP as it pertains to USSC Geneva Works is contained in four volumes. Appendix I - Ambient Air Quality deals with the design, operation, and results of the NEIC air quality monitoring effort. Appendix II - Source Identification deals with the evaluation of the process operations and the air pollution control equipment, as well as the development of a revised emissions inventory. Appendix III - Source/Receptor Relationships deals with the methodology employed, analyses performed, and results of the NEIC emissions characterization effort. The fourth volume, Summary Report, contains an analysis of all the findings in the three appendices, and the recommendations.

SITE DESCRIPTION

The United States Steel Corporation (USSC) - Geneva Works is a steel production facility located on the eastern shore of Utah Lake near Orem, Utah [Figure 1]. The facility, constructed in 1942-43, was owned and operated by the U. S. Government during World War II. After the War it was purchased by USSC and has been operated by them ever since.

The Geneva Works is a totally integrated steel production facility. Three blast furnaces, four coke batteries, a coke byproducts complex containing three separate plants, a sintering plant, ten open hearth furnaces, and rolling mills for structural shapes, plate and strip steel and steel pipe comprise the main production facilities. Support services include a foundry area, a power plant with turbo blowers and turbo generators, slag handling facilities and shop areas. Figure 2 is a plot layout for the facility.

About 4,600 people are employed at the Geneva Works when the plant is in full operation. Estimated annual production capacities provided by USSC are based on a three-blast-furnace operation supplying about 1,440,000 m. tons (1,585,000 tons)/yr of hot metal. The open hearth furnaces produce about 2,200,000 m. tons (2,400,000 tons)/yr of ingot steel from the hot metal plus scrap. The ingot steel is consumed to produce about 670,000 m. tons (750,000 tons) of steel plates, 960,000 m. tons (1,060,000 tons) of coiled strip, 140,000 m. tons (155,000 tons) of sheets, and 77,000 m. tons (85,000 tons) of structural shapes. Ingots are also shipped to other USSC plants on the West Coast for further processing.

Figure 1. Facility Location — USSC Geneva Works

PROJECT DESCRIPTION

In June 1976 the NEIC developed an addendum to the Study Plan for Air Quality Monitoring at USSC Geneva Works [Addendum A]. In this addendum the required activities and time scheduling for the second phase of the study (emissions inventory/characterization) were defined.

On July 1 and during the period August 23-27, 1976, NEIC personnel conducted a thorough facilities inspection and operations evaluation at the Geneva Works. The plant visits were announced in advance to USSC and had been preceded by a letter sent on June 8, 1976 under the authority of Section 114 of the Clean Air Act, as amended, requesting substantial quantities of information. A subsequent letter dated November 4, 1976 requested additional process and operating data [copies of both letters appear in Addendum B]. The information obtained by both letters plus that obtained during the July 1 and August 23-27 plant visits have been incorporated into this appendix.

The purposes of the plant visits were threefold: 1) to obtain an understanding of the routine operations of the various processes at the facility and the process variability, 2) to inspect air pollution control equipment and work practices in use at the facility, and 3) to develop an emissions inventory for particulate matter emitted from the facility. The utility of the emissions inventory is, of course, greatly influenced by the success of the first two objectives, as well as the quality of the information obtained from the Company during the inspection interviews and from the Section 114 letter responses.

The facility inspection was prescheduled with USSC personnel to allow approximately one-half day for each of the major processes, with time allotted for the smaller processes and/or support functions on an 'as available' basis. Pre-inspection conferences were held each morning between USSC Plant Engineering and NEIC personnel for an overview of the unit operations and coordination of the day's activities. The following schedule was observed during the inspection:

Monday, August 23, 1976

a.m. - Pre-inspection briefing

p.m. - Blast furnace operations

Tuesday, August 24, 1976

a.m. - Open hearth furnaces

p.m. - Continuation of same
Foundry area
Open hearth control system

Wednesday, August 25, 1976

a.m. - Raw materials handling
Sintering plant
Sintering plant control systems

p.m. - Coke production
Open hearth control system

Thursday, August 26, 1976

a.m. - Rolling mills

p.m. - Coke byproduct plants
Coke plant

Friday, August 27, 1976

a.m. - Power plant
Pig casting machine
Raw material unloading
Hot metal mixing building

p.m. - Pipe mill
Inspection debriefing

The Heckett Engineering Company's slag handling operations, located on the northwest corner of the USSC plant site [Figure 2], were inspected independently on July 1, 1976. NEIC personnel worked directly with Heckett personnel in arranging and conducting this inspection, since this operation, although located on USSC property, is independent of USSC.

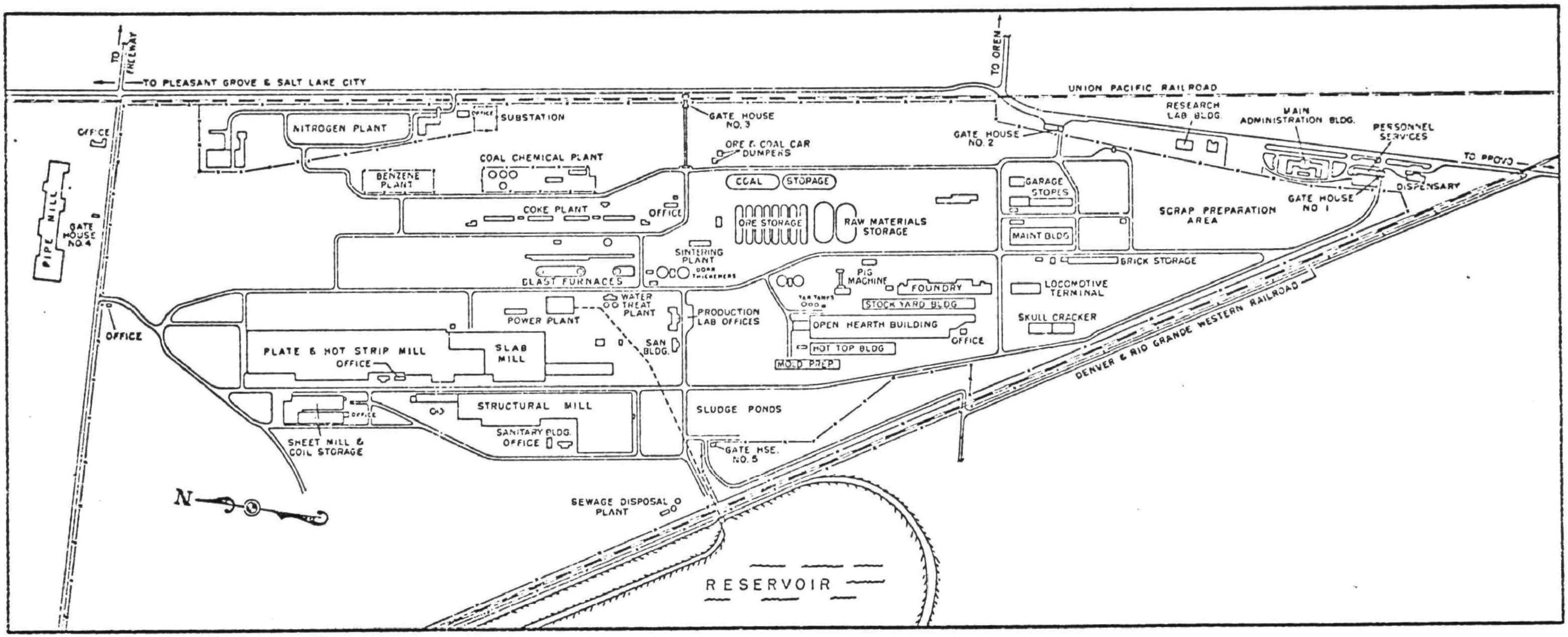

Figure 2. Plot Layout — USSC Geneva Works

II. SUMMARY AND CONCLUSIONS

In response to a request by the EPA Division of Stationary Source Enforcement, the NEIC undertook an evaluation of the particulate emissions from the United States Steel Corporation - Geneva Works at Orem, Utah, and the effect of these emissions on the ambient air quality of the Wasatch Front Intrastate AQCR. One portion of the NEIC program was oriented to investigating the particulate emission potential of USSC process operations, the evaluation of installed air pollution control equipment, and the development of a revised emissions inventory for the facility. Facility inspections were conducted on July 1 and August 23-27, 1976 to obtain specific process information to evaluate subjectively the particulate emission potential of the various processes. Two comprehensive letters were also written to USSC requesting supplemental information on plant operations. This appendix summarizes the results of these investigations.

The following conclusions were developed based on the information obtained during those site visits and from the information provided by USSC in response to EPA letters.

COKE OVENS

1. Charging operations contribute significantly to the particulate emissions associated with the coke batteries. A form of stage charging is employed at Geneva; however, the emissions observed during seven charge sequences were in excess of those at other stagecharged batteries observed by NEIC personnel. Visible emissions during charging ranging from 40 to 100% opacity and in excess of 35 seconds duration were observed during the inspection.

A major problem associated with the stage-charging technique employed at Geneva appears to be an inadequate number of topside personnel for the charge schedule. Two persons, a larry car operator and a lid-man, are responsible for a variety of topside operations including the entire charge sequence, cleaning of goosenecks, mudding of charge port and standpipe caps, etc. The charge sequence of one oven every eight minutes leaves very little time for error in personnel coordination.

The current practice at Geneva of delaying the operation of the push machine leveling bar until after the charge sequence is completed is contrary to the practice at other coke batteries observed by NEIC personnel. USSC personnel stated that the coal used at Geneva Works to charge the ovens has a naturally flat angle of repose and, hence, the need for a leveling operation during the charge is minimal. From the density of charging emissions noted during the inspection, it appeared that the oven aspiration was not sufficient to evacuate the gas volumes generated during the charge. Insufficient steam aspiration at the collector mains and/or peaking of the coal in the ovens could be contributing to the charging emissions problems.

2. Several topside emissions were noted at the Geneva facility. Numerous leaks were noted from oven charge port lids and standpipe caps. The lid luting efforts were only partially successful, possibly due to the technique employed (i.e., mopping the mud vs. pouring from a ladle), the consistency and/or amount of luting material used, the lid/casting interface fit, or the general shortage of topside personnel.

Several significant leaks were noted in the collector mains themselves. These leaks appeared to be due to inadequate maintenance.

3. Coke pushing emissions observed during the inspection ranged in opacity from 20 to 30% and appeared to result from thermal buoyancy of coke fines. No emissions normally associated with uncoked coal, i.e., green coke, were noted during the inspection.

4. A brief inspection of leaking pushside doors and chuck doors on battery 1 indicated that this battery would not have complied with the SIP regulation.

5. Considerable quantities of fine particulate matter were noted in the coke quench plume after the steam had dissipated. USSC quenches the hot coke with contaminated water which contains waste products from the coke byproducts plant, such as excess flushing liquor.

USSC reportedly uses impregnated pine baffles in the quench tower chimneys to knock out large particulate in the quench plume. It was noted that the baffles in the north quench tower were in poor repair during the inspection.

6. The combustion stacks on batteries 1 and 4 were noted to periodically discharge dense plumes; battery 1 stack emissions were periodically in excess of 40% opacity.

COKE BYPRODUCT PLANT

1. The majority of the operations conducted in these facilities employ closed systems and, hence, do not pose a particulate emission problem.

2. Waste flushing liquor and other waste byproduct liquid streams resulting from these operations are currently discharged to the coke quench water systems. As a result, they indirectly contribute to the particulate emissions from the complex.

3. The prill tower, and driers/coolers, and the blending operations at the ammonium nitrate facility are potential sources of particulate emissions. Of these sources, the uncontrolled prill tower exhaust appears to be the most significant with calculated emissions averaging

0.13 m. ton (0.14 ton)/day. The other sources discharge to control systems.

4. There are no sulfur removal systems installed on the coke oven gas treatment facilities at the Geneva Works. Sulfur dioxide emissions from the combustion of these gases at the coke ovens and throughout the facility could substantially contribute to the ambient sulfur dioxide levels in the AQCR. Further investigation of these contributions is beyond the scope of the NEIC project.

SINTERING PLANT

1. Fugitive emissions were observed at the iron ore crushing and screening stations adjacent to the sintering plant. Water spray systems at these locations were ineffectual or inoperative.

2. It is questionable whether the sintering machine windbox emissions control system is adequate to meet the SIP requirement of 0.08 g/m^3 (0.035 gr/scf). The USSC-quoted removal efficiency for the scrubber systems appears to be overstated. The potential for particulate addition due to mist carryover has been neglected in USSC considerations of particulate removal efficiencies.

Significant particulate plumes ranging from 10 to 40% opacity were noted from the windbox scrubber exhaust stacks after the steam dissipated.

3. The exhaust hooding and ductwork associated with the discharge-end of the sintering machines was in very poor repair. Collection efficiencies were severely reduced and fugitive emissions from these sources were observed to be significant. Insufficient information was available to evaluate the performance of the scrubber system which theoretically controls the emissions from these sources. However, in light of the collection efficiency problems mentioned above, it is

improbable that the scrubber is currently treating a satisfactory proportion of the discharge end emissions.

4. Heavy fugitive emissions were noted at the sinter hot screening facility. Incomplete sintering of the feed materials and poor operation of water spray nozzles contributed to this problem.

5. Periodic heavy emissions were noted from the vents serving the sintering plant pug mills. Company personnel indicated that water supply problems contribute to this condition.

6. The sintering plant is an antiquated facility. The material feed systems, pug mills, and sinter cooling facilities were originally installed in the early 1940's and are not state-of-the-art.

BLAST FURNACES

1. The furnace hot metal casting and slag flushing operations are significant sources of fugitive particulate emissions. These emissions are currently uncontrolled.

2. Some particulate leakage was noted from the hopper bells atop furnaces 2 and 3. Furnace 1 was not in operation during this inspection.

3. No furnace slips were observed during this inspection.

4. No visible emissions were noted from the stove combustion stacks when the furnaces were in a normal operating mode.

OPEN HEARTH FURNACES

1. It is questionable whether the emission control systems on the

open hearth furnace exhausts can comply with the SIP regulation of 0.062 g/m^3 (0.027 gr/scf). The electrostatic precipitator maintenance and operating procedures appear inadequate. The USSC-derived particulate removal efficiencies for the scrubber units used on these systems appear to be overstated. Mist carryover from the scrubbers, adding to the exhaust gas particulate load, appears to be a significant problem.

2. The open hearth furnace operations are significant sources of fugitive particulate matter. Fugitive emissions were observed from hot metal transfer and reladling operations, furnace leaks, furnace charging and tapping operations, and ingot pouring procedures. All of these fugitive emissions are uncontrolled.

ROLLING MILLS

1. There are no hot scarfing operations at the Geneva Works. Handscarfing of slabs and blooms constitutes a minor fugitive emission problem.

2. The major particulate emissions associated with the rolling mills are the combustion of fuel oil in the soaking pits and reheat furnaces of the facilities.

SLAG HANDLING FACILITIES

Particulate emissions associated with this operation include fugitive emissions from storage piles, haul roads, and crushing operations. These emissions appear to be controllable with judicious use of water sprays.

POWER PLANT

The five power boilers are potential major sources of particulate emissions when they are fired with coal. Currently none of these boilers has an emission control system. USSC is in the process of installing baghouse control systems for the three larger boilers.

MISCELLANEOUS SOURCES

1. The foundry sand reclaim system is a potential source of particulate emissions. Emissions from this system are reportedly controlled by wet scrubbers. These scrubbers were not seen in operation during the inspection.

The foundry casting operations are potential minor sources of fugitive particulate emissions.

2. The pig casting machine at Geneva is a potential minor source of fugitive emissions. This unit is only operated intermittently.

3. The drier exhaust stacks on the chemical coke plant emit considerable quantities of particulate emissions. These exhaust stacks are uncontrolled.

EMISSIONS INVENTORY

Particulate emissions data computed by NEIC for the various sources at the Geneva Works indicate an average daily particulate emission rate during the period June-August 1976 of approximately 36 m. tons (38 tons)/day. Fugitive emissions from storage piles, paved and unpaved roads, and various open areas accounted for approximately 42% of this total. Several significant differences were noted between the NEIC-calculated figures and those previously submitted by USSC to the EPA. The majority of these differences can be accounted for by the use of updated or additional emission factors, more in-depth evaluation of the sources, or consideration of additional sources.

III. COKE PLANT

PROCESS DESCRIPTION AND INSPECTION OBSERVATIONS

There are four coke batteries at the Geneva facility, numbered 1, 2, 3, and 4 in a south-to-north orientation. Each battery has sixty-three Becker type underjet ovens. The ovens are tapered from 33 cm (13 in) wide at the pusher side to 39.4 cm (15.5 in) wide at the coke side and are 4 m (13 ft) high by 12.3 m (40.5 ft) long. The coke ovens average 16.3 m^3 (576 ft^3) in volume and produce approximately 8 m. tons (9 tons) of coke per 13.2 m. tons (14.5 tons) of coal charged. The normal coking cycle for these batteries is 16.25 hours during the summer months and 15.75 hours in the winter.

Coal Preparation

Coal used in the coking operations is received from three sources. High volatile content coal is obtained from two USSC mines operated at Price, Utah and at Sommerset, Colorado. Both of these coals average 37% volatile material, 0.6 to 0.7% sulfur, and 7.0% ash, all percentages by weight. The Sommerset coal is washed and dried at the mine site. The Price coal is washed and dried at Wellington, Utah.

USSC purchases medium volatile coal from the Mid-Continent Coal Company which operates a mine near Carbondale, Colorado. This coal averages 25% volatile material, 0.6% sulfur, and 6.5% ash. It is washed and dried at the Carbondale site before being shipped to the Geneva Works.

Coal from all mines is received at Geneva in gondola railroad cars. The cars are emptied by a Link Belt rotary railroad car dumper. The coal is transported via conveyor belts to two storage yards with a total net capacity of 68,000 m. tons (75,000 tons).

High and medium volatile coals are reclaimed from the storage yards and transported via conveyor belts to two Pennsylvania center feed hammer mills operating in parallel. Each of these units has a capacity of 320 m. tons (350 tons)/hr. The crushed coals are then blended to obtain the desired volatile content and sent to two Jeffery Manufacturing Company reversible hammer mills for pulverizing and blending. No. 2 fuel oil (without additives) is mixed with the blended coal at this time. Approximately 3.1 liters/m. ton coal (0.75 gal/ton coal) of oil is added. The pulverized coal is screened and then sent to storage bunkers atop the coke batteries. Oversized material from the screening operations is recycled to the secondary hammer mills.

The final coal blend sent to the storage bunkers is 70% less than 0.31 cm (1/8 in) and has a moisture content of 5.0 to 5.5% by weight. Volatile content is about 35%.

There are two storage bunkers at the coke batteries, each with a capacity of 2,300 m.tons (2,500 tons). Each bunker serves two batteries. One bunker is located between batteries 1 and 2 and the other between batteries 3 and 4.

Charging

USSC employs a stage charging technique at Geneva. The ovens each have three charging ports and dual gas collection mains. There are three, three-hopper larry cars available at the batteries. Normally one is kept in reserve status and the other two service the four batteries --

one for batteries 1 and 2 and one for batteries 3 and 4. Two topside personnel operate as a team servicing each pair of batteries. They alternate between the larry-car-man and lid-man roles. It is normal procedure to charge (and push) seven ovens per battery on an "alternating tens" sequence and then to repeat the sequence on the adjoining battery.

A normal charging sequence lasts approximately 2.5 to 3 minutes from the time the larry car is positioned above the oven charge ports until the final port lid is replaced at the end of the charge. The procedural sequence is as follows.

1. The larry car hoppers are loaded with the coal charge at the coal storage bunker and the car moves to the oven to be charged.

2. The charging port lids from ports No. 1 and 3 are manually removed while No. 2 lid remains in place.

3. The larry-car-man lowers the hopper sleeves from hoppers No. 1 and 3 around the charge ports.

4. The steam aspiration jets at both collector mains are turned on and the oven is connected to the two collector mains by the lid-man.

5. The larry-car-man discharges hoppers 1 and 3 simultaneously into the oven.

6. After hoppers No. 1 and 3 have been discharged into the oven, the drop sleeves are retracted and the larry car is backed off about 3 m (10 ft).

7. The lids on ports No. 1 and 3 are then replaced, and lid No. 2 is removed.

8. The larry car is then repositioned over the oven and hopper No. 2 is discharged. All three of the larry car hoppers discharge approximately the same quantity of coal into the oven.

9. At the conclusion of No. 2 hopper discharge, the larry car is once again backed off about 3 m (10 ft), and No. 2 lid is replaced.

10. The two steam aspiration systems are then turned off and the charge port lids are mudded with a sealing mud.

11. The larry car then returns to the bunker for another coal charge.

12. After the charging operation is completed, the pusher machine operator opens the oven chuck door and makes one complete pass of the oven with the leveling bar. USSC personnel reported that only one leveling bar pass is required because the coal has a relatively flat natural angle of repose and assumes a flat surface without additional leveling.

During the NEIC inspection of the coke batteries, seven oven charges were observed. Visible emissions ranging from 40% to 100% opacity were noted from all three charging ports. The emissions did not pass from the charge ports through the hoppers to the atmosphere; rather they normally escaped from the ports directly to the atmosphere. Emissions ranged from black and brown to yellow-white in color and lasted from 30 to 90 seconds.

USSC personnel reported they had modified the steam aspiration systems for the batteries in an attempt to reduce the charging emissions. They have experimented with various sized steam nozzles ranging as large as 1.9 cm (3/4 in) diameter units. They found that too many fine particles were carried over into the collector mains with these larger units and decided to use 1.3 cm (1/2 in) diameter nozzles. Plant steam is reported to be delivered to the aspiration nozzles at 8.8 kg/cm^2 (125 psi) gauge pressure. USSC personnel had no records on steam usage per battery nor did they have any figures as to the amount of gases which could be aspirated from an oven with the 1.3 cm (1/2 in) nozzles at 8.8 kg/cm^2 (125 psi) steam pressure.

Topside

The general condition of the topside brickwork of the batteries appeared to be good. There were no noticeable leaks in the paving brick nor were there leaks at the brickwork/port casting interfaces. USSC personnel mentioned that several port castings are in poor condition resulting in a poor seal between the casting and the lid.

Several significant leaks were noted in the collector mains themselves and the oven standpipes. These leaks were apparently the result of corrosion, poor joints, etc.

The oven charging port lids and standpipe caps were routinely sealed with a luting material (refractory mud slurry). The luting material was swabbed onto the lid or cap with mop-like devices. The sealing efforts were only partially successful; numerous leaks were noted on both the charging port lids and standpipe caps.

The goosenecks and standpipes were manually cleaned by topside personnel working on the first and second turns. The pipes were rodded out with steel bars while the oven was decarburizing before a charge.

A general impression obtained during the topside inspection was that the two topside personnel have a large number of tasks to perform and cannot successfully do them all. The charge sequence requires each topside crew to charge an oven every eight minutes. The charge itself takes 2-1/2 to 3 minutes and the travel time to and from the bunker plus filling the larry car hoppers accounts for another 3 to 4 minutes. It is obvious that little time is available for lid sealing and gooseneck cleaning, much less attending to operational abnormalities. Also, considerable coordination is required between the larry car operator and the lid-man during the charge to insure that the oven is connected to the collector main and aspirated correctly. It was noted that such coordination was lacking at times during this inspection.

Pushing

The Geneva coke push cycle is similar to the charge cycle, in that seven ovens are pushed on one battery in an alternating tens sequence. After completing the sequence on one battery, the pusher machine moves to the adjacent battery. One pusher machine services two batteries.

Five coke pushes were observed during this inspection. None of these pushes were noted to contain green coke; all observed pushes appeared to be thoroughly coked. No voluminous clouds of smoke and flame were observed. It was noted, however, that substantial quantities of fine coke particles were carried aloft by thermal buoyancy, resulting in plumes of 20 to 30% opacity.

Time did not permit an exhaustive visible emissions evaluation of pushing operations; however, at times during the remainder of the week, it was possible to observe additional pushes from a distance. Although no official records were kept, it appeared that at least two to three times per day dense push emissions normally associated with green coke were observed.

To assure homogeneous coking in each oven, Geneva personnel routinely check the flue and oven temperatures to insure that an even heat distribution is being obtained. On the day turn (No. 2), the two end ovens of each battery get a complete cross-wall check of flue temperatures. Also, all ovens are checked for coke and push side flue temperatures. On No. 3 turn, the coke side flues are checked on all ovens. Three ovens on each battery, on a rotating basis, are checked during each turn for oven temperatures. Any temperature irregularities noted during these inspections are corrected by adjusting the burning patterns of the underfire jets or by removing the jets for major maintenance and cleaning.

Quenching

There are two coke quench towers at the coke plant. The south tower services batteries 1 and 2 and the north tower services batteries 3 and 4. Contaminated industrial water from the byproduct plant is used at both towers.

Both of the quench towers are equipped with impregnated white pine baffles which are arranged in a single layer just below the stack portion of the tower. The baffle design is based on the results of a study conducted at the USSC Clairton, Pennsylvania, coke works.

Geneva personnel reported that it is difficult to keep the quench tower baffles in place due to the intense heat of the coke. The baffles must be replaced "every few months." During the NEIC inspection it was noted that several of the baffle portions in the north quench tower were missing.

As mentioned above, USSC uses contaminated byproduct recovery wastewater for quench water. The quench water for the south tower contains the "devil liquor" which is acquired from blowdown of the ammonia sulfate recovery process and the excess flushing liquor. The quench water for the north tower contains contaminated caustic material from both the Benzene Plant and the Nitrogen Plant plus condensed water from the latter plant. USSC reported that they use approximately 15,000 liters (4,000 gal) of contaminated water per quench. The analyses of an average quench water sample are summarized in Table 1.

During a quench, both towers exhibited copious quantities of saturated steam. Substantial particulate plumes were observed from both towers after the steam had dissipitated. The particulate plume from the south tower appeared to be consistently denser than that from the north tower. Also, particulate emissions continued to evolve from the quench car after it had been removed from the quench tower area. The particulates were noted to be white-grey in color.

Doors

Leaks from the push side, coke side, and chuck doors of the four batteries were observed during this inspection. A brief door survey was conducted on the pushside doors of battery 1; 12% of the oven doors and 20% of the chuck doors were observed to be leaking during this inspection.

Geneva personnel reported that they have a routine door maintenance program. Every door and door jamb assembly is cleaned manually with a spud bar when the door is removed during a push sequence. Daily, twelve doors per battery, on a rotating schedule, are given a thorough cleaning. The normal door cleaning complement consists of three persons per pair of batteries: two on the pusher side, and one on the coke side. On the day turn, there are two additional men per pair of batteries, one for the pusher side and the other for the coke side. These individuals are responsible for cleaning the chuck door (on the pusher side) and the door jambs down to the first lock bar (on both sides).

Table 1

AVERAGE CHEMICAL ANALYSES OF QUENCH WATER
USSC - GENEVA WORKS

Chemical Constituent	Concentration (ppm)
Total Dissolved Solids	4,876
Total Suspended Solids	155
Phenol	45
Sulfates	64
Sulfites	352

Geneva personnel report that they also routinely remove doors from the ovens for major repair of the refractory plugs and knife edges. Through July 24, 200 doors were reported to have been rehabilitated during 1976 and 90% of these had received both plug change and knife edge repair.

The oven doors at Geneva are equipped with spring steel knife edges. These knife edges can be externally adjusted while the doors are in place. If significant leakage is noted from any door, the battery maintenance personnel can adjust these knife edges to attempt to seal the knife edge against the jamb.

Combustion System

By design, the Becker type coke ovens burn fuel gas on an entire oven wall simultaneously. The products of combustion from the vertical flues of the walls in which the gas is burning ("on" walls) enter short bus flues and then are conducted over the top of the oven through cross-over flues to a companion series of bus flues on the opposite wall ("off" walls). The combustion products are routed from here through the vertical flues of the "off" wall to checker regeneration systems for heat recovery. Every thirty minutes the gas flow through the checkers and flue system is reversed. The stored heat in the checker brickwork is thus recovered by the incoming combustion air.

The products of combustion leaving the regenerative checkers are collected in waste heat flues and routed to waste heat stacks. Each battery has its own waste heat stack which is 76 m (250 ft) high and tapers from a base diameter of 5.2 m (17.25 ft) to an outlet diameter of 3.3 m (10.75 ft).

The main parameters affecting emissions discharged from the waste heat stacks are the air-to-fuel ratio in the combustion gases, the "cleanliness" of the fuel gas, and the general condition of the oven walls. Geneva uses coke oven byproduct gas as fuel to the coke oven underfire system. This gas, which has been purified in the byproduct recovery plant, consists mainly of methane and hydrogen and has an average heat content of 4,000 to 5,200 kg-cal/m^3 (560 to 580 Btu/ft^3). Approximately 0.8 x 10^6 m^3 (27 x 10^6 scf)/day of this fuel is burned in the four coke batteries. Table 2 is an approximate chemical analysis, provided by USSC personnel, of this gas.

During the inspection an evaluation of oven wall condition was not conducted. However, Geneva personnel reported they use a mud gun to repair brickwork cracks with a fireclay mud slurry. They reportedly repair three to four ovens per day. They do not routinely mud the roofs of the ovens since they feel that their roof decarburization program has helped improve roof brick life.

Visible emissions were observed from the four battery waste heat stacks periodically throughout the duration of the week-long inspection period. Batteries 1 and 4 exhibited the densest plumes for the longest periods of time. At times, battery 1 stack emissions exceeded 40% opacity.

Table 2

APPROXIMATE CHEMICAL ANALYSIS OF COKE OVEN UNDERFIRE FUEL GAS USSC - GENEVA WORKS

Gas Constituent	% by Volume
Hydrogen	50
Methane	26
Carbon Monoxide	10
Carbon Dioxide	3
Nitrogen	4
Hydrogen Sulfide	0.48
Miscellaneous Hydrocarbon	6.52

IV. COKE BYPRODUCT RECOVERY FACILITIES

PROCESS DESCRIPTION

Coal decomposition products, which are mostly gaseous, are exhausted from the individual coke ovens through the oven standpipes and goosenecks into the battery collector mains. There are two collector mains per battery which are connected by jumper pipes at the north and south ends of the batteries. These jumper pipes are center tapped to four mains, one per battery, which route the decomposition products to the Byproduct Gas Plant. At the Geneva Works, byproduct recovery is accomplished in three separate plants: the Byproduct Gas Plant, the Benzene Plant, and the Nitrogen Plant. Each is discussed separately.

Byproduct Gas Plant

Figure 3 shows a simplified process flow for the Byproduct Gas Plant.

The coal decomposition products collected from the four batteries are first passed through knock-out pots to remove the main flushing liquor. This liquor is a combination of the liquor sprayed into the collector mains to flush out particulate matter and condensed tars from the coke ovens and the condensed water vapor driven from the charged coal. The flushing liquor collected in the knock-out pots is sent to tar decanter units. Here tar-like materials are removed from the liquor by gravity separation, stored, and ultimately sold to a scavenger operation. The separated flushing liquor is then chilled in shell and tube cooling units before advancing to the next stage of the gas treatment.

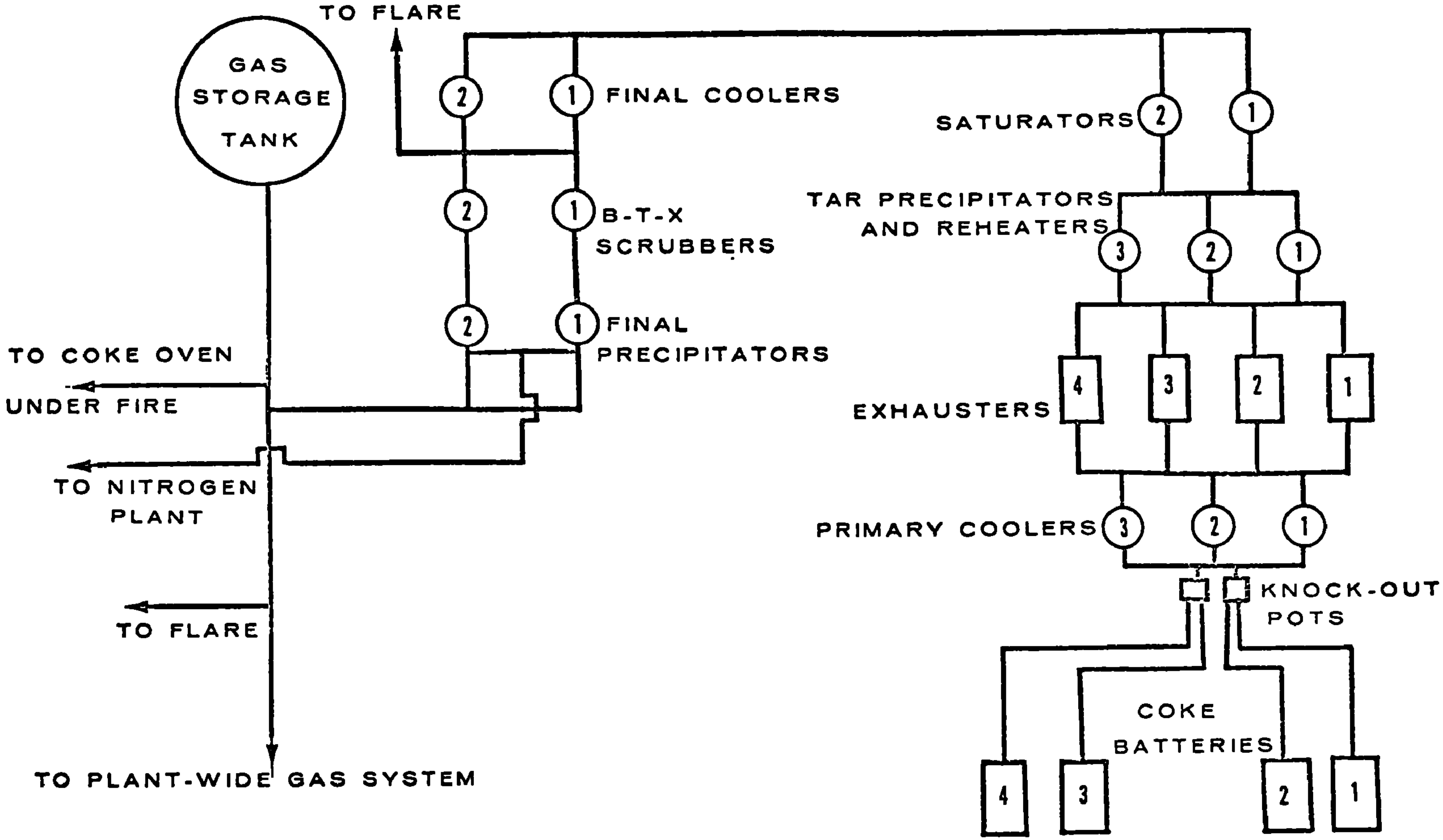

Figure 3. By-Product Gas Plant Flow Diagram — USSC Geneva Works

The coke oven gases are exhausted from the knock-out pots into three parallel cooler units. Here the gases are cooled by indirect contact with the chilled, decanted flushing liquor mentioned above. The coolers are vertical steel towers with wooden baffles. The flushing liquor discharged from these coolers is recycled through the shell and tube chiller units in a closed loop. Flushing liquor is continuously blowndown from this loop and sent to an ammonia stripping still for ammonia recovery. Effluent from this still is either recycled to the collector mains or discharged from the system and used as coke quench water. The wasted flushing liquor is termed "devil liquor."

The cooled coke oven gases are discharged from the primary coolers through four parallel steam powered, centrifugal pumps termed exhausters. These units supply 325 mm water vacuum to bring the coke oven gases from the ovens, through the collector mains, knock-out pots and primary coolers and supply pressure to force the coke oven gas through the remainder of the gas cleaning systems.

From the exhausters, the coke oven gases are routed through three banks of electrostatic precipitator (ESP) units and gas reheaters. Additional tar materials are removed from the gases in the ESP's and sold to scavengers.

After passing through the ESP's and reheaters, the gases are bubbled through two parallel sulfuric acid tanks called saturators. Ammonia in the coke oven gas reacts with the sulfuric acid to form ammonium sulfate $(NH_4)_2SO_4$. The $(NH_4)_2SO_4$ crystals precipitate, are collected, centrifuged, and air-dried in piles before being sold as fertilizer. Centrate from this operation is returned to the saturators. The sulfuric acid concentration is maintained between 3% and 14% by the addition of 96% acid. Production capacity of this process is about 73 m. tons (80 tons)/day of dried ammonium sulfate.

From the saturators, the coke oven gases are sent to two parallel final coolers. These units are bubble tray towers which provide contact cooling of the gases with decanted tar materials. The tar also absorbs naphthalene from the coke oven gases. The naphthalene is reclaimed along with the tar by the scavenger operation.

From the final coolers, the coke oven gases are passed through two countercurrent flow scrubbers containing a packing material of curled steel strips called "curlings." Here the gases are scrubbed with "wash oil" which has been returned from the Benzene Plant. The wash oil absorbs benzene, toluene, xylene, and solvent from the gas stream. The saturated wash oil is then returned to the Benzene Plant.

From the scrubbers, the coke oven gas passes through two parallel ESP's. Here the remaining tars and other condensed materials are removed from the gas stream. The resulting purified gas is then separated essentially into three gas streams. About a third of the total gas produced is returned to the coke ovens as fuel to the underfire system. Another third is sent to the Nitrogen Plant. The remaining third is introduced into a plant-wide fuel gas system. A flare is available to burn any coke oven gas in excess of the plant requirement and storage capacity.

Benzene Plant

Figure 4 is a simplified process flow diagram for the Benzene Plant.

Saturated wash oil is pumped from the Byproduct Gas Plant through two parallel heat exchangers and two parallel heater units. The heated wash oil is then introduced into two parallel stills where it is steam stripped by a countercurrent flow of high pressure steam. Benzene,

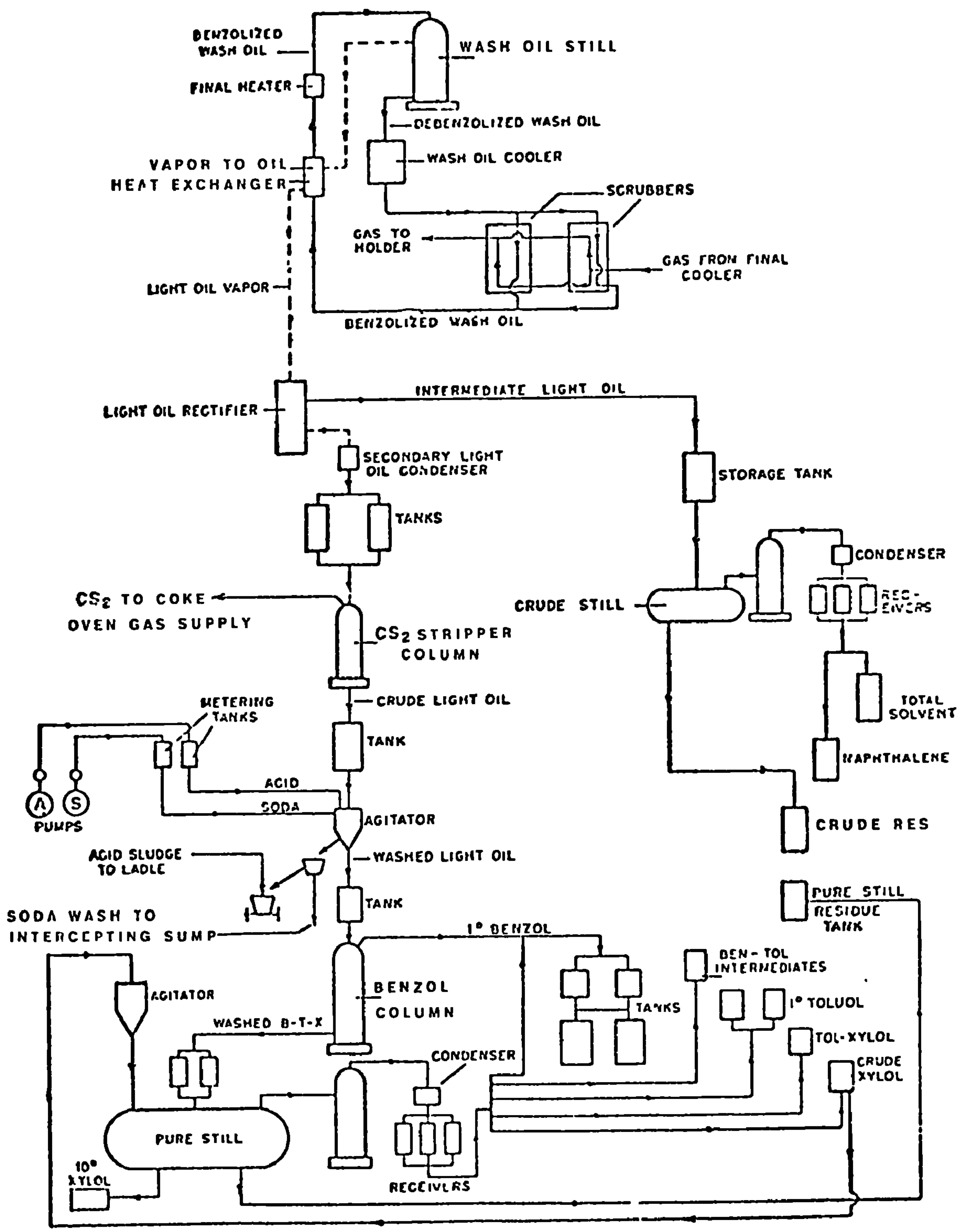

Figure 4. Benzene Plant Flow Diagram — USSC Geneva Works

toluene, xylene (B-T-X) and solvent are stripped from the wash oil and removed from the still as overhead vapors.

The stripped wash oil is then passed through cooler units and recycled to the Byproduct Gas Plant where it is used to absorb more B-T-X from the coke oven gas. Make-up wash oil, purchased from the American Oil Company, is added as needed.

Stripped vapors from the wash oil stills, now termed light oil, are passed through the wash oil heat exchangers and sent to the light oil rectifier, which is a fractionation column. About 80 m^3 (21,000 gal)/day of light oil is processed.

The bottoms from the light oil rectifier, termed intermediate light oil, are routed to a storage tank. From here they can be batch distilled in a "crude still." The bottoms from this operation are crude residue which can be burned as a fuel at the open hearth furnaces. Overhead vapors from the batch still are fractionated and condensed. Naphthalene and crude aromatic solvents are the products of this distillation stage.

Overhead vapors from the light oil rectifier are condensed to form a material termed secondary light oil. This material is passed through a steam stripping column to remove carbon disulfide (CS_2). The CS_2, which amounts to about 1.5% by weight of the original light oil, is mixed with the underfire gas supplied to the coke ovens.

The stripped secondary light oil, now termed crude light oil, is mixed with 94% to 98% sulfuric acid and 50% sodium hydroxide to remove impurities such as mercaptans, sulfides, etc. The washed light oil is then stored for further processing. Acid sludge resulting from the acid wash is hauled to landfill. Spent caustic from the caustic wash is sent to a process wastewater sump and is ultimately used in the north quench tower.

Washed light oil from the storage tanks is stripped of benzene in the benzol column. The resultant pure benzene, termed 1° Benzol, is condensed and stored in tanks.

Bottoms from the benzol column contain residual amounts of benzene plus toluene and xylene. These bottoms are fed to a batch still where they are further separated by fractionation distillation. The products from this unit operation include pure benzene (1° Benzol), pure xylene (10° xylol) and pure toluene (1° toluol), plus mixtures of benzene and toluene, and toluene and xylene.

About 53 m^3 (14,000 gal) of 1° Benzol, 11 m^3 (3,000 gal) of 1° toluol, 4 m^3 (1,000 gal) of 10° xylol, and 8 m^3 (2,000 gal) of crude solvent are produced each day from the 80 m^3 (21,000 gal)/day of light oil processed. About 4 m^3 (1,000 gal)/day is regarded as "lost" material.

The B-T-X produced from this facility are extremely pure grades. The 1° and 10° terms used to describe the materials indicate that all of the material will volatilize within 1°F and 10°F of the boiling point, respectively. The B-T-X materials produced at the Geneva facility are considered to be suitable for nitrification.

Nitrogen Plant

Figure 5 is a simplified process diagram for the Nitrogen Plant. This facility is actually five separate plants in one unit: an air separation plant, a coke oven gas purification and separation plant, an ammonia production plant, a nitric acid production plant, and an ammonia nitrate production plant.

In the air separation plant, atmospheric air is filtered and then subjected to cryogenic separation into oxygen and nitrogen. The oxygen

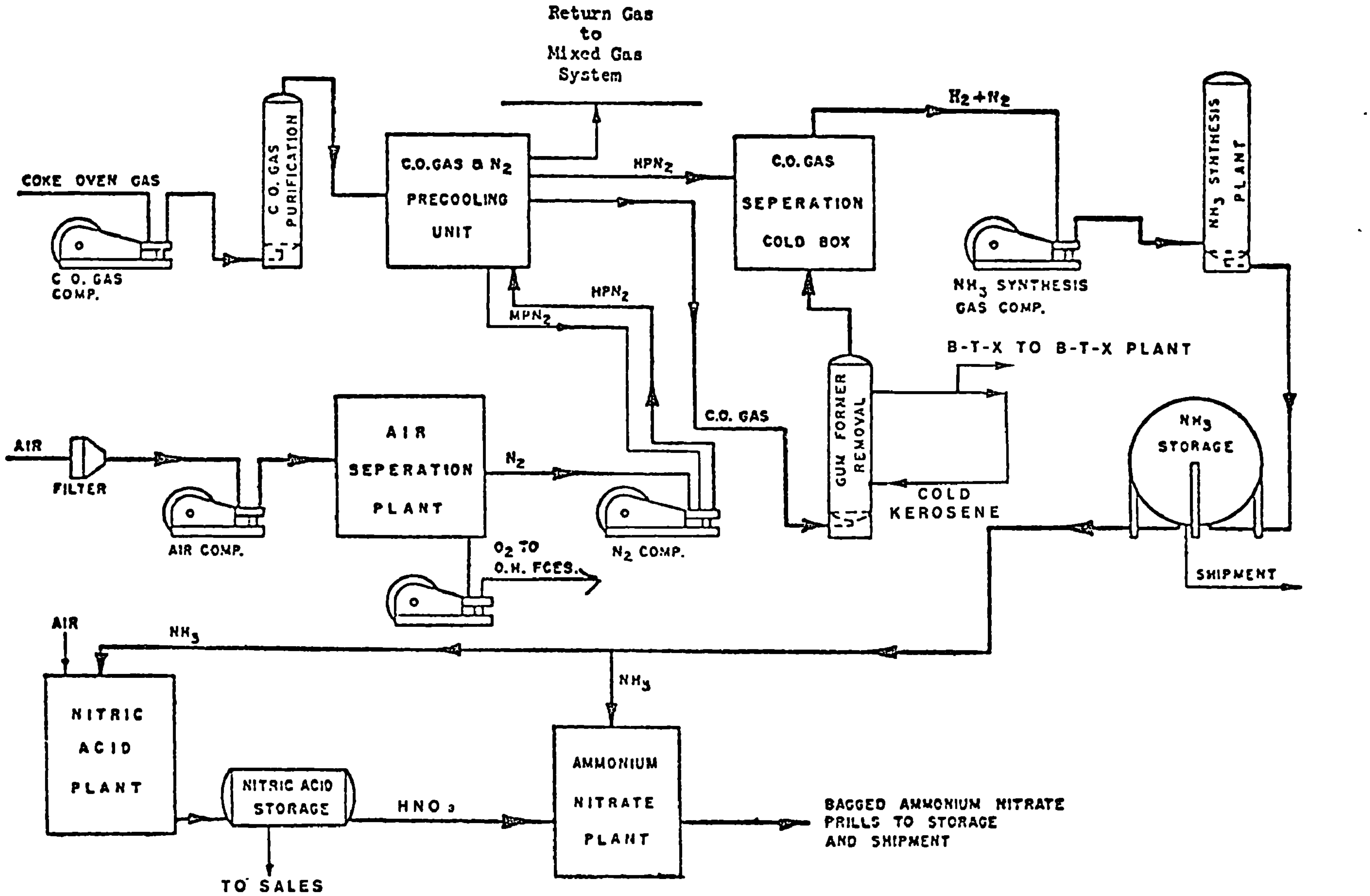

Figure 5. Nitrogen Plant Flow Diagram — USSC Geneva Works

is sent to the open hearth steel furnaces where it is used for lancing of molten steel to remove impurities.

Coke oven gas is received from the Byproduct Gas Plant after the gas has been partially purified [Figure 3]. At the Nitrogen Plant the coke oven gas is compressed and further purified by sequential scrubbing with an ammonia solution, water, caustic solution, and water again. Hydrogen sulfide is removed from the coke oven gas by the ammonia scrubbing process. Other impurities are removed by the subsequent scrubbing stages. Liquid blowdown from these scrubbing processes are ultimately sent to the north quench tower.

The purified coke oven gas is routed to a cryogenic precooling unit. Nitrogen from the air separation plant is compressed and sent to the precooling unit also. In the precooling unit, hydrogen is separated from the higher boiling point constituents (higher boilers) in the coke oven gas. The higher boilers are mixed with the hydrogen sulfide removed earlier and returned to the mixed gas system.

The hydrogen from the coke gas is further purified by scrubbing it with a cold kerosene solution which absorbs trace quantities of B-T-X from the hydrogen. The recovered B-T-X is recovered in the Benzene Plant.

In the ammonia plant the purified hydrogen and nitrogen are compressed to about 270 kg/cm^2 (3,800 psi) and passed through a bed of iron oxide catalyst. The resulting product is liquid, anhydrous ammonia. About 180 m. tons (200 tons)/day of this material are produced, of which 25% is sold and 75% is used in subsequent processes. The anhydrous ammonia is stored in pressurized vessels at the site.

In the nitric acid plant, anhydrous ammonia is mixed with air and passed over a platinum catalyst to form nitrogen dioxide vapor. This vapor is then absorbed in water to produce a 56% solution of nitric acid. The Geneva nitric acid plant has a nominal production capacity of 350 m^3 (90,000 gal)/day of 56% nitric acid. A portion of this production is concentrated to 60% and sold. The remainder is used in the production of ammonium nitrate.

In the ammonium nitrate plant, anhydrous ammonia, water, and 56% solution of nitric acid are reacted to form an 83% solution of ammonium nitrate. This solution is concentrated to 96% by evaporation. The concentrated solution is then pumped to the top of a 49 m (160 ft) high prill tower. Atop the prill tower, the concentrated solution is passed through strainer-like discs which form small droplets. These droplets free-fall the 49 m (160 ft) to the bottom of the tower. During this fall they cool from 150 to 74°C (300 to 165°F) and crystallize into spheroids of ammonium nitrate with 4% water of crystallization. About 85% of these spheroids are retained on a No. 14 screen.

The spheroids (prills) are removed from the bottom of the prill tower by a conveyor belt. This belt transports the prills to a shaker pan which discharges them into a series of driers and coolers. The prills are here dried and cooled from 4% moisture and 74°C (165°F) to 0.04% moisture and 29°C (85°F).

From the final cooler, the prills are screened, blended with talc to form a water resistant talc barrier and sent to final storage or sales. The ammonia nitrate plant has a nominal capacity of 270 m. tons (300 tons)/day of prilled product.

INSPECTION OBSERVATIONS

The Byproduct Gas Plant and Benzene Plant are not inherently sources of particulate emissions since they incorporate closed gas cleaning systems. The excess coke oven gas flare unit at the Byproduct Gas Plant is the only potential source of continuous particulate emissions. Total dissolved solids in the liquid blowdowns from the various gas cleaning processes may be released as particulate matter during coke quenching operations.

The Nitrogen Plant appears to be the main source of particulate emissions related to the coke byproduct operations. The prill tower which is uncontrolled is the primary emission point. USSC personnel have estimated that approximately 135 kg (300 lb)/day of ammonium nitrate fines are lost to the atmosphere from the prill tower. A fine, fume-like plume was observed to be continuously discharged from the top of the prill tower during the inspection.

The four rotary prill dryer/cooler units are also potential sources of emissions of ammonium nitrate fines. Exhaust gases from these units are discharged to three identical C. O. Bartlett and Snow Co. Model No. 77-21-123 wet cyclone collector systems operating in parallel. The collector systems, which were installed in 1958, each have a design gas flow capacity of 270 m^3/min (9,400 acfm) and a design collection efficiency of 98% to 99%. USSC has no emission test data for these units. No visible emissions were observed from the collector exhaust stacks observed during the inspection.

The prill screening and talc/prill blending operation are vented to a baghouse which discharges through the side of the building to the atmosphere. The baghouse is a Wheelabrator No. 8-R Model 126D, Dustube Dust Collector which employs cotton bags. The air-to-cloth ratio for the unit is 2.72:1 at an average headloss of 4.6 cm (1.8 in) water. The design collection efficiency of the unit is 99%. USSC has no emission test data for this unit.

There are no combustion devices (process heaters, furnaces, etc.) associated with the various byproduct plants. Steam heat exchangers are used where heat transfer is required. Steam is supplied from the Geneva central power plant.

V. SINTERING PLANT

The Sintering Plant personnel are responsible for the receipt and handling of all iron ore materials and limestone at the Geneva facility as well as the operation and maintenance of the sintering machines themselves. The materials handling, process operations, and particulate emission control system are discussed in this Section.

PROCESS DESCRIPTION

Materials Handling

Iron ore is received in two forms at the Geneva facility, a magnetic concentrate from southern Utah and beneficiated ore pellets received from a USSC facility at Atlantic City, Wyoming. The magnetic concentrate as received at Geneva contains about 7% to 8% water and has an iron content of about 57.5%. The beneficiated ore pellets (called agglomerate) are received at Geneva at an iron content of about 63% to 67%.

All of the iron ore is received at Geneva by rail. The railroad cars are unloaded by a single Link Belt rotary railroad car dumper. The ore materials are transported from the dumper to the storage area by conveyor belt. At the storage area, the ore is stacked into long storage piles with three Robbins double-wing stacker units. The ores can be blended with limestone at these stacks by alternating the raw materials being fed to the stacker units.

There are eight storage beds for the magnetic concentrate and two storage beds for agglomerate. The total storage capacities are 82,000 m. tons (90,000 tons) and 120,000 m. tons (130,000 tons), respectively.

Ore is reclaimed from the storage piles by two Robbins-Messiter reclaiming machines and a Robbins rotary buck wheel reclaimer. The ore is transferred from the reclaimers to screening facilities by conveyor belts.

Agglomerate pellets are screened to remove fines before being transported to storage hoppers. From the storage hoppers they are transported directly to the blast furnaces. The agglomerate fines reclaimed at the pellet screening station are transferred by conveyor belt and stored in two storage silos at the Sintering Plant.

The magnetic concentrate, as received at Geneva, has a wide distribution of particle sizes ranging from fine dust to large rocks. This material is reclaimed from storage piles and sent by conveyor system to a crushing and screening facility. Here the ore is passed through scalping screens to produce size cuts of +5 cm (+2 in), +0.6 cm to -5 cm (+1/4 in to -2 in) and -0.6 cm (-1/4 in). The +5 cm (+2 in) cut is routed directly to two parallel Hydrocone crusher units. The resulting crushed ore is recycled to the scalping screens. The +0.6 cm to -5 cm (+1/4 in to -2 in) cut from the scalpers is sent directly to the blast furnace feed storage hoppers. The -0.6 cm (-1/4 in) cut from the scalpers is sent to four storage silos at the Sintering Plant.

Sintering

The function of the Sintering Plant is to fuse fine iron ore particles, iron flue dust from the blast furnace and other iron bearing fines into clinker-type materials which have the structural strength and porosity required of blast furnace charge.

There are two Dwight Lloyd sintering machines at this facility each with a maximum capacity of 1,400 m. tons (1,500 tons)/day, operating three turns per day. A maximum month's production from the Sintering Plant during 1975 was 81,000 m. tons (89,000 tons) and the average monthly production was 46,000 m. tons (50,000 tons). Generally, both of the sintering machines are operated when the Sintering Plant is operated.

In the sintering process, iron bearing materials (e.g., agglomerate fines, magnetic concentrate, blast furnace flue dust and clarifier sludge, returns from slag reprocessing) are mixed with coke breeze (fines), dolomite limestone, recycled sinter fines, and water in two drum type pug mills. A typical Sintering Plant feed composition is shown in Table 3. From the pug mills, the mixed materials are transported via conveyor belts to the sintering machines. Here the materials are distributed by swinging spouts onto the machines' traveling grates. The grates carry the bed of feed materials through an ignition furnace where overhead gas burners ignite the coke breeze. The grate then transports the ignited bed over a series of windbox sections which are 1.8 m (6 ft) wide and total 31 m (102 ft) long. As the grate traverses the windbox sections, air is pulled down through the feed bed into the windboxes causing the combustion zone to penetrate deeper into the bed. The coke breeze combustion creates sufficient heat to sinter the fine iron ore particles together into porous, coherent lumps. Ideally, as the traveling bed approaches the end of the windbox, the combustion zone should just be touching the traveling grate.

At the end of the windboxes, the grates discharge the sinter onto a bar grizzly to break up the large pieces. From here the sinter is transported by conveyor belts to a hot screening operation. Oversize material rejected by these screens is sent directly to the blast furnace feed hoppers. Sinter fines from the screens are returned to the sinter feed pug mills and blended with the incoming feed materials.

PARTICULATE EMISSION SOURCES

The largest potential sources of particulate emissions at the Sintering Plant proper are the windbox exhaust systems. Both sintering

Table 3

TYPICAL COMPOSITION OF
SINTERING PLANT FEED MATERIALS
USSC - GENEVA WORKS

Material	% by Weight in Feed
-0.6 cm (-1/4 in) magnetic concentrate	40
Blast furnace flue dust	9
Sinter fines recycle	5
-0.3 cm (-1/8 in) dolomite	13
Slag ore fines recycle	5
Coke breeze	5
Blast furnace clarifier sludge	3
Agglomerate (pellet) dust	20
Total	100

machines have identical windbox exhaust systems. Air is drawn through the sinter bed and grates to promote combustion of the coke breeze. Combustion products and sinter fines are drawn through the sinter bed by the air stream into the windbox exhaust system. The next largest potential source of particulate emissions related to the Sintering Plant is the sinter discharge end. Hot sinter is discharged from the grate pallets at the end of the windbox section onto bar grizzlies. Considerable amounts of dust are generated at this point, especially if the sinter bed has not been completely fused together before reaching the discharge location. The unfused materials are easily entrained because of their fine size distribution. The grizzly bars are enclosed units which are vented by duct work to a scrubber unit and exhaust fan.

Another potential source of particulate matter at the Sintering Plant is the sinter screening station. USSC reportedly employs water sprays at this screening station to minimize particulate emissions. Again the amount of emissions from this location will depend on the relative degree of fusing of the sinter achieved on the sinter grates. If the sintering process is incomplete, more fines will be generated by the screening process and the fugitive emissions will be higher.

The last significant sources of particulate matter noted at the Sintering Plant are two vent stacks which serve the two feed material pug mills. Neither of these emission points is controlled.

PARTICULATE CONTROL SYSTEM

The windbox emission control system consists of two identical trains, each handling the emissions from an individual Dwight Lloyd sintering machine. An emissions control train includes a fan, two parallel banks of three cyclones in series, and a partial orifice scrubber [Figures 6 and 7]. The discharge end emission control system consists of a single scrubber and fan which handle the emissions from both sintering machines [Figure 8].

Process Emissions

The Sintering Plant is an intermittent operation with the temperature and volume of windbox gases maintained at a relatively constant level when the lines are operating. The emissions consist of some gaseous combustion products and entrained particulate which is generated as air is drawn through the sinter bed. The particulate loading, sizing and characteristics can vary with the feed composition, bed depth, and bed speed. Windbox emissions are mainly generated early in the sintering process and at the point where the flame front has reached the bottom of the bed.

Like the windbox emissions, discharge end emissions will also have variable particulate characteristics. Discharge end emissions result when sinter is allowed to drop from the end of the sinter machine pallets. The quantity and characteristics of particulates released are functions of some of the same parameters as are the windbox emissions. The particulates are vented from the system at a relatively constant flow rate. Temperatures may be expected to vary somewhat being especially dependent upon where on the bed the flame front has ended relative to the sinter discharge end.

Table 4 shows the expected characteristics of the windbox and discharge end emissions from the Sintering Plant, as provided by USSC.

Windbox Cyclones

The cyclones in the windbox emission control system are multiple

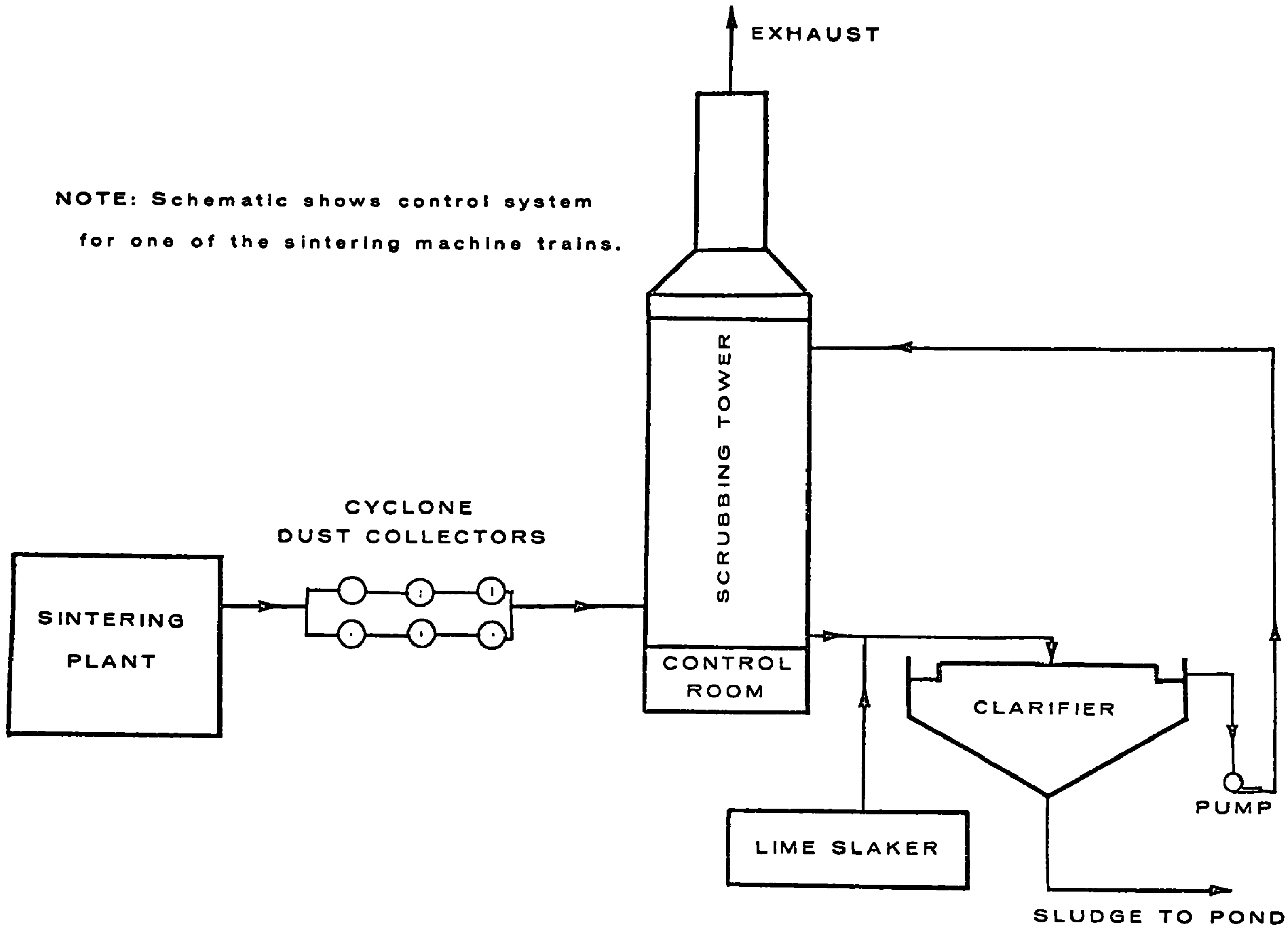

Figure 6. Sintering Plant Windbox Emission Control System — USSC Geneva Works

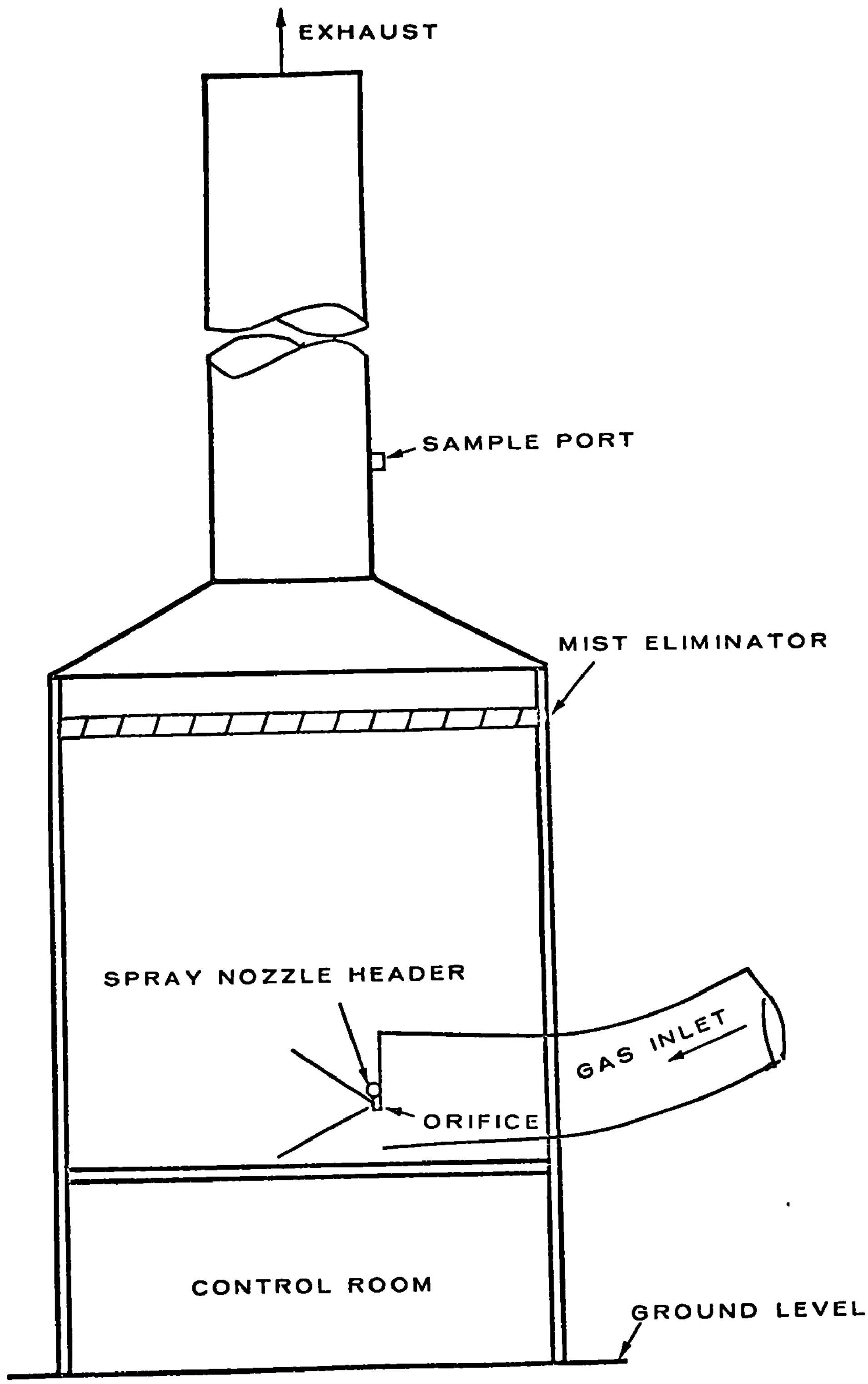

Figure 7. Sintering Plant Windbox Scrubber
USSC Geneva Works

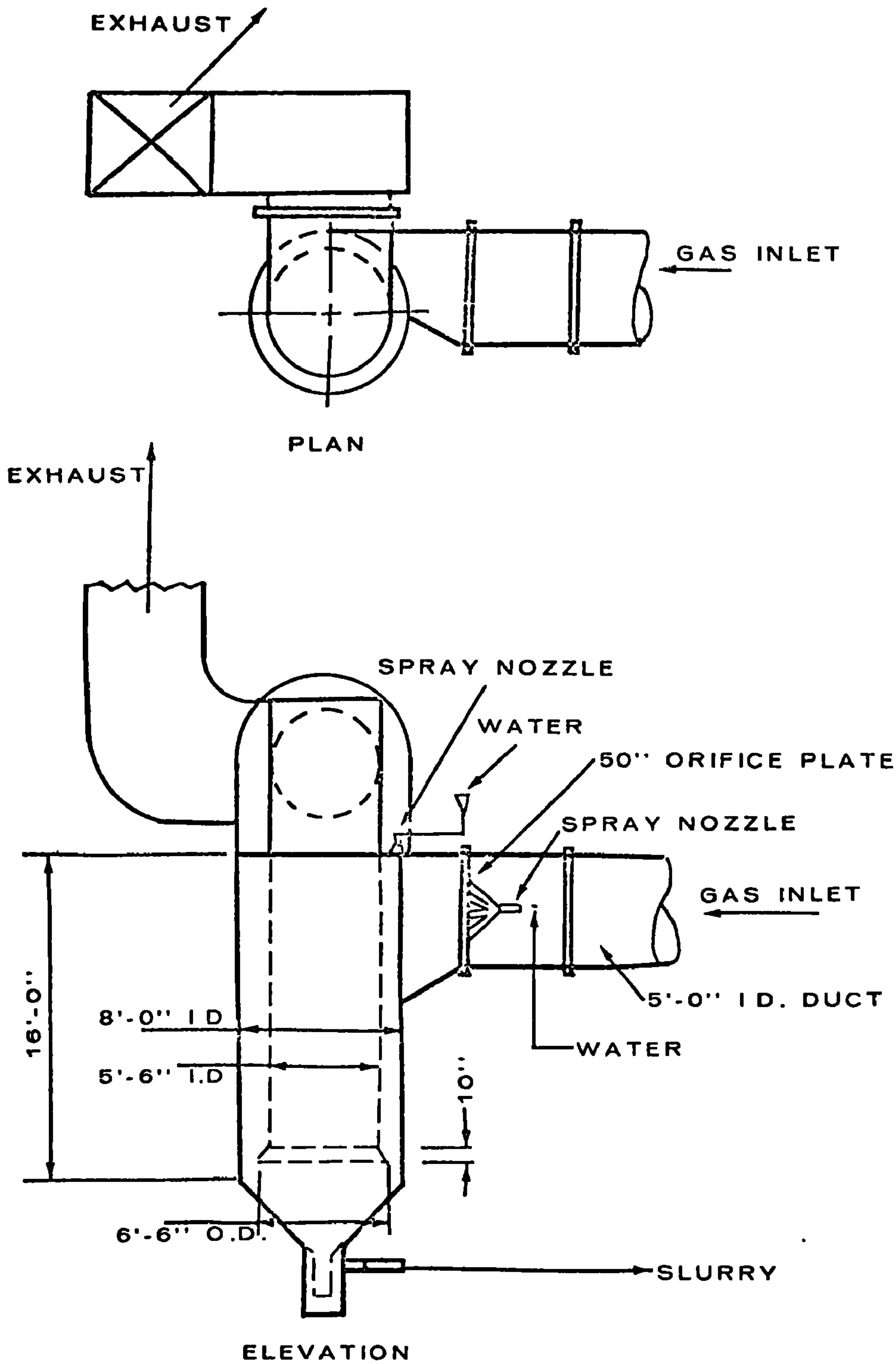

Figure 8. Sintering Plant Discharge End Scrubber

USSC Geneva Works

Table 4

CHARACTERISTICS OF EXHAUST GAS AND PARTICULATE EMISSIONS FOR SINTERING PLANT USSC - GENEVA WORKS

Parameter	Windbox Exhaust		Discharge-end Exhaust
Temperature	93°C (200 °F)		82°C (180°F)
Pressure (at fan discharges)	61 cm (24 in) W.G.		18 cm (7 in) W.G.
Flow rate	5,000 m^3/min (180,000 scfm)		2,200 m^3/min (80,000 scfm)
Particulate Concentration	7g/m^3 (3 gr/scf)		2g/m^3 (1 gr/scf)
Particulate Size Range	+40μm	53%	not available
	20-40μm	10%	
	10-20μm	16%	
	5-10μm	14.5%	
	0-5μm	6.4%	
Particulate Composition (% by weight)	SiO_2	13.11	not available
	Al_2O_3	3.49	
	CaO	4.14	
	MgO	3.46	
	Fe	40.60	
	C	15.05	
Particulate Specific Gravity	3.5		3.5 (estimate)

centrifugal type dust collectors with primary settling chambers. Table 5 presents general, physical, and design data for the cyclones, as provided by USSC. The cyclones, due to their simplistic design, should be capable of operating as designed. There are no moving or energized parts to require constant monitoring. The inlet velocity, which has an important effect on particulate removal, should remain relatively constant since the windbox fans maintain a relatively constant flow and the cyclone liners are frequently inspected for wear. Another important factor affecting particulate removal by the cyclones is the presence of air inleakage which could interfere with the cyclonic gas flow pattern. Since the cyclones are routinely inspected for physical integrity this should not be a problem.

The major variables affecting cyclone operation are the fluctuating grain loading and particle size resulting from the sintering operation. Assuming the cyclones were designed for worst case conditions, these variables should not affect cyclone operation.

USSC has indicated that the cyclone shells are inspected weekly and repaired as necessary. The brick refractory liners are inspected monthly and also repaired as necessary. The bottom cones and discharge valves were reported to be checked daily. These procedures, if adhered to, should insure that inlet velocity is maintained, inleakage is minimized, and cone dust buildup with resultant carryover is minimized.

Observations of maintenance were limited during the inspection. With the exception of one obviously malfunctioning solid discharge point, the rubber flapper discharge valves appeared to be in good condition.

Windbox Scrubbers

The scrubbers used in the windbox emission control system are USSC-designed and constructed partial orifice scrubbers [Figure 7]. Initially

Table 5

GENERAL, PHYSICAL, AND DESIGN PARAMETERS FOR SINTERING PLANT WINDBOX CYCLONES USSC - GENEVA WORKS

Parameter	Specification
General	Number of cyclones - 6 per train, 2 identical trains
	Date Installed - 1953
	Manufacturer - American Blower Manuf. Co.
	Model - No. 42 type D
Physical	Arrangement - 2 parallel sets of 3 cyclones in series
	Cyclone diameter - 3.7 m
	Cyclone height - 10 m
	Cyclone inlet width - 3.1 m
	Diameter of cyclone outlet - 2.1 m
Design	Particulate removal efficiency - 85%
	Inlet velocity - 1,300 m (4,400 ft)/min

erected in 1962, the scrubbers were modified in 1975 by relocating internal sprays. USSC reported that this was done to provide better mist elimination. Scrubber spray water consists of recycle water from the neutralization/clarification system diluted with plant makeup water. The discharge from the scrubber is pumped to the clarification/ neutralization system for treatment.

General and design parameters for the windbox scrubbers, as provided by USSC, are shown in Table 6. USSC stated that the scrubbers were originally designed for hydrogen fluoride (HF) removal and were selected because they would provide adequate HF removal and good access for maintenance. However, the use of these scrubbers for particulate removal is questionable for two reasons: particulate removal capability, and mist carryover.

The most questionable design parameter is the reported particulate removal efficiency (95%). This efficiency, which is typically a function of the size of the particulate removed and the energy input into the scrubber, appears to be higher than would be expected for the size range of particulate estimated to be discharged from the cyclones. Although there is a lack of good particle size information, it is questionable that these low pressure drop (5 to 7 cm W.G.) scrubbers could remove the 95% of the particulates necessary to provide an outlet grain loading of 0.08 g/m^3 (0.04 gr/scf).

A second questionable design feature is the use of a packed bed mist eliminator without a spray wash to clean off solids deposits. The scrubbing media is saturated with dissolved solids which precipitate in the packed bed. As the solids accumulate in the packed bed, higher velocities are created around the plugged areas of the bed. At higher velocities, more liquid is re-entrained, lowering the efficiency of the mist eliminator. The mist carried over contains suspended and dissolved solids which increase the particulate grain loading of the exhaust gas.

Table 6

GENERAL AND DESIGN PARAMETERS FOR SINTERING PLANT WINDBOX EMISSION SCRUBBERS USSC - GENEVA WORKS

Parameter	Specification
General	Number of scrubbers - 2
	Date installed - 1962
	Scrubber type - partial orifice
	Manufacturer - USSC
Design	Particulate inlet loading - 1g/m^3 (0.5 gr/scf)
	Particle size - 95% <5μm
	Particulate specific gravity - 3.6
	Particulate removal efficiency - 95%
	Scrubber pressure drop - 5-7 cm (2-3 in) W.G.
	Scrubber water rate - 2,600 1(700 gal)/min
	Scrubber gas velocity - 2.1 (6.9 ft)/sec
	Gas volume - 5,000 m^3/min (180,000 scfm)
	Gas temperature - 93°C (200°F)
	Gas pressure - 730 mm Hg

This carryover could result in an 0.02 to 0.07 g/m^3 (0.01 to 0.03 gr/scf) addition to the particulate grain loading [Addendum C].

There are no gas side controls or monitors used for the windbox scrubbers other than a WP-50 single point sampling train located, at the time of the inspection, just above the mist eliminator of the north scrubber. The train withdraws periodic samples of gas which are then later analyzed by USSC personnel. The data obtained from this train are highly questionable since the gas sampled may or may not exhibit particulate concentrations representative of the entire gas stream. The scrubber liquid pressure is monitored at the pumps and maintained manually. No other scrubber-operating parameters are monitored. As a result of the lack of operating indicators, only visible emissions observations were available as an indicator of collection efficiency. The opacity of the plume after the steam had detached was typically in the range of 10% to 40%. It was also observed that there was significant mist fallout which appeared as large "rain" droplets near the base of the scrubber stacks.

USSC personnel reported that the scrubbers are cleaned every 3 to 4 weeks. The cleaning program was said to include inspection, replacement of nozzles, flushing of pipes, and the removal of scale from the mist eliminator and scrubber internals.

The maintenance of the mist eliminator is not adequate because, as reported by USSC, the buildup of solids occurs immediately. This buildup would be accompanied by higher droplet carryover and increased particulate loads. However, keeping the mist eliminator clean enough to minimize mist carryover problems could require a high frequency of down time. This problem could be handled by design modification. Such design modification might include intermittent mist eliminator wash systems, alternative mist eliminator designs and orientation, and/or use of an anti-scaling agent.

Discharge-end Scrubber

The Sintering Plant discharge-end emissions are treated by a single wet scrubber. The scrubber consists of an orifice plate section followed by a cyclone [Figure 8]. There are sprays located at the orifice opening and in the entrance to the cyclone. Limited data are available on the discharge-end particulate emissions and, as a result, the analysis of this scrubber's particulate emission control capability is limited.

Table 7 shows some of the more relevant general and design parameters pertaining to the discharge-end scrubber. Without approximate particle size information, it is not practical to evaluate design in any great detail. The orifice/cyclone scrubber should be capable of 97% particulate removal assuming that a very small portion of the total particulate is less than 2μm to 3μm in diameter. Mist carryover effects are also difficult to estimate since the system has a wet fan downstream from the scrubber, which would collect a large portion of the mist droplets.

Operation of the discharge-end scrubber is not monitored, other than the scrubber water pressure. No observations of scrubber operation or emissions were made during the inspection. The emissions were not observed because they were not considered to be representative at the time of the inspection because there were malfunctions in the sintering process and water system.

Maintenance problems may result from the abrasive nature of the particulate-laden gas stream and the collection of mist on the wet fan. The largest abrasive wear would be on the orifice plate but since this is, by design, a large opening orifice (127 cm opening for a 152 cm duct) this should not have a major influence on particulate removal capabilities. The wet fan, however, may have an important effect on performance; the Company indicated no particular difficulties with the fan. It is believed, however, that the high potential for deposits on,

Table 7

GENERAL AND DESIGN PARAMETERS FOR SINTERING PLANT DISCHARGE - END SCRUBBER USSC - GENEVA WORKS

Parameter	Specification
General	Number of scrubbers - 1
	Date installed - 1962 (estimated)
	Scrubber type - orifice/cyclone
	Manufacturer - USSC
Design	Particulate inlet loading - 0.23 m^3 (0.1 gr/scf)
	Particle size - unavailable
	Particulate removal efficiency - 97%
	Scrubber water rate - 1,100 l(300 gal)/min
	Scrubber gas velocity - 7.9 m (26 ft)/sec
	Gas volume - 2,200 m^3/min (80,000 scfm)
	Gas temperature - 80°C
	Gas pressure - 822 mm Hg

and corrosion and abrasion of, the fan blades could make this a major problem area.

INSPECTION OBSERVATIONS

The Sintering Plant is an antiquated facility with several design inadequacies which hinder optimum operating modes and substantially add to the plant's air pollution potential. Sintering Plant personnel discussed some of these problem areas with NEIC personnel during the inspection.

The major problem areas are associated with the feed preparation systems. The pug mills do not provide adequate mixing of the feed materials. This, in turn, results in uneven sintering on the traveling grates. Additionally, there is an inadequate and unreliable water supply available to the pug mills. During the inspection, intermittent heavy discharges of particulate matter from the two pug mill stacks were noted.

Another problem related to the material feed equipment is that the proportioning controls on the ore, coke, and pellet fines systems are inadequate. The proportioning systems do not consistently maintain fixed set ratios of the various feed materials.

A major concern with the feed systems is the lack of surge storage and proportioning controls on the sinter fines recycle systems. The fines are currently recycled directly as they are received from the sinter screening station, with little control on the correct ratios required. The amount of recycle fines added to the feed materials is critical in that it affects the sinter bed porosity.

A final problem mentioned by the plant personnel is the lack of adequate sinter cooling facilities. Having to bundle the sinter in a hot form increases conveyor belt maintenance and equipment down time.

Not all of the materials handling procedures were in operation at the time of this inspection. No ore railroad cars were being unloaded, nor were the ore pile stackers being used. The pile reclaimers and the ore crushing/screening station were observed in operation.

No fugitive emissions were noted from the ore reclaiming operations, the primary grizzly screens, or the crushers. However, considerable fugitive emissions were noted from the secondary screening operations which receive the pulverized ore from the crushers.

The ore received from Southern Utah contains 7% to 8% moisture. It appeared that this moisture was sufficient to suppress dusts during the preliminary material handling stages. However, the ore produced from the crushing of oversized ore chunks is apparently much drier. When this material was screened, it liberated significant quantities of dust. USSC personnel stated that water sprays are usually used to suppress the dusts at these screens. During this inspection, the water sprays were not in operation.

It was noted during the inspection that the ductwork serving the grizzly bar hooding at the sinter line discharge-end was in disrepair. Several rusted-out holes were noted in the ducts. Suspended particulate matter was heavy in the atmosphere near the hooding. Since the water spray system was not in operation, considerable fugitive emissions were also noted at the sinter screening station during the inspection.

VI. BLAST FURNACES

There are three blast furnaces at the Geneva facility which are used to convert iron ore, agglomerate, and sinter, into pig iron. The three furnaces are numbered 1, 2, and 3 in a south-to-north plant orientation. All three of the furnaces are essentially identical; each is 32.3 m (106 ft) high with a hearth diameter of 8.1 m (26.5 ft). The nominal production capacity of the three furnaces is 1,680,000 m. tons (1,850,000 tons)/yr. The daily production capacity varies significantly with the type of materials fed to the furnaces. The furnaces are each nominally rated at 1,600 m. tons (1,800 tons)/day capacity with a feed material based on ore and sinter. However, when the feed is predominantly agglomerate or pelletized ore the furnace capacity is increased to 2,000 to 2,200 m. tons (2,200 to 2,400 tons)/day.

PROCESS DESCRIPTION

Materials Handling

Coarse ore, agglomerate pellets, sinter and coke, which have been screened to remove fines, and dolomite limestone are transported from their respective storage facilities by railroad transfer cars to the blast furnace area. The materials are discharged from the transfer cars to below grade storage bins. From these bins, the materials are discharged into a scale car which transfers predetermined amounts of the materials to skip hoists which actually feed the furnaces.

Alternating skips of coke, ore, and limestone are fed to the furnace. The skip hoist lifts the load to the top of the furnace and dumps it into a receiving hopper. The receiving hopper is isolated from the furnace proper by two sets of inverted cone-shaped cast steel plates called bells. These bells can be independently depressed providing access to the furnace proper. The uppermost bell, termed the small bell, isolates the receiving hopper from the region between the two bells which is termed the hopper. The lower bell, termed the large bell, isolates the furnace from the hopper.

After the skip hoist discharges its load of material into the receiving hopper, it descends the skip bridge to be reloaded. Simultaneously, another skip ascends the bridge with another load of material. The small bell is then depressed, allowing the skip load to enter the hopper area. The small bell is then closed and another skip load is dumped into the receiving hopper. The cycle is repeated until three skip loads are in the hopper area. Then, the small bell is closed and the large bell is opened allowing the feed material to enter the furnace.

During the inspection, blast furnace 2 was operating in a split filling mode. The term split filling means that more than one large bell dump is required to accomplish a single charge. The charge sequence was small bells of ore (O), stone (S), and coke (C) followed by a large bell dump and then small bells of ore (O), coke (C) and coke (C) with a second large bell dump. This sequence is denoted as OSC/OCC with the entire sequence constituting a single charge. The average charge composition during the inspection is presented in Table 8.

Furnaces

Each of the blast furnaces has three regenerative stoves which are used to preheat the blast air (wind) introduced into the blast furnace tuyeres. The stoves preheat the wind to about 930 to 980°C (1,700 to 1,800°F). Normally the checkers in two of the three stoves are being

Table 8

AVERAGE COMPOSITION OF CHARGE
TO BLAST FURNACE 2 - August 23, 1976
USSC - GENEVA WORKS

Material		Weight by charge kg	Weight by charge lb
Ore†		24,000	52,800
Dolomite		5,700	12,600
Roll Scale††		1,100	2,500
Coke		9,500	21,000
	Total	40,300	88,900

† *Ore was 80% agglomerate pellets, 10% concentrate, 10% sinter*

†† *Roll scale is material reclaimed from scarfing operations, and other product finishing steps.*

heated by combustion of blast furnace off-gas. The third stove is used to preheat the wind by reclaiming heat previously stored in the checker brickwork. The stoves are on the heat cycle for about 1.5 hours and then on blast wind for 1 hour. The wind to any given blast furnace averages about 2,400 m^3/min (85,000 acfm). When only two of the three blast furnaces are in operation, as was the case during the inspection, additional turbines can be added to increase the wind to the operating furnaces to about 3,100 m^3/min (110,000 acfm).

Steam at a rate of 14 to 18 g/m (6 to 8 gr/scf) is added to the wind at the tuyeres. Natural gas, during the summer months when it is readily available, is also added here at a rate of about 28 m^3/min (1,000 acfm). The steam addition reacts with the coke in the furnace burden to produce hydrogen which aids in the reduction of the iron oxides in the ore; it also helps to cool the tuyeres and burden materials, and reportedly reduces the burden slip potential. Natural gas addition helps reduce the amount of coke required in the furnace burden and provides a means by which the furnace hearth temperature can be more effectively controlled.

At Geneva Works, the blast furnace operators reduce the wind supply to the furnace every half hour. This procedure, termed checking, causes the furnace burden to slump in a controlled fashion, and reportedly minimizes the potential for a stuck burden which bridges between the furnace walls. Such bridging leads to uncontrolled burden collapses which are called slips. When slips occur, top pressures in the furnace increase instantaneously, resulting in potential damage to the furnace structure and off-gas handling systems.

The hot metal tap-to-tap cycle for the Geneva blast furnaces varies from 4 to 5 hours depending on the type of furnace burden. A normal tap is about 320 m. tons (350 tons) of hot metal per furnace and lasts about 45 minutes. The hot metal is transferred from the furnaces to ladle cars via runners constructed in the cast house sand floor. The hot metal ladles are then transferred via railroad tracks to the open hearth area.

At the midpoint of each tap-to-tap cycle is a slag flushing operation. The flush lasts about 30 to 45 minutes or as long as required to fill four slag ladle cars. The slag is flushed from the furnace via the monkey hole, a tap hole which is about six feet higher on the furnace than the hot metal tap hole. The slag which floats on the hot metal surface in the furnace hearth flows from the monkey down runners to the slag ladle cars. The slag is then taken to a dump area at the northern end of the facility. The slag is ultimately reclaimed from the dump area and processed by the Heckett Engineering Company.

PARTICULATE EMISSION SOURCES

The off-gases from the blast furnaces contain a high percentage of carbon monoxide (CO) formed by the combustion of the burden coke in the reducing atmosphere of the furnaces. These off-gases have a heat value of about 760 kg-cal/m^3 (85 Btu/scf) and hence, it is practical to reclaim them. However, the off-gases also contain high particulate grain loadings which must first be removed before the gases can be used for fuel.

The other major potential sources of particulate emissions at the blast furnace are in the cast houses where the hot metal tapping and slag flushing operations occur. The emissions from both of these operations are fugitive, and they emanate from the open building sides and roof louvers.

PARTICULATE CONTROL SYSTEM

At the Geneva Works, the blast furnace gases are subjected to four stages of particulate removal. Each furnace has its own particulate removal train and all are identical. Off-gases from each furnace are collected in four vertical ducts called uptakes. The tops of two adjacent uptakes are joined together to form two pairs, each pair being connected to a large descending duct called a downcomer. Each joined pair of uptakes terminates as a single duct with a counter-weighted flap valve called a bleeder valve. These valves can be opened to release excessive pressure from the furnace interior to the atmosphere. At Geneva, the bleeder valves are set to open at a pressure of 0.4 kg/cm^2 (6 psi) above the normal furnace topside pressure.

The downcomer carries the off-gases to a cyclone dust collector, which is original equipment. The unit, designed by Freyn Engineering Company, has a 10.6 m (35 ft) inside diameter shell by 10.9 m (36 ft) high chamber. It is a top-entry, top-exit design. There is a bleed-off valve to the atmosphere located just ahead of this cyclone collector. The bleeder valve is set to open at 0.3 kg/cm^2 (4 psi) above the normal furnace topside pressure.

After the gases are partially treated for particulate removal in the cyclone, they are routed to an orifice scrubber. This unit consists of an orifice plate with an upstream water spray system. The orifice scrubber unit was designed by USSC personnel.

The gases from the orifice scrubber are routed to a second stage of scrubbing in a baffle type counter-current gas washer designed by the Freyn Engineering Company. The unit is 5.8 m (19 ft) in diameter and 18.2 m (60 ft) long. The gases enter the bottom of the unit and water enters the top.

From the gas washer, the gases are routed to a Western Precipitation wet electrostatic precipitator. The unit is 8.5 m (28 ft) in diameter and contains 260 tubes, each 0.3 m (1 ft) in diameter and 4.5 m (15 ft) long. There is a final gas bleed-off valve located on the gas ductwork after the ESP unit. This bleeder is set at 0.1 kg/cm^2 (2 psi) above the normal furnace topside pressure.

The blast furnace gas dust cleaning systems are each designed to handle variable flow rates from 1,800 to 3,100 m^3/min (65,000 to 110,000 scfm) with an overall particulate collection efficiency of 99.5%. USSC personnel reported that the actual gas flow rates for these systems are variable, but fall within the design ranges.

Particulate matter collected in the cyclone units is transported in a dry form to the Sintering Plant where it is ultimately incorporated into the feed materials. The particulate matter collected in the scrubber and ESP is in a slurry form. This slurry is piped to a Dorr thickener where the particulate materials are concentrated into a sludge. This sludge is vacuum filtered to form a cake which is ultimately used as a feed material at the Sintering Plant.

The clean off-gases (blast furnace gas) exit from the ESP and are fed to a collector main which feeds various combustion sources in the plant or to a gas storage tank. The blast furnace stoves are fueled directly from this main. The blast furnace gas is also used to fuel five power boilers. The blast furnace gas is additionally used to supplement natural gas to obtain a mixed gas supply. The addition of blast furnace gas reduces the natural gas heat content and results in a mixed gas heat content of about 5,100 kg-cal/m^3 (575 Btu/scf).

Table 9 shows the typical composition, as supplied by USSC personnel, of the clean blast furnace gas.

Table 9

TYPICAL COMPOSITION OF CLEAN BLAST FURNACE GAS
USSC - GENEVA WORKS

Gas Constituent	Concentration % by volume
Hydrogen	2.5
Oxygen	0.01
Nitrogen	54.4
Carbon Monoxide	22.5
Carbon Dioxide	20.5
Particulate Matter	0.001 to 0.002 g/m^3 (0.002 to 0.005 gr/acf)

INSPECTION OBSERVATIONS

The hot metal taps and slag flushes are by far the major particulate emission contributors of the blast furnace-related activities. Visible emissions in excess of 40% opacity were noted from both the cast and flush operations.

Geneva personnel indicated that the amount of emissions associated with a given tap depends on the silicon dioxide (SiO_2) content of the hot metal. They try to maintain the SiO_2 level at about 1.0%. When it drops to about 0.7%, heavy emissions of red-brown iron oxide evolve during the tap. This condition was observed during the inspection.

A strong irritating odor was noted in the cast house area during the slag flushing operation. The odor was characteristic of an oxide of sulfur or phosphorous and persisted for the duration of the flush. The particulate emissions observed during the flush were blue-white in color.

Some leaking of the furnace bells was noted on both blast furnaces 2 and 3. The bell leakage was evident whenever a skip hoist unloaded into the bell hoppers. Blast furnace 1 was not in operation, but rather was banked in a stand-by condition due to reportedly unfavorable market conditions.

The combustion stacks on the furnace stoves had no visible emissions when the furnaces were in a normal operating mode. Once during the inspection, blast furnace 2 was placed in a backdrafting mode to repair a water leak at one of the furnace tuyeres. When the furnace was back-drafted, a white-blue plume was noted from the stove combustion stack. This plume appeared to consist mainly of condensed steam.

There are several circular or strip chart meters, located in each blast furnace control room, which are used to monitor pertinent furnace operating parameters. Table 10 summarizes the parameters monitored.

Table 10

OPERATING PARAMETERS MONITORED AT BLAST FURNACES
USSC - GENEVA WORKS

1	Blast Pressure
2	Furnace Topside Pressure
3	Furnace Topside Gas Temperature
4	Blast Temperature
5	Furnace Temperature at Various Locations
6	Stove Stack Temperature
7	Steam Injection Rate at Tuyeres
8	Furnace Burden Height
9	Water Pressure to Furnace Cooling Members
10	Water Flow Rate Through Gas Cleaning Scrubber
11	Gas Pressure Before and After Scrubber
12	Gas Collector Main Pressure
13	Stove Dome Pressure
14	Pressure Between Furnace Bells
15	Blast Rate
16	Natural Gas Injection Rate at Tuyeres
17†	Gas Bleeder Pressure (actual and set-point for release to atmosphere)

† *Gas bleeder pressures are monitored but not recorded. All other listed parameters are recorded on circular or strip charts.*

VII. OPEN HEARTH FURNACES

There are ten basic hearth construction open hearth furnaces at the Geneva Works. These units are used to convert pig iron from the blast furnaces, scrap steel, and some iron ore into finished steel. The total annual production of ingot steel from these furnaces is about 2,300,000 m. tons (2,500,000 tons)/yr. The majority of this production is tin plate steel. Table 11 lists the metallurgical range of steels produced at this facility. The majority of the steel produced has a carbon content of less than 0.25%. However, some high carbon steel (0.93% carbon) is produced for grinding rod manufacture.

PROCESS DESCRIPTION

Hot Metal Handling

Molten pig iron (hot metal) is transported by rail to the open hearth building from the blast furnace cast houses in ladles. The ladles are received at the mixer building which adjoins the north end of the open hearth building. At the mixer building, the ladles are hoisted approximately 23 m (75 ft) by overhead crane from the building floor to one of two Pennsylvania hot metal mixer vessels. The hot metal is poured from the ladles into the mixer units.

The two hot metal mixers have a rated capacity of 730 m. tons (800 tons) each. These vessels are not mixers in the true sense of the word, since external energy is not added to the hot metal via vessel rotation, agitator blades, etc. The mixers serve as a hot metal surge storage to compensate for differences between the blast furnace supply and the

Table 11

METALLURGICAL COMPOSITION RANGES OF STEELS PRODUCED USSC - GENEVA WORKS

Component	% by weight
Carbon	0.04 to 0.93
Manganese	0.03 to 1.75
Phosphorous	0.035 to 0.075
Silica	0.04 to 0.15
Sulfur	0.015 to 0.045

open hearth demand. Some hot metal mixing is achieved by combining the contents of several hot metal ladle cars to one mixer. During the inspection, only one of the mixers (the north unit) was in operation. The south mixer was off-line for repair to its refractory brick lining.

Hot metal is supplied from the mixer units to the open-hearth furnaces by reladling. When hot metal is required at one of the furnaces, the mixers are rotated about 45° and hot metal is poured into waiting ladle cars. These cars, generally three per open hearth charge, are then transported by rail to the furnace being charged.

Furnaces

The ten basic hearth open hearth furnaces are rated at 314 m. tons (345 tons)/heat and have an average tap-to-tap cycle of 8 to 9 hours. The primary function of these furnaces is to reduce the carbon content of pig iron received from the blast furnaces from about 4% to below 1%. Trace impurities are also removed from the hot metal in the slag formed in the furnace.

During this inspection period, only five of the furnaces (90, 93, 94, 96, and 99) were in operation [Figure 9]. Under normal production schedules, seven to eight of the furnaces are operated simultaneously while two to three of them are undergoing major rebuilding or maintenance. Due to a general slump in the demand for steel production, the furnace production had been curtailed at the time of the NEIC inspection.

The open hearth furnaces are both reverberatory and regenerative in design. They are reverberatory in that the charge to the furnace is heated both by a flame passing over the charge and from radiation from the relatively low roof of the furnace. The furnaces are regenerative in that the hot gases from combustion of the fuel pass out of the

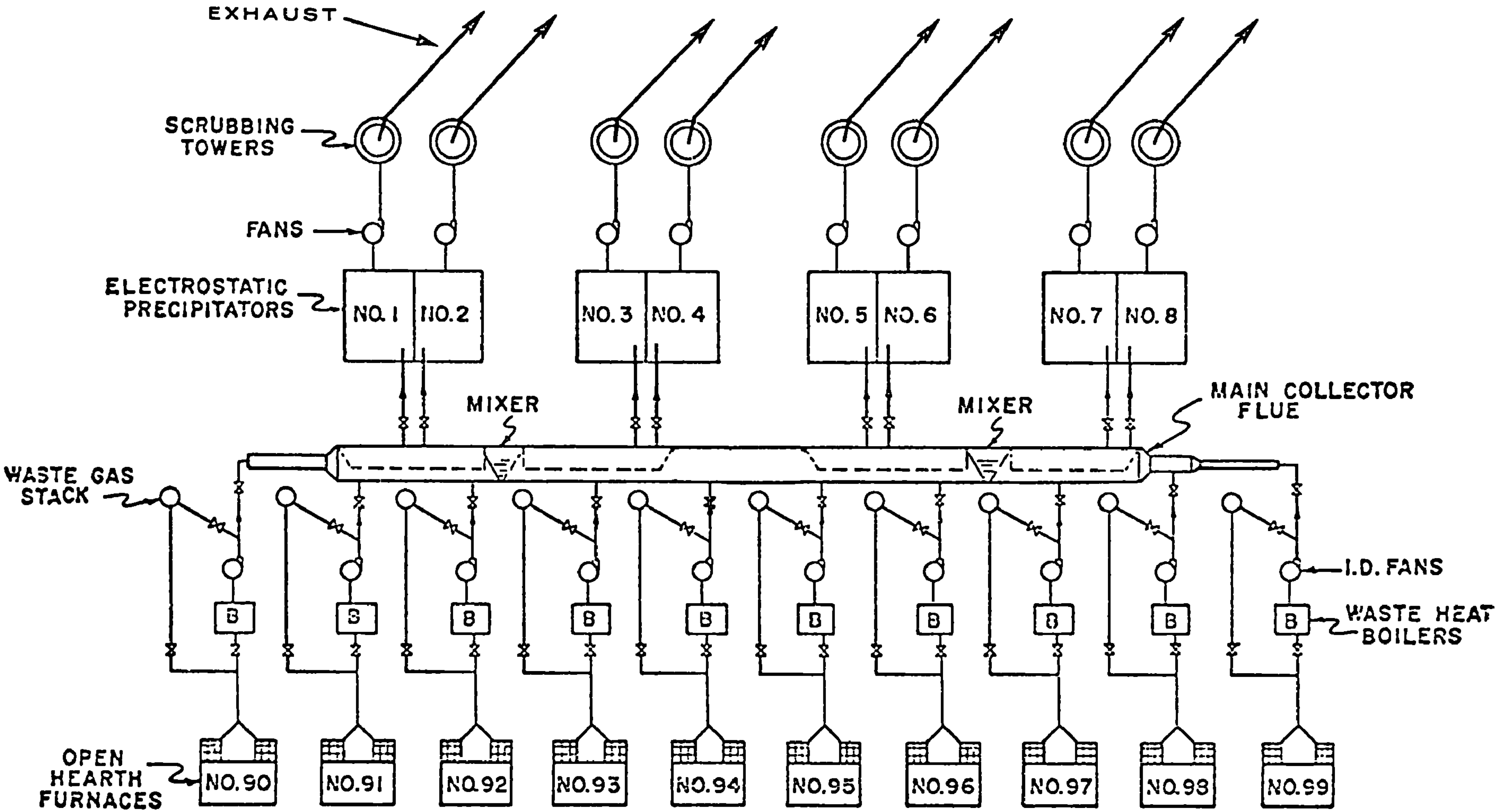

Figure 9. Open Hearth Emission Control System – USSC Geneva Works

reverberatory furnace through regenerative chambers which contain fire brick arranged in checker-work patterns. The hot combustion gases relinquish heat to the checker bricks. Periodically, the air flow and combustion pattern directions are reversed, allowing the combustion air to be pre-heated by the previously heated checker work. This procedure permits higher flame temperatures than could be obtained with cold combustion air. At the Geneva Works open hearths, the frequency of checker reversal is about five to six times per hour. The reversal frequency is controlled primarily by the checker temperature with a time clock override.

The open hearth furnaces can be fueled with natural gas and/or No. 6 fuel oil. Pitch and tar obtained from the coke byproduct recovery plant can be used in place of the fuel oil; however, USSC personnel report that pitch and tar are no longer used for fuel since the market value of these materials is higher than their equivalent fuel market value. Normally the furnaces are operated with 35% of the heat input obtained from natural gas and the remainder from fuel oil.

The open hearth furnaces are normally run continuously between major repair periods. The length of run between major repairs, termed the furnace campaign, is usually five to six months, with minor repairs being made as required. A major furnace repair takes two weeks to a month.

A normal open hearth furnace cycle begins just after the furnace tap has been completed. The first half-hour of the cycle is termed the fettling period. During this time, minor furnace repairs are made to the hearth bottom and bench by flinging twice-baked dolomite into the furnace with a dolomite gun. Pools of molten steel or slag remaining in the furnace bottom after the tap are blown from the furnace with compressed air.

Once the fettling period is concluded, the charge period begins. The charging machine places a layer of limestone on the hearth bottom using preweighed charging boxes. These boxes are introduced into the furnace through charging doors located on the front wall of the furnace. Iron ore and scrap steel are then placed on top of the limestone layer. The layered combination of limestone, ore, and scrap steel is termed the header. The period required for the total cold charging of the furnace varies from 1 to 1.5 hours. The furnace burners are operating during this period.

Once the furnace has been cold charged, the charge doors are banked with twice-burned dolomite lime and the melt period begins. The melt lasts approximately 45 to 60 minutes.

At the conclusion of the melt period, hot metal which has been religioned from the hot metal mixers is poured into the furnaces from ladles handled by an overhead crane. Normally three ladles of hot metal are added. A typical charge to a furnace is 390,000 kg (850,000 lb) of total metal of which 160,000 to 280,000 kg (350,000 to 615,000 lb) are hot metal. The hot metal charge period consumes approximately one-half hour.

Following the hot metal charge, the slag flush period begins. A small break is made in the dolomite bank at the center charging door. The slag overflows the bank and flows through a floor grate to the slag pit beneath the furnace. After the slag is cooled it is broken up and removed by front-end loader to be ultimately reprocessed at the Heckett Engineering facility. The slag run-off period lasts approximately one hour.

The ore boil and lime boil periods follow the flush period. The ore boil, characterized by a gentle and even aggitation of the molten steel, is caused by the evolution of carbon monoxide (CO) gas. The

CO gas is formed by the oxidation of carbon contained in the molten pig iron contacting reducible iron oxides in the ore and scrap charge. The lime boil, which is characterized by a more violent aggitation of the molten metal, is caused by the evolution of carbon dioxide (CO_2) gas from the calcining of limestone. As the lime boil progresses, chunks of lime migrate up through the molten metal and react with various impurities in the slag materials. The ore and lime boil periods require about 2.5 hours.

After the ore and lime boil periods have subsided, the working or refining periods begin. At this time all charged materials are in a molten form, and the lime has risen from the header to the slag layer. The purposes of the refining period are to oxidize the remaining phosphorous and neutralize it in the slag, to reduce the carbon to the desired percentage, to lower the sulfur content, and to raise the temperature of the molten metal bath to a point suitable for finishing and tapping of the steel. Additional iron ore and/or limestone are added to the molten steel during the refining period if chemical analyses of the molten metal indicate that the carbon, phosphorous, silica, and/or sulfur content are too high. Likewise, additional hot metal may be charged during this period if the levels of these components are too low. The refining period lasts about 2.5 hours.

The majority of the open hearth chemical reactions are based on oxidation of various impurities in the metal, such as carbon, phosphorous, sulfur. Oxygen for these reactions comes, in part, from the iron oxides in the ore and scrap materials. Pure oxygen is also introduced into the molten bath through oxygen lance tubes suspended through the furnace roof. There are two such lances per furnace located about mid-furnace in a front-to-back direction and opposite the number 3 and 5 charge doors. The oxygen lancing rate is about 1,100 m^3/hr (38,000 acfh) per furnace. The oxygen lancing period begins shortly after the hot metal addition to the furnace and continues up through the refining period, accounting for about one-half of the entire heat period.

At the end of the refining period the furnace is readied for the tap. A ladle capable of holding the entire furnace contents is positioned at the rear of the furnace below the tap hole and tapping spout. The clay-loam plug and most of the dolomite which block the tap hole are manually removed. The tap hole is then completed by detonating an explosive charge of nitroglycerine in the hole. When the hole is completed, the furnace contents are emptied into the ladle via the tap spout. Steel additives and alloying materials are added to the ladle from storage hoppers by feeder mechanisms as the molten steel is pouring into the ladle. Slag materials accumulate on the surface of the molten metal in the ladle. Toward the end of the tap, the slag overflows the ladle's slag spout and is discharged into the slag pit.

Each furnace has its own operations booth which contains the various monitors and recorders required to accurately control the heat cycle. Table 12 summarizes the parameters which are monitored at each furnace.

Ingot Pouring

At the end of the tap, the ladle of molten steel is transported to the pouring platforms which are situated along the inside wall of the open hearth building opposite the rear of the furnaces. Ingot molds standing on mold rail cars are situated along these platforms ready for filling. The ladle is equipped with a lever-actuated pouring nozzle which is situated in the ladle bottom. Operators, standing on the pouring platforms and working in conjunction with the crane operator, operate the nozzle lever to direct molten steel from the ladle into the ingot molds. The actual pouring operation takes about 45 to 60 minutes.

Table 12

OPERATING PARAMETERS MONITORED AT OPEN HEARTH FURNACES

USSC - GENEVA WORKS

	Parameters	Units
1	Oxygen in Furnace Exhaust Gases	%
2	Natural Gas Consumption by Furnace Burners	scfh
3	Oxygen Flow to Both Furnace Lances	scfh
4	Combustion Air Flow	scfh
5	Fuel oil Consumption by Furnaces Burners	gph
6†	Carbon Content of Metal Bath	%
7†	Temperature of Metal Bath	°F
8	Furnace Pressure	inches of water
9††	Exhaust Gas Temperature	°F

† *The metal bath carbon content and temperatures are periodically obtained from grab samples of the bath.*

†† *Exhaust gas temperatures are obtained from four locations, after both sets of regenerative checkers and in both flues leading to the waste heat boiler.*

PARTICULATE EMISSION SOURCES AND INSPECTION OBSERVATIONS

The open hearth furnaces discharge their combustion gases through the regenerative heating systems to collection and control equipment. After passing through the checker brickwork, the gases are routed to waste heat boilers and induced draft fans on each furnace. The fans discharge into a common collector main which serves both to mix the exhaust gases and to equalize the flow variations associated with furnace operations. From the manifold, the gases are routed to eight banks of electrostatic precipitator/scrubbing tower systems operating in parallel. From the scrubbers, the gases are discharged to the atmosphere.

There are considerable quantities of fugitive emissions associated with the hot metal mixing and furnace operations. These fugitive emissions are essentially uncontrolled. It was observed during the inspection that these emissions escape through louvers in the building roof to the atmosphere.

There are significant fugitive emissions associated with the hot metal transfer and reladling operations. Kish, a graphite-like material, is liberated from the hot metal during both the transfer and reladling operations, and fallout of this material is very noticeable. Copious quantities of smoke and fume were noted within the mixing building during these operations. Substantial amounts of these emissions exit the building through roof louvers as fugitive emissions.

The pouring of hot metal from the ladles to the mixer during transfer operations takes approximately two minutes per ladle. The emissions from this operation did not appear to be too dense. A typical reladling operation from the mixer to the ladle transfer cars takes about four to five minutes for a three-ladle transfer. Relatively heavy emissions were observed during these operations. The mixing building personnel indicated that the heaviest emissions occur when the silicon dioxide and/or sulfur content of the hot metal is high.

The open hearth furnaces themselves are operated under a slight positive pressure to minimize air infiltration into the combustion and regenerative zones. Since they are under positive pressure, the furnaces tend to leak fugitive emissions at various points such as charge door seals, faulty brickwork, etc. The degree of such leakage appeared to vary from furnace to furnace, reportedly in proportion to the relative length of time into the current campaign. The furnace leakage was continuous throughout the heat cycle. The heaviest leakage appeared to occur whenever a checker reversal occurred.

Fugitive emissions occurred during the various furnace charging periods, whenever the charge doors were opened. The emissions during the scrap and hot metal charges were relatively light, with the heaviest emissions occurring during the light scrap charges. A relatively heavy emission of 30 to 60 seconds duration was noted at Furnace 94 when a charge of iron ore was added to the molten metal bath near the end of the refining cycle.

The heaviest fugitive emissions occurred during the furnace tapping operations. These emissions were also of significant duration. The entire furnace tap operation lasted 8 to 10 minutes. The heaviest emissions occurred when the molten steel first entered the receiving ladle. The second heaviest emissions were observed during the 4 to 5 minute period during which alloys and additives were added to the molten steel in the ladle. The emissions from the latter operation were very dense and reddish in color.

Relatively heavy fugitive emissions were also noted throughout the ingot casting period. The emissions from this operation were not as heavy as from the tapping operation, but lasted considerably longer, about 45 minutes.

PARTICULATE CONTROL SYSTEM

Figure 9 shows a flow diagram of the open hearth furnace emission control system, which consists of a main collector flue and eight gas treatment trains. The collector flue receives off-gas from the ten waste heat boilers through individual induced draft fans. The flue combines and mixes the off-gases so that their temperature and particulate concentrations are equalized as much as possible prior to entry into the individual gas treatment trains. Each gas treatment train consists of an electrostatic precipitator, a fan, and a scrubbing tower arranged in series.

Process Emissions

The gases emitted from the open hearth process consist principally of air which has been modified by the oxidation of fuel. As the resultant combustion gases sweep across the surface of the furnace charge, particulate is entrained and carried out with the gases. As the furnace is cycled throughout a heat, the amount, size range and characteristics of particulate from the furnace can be expected to vary significantly. However, since there can be as many as ten furnaces on-line in various stages of a heat, the ranges in particulate emissions from the open hearths overall tend to be less varied than those from an individual furnace. The temperature of the off-gases to the particulate control system should be fairly uniform, because of the flue gas collector main and the waste heat boilers. By nature of the operation, the gases leaving the waste heat boilers are expected to have reasonably constant temperatures ($\pm$ 8°C). The off-gas flowrate, on the other hand, can be expected to vary significantly. It will change with such variables as the number of furnaces in operation, air inleakage at the checkers, etc.

The expected characteristics of the emissions from the open hearth furnace system are shown in Table 13.

Table 13

CHARACTERISTICS OF EXHAUST GAS AND PARTICULATE EMISSIONS FOR OPEN HEARTH FURNACES USSC - GENEVA WORKS

Parameter	Furnace Exhaust	
Temperature	220 to 228°C (425 to 450°F)	
Pressure	-9 to -13 cm (-3.5 to 5.0 in) W.G.	
Flow Rate	1,900 std m^3/min (67,000 scfm) per train	
Particulate Concentration	2 to 7 g/m^3 (1 to 3 gr/scf)	
Particulate Size Range	>149μm	0.1%
	7-149μm	1.2%
	44-74μm	8.7%
	20-44μm	1.0%
	10-20μm	3.0%
	5-10μm	5.0%
	<5μm	81.0%
Particulate Composition (% by weight)	Fe	65
	CaO	1.9
	Al_2O_3	1.4
	Zn	1.0
	SiO_2	0.89
	MgO	0.81
	S	0.50
	Pb	0.30
	K_2O	0.30

Electrostatic Precipitators

The electrostatic precipitators (ESP's) used in the open hearth furnace emission control system are Research-Cottrell plate-type precipitators initially installed in 1955. The ESP's were modified in 1972 by increasing the number of transformer-rectifier sets for each ESP from two to three. The ESP's have three electrical fields with two sections per field. Perforated plate distribution devices are located at both the inlet and outlet of the precipitators. Dust which is collected in the ESP hoppers located below the collection plates is transferred through wet eductors to a clarifier. USSC has reported that the ESP design particulate removal efficiency is currently 95.8% with an inlet dust loading of 8 g/m^3 (3.4 gr/scf).

General, physical, and design parameters for the precipitators were supplied by USSC and are presented in Table 14. All parameters appear typical of literature values for other open hearth applications. The resistivity value given in Table 14 was determined by USSC consultants through laboratory measurements. Such laboratory data are typically more than an order of magnitude higher than for actual operating conditions. Nonetheless, the actual resistivity should still be well within the accepted range for effective precipitator performance.

The operation and control of the open hearth ESP's are monitored by various meters located in the ESP control room. There are meters for primary current and voltage, secondary current and voltage, and spark rate. During the inspection, one set of readings was taken from the meters. These data are shown in Table 15.

The usefulness of the data shown in Table 15 is limited. The data presented are for only one set of operating conditions, but do provide an indication of the parametric values. It should be noted that each field in a given precipitator is energized differently -- fields 1 and 3

Table 14

GENERAL, PHYSICAL, AND DESIGN PARAMETERS FOR OPEN HEARTH FURNACE ELECTROSTATIC PRECIPITATORS USSC - GENEVA WORKS

Parameter	Specifications
General	Number of Precipitators - 8
	Date Installed - 1955
	Precipitator Type - Plate
	Manufacturer - Research Cottrell
Physical	Number of mechanical sections - 4
	Collection area
	Electrical field 1 - 562 m^2 (6,043.5 ft^2)
	Electrical field 2 - 562 m^2 (6,043.5 ft^2)
	Electrical field 3 - 1,124 m^2(12,087 ft^2)
	Number of gas passages - 34
	Width of gas passages - 20 cm (8 in)
	Flow distribution devices - perforated plates located at inlet and outlet
	Number of HT sections per field - 2
	T-R sets
	field 1 - 1/2 wave, silicon/saturables reactor
	field 2 - 1/2 wave, silicon/transistor
	field 3 - 1/2 wave, silicon/saturable reactor
	DC Voltage - 45 kV design, 35 kV actual
	Control mode - automatic voltage control based on spark rate (200 - 400 sparks/min setting)
	Meters - primary current and voltage, secondary current and voltage, spark rate
Design	Particulate removal efficiency - 95.8%
	Specific collection area - 180 ft^2/1,000 acfm
	Resistivity - 4 x 10^9 ohm-cm @ 205°C
	Velocity - 1.6 m (5.2 ft)/sec
	Precipitation rate parameter - 8.05 cm/sec

Table 15

OPERATING DATA COLLECTED FROM OPEN HEARTH FURNACE ELECTROSTATIC PRECIPITATORS - AUGUST 24, 1976[†]
USSC - GENEVA WORKS

ESP	Field	Primary Voltage Volts	Primary Current Amps	Power kVA	Secondary Current milliamps	Secondary Voltage kV	Spark Rate spm	Power kW	Power Efficiency kW/kVA	Current μA/m²	Current μA/ft²
1	1	240	23	5,500	40	30	380	1,200	21%	0.61	6.6
	2	270	29	7,800	160	34	390	5,400	69%	2.5	26.5
	3	240	33	7,920	80	35	260	2,800	35%	0.61	6.6
2	1	260	30	7,800	NR[††]	35	350	--	--	--	--
	2	260	32	8,300	150	34	5	5,100	61%	1.2	12.4
	3	230	32	7,360	70	32	10	2,200	30%	0.54	5.8
3	1	240	22	5,300	NR	32	260	--	--	--	--
	2	240	26	6,500	160	31	130	5,000	77%	2.5	26.5
	3	220	43	9,500	100	26	115	2,600	27%	0.77	8.3
4	1	240	23	5,500	45	30	310	1,400	25%	0.69	7.4
	2	250	32	8,000	170	27	35	4,600	58%	2.6	28.1
	3	230	35	8,000	80	27	180	2,300	29%	0.62	6.7
5	1	260	25	6,500	NR	35	290	--	--	--	--
	2	270	29	7,800	160	32	280	5,100	65%	2.5	26.5
	3	220	25	5,500	50	31	230	1,500	27%	0.38	4.1
6	1	240	27	6,500	50	30	135	1,500	23%	0.77	8.3
	2	270	32	8,600	180	35	130	6,300	73%	2.8	29.8
	3	230	38	8,700	90	30	300	2,700	31%	0.69	7.4
	7	Not in operation									
8	1	210	12	2,500	25	32	380	800	32%	0.38	4.1
	2	250	20	5,000	110	31	10	3,400	58%	1.7	18.2
	3	200	6	1,200	10	28	375	280	23%	0.07	0.8

† *Data obtained between 2:00 and 4:00 p.m. from ESP control room meters.*
†† *Reading was low or off scale.*

utilize the older saturable reactor transformer-rectifier (T-R) sets, while field 2 uses a transistorized set. Field 3 also energizes twice the collection area of the other two fields.

From Table 15, it appears that fields 1 and 3 in each ESP are operating at relatively low current densities ($<1\mu$ amp/m^2), as compared to other industrial ESP applications. Although no specific data are available for ESP applications for open hearth furnaces, in general, low current density would result in lowered particulate removal efficiencies. The very low current density and power input for the No. 8 ESP is apparent compared to the other ESP's. This may indicate that there are energization problems in that ESP. The relatively low power efficiency (kW/kVA) for fields 1 and 3 in all ESP's is probably an indication of the less efficient energizing units (T-R sets) for those fields.

In addition to energization characteristics, the gas flowrate control which balances the flow between the individual ESP's was reviewed. This control is accomplished by measuring the ESP-induced draft fan motor currents and attempting to balance those currents by adjusting inlet dampers to the ESP's. Since motor current is a function of both pressure drop and flowrate, a flowrate control based on fan motor current alone is useful only if the pressure drop across the individual gas treatment trains is roughly the same. As will be pointed out in the following paragraph, there is probably significant pressure drop variation between individual gas treatment trains. As a result, some ESP's may be handling higher than design flows, while others are handling lower than design flows. This would reduce overall particulate removal efficiency when the open hearth furnaces are at or near maximum operating capacity.

The following observations on ESP maintenance are based on a short visual inspection of the inside of the inactive ESP (No. 7) and discussions with USSC representatives. During the visual inspection the following was found:

1. A large buildup of particulates was observed over the face of the inlet flow distribution plate, covering up approximately 50% to 60% of the total plate surface area. This condition can contribute to significant flow imbalances within the precipitator and cause increased turbulence and pressure drop.

2. Several relatively large particulate deposits (2 to 5 cm thickness) were noted on the collector plates. Such deposits can produce increased turbulence, flow imbalance and pressure drop, as well as affect voltage-current characteristics. These deposits further indicate that the rapping system may not be operating properly. In addition, re-entrainment losses caused by higher gas velocity through constricted flow passages may also result.

USSC representatives indicated that each ESP is taken off-line for cleaning and maintenance every 3 to 4 months. The statements as to the extent of the maintenance provided, however, were not entirely consistent between representatives. Typical maintenance as performed by USSC probably includes removal of broken or malfunctioning corona wires, checking and cleaning insulator wires, and removal of particulate buildup on collection plates as can be accomplished by an air lance. Any significant particulate buildup would probably include continuous, prolonged use of the mechanical rappers. Only if major electrical problems or very severe dust buildup were found would an extensive cleaning program be initiated. USSC did not appear to conduct routine inspections of the precipitators by knowledgeable personnel to check for poor flow distribution, significant dust accumulations, etc.

Scrubbers

The scrubbers used in the open hearth furnace emission control system are USSC-designed and constructed partial-orifice wet scrubbers

[Figure 10]. Initially erected in 1962, the scrubbers were modified during 1973 through 1975 by relocating internal sprays and removing the mist eliminator. USSC reported that this was done to reduce maintenance requirements and provide better mist elimination. Scrubber spray water consists of recycle water from the neutralization/clarification system diluted with plant makeup water. The discharge from the scrubber is pumped to the clarification/neutralization system for treatment.

General and design parameters for the open hearth scrubbers, as supplied by USSC, are shown in Table 16. USSC stated that the scrubbers were originally designed for hydrogen fluoride (HF) removal and were selected because they would provide adequate HF removal and good access for maintenance. However, the use of these scrubbers for particulate removal is questionable for two reasons: particulate removal capability, and mist carryover.

The most questionable design parameter is the reported particle removal efficiency (75%). This efficiency is typically a function of the size of particulate removed and the energy input into the scrubber (pressure drop). The USSC-reported efficiency for these units appears to be much higher than would be anticipated for low pressure drop operations (10 cm W.G.) with the submicron particulates anticipated. The particle size data provided by USSC is limited and is based on laboratory measurements rather than in-situ measurements. However, based on other open hearth operations, the majority of the particulates in the gas stream is expected to be in the submicron size range. This submicron particulate typically requires high scrubber energy inputs (i.e., 50+ cm W.G.) to obtain 75% removal. For example, wet scrubber tests sponsored by the EPA have indicated that even with an energy input of 50 cm W.G., collection of fine particulates would be much less than 50% for $<0.5\mu m$ particles. Although factors other than classical impaction dynamics (i.e. diffusiophoretic and electrophoretic forces) may enhance particulate capture in the treatment system, it is highly questionable that the USSC scrubbers could remove as much as 75% of the particulates.

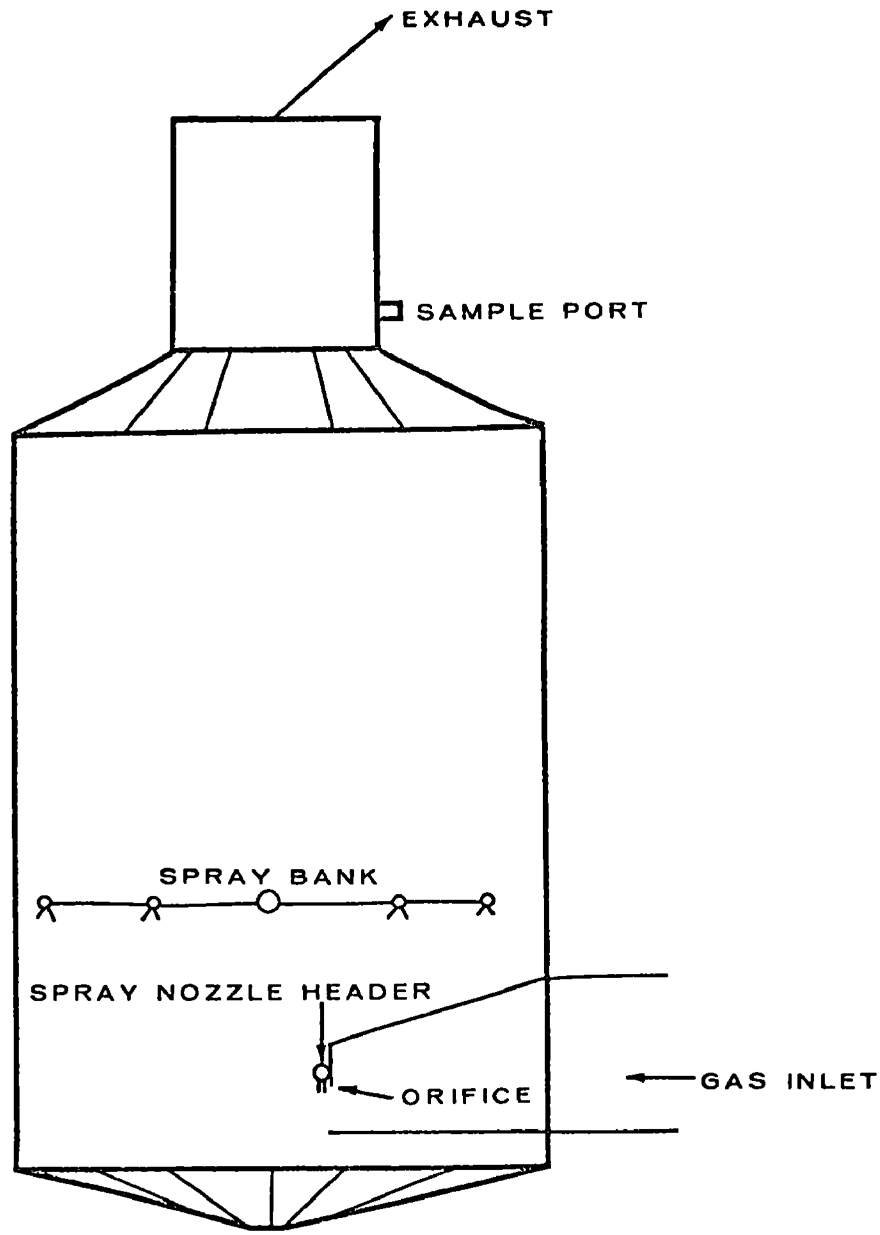

Figure 10. Open Hearth Scrubber – USSC Geneva Works

Table 16

GENERAL AND DESIGN PARAMETERS FOR OPEN HEARTH FURNACE SCRUBBERS USSC - GENEVA WORKS

Parameter	Specification
General	Number of scrubbers - 8
	Date installed - 1962
	Scrubber type - partial orifice
	Manufacturer - USSC
Design	Particulate inlet loading - 0.23 g/m^3 (0.1 gr/scf)
	Particle size - submicron (estimated)
	Particulate removal efficiency - 75%
	Scrubber pressure drop - 10 cm (4 in) W.G.
	Scrubber water rate - 2,500 l(650 gal)/min
	Scrubber gas velocity - 0.85 m (2.8 ft)/sec
	Gas volume - 1,900 m^3/min (67,000 scfm)
	Gas temperature - 200°C
	Gas pressure - 640 mm Hg

A second questionable design feature is the lack of mist eliminators. USSC stated that the bank of sprays located above the orifice sprays [Figure 10] provide adequate mist elimination. However, with a gas velocity of 0.85 m (2.8 ft)/sec, a large portion of <250μm diameter droplets will be carried out with the gas stream. The hollow cone nozzles used in the USSC open hearth scrubbers when operating at 11 to 12 atmospheres (150 to 170 psig) pressure and under evaporating conditions will produce a significant amount of <250μm diameter droplets. These droplets would contain dissolved and suspended solids which would become particulate upon leaving the stack. Based on rough calculations, this droplet carryover could amount to an 0.02 to 0.07 g/m^3 (0.01 to 0.03 gr/scf) addition to the exit particulate concentrations [Addendum C].

Operation of the open hearth furnace scrubbers is not monitored, other than the scrubber water pressure. Two WP-50 single point sampling trains are located on two of the gas treatment trains. However, the utility of the resultant data has been discussed previously. As a result of the lack of operating indicators, the analysis of the open hearth furnace scrubber operations was limited to observation of the exhaust plumes from active scrubbers and the internals of the inactive No. 7 scrubber. The following points were noted during the inspection:

1. The opacity of the plume, after the steam had dissipated, was highly variable. There were, however, many cases when the plume opacity was in the range of 40% to 60%.

2. There was a significant buildup of solids in the No. 7 scrubber unit at the wet/dry interface, just as the incoming gas contacts the orifice spray. The effect of this phenomena on particulate removal is not readily apparent.

3. There was a significant buildup of solids on the scrubber wall just opposite the gas entrance. This would indicate that the

> major portion of the gas was flowing up one side of the scrubber. Consequently, it can be deduced that the gas stream is not well distributed as it reaches the top section of sprays. With the resulting higher velocities and reduced spray coverage, mist carryover would increase and effective particulate removal would decrease.

USSC reported that routine maintenance is performed on the open hearth scrubbers by Company personnel about every 3 to 4 months. The maintenance program involves removing solids deposits, which are predominantly calcium sulfate and calcium fluorides. The areas most affected by these deposits are the inlet orifice wet-dry interface, the scrubber waste slurry discharge drain and the nozzles, piping, and piping supports. Since the recycle water supplied from the clarification/neutralization system is low in total suspended solids and is below saturation with respect to dissolved solids, degradation in the nozzle spray pattern resulting from effects of plugging, scaling or erosion should be adequately minimized with the current 3 to 4 month inspection frequency. Overall, there did not appear to be major maintenance problems of the open hearth scrubbers which would affect nominal particulate removal.

VIII. ROLLING MILLS

The final steel products from the Geneva facility include plate and coiled strip steel, steel pipe, and structural shapes such as I-beams, angles, and channels. The conversion of the open hearth ingots into these products occurs in the various rolling mills.

PROCESS DESCRIPTION

Slab Mill

The ingots produced at the open hearth building are cooled and transported in their molds by railroad car to the slab mill. Here the molds are stripped from the ingots by overhead cranes and placed in reheat ovens known as soaking pits. The function of the soaking pits is to raise the temperature of the steel until it is sufficiently plastic to allow reduction from ingot size by rolling.

At the slab mill there are twenty soaking pits. Sixteen of these units are bottom fired and four are top fired. Each of the twenty pits have a rated capacity of 5×10^6 kg-cal (20×10^6 Btu)/hr heat input. They were originally designed to be fueled with excess coke oven gas. However, under current operating modes, the pits are fueled exclusively with mixed gas, which is natural gas stabilized with blast furnace gas to a heat value of 4,980 to 5,160 kg-cal/m^3 (560 to 580 Btu/scf).

The heated ingots are removed from the soaking pits by overhead crane and placed on a buggy unit. The buggy is used to transport the ingot to the head end of the 110 cm (45 in) diameter slab mill.

The 110 cm (45 in) mill has, until just recently, served the dual role of producing slabs and blooms from ingots. Slabs are the starting point for producing sheet, plate, and strip steel. Blooms are the starting point for producing structural steel shapes. The 110 cm (45 in) mill can roll either shape. Previously the blooms and slabs were then segregated after this mill for final rolling in the appropriate finish mill. USSC has recently completed construction of a new bloom mill which is an integral part of the structural mill. The new bloom mill, discussed in detail later in this section, thus removes the dual rolling duties from the 110 cm (45 in) mill and allows it to be used exclusively for slab rolling. USSC feels that the new bloom mill will eliminate a substantial bottleneck in the production facility and permit optimization of plant production. The following discussion considers the 110 cm (45 in) mill strictly as a slab mill.

Slabs produced in the 110 cm (45 in) mill are edge-treated and sheared to length before being removed to a holding yard. At the holding yard, the slabs are examined and any surface blemishes which are found are removed by hand scarfing. There are no automatic scarfing operations at the Geneva facility. The scarfed slabs are then stockpiled in the holding yard to await finish rolling.

Plate and Hot Strip Mill

The slabs are removed from the storage yard and placed in reheating furnaces. There are four, three-zone reheating furnaces of the pusher design which serve the plate and hot strip mill. Each furnace has three heating zones: the top, bottom, and hearth zones. The hearth zones are fueled with mixed gas exclusively. The top and bottom zones are fueled with mixed gas and/or No. 6 fuel oil. The furnaces each have a rated capacity of 63 x 10^6 kg-cal (250 x 10^6 Btu)/hr heat input.

The plate and hot strip mill is a dual purpose mill which can produce either plate steel or coils of strip steel. Slabs from the reheat furnaces enter the rolling line. They are first subjected to edging and scale breaking operations. The slabs are then passed through a broadside mill which is a Mesta 340 cm (132 in), 4-high mill. This mill reduces the slab thickness and obtains the finished plate width. The rough plate then passes to a reversing rougher, which is also a 4-high mill used to further reduce the rough plate to a thickness suitable for finish rolling.

The rough plate passes through a pair of pinch rollers to six finishing strands. This operation also includes a 4-high mill. On the finishing strands, the plate is reduced to final thickness.

The finished plate passes through a runout area to a leveler which flattens it, and then to the finishing facility. Here the plate is cut to finished length and width. The finished plate is then sent to stockpile. Plate up to 3 m (10 ft) wide and 12 m (40 ft) long can be produced at this facility.

Essentially the same rolling equipment is used to produce steel strip. However, after the strip is leveled it can either be cut into short lengths on a flying shear and stacked by a hot piler or it can be rolled into coils. At Geneva Works there are two Bliss hot strip rotating mandrel downcoilers and one Mesta hot strip stationary mandrel downcoiler which can receive the continuous strip from the mill and produce coils of strip steel.

Structural Mill

With the completion of the new 100 cm (40 in) bloom mill, the structural mill is now an autonomous unit. Ingots are received at this mill in molds, stripped, and placed in the soaking pits by overhead cranes. There are eight soaking pits for the structural mill. Each pit has a rated heat input of 9 x 10^6 kg-cal (36 x 10^6 Btu)/hr and can be fueled with mixed gas and/or No. 6 fuel oil.

Heated ingots are removed from the soaking pits and placed on a buggy by overhead crane. The buggy conveys the ingot to the bloom mill where it is reduced in cross-section to form a bloom.

The blooms are sent to a storage yard where they are inspected for surface defects. If defects are found, the entire bloom is manually scarfed as there are no automatic scarfing machines at this facility. There are ten hand scarfing stations, four to ten of which are operated simultaneously, depending on production rates. The scarfing stations are operated 24 hr/day.

From the storage yard, the blooms are placed in three, three-zone pusher-type reheat furnaces. These reheat furnaces are similar to those used in the plate and hot strip mill in that they have top, hearth, and bottom heating zones. The top and bottom zones are fueled with mixed gas and/or No. 6 fuel oil. The hearth zones are fueled with mixed gas exclusively. The furnaces each have a rated capacity of 50 x 10^6 kg-cal (200 x 10^6 Btu)/hr heat input.

Blooms from the reheat furnaces enter the structural shape rolling line. They first are passed through an 81 cm (32 in) 2-high Birdsboro reversing mill to produce a blank. This blank is then passed through a 66 cm (26 in) 3-stand, 3-high Morgan structural mill to produce the desired structural steel shapes. The structural mill has an annual production capacity of 77,000 m. tons (85,000 tons) and an average daily production capacity of 210 m. tons (236 tons).

Pipe Mill

The pipe mill is located in a separate building situated at the northern end of the Geneva Works. There are two steel pipe production lines in this plant. One line produces pipe ranging in diameter from 10 to 40 cm (4 to 16 in); the second line produces the large diameter pipe ranging from 50 to 100 cm (20 to 40 in). Neither of these lines incorporates furnaces, ovens or other combustion devices since all of the rolling or forming is accomplished cold.

The small diameter line produces steel pipe by a continuous forming and electric-resistance welding process. Strip steel is fed into the head end of the line from coils. The strip is passed through a series of forming rolls which sequentially convert the flat strip into a circular shape. The circular shape is then passed through welding electrodes to form a continuous strand of pipe. The welded pipe is then passed through sizing mills which insure a round finished product of desired diameter. Straightening the pipe also occurs here. After sizing, the pipe is cut to predetermined lengths by traveling saws and transferred to the finishing floor. The lengths of pipe are again straightened, if required, and subjected to special cutting and end finishing, when needed, before being packed for shipment.

The large diameter line produces pipe on a piece-by-piece basis by electric welding of formed plate steel. Steel plates used in the process are received from the plate mill. At the pipe mill, plates are edge-planed to provide square and true edges. The plates are then edge-crimped in a crimping press and transferred to a "U"-ing machine. This device forms the crimped plate into a U-shape using hydraulic presses and a large die. The U-shaped plate is next transferred to the "O"-ing machine, which uses hydraulic pressure and special dies to form the U-shape into an almost closed circular shape. From here the O-shape is sent to welding machines which place inside and outside welded beads along the gap using submerged-arc techniques. The welded pipe section is then sent to an expanding station where it is expanded to final size and roundness by subjecting it to internal hydraulic pressure against a retaining jacket. After expanding the pipe, the hydraulic pressure is reduced and the pipe pressure is tested. The expanded pipe is then routed to the finishing area where it is end-faced and beveled, if being prepared for field welding.

PARTICULATE EMISSION SOURCES AND INSPECTION OBSERVATIONS

A complete inspection was made of the rolling mill facilities. The entire plate and hot strip mill, the 110 cm (45 in) slab mill, and the small diameter pipe mill line were not operating during the inspection. The former was not operating due to emergency repair of the slab mill. The small diameter pipe mill was not operating because product inventory was high. The structural mill and the large diameter pipe mill were observed in operation.

The rolling mill operations appear to contribute relatively small amounts of particulate emissions to the overall emissions from the Geneva Works. The largest potential emission sources are the eight soaking pits in the new 100 cm (40 in) bloom mill and the seven slab and bloom reheat furnaces, all of which can burn No. 6 fuel oil. The air-to-fuel ratio control for these units is accomplished by manual adjustment. There are no stack gas opacity meters on these systems so there is no reliable method to permit the operators to maintain clean burning stacks.

The other potential sources of particulate emissions related to the rolling operations are the hand scarfing stations in both the plate and hot strip mill and the structural mill. Scarfing was observed at both of these locations during this inspection. Some scarfing-related fugitive emissions did escape from the louvers in the roofs covering these areas. The magnitude of these emissions did not appear significant when compared with other particulate emission sources at the Geneva Works.

IX. SLAG HANDLING

All slag produced at the blast furnaces and open hearth furnaces at the Geneva Works is processed at a plant adjacent to the northwest end of the steel production operations. The slag processing facilities are operated under contract between USSC and the Heckett Engineering Company. The Geneva plant is one of several similar operations carried out by Heckett throughout the world. The primary objective is to recover metallics (iron and steel) from slag. Additionally, at the Geneva plant non-metallics from the slag are processed to produce aggregates for road building materials and for railroad ballast. At Geneva, Heckett employs about 70 people, operating 16 hr/day, 5 days/week.

Slag from either the blast or open hearth furnace is transported to the Heckett plant by USSC vehicles. Although some metallics are recovered from the blast furnace slag, the bulk of the metallics are recovered from the open hearth slag. Thus, Heckett operates two processing lines, or "sides," the open hearth and blast furnaces "sides."

PROCESS DESCRIPTION

Open Hearth Side

A flow diagram of the process is shown in Figure 11. Throughput is about 180 m. tons (200 tons)/hr. Hot open hearth furnace slag is off-loaded from USSC trucks and cooled for 3 to 4 days prior to processing. Simple lawn sprinklers are used to cool the slag and assist in reducing potential dust emissions. A magnet is used to separate large metallic pieces from the non-metallic or mixed material and these larger pieces are returned to the open hearth furnaces. The remaining material

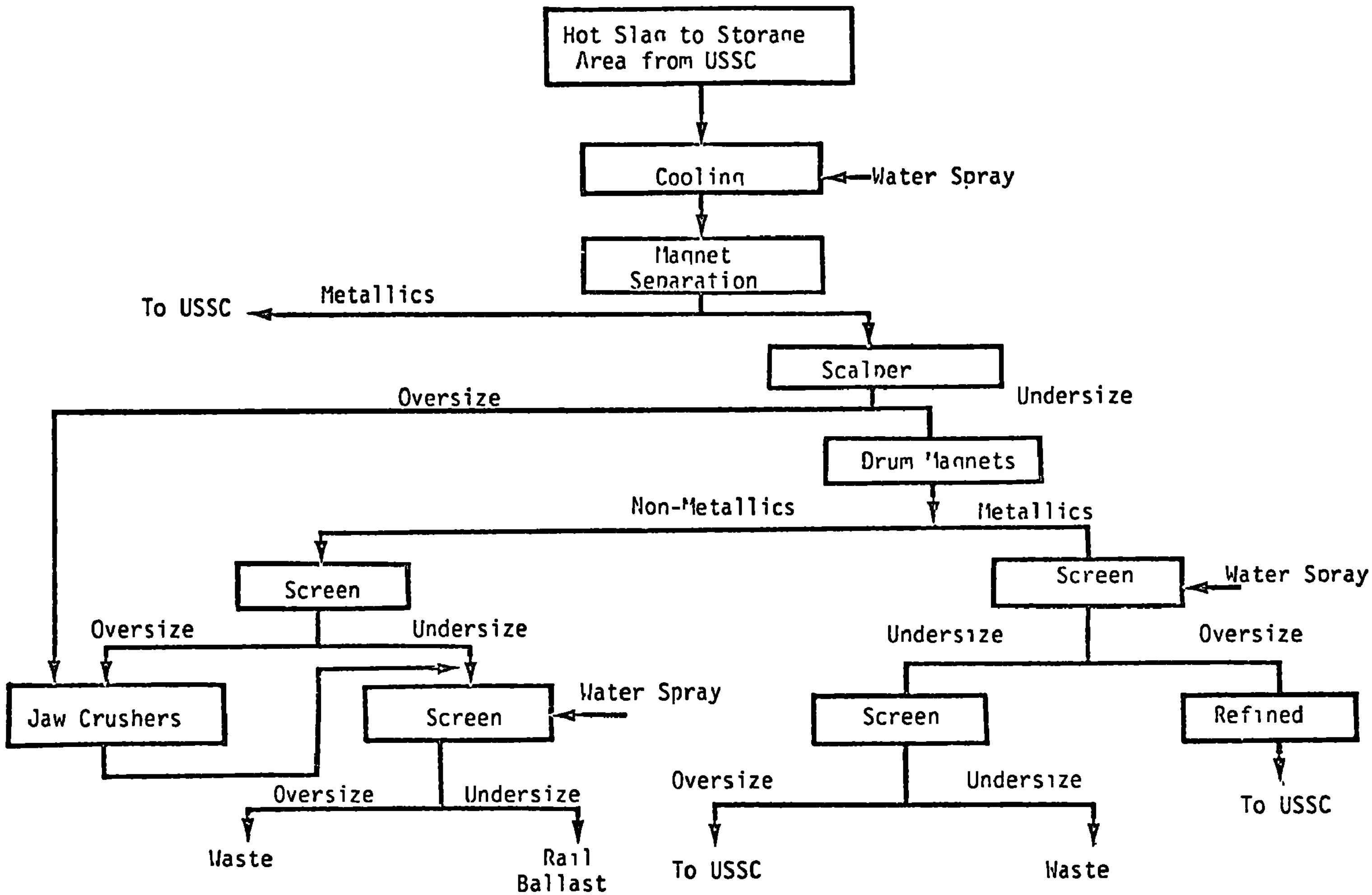

Figure 11. Open Hearth Slag Processing Flow Diagram

Heckett Engineering Company

is moved by front-end loader to one of two feeders which transfer the material to belt conveyors. The material passes through "scalpers" which separate all material greater than 30 cm (12 in). Material smaller than 30 cm (12 in) is conveyed through drum magnets which separate non-metallic material from metallic material.

The non-metallic material passes through screens which separates material greater than 10 cm (4 in). Oversize material passes through a jaw crusher and then rejoins the undersize material to be screened again. Material greater than 2.5 cm (1 in) is wasted, while undersize material is sold as railroad ballast.

Metallic material separated by the drum magnets is screened to segregate all material greater than 12.5 cm (5 in). The oversize material is "refined" by passing slowly through a "barrel," a rotating drum where non-metallic material is removed by impact with the drum sides, as well as the other material in the drum. Retention time in the drum is about 30 minutes. The refined metallics are then transported to USSC for melting in the open hearth furnaces. The undersize material is screened and all material less than 0.9 cm (3/8 in) is wasted. Oversize, ranging from 0.9 cm (3/8 in) to 12.5 cm (5 in), is transported to USSC for melting in the blast furnaces.

Blast Furnace Side

A flow diagram of the process is shown in Figure 12. Throughput was about 180 m. tons (200 tons)/hr. However, plans for major process changes to be made in October 1976 increased the capacity to about 360 m. tons (400 tons)/hr.

Molten slag from the blast furnaces is transported by rail and dumped at the Heckett site in one of two "pits." The partially cooled

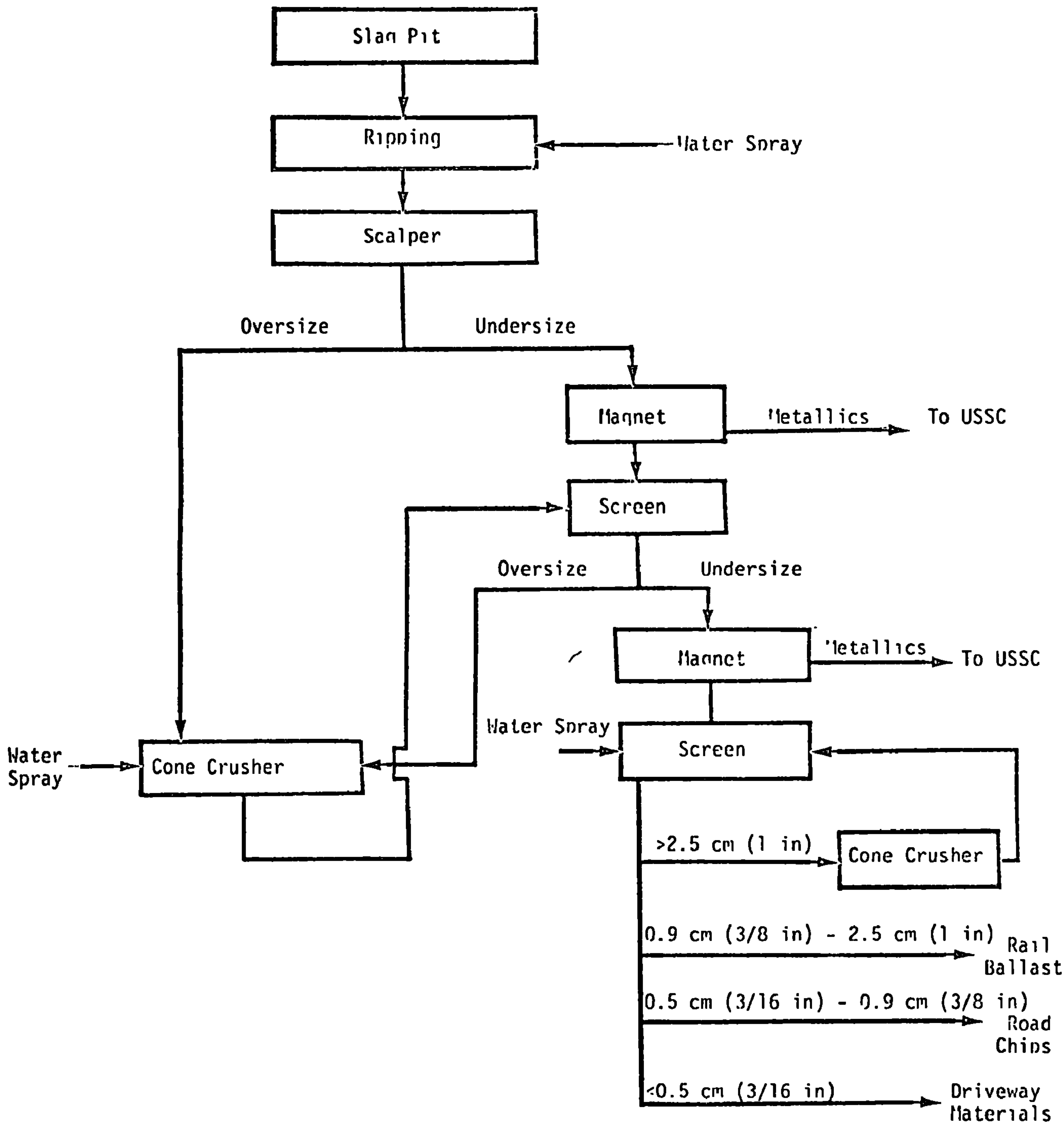

Figure 12. Blast Furnace Slag Processing Flow Diagram

Heckett Engineering Company

material is "ripped," or broken up by USSC-operated bull dozers, and then sprayed with water to complete the cooling process and to assist in reducing fugitive emissions. The cooled wet slag is moved by front end loader from the pit to a hopper from which it moves over a "scalper" which removes all material greater than 28 cm (11 in). Undersize material passes by a magnet which removes the limited amount of metallic material. The non-metallic material is screened to remove any material greater than 10 cm (4 in). The oversize passes through a cone crusher and is returned to the screen. Undersize is conveyed to a crusher building and passes by a second magnet for further removal of the limited metallics material.

After removal of the metallics, the material passes through screens which segregate the material into four size categories (-0.5 cm, +0.5 cm to -0.9 cm, +0.9 cm to -2.5 cm, and +2.5 cm). The latter material is processed in a cone crusher and returned to the screens. The +0.9 cm to -2.5 cm material is sold as railroad ballast; the +0.5 cm to -0.9 cm material is sold as road chips, the material used as overlay on asphalt roads and streets. The smaller material (-0.5 cm) is sold for use on driveways or for "de-icing". The road chips must be cleaned prior to sale and this is accomplished by "wet screening," or washing.

PARTICULATE EMISSION SOURCES AND CONTROL SYSTEM

Virtually all phases of the operation are potential sources of particulate emissions. These include the roadways used for hauling materials, loading and unloading of raw and finished materials, screening and crushing operations, and conveying materials between process steps.

The primary method for abatement of emissions is the use of water. The slag is thoroughly wetted prior to beginning of processing on either side. On the open hearth side, water sprays are utilized on the final screening of the non-metallic material and on the screen prior to barrel-refining the metallic material. Water sprays are used on the blast furnace side prior to final screening. Location of water spray devices is shown as Figures 11 and 12. To control dust on roadways a 13,000 liter (3,500 gal) water truck is operated virtually continuously.

INSPECTION OBSERVATIONS

At the time of the July 1 inspection, all processes were in operation. The water spray systems were adequately operating to prevent fugitive dust emissions from the various crushing and screening operations. Where roadways had been freshly watered, dust emissions were adequately controlled. Dumping of waste materials was being conducted at the north end of the USSC property about 300 m (300 yards) south of an NEIC air monitoring station (No. 3), and no fugitive dust was observed from the dumping operation. However, the roadway to the dump site had not been watered, and fugitive dust was observed from movement of the trucks. Fugitive dust had been observed previously from this area, as well as from other Heckett roadways.

X. POWER PLANT

USSC operates a power plant at the Geneva Works which produces steam, electric power, and compressed air for use throughout the complex. Five boilers supply steam to drive electric generation and compressing equipment. Electrical power is generated with a single General Electric 50,000 kW turbogenerator. Additional electrical power is purchased from the Utah Power and Light Company on an as-needed basis. Four Ingersoll-Rand turbo blowers, each rated at 2,700 m^3/min (95,000 acfm) up to 2.5 kg/cm^2 (35 psig), provide compressed air for use primarily in the blast furnaces.

PROCESS DESCRIPTION

Small Boiler Units

There are two Babcock and Wilcox Sterling-type water tube boilers, Units 2 and 3, each rated at 68,000 kg (150,000 lb) steam/hr at a delivery pressure of 32 kg/cm (450 psi) and a temperature of 400 °C (750°F) at the superheater outlet. Each boiler has a heating surface of 1,170 m^2 (12,536 ft^2).

These boilers can be fueled with mixed gas, blast furnace gas, or coal. The boilers have travelling grates and normally operate with a bed depth of 11.5 to 12.7 cm (4.5 to 5 in) when operating on coal. The rated heat input for each boiler is 52 x 10^6 kg-cal (206 x 10^6 Btu)/hr.

Boilers 2 and 3 share a common exhaust stack. This tapered stack is 61 m (200 ft) high and 3.3 m (11 ft) in diameter at the top. There are no stack gas opacity meters on this stack or on the ductwork leading from the boilers to the stack.

Large Boiler Units

Boilers 4, 5, and 6 are Babcock and Wilcox Sterling-type water tube units which are each rated at 136,000 kg (300,000 lb)/hr of steam at a delivery pressure of 32 kg/cm (450 psi) and a temperature of 400°C (750°F) at the superheater outlet. These boilers each have a heating surface of 2,070 m^2 (22,270 ft^2).

These three boilers can be fueled with mixed gas, blast furnace gas, or pulverized coal. When on the latter fuel, the coal is introduced into the boilers through direct entry, front wall burners which are inclined at about 60° downward into the combustion zone. Each boiler has a rated heat input of 100 kg-cal (412 x 10^6 Btu)/hr.

Each of the three boilers has its own waste gas stack. The tapered stacks, which are identical, are 3.3 m (11 ft) in diameter at the outlet and 61 m (200 ft) high. Each of the boilers is equipped with a Bailey Bolometer stack gas opacity detector which is located in the breeching between the boiler and the exhaust stack.

PARTICULATE EMISSION SOURCES AND CONTROL SYSTEM

Each of the five boilers has the potential for emitting significant quantities of particulate matter, especially when fueled with coal. There are no emission control devices currently installed on these stacks.

USSC has reportedly contracted with Wheelabrator, Inc. for the design and installation of a single baghouse control system to treat the exhaust gases from boilers 4, 5, and 6. USSC has proposed to operate these boilers with pulverized coal exclusively once the baghouse is installed. Boilers 2 and 3 would be fueled on blast furnace gas or mixed gas only after the baghouse is installed. There would be no control equipment installed on these two boilers.

The new baghouse to be installed on the exhausts from boilers 4, 5 and 6 will be a Wheelabrator-Frye, Inc. Model 264, series 8RS, size 1618D Dustube Dust Collector. The unit will have fiberglass cloth bags, operate at 290°C (550°F), have an air-to-cloth ratio of 3.2:1 at a design head loss of 12.7 to 17.8 cm (5 to 7 in) water, and be designed for a particulate collection efficiency of 99.6%.

XI. MISCELLANEOUS OPERATIONS

There are several operations at the Geneva Works which, due either to their intermittent operation or size, constitute a relatively small potential impact on the total particulate emissions from this complex. These sources are discussed below.

FOUNDRY

USSC operates a foundry which produces ingot molds and stools, slag and hot metal ladles, and miscellaneous castings for use within the complex.

The majority of the castings made in the foundry are ingot molds and stools used in the casting of steel ingots. The foundry schedules about 360 m. tons (400 tons)/day of hot metal from the blast furnaces for the production of ingot molds. The average life of an ingot mold is reported to be 47 casts before cracks occur or some irregularity requires that it be retired from service. The retired mold is recycled as feed scrap to the open hearth furnaces. The foundry prepares green sand cores and flasks for casting of ingot molds. The cores are baked in core baking ovens, each fueled by natural gas and each rated at 5×10^6 kg-cal (20×10^6 Btu)/hr heat input.

The majority of the castings done at the foundry use green molding sands. A typical green sand composition is 2.5% bentonite clay, 1.7% gilsonite (a coal-like material), 2% C-grade coal, 1.3% fireclay, 27% new sand, and 65.5% recycled sand. Recycled sand is obtained by reclaiming the green sand from the ingot mold flasks after casting.

There are three National Hydrofilter wet scrubber systems on the sand reclaiming system at the foundry. The smaller system has a design capacity of 600 m^3/min (21,000 acfm); the larger two units are rated at 960 m^3/min (34,000 acfm). USSC has no emission test data on these scrubbers. They were reportedly designed to reduce the particulate concentration in the exhuast gases to 0.11 g/m^3 (0.05 gr/scf) or better.

The foundry also prepares some molds and cores for steel castings such as slag ladles. These molds are transported to the pouring floor of the open hearth building and cast at this location.

There is a small gas-fired reverberatory furnace located at the foundry building. This furnace is used to melt aluminum and copper for specialty casts required at the facility.

Table 17 lists a typical month's production at the foundry during 1975. It should be noted that the majority (92%) of the tonnage cast at the foundry is accounted for by ingot molds and stools used at the Geneva facility.

During the inspection, ingot mold casts were observed. Some fugitive particulate emissions were noted during the cast period, but these emissions were not considered significant when compared with other sources at the complex. The sand reclaiming operations were not being conducted during the inspection period. Mold shakeout and sand reclaim took place during the night turn.

PIG CASTING MACHINE

There is a Pittsburg Coal Washer Company two-strand pig casting machine at the Geneva Works. It is east of the open hearth building, just north of the foundry area. This machine casts 18 kg (40 lb) iron

Table 17

TYPICAL MONTHLY PRODUCTION AT FOUNDRY - 1975
USSC - GENEVA WORKS

Product	m. tons	tons
Ingot Molds	5,000	5,510
Ingot Stools	1,380	1,522
Ingot Molds for Torrance, Calif. plant	71	78
Miscellaneous Iron Castings	161	177
Miscellaneous Steel Castings	290	318
Miscellaneous Aluminum Castings	∿1	1
Miscellaneous Copper Castings	∿1	1

pigs. The pig machine is used whenever hot metal is produced at the blast furnaces in quantities in excess of that which can be used by the open hearth furnaces. The excess hot metal is cast into pigs which can be stockpiled and later charged to the open hearths as solid iron. The pig machine has a maximum capacity of 18 m. tons (20 tons)/hr and has an average production of 1,700 m. tons (1,900 tons)/month.

The pig casting machine is a potential source of fugitive particulate emissions when the hot metal is transferred from the ladles to the pig molds. The strands are not enclosed in a building, so any particulate emitted is discharged directly to the atmosphere. The pig casting machine was not in operation at the time of the inspection.

CHEMICAL COKE PLANT

A small portion of the coke produced at the Geneva Works is further processed to produce a dried and homogeneously sized grade of coke which is sold as chemical coke. This material is sold to chemical companies such as Stauffer Chemical.

At the chemical coke plant, coke is crushed in a two-stage roll crusher (Gunlach Model 70-DA) and screened to produce 1.9 x 0.5 cm (3/4 x 3/16 in) particles. This material is then dried in two gas-fired Jefferey vibrating conveyors, 1.5 m (5 ft) wide and 12.2 m (40 ft) long. The driers can be operated in series or parallel. The dried product is transferred by conveyor belt to storage hoppers and ultimately shipped by rail.

The production capacity of the chemical coke plant is 127 m. tons (140 tons)/day.

The chemical coke plant was in operation during the inspection. Considerable amounts of particulate matter were discharged from the dryer and crusher exhaust stacks.

XII. EMISSIONS INVENTORY

An emissions inventory for the USSC Geneva Works has been developed from: a) production and operational data supplied by the Corporation in letters to the Environmental Protection Agency;[1,2] b) data gathered by EPA and contractor personnel during plant visits the weeks of August 16 and 23, 1976; c) EPA pubication AP-42, Compilation of Air Pollutant Emission Factors;[3] and d) unpublished references including two tables of emission factors -- one compiled by EPA,[4,5] and the other by Midwest Research Institute[6] -- and a fugitive dust study conducted by Midwest Research Institute.[7]

The emissions inventory for the Geneva Works was compiled according to the following stipulations: only particulate emissions were inventoried; emissions were based on actual production data for the summer (June, July, and August)[1] of 1976; and emissions were calculated on an average daily rate (tons/day) for each month and for each source.

The following sources were inventoried:

- Coke plant
  - coal handling
  - charging
  - oven/door leaks
  - pushing
  - quenching
  - combustion
  - coke handling
- Open hearth furnaces
  - stack
  - fugitive (taps, scrapcharge, hot metal charge, flushing, bottom repair, leaks, etc.)
- Blast furnaces
  - material loading
  - material dumping
  - leaks
  - building monitors
  - off-gas combustion
- Boilers
  - gas combustion
  - coal combustion

Sintering Plant
- stack
- fugitive

Rolling Mills
- fugitive (scarfing)
- combustion

Nitrogen plant
- prilling
- dryer and coolers

Fugitive Dust
- unpaved roads
- paved roads
- open areas
- storage piles

Table 18 is a summary of the NEIC-calculated particulate emissions itemized by source. A more detailed breakdown of emissions estimates and the calculations used to obtain them is contained in Addendum D. Table 19 is a comparison of particulate emissions submitted by USSC to EPA in a letter dated July 8, 1976[1] and those calculated by the NEIC and summarized in Table 18. The calculations submitted with the USSC emissions data are contained in Addendum E.

The main difference between the NEIC and USSC total daily emissions estimate totals is due to the NEIC inclusion of fugitive (unpaved roads, paved roads, open areas and storage piles) sources in its inventory. However, the differences in emissions from the process sources (coke plant, blast furnaces, open hearth furnaces, sintering plant, rolling mills, boilers, and nitrogen plant) are also large. With the exception of the coke plant where production rates are known to be nearly the same for both inventories, production rate differences may account for some of the differences between the two inventories. Most production rates are not referenced in the USSC inventory.[1] However, the more significant differences are probably due to other reasons and are discussed below on a source-by-source basis.

For the coke plant emission estimates, the differences can be attributed to the use by the NEIC of updated emission factors.[4] The updated factors decrease the allowable reduction in quench emissions due to baffles from 75% to 50% and include new factors for combustion and

Table 18

SUMMARY OF EPA-NEIC
PARTICULATE EMISSIONS ESTIMATES
SUMMER 1976
USSC - GENEVA WORKS

Source	m. tons/day	tons/day	% of Total
Coke Plant	5.90	6.50	17.12
Blast Furnaces	6.29	6.93	18.25
Open Hearth Furnaces	3.88	4.27	11.25
Sintering Plant	2.22	2.45	6.45
Rolling Mills	0.54	0.60	1.58
Boilers	0.38	0.42	1.11
Nitrogen Plant	0.63	0.69	1.82
Unpaved Roads	2.10	2.31	6.08
Paved Roads	0.41	0.45	1.18
Open Areas	1.70	1.87	4.92
Storage Piles	10.42	11.48	30.23
Total	34.47	37.97	100

Table 19

COMPARISON OF PARTICULATE EMISSIONS ESTIMATES
USSC AND EPA-NEIC EMISSIONS INVENTORIES
USSC - GENEVA WORKS

Source	NEIC		USSC	
	m. tons/day	tons/day	m. tons/day	tons/day
Coke Plant	5.90	6.50	4.50	4.96
Blast Furnaces	6.29	6.93	0.06	0.07
Open Hearth Furnaces	3.88	4.27	1.09	1.20
Sintering Plant	2.22	2.45	0.84	0.92
Rolling Mills	0.54	0.60	0.36	0.40
Boilers	0.38	0.42	7.97	8.78
Nitrogen Plant	0.63	0.69	N.C.†	N.C.
Unpaved Roads	2.10	2.31	N.C.	N.C.
Paved Roads	0.41	0.45	N.C.	N.C.
Open Areas	0.70	1.87	N.C.	N.C.
Storage Piles	10.42	11.48	N.C.	N.C.
Total	34.47	37.97	14.82	16.33

† *N.C. - not calculated*

coke handling. Also the 60% emission reduction factor for oven and door rehabilitation, which appears in the USSC inventory,[1] was not used in the NEIC inventory. During the NEIC August 1976 inspection of the coke plant, visibility from one end of the batteries to the other was observed to be significantly obscured by smoke from oven and door leaks.

For the blast furnace emission estimate differences, the USSC inventory included only off-gas combustion emissions, while the NEIC inventory included material loading, material dumping, furnace leaks, and building monitor emissions, in addition to off-gas combustion emissions.

The differences in the open hearth furnace and sintering plant emissions estimates can be attributed to differences in the method of calculation. The USSC emissions from these sources were calculated from in-stack monitoring data.[1] The NEIC emissions from these sources were calculated from updated emission factors.[4] As a result of the inspection, the accuracy of the data derived from the in-stack monitoring equipment has been questioned. In addition, the NEIC emissions estimates include the calculated effect of fugitive emissions from these two facilities.

The differences in the rolling mill emissions are small and can probably be attributed to the fact that the NEIC inventory includes scarfing emissions and the USSC inventory does not.

The large difference between the NEIC and USSC inventories for the boiler emissions can be attributed to the fuels' use factors that the calculations are based on. The NEIC boiler emission calculations are based mainly on the summer use of natural gas to fire the boilers, while the USSC boiler emission calculations are based on yearly data and include winter data, during which coal is used to fire the boilers.

ADDENDA

ADDENDUM A

ADDENDUM 1 TO STUDY PLAN FOR AIR QUALITY MONITORING AT USSC-GENEVA WORKS

AIR QUALITY MONITORING
USSC-GENEVA WORKS, UTAH

INTRODUCTION

The purpose of this addendum is to provide a more definitive description of the required activities, time scheduling, and study responsibilities for Phase II of the USSC Geneva Works Study. Phase II will consist of three activities: (1) updating the existing emissions inventory of all sources within the property boundaries of the USSC Geneva Works, (2) conducting emission characterization studies, and (3) evaluating the potential for and conducting emission source tests and remote sensing activities as required to fulfill the objectives of the Study Plan. Phase II will be initiated immediately and will extend beyond the completion of Phase I activities. The scope of each activity of Phase II is described below.

EMISSION INVENTORY

This activity will be comprised of three inseparable tasks: (1) an evaluation of the basis of the existing emissions inventory and updating of it based on newly acquired data, (2) thorough process inspections to observe process operations and control systems, and

(3) an evaluation of the in-stack monitoring equipment and the data derived from it. The primary objective of Tasks (2) and (3) is to aid in the accomplishment of Task (1).

To initiate Task (1), EPA Region VIII will send USSC Geneva Works a Section 114 letter asking for essential information, as follows:

(1) background information used to develop the USSC Geneva Works emission inventory for 1974 particulate matter;

(2) all Company continuous monitoring data for the open hearth and sintering stacks collected during the study period;

(3) all particulate matter ambient air quality data for all USSC Geneva Works sampling sites collected during the study period;

(4) process block flow diagrams, control equipment design parameters, and daily operating records for process and control equipment.

The Company will be requested to periodically report emissions and air quality data collected during the study period to the EPA.

Process inspections [Task (2)] will be conducted by the EPA-NEIC during mid to late August. The process inspections will be conducted in an orderly series. Each inspection will be devoted to a major process unit. USSC will be provided a schedule of inspections and be requested to discuss the process and control equipment information available at the time of each process inspection. A tentative listing of process units for the inspections is as follows:

1) open hearth furnaces
2) sintering and ore preparation operation
3) blast furnaces
4) coke plant
5) coke by-products and benzol plant
6) nitrogen plant
7) rolling mills and boilers
8) Heckett Engineering facility*

Following the completion of the individual inspections, time will be allocated to discuss with the Company miscellaneous air pollution sources and to clarify outstanding issues.

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*The facility located on USSC property which crushes and grinds USSC Geneva Works slag into aggregate.

Task (3) will include an EPA-NEIC evaluation of the in-stack monitoring equipment following receipt of pertinent information and completion of the process inspections. The emission monitoring equipment will be evaluated for its comparability with the minimum emission monitoring requirements of 40 CFR Part 51, Appendix P, and accepted emission monitoring methods, as well as for operational and maintenance procedures. In addition, during the process inspections, the EPA-NEIC will evaluate the suitability of the individual process units to be emission tested. Suitability will be determined as a function of sampling port size and location, flow disturbance locations in the exhaust gas streams, estimated accuracy of a test, etc.

EMISSION CHARACTERIZATION

The primary objective of this activity is to enable correlation of particulate catch at the air quality monitoring sites with the particulate matter emitted by the individual process units at USSC Geneva Works. Individual tasks will include collection of particulate samples at or near each individual process unit and a quality assurance audit of all particulate matter air quality data collected in the vicinity of USSC Geneva Works during the study period--EPA, State, and Company. The first task will be conducted in early September for approximately three weeks. The second task will be conducted as time permits during the study period.

The particulate samples collected at or near each process unit will be used to identify specific physical and/or chemical characteristics of that particular emission. An attempt will be made to gather at least two samples at or near each process unit during each unique phase of that unit's process cycle. A list of the process units, process cycle phases, and the minimum number of particulate samples to be taken will be completed and distributed following the completion of the process inspections and prior to the initiation of this activity. During this activity, visible emission observations will be made during the period particulate samples are obtained.

Each EPA particulate air quality monitoring site will be routinely audited. As time permits during the study period a quality assurance audit will be conducted for State and Company monitoring and laboratory facilities. A quality assurance audit will include an equipment calibration check, an evaluation of the site location, and a check on laboratory procedures.

SOURCE TESTING AND REMOTE SENSING

A decision on whether or not to source test will be based on the findings of the air quality monitoring network and the evaluation of the in-stack monitoring equipment. However, some testing, such as at the open hearth furnace roof monitors and at the sinter plant transfer points, may be conducted prior to the completions of Activities (1) and (2) [Emission Inventory and Emission Characterization]. Any other actual source testing will not take place until after the process inspections.

Remote sensing techniques, including aerial photography and/or plume tracking/opacity LIDAR, will be employed during the emission characterization activity to identify source/receptor relationships.

ADDENDUM B

EPA JUNE 8 AND NOVEMBER 4, 1976 LETTERS TO USSC-GENEVA WORKS

ENVIRONMENTAL PROTECTION AGENCY
REGION VIII
SUITE 900, 1860 LINCOLN STREET
DENVER, COLORADO 80203

June 8, 1976

United States Steel Corporation - Geneva Works
P. O. Box 510
Provo, Utah 84601

ATTENTION: Mr. H. A. Huish, General Superintendent

RE: United States Steel Corporation - Geneva Works

Dear Mr. Huish:

Pursuant to the authority contained in Section 114 of the Clean Air Act, as amended, (42 U.S.C. 1857 et seq), we are formally requesting that the following information on the Geneva Works be provided to this office. The information requested is required in the development of implementation plans under Section 110 of the Clean Air Act and for a determination of attainment of ambient air standards.

The data requested in items A through D below should be submitted not later than 30 days following receipt of this letter. Process and monitoring data requested in items E through G below should be submitted for the period June 1 through October 1, 1976, by the 10th of the month following the month the data was collected.

Please provide:

A) all background information (emission and production data, calculations, assumptions, etc.) used to develop the estimated 1974 particulate emissions inventory submitted by USSC to EPA Region VIII.

B) the description (manufacturer, type, model number), and location (number of diameters upstream and downstream from flow disturbances) of the continuous emission monitors on the open hearth scrubber and sintering plant scrubber stacks.

C) the description (manufacturer, type, model number), and location on a map of all ambient air monitoring sites owned and/or operated by USSC, Geneva Works.

D) control equipment and process data listed below:

1) block flow diagrams for:

a) coke by-products plant

b) benzol plant

c) nitrogen plant

2) electrostatic precipitators

   a) manufacturer, type, model number

   b) manufacturer's guarantees, if any (i.e., percent efficiency at 10 microns, grains/scf,* lbs/hr)

   c) date of installation or last modification and a detailed description of the nature and extent of the modification

   d) description of cleaning and maintenance practices, including frequency and method

   e) design and actual values for the following variables:

      1) current (secondary - amps)

      2) voltage (secondary and primary)

      3) rapping frequency (times/hr) and intensity (psig)

      4) collection plate area (ft^2)

      5) number of stages

      6) particulate resistivity (ohm-centimeters)

      7) conditioning agents added and amount (lbs/hr)

      8) effective migration velocity (ft/sec)

      9) gas flow rate (scfm)

      10) operating temperature (°F) and pressure (psig)

      11) inlet particulate concentration and particle size distribution (lbs/hr) or grains/scfm)

      12) outlet particulate concentration and particle size distribution (lbs/hr or grains/scfm)

      13) pressure drop (inches of water)

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* *State standard conditions used for temperature and pressure.*

14) gas velocity (fps)

15) spark rate

f) quantity of fines removed or recycled per day

g) collection plate height, collection plate length, discharge electrode total length, number of flow passages, width of flow passages,total number of bus sections and number in series with gas flow

h) flow distribution devices (location and type)

3) scrubbers

a) manufacturer, type, model number

b) manufacturer's guarantees, if any (i.e., percent efficiency at 10 microns, grains/scf, lbs/hr)

c) date of installation or last modification and a detailed description of the nature and extent of the modification

d) description of cleaning and maintenance practices, including frequency and method

e) scrubbing media (composition)

f) design and actual values for the following variables:

1) scrubbing media flow rate (gals/min) vs. gas flow rate (scfm)

2) pressure of scrubbing media (psig)

3) gas flow rate (scfm)

4) operating temperature (°F) and pressure (psig)

5) inlet particulate concentration and flow rate (lbs/hr or grains/scfm)

6) outlet particulate concentration and flow rate (lbs/hr or grains/scfm)

7) pressure drop (inches of water)

8) gas velocity (ft/sec)

9) pressure drop vs. particle collection efficiency

g) dimensions of scrubber (vertical, horizontal), location of spray nozzles, flow distribution devices, details of scrubber internals

h) sketch or plan of scrubber

i) type of pollutants removed

j) mist eliminator (type, superficial gas velocity, location, spray rate and operation)

4) cyclones

a) manufacturer, type, model number

b) manufacturer's guarantees, if any (i.e., percent efficiency at 10 microns, grains/scf, lbs/hr)

c) date of installation or last modification and a detailed description of the nature and extent of the modification

d) description of cleaning and maintenance practices, including frequency and method

e) number of cyclones and physical arrangement (include a diagram, if available)

f) dimensions of cyclone (diameter, length)

g) inlet temperature, velocity (ft/min), flow rate (cfm)

h) quantity of material removed or recycled per day

i) approximate inlet particle type, specific gravity, and size distribution

E) process data listed below reflecting daily averages:

1) coke plant

a) amount of coal charge by battery (tons)

b) coking time - average for battery

c) number of charges and pushes for each battery

2) blast furnaces

a) amount of ore charged by furnace (tons)

b) amount of agglomerates charged by furnace (tons)

c) number of slag and hot metal taps by furnace

d) furnace pressure recorder data or estimate of total elapsed time and time of day by-pass valve is open for each furnace

e) the frequency, total elapsed time and time of day top gas dust removal equipment is by-passed, if applicable

3) open hearth furnaces

a) production rate by furnace (tons)

b) number of charges and taps by furnace

c) duration and amount of oxygen lancing by furnace per heat

d) percent of hot metal and of cold scrap charged, by furnace

e) frequency, total elapsed time and time of day control equipment is by-passed or non-operational

f) the number of bottom repairs, length of down time and time of day repair takes place by furnace

4) sintering plant

   a) production rate (tons)

   b) frequency, total elapsed time and time of day control equipment is by-passed or non-operational

   c) average number of start-ups and time of start-up

   d) approximate ratio of charged materials in sintering operation

5) rolling mills

   a) tonnage scarfed

   b) frequency, total elapsed time and time of day control equipment is by-passed or non-operational, if applicable

   c) composition and amount of gas used to fire soaking pits

6) coke by-products and benzol plant

   a) production rates (tons or scf)

7) nitrogen plant

   a) production rates (tons)

8) boilers

   a) composition and amount of fuel used to fire boilers

F) the data from the continuous emission monitors on the open hearth and sintering plant scrubber stacks, as well as any emission test data conducted at any process unit.

G) the particulate matter data from all ambient air monitoring sites owned and/or operated by USSC, Geneva Works.

Any questions relating to this request should be brought to the attention of Mr. Robert King (303/234-5306) or Mr. Jonathan Dion (303/234-4658) of the United States Environmental Protection Agency - National Enforcement Investigations Center, Denver, Colorado.

Sincerely,

John A. Green
Regional Administrator

cc: Dr. Philip X. Masciantonio
Director, Environmental Control
U.S. Steel Corporation
600 Grant St., Pittsburgh, PA 15230

ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF ENFORCEMENT
NATIONAL ENFORCEMENT INVESTIGATIONS CENTER
BUILDING 53, BOX 25227, DENVER FEDERAL CENTER
DENVER, COLORADO 80225

DATE: November 4, 1976

Mr. H. A. Huish
General Superintendent
United States Steel Corporation
Geneva Works
P. O. Box 510
Provo, Utah 84601

Dear Mr. Huish:

As a result of the recent on-site inspections conducted by NEIC personnel at the Geneva Works, we are in need of additional information to complete studies of the air pollution control equipment, process operation, and emissions inventory.

The following information is needed.

A. Blast Furnaces

1) How is material transferred from coke storage, ore storage, sinter storage to the skip hoists?

2) What was the hot metal production from the blast furnaces for June, July, August and September of 1976 (tons/month)?

3) What is the design data (type manufacturer, model number, design and actual flow rates and efficiency) on cyclones, scrubbers, and ESP's used as blast furnace gas cleaning devices?

4) Please provide test data on BF gas composition and particulate content.

B. Sintering Plant

1) Please provide the following information on the sinter plant cyclones:

a) manufacturer and model

b) height of cyclone (ft.)

c) diameter of cyclone (ft.)

d) expected variation in temperature and pressure of inlet gas (°F, psig)

e) diameter of gas outlet from cyclone (ft.).

2) Please provide the following information on the sinter plant discharge end (north end) scrubbers:

a) gas flow rate, temperature pressure and fluctuations (scfm, °F, psig)

b) spray configuration and location of nozzles

c) scrubbing media flow rate and pressure (gallons/min., psig)

d) inlet particulate concentration and particle size distribution (gr/scf)

e) outlet particulate concentration and particle size distribution (gr/scf)

f) gas velocity through scrubber (ft./sec.)

g) sketch of scrubber.

3) Please provide the following information on the sinter plant windbox scrubbers:

a) spray nozzles; type, location and number

b) TDS of discharge from scrubbers (mg/l)

c) TSS of water spray into scrubber (mg/l)

d) gas pressure at inlet (psig).

C. Coke Ovens

1) Please provide the height, base diameter and exit diameter of the coke battery waste heat stacks (ft.).

2) What is the amount of gas burned in the coke ovens and the gas analysis (MCF/month, % by weight of H_2, CH_4, etc., gr/ft^3 of S and particulate)?

3) What is the amount of quench liquor used per quench and the chemical analysis of the quench liquor (i.e., TDS, TSS, phenol content, sulfate, sulfide, sulfite content--mg/l)?

4) Briefly describe the chemical coke production process. Include a process diagram.

5) What is the average production rate of chemical coke (tons/day)?

D <u>Open Hearth Furnaces</u>

1) Please provide the BTU input to a typical open hearth. Include the range during the cycle (10^6 BTU/hr).

2) Please provide the following information on the open hearth ESP's:

a) pressure of gas at inlet (psig)

b) secondary design current amps

c) particulate composition.

3) Please provide the following information on the open hearth scrubbers:

a) spray nozzle manufacturer and model number, location and number

b) TDS of discharge (mg/l)

c) TSS of water spray into scrubber (mg/l)

d) gas pressure at inlet (psig).

E. Foundry and Pig Machine

1) What are the ratings for the core baking ovens (10^6 BTU/hr input)?

2) Please provide the amount and type of fuel used for the core baking ovens and reverberatory furnaces for June, July, August, and September of 1976 (MCF/month or gallons/month).

3) Please provide data on the air pollution controls for the sand handling and reclaim systems at the foundry (manufacturer and model, design and actual scfm and efficiency).

4) What is the amount of hot metal and steel poured at the foundry for June, July, August and September of 1976 (tons/month).

5) What is the production capability and average monthly production of the pig machine (tons/hr, tons/month)?

F. Rolling Mills

1) What are the base diameters, exit diameters, heights (ft.), number and location of stacks serving the soaking pits?

2) What are the ratings of the soaking pits and reheat furnaces (10^6 BTU/hr input)?

3) What is the amount and type of fuel used for the reheat furnaces and soaking pits at all rolling mill operations for June, July, August and September of 1976 (MCF/month, gallons/month)?

G. Coke By-Products and Nitrogen Plant

1) Where is the "surplus gas flow" shown near the primary coolers on Figure 4-1 "By Product Gas System" (provided by USSC to EPA) sent?

2) Where does centrate from $(NH_4)_2SO_4$ at the by-products plant centrifuging operation go?

3) Please provide the following information on the four cyclonic scrubbers serving the prill dryers:

a) manufacturer, type, model

b) height of the cyclones (ft.)

c) diameter of the cyclones (ft.)

d) gas flow rates, temperatures, pressures, and fluctuations (SCFM, °F, psig)

e) spray configurations and locations

f) scrubbing media flow rates and pressures (gallon/min, psig)

g) diameter of gas outlets from cyclones (ft.).

4) Please provide the following information on the baghouse serving the prill screening and talc prill blending operations:

a) manufacturer, type, model

b) filter material and weave

c) air to cloth ratio

d) pressure drop (in, of water)

e) collection efficiency

f) stack test data

H. <u>Boilers</u>

1) What is the heat input for all three boilers (10^6/BTU/hr)?

2) What are the base diameters, exit diameters, and heights for the boiler stacks (ft.)?

3) What is the percent ash of the coal used to fire the boilers?

4) Please provide the following information on the baghouses that will be used to control boiler emissions:

a) manufacturer, type, model

b) filter material and weave

c) maximum service temperature of filter material (°F)

d) air to cloth ratio

e) pressure drop (in. of water)

f) collection efficiency.

I. General

1) What is the porosity of the ceramic alumdum thimbles used in the particulate monitoring equipment?

2) What is mixed gas?

3) Where are blast furnace, natural, mixed and coke oven gas used and what are their average monthly usage figures (MCF/month)?

We would appreciate it if you would submit the information requested above no later than 30 days following the receipt of this letter.

Any questions concerning this request should be brought to the attention of Mr. David Brooman, Mr. Robert Gosik or Mr. Jonathan Dion (303/234-4658) of the U. S. Environmental Protection Agency, National Enforcement Investigations Center, Denver, Colorado.

Thank you for your cooperation.

Sincerely,

Thomas P. Gallagher
Director

ADDENDUM C

PARTICULATE GRAIN LOADING CALCULATIONS

ADDENDUM C

APPROXIMATION OF PARTICULATE LOADING DUE TO MIST CARRYOVER SINTERING PLANT AND OPEN HEARTH SCRUBBERS USSC - GENEVA WORKS

SINTERING PLANT (one scrubber)

1. Assumptions
   a. Scrubber liquid droplets <500µm diam. will be entrained in gas stream.
   b. Aproximately 10% of scrubbers liquid is atomized to <500µm diam. droplets under typical scrubber operating conditions.
   c. Mist eliminator efficiency is 50%.
   d. There are 2,900 ppm TDS and TSS in scrubber liquid.

2. Calculation

$$\frac{700\ \text{gal}}{\text{min}} \Big/ \frac{8.34\ \text{lb}}{\text{gal}} \Big/ \frac{10\ \text{lb of} <500\mu\text{m}}{100\ \text{lb sprayed}} \Big/ \frac{5\ \text{lbs lost}}{10\ \text{lbs of} <500\mu\text{m}} \Big/ \frac{2{,}900\ \text{lb solids}}{100^{6}\text{lb lost}} \Big/$$

$$\frac{7{,}000\ \text{gr}}{\text{lb}} \Big/ \frac{1}{180{,}000\ \text{scfm}} \Big/ \quad \cong \quad 0.03\ \text{gr/scf}$$

OPEN HEARTH (one scrubber)

1. Assumptions
   a. Scrubber liquid droplets of <250µm diam. will be entrained in gas stream
   b. Approximately 5% of scrubber liquid is atomized to <250µm. diam. under typical scrubber operating conditions.
   c. Spray capture of carryover droplets is 60%, net.
   d. There are 2,500 ppm TDS and TSS in scrubber liquid.

2. Calculation

$$\frac{650\ \text{gal}}{\text{min}} \Big/ \frac{8.34\ \text{lb}}{\text{gal}} \Big/ \frac{5\ \text{lb of} <250\mu\text{m}}{100\ \text{lb sprayed}} \Big/ \frac{4\ \text{lbs lost}}{10\ \text{lbs of} <250\mu\text{m}} \Big/ \frac{2{,}500\ \text{lb solids}}{10^{6}\ \text{lbs lost}} \Big/$$

$$\frac{7{,}000\ \text{gr}}{\text{lb}} \Big/ \frac{1}{67{,}000\ \text{scfm}} \Big/ \quad \cong \quad 0.03\ \text{gr/scf}$$

ADDENDUM D

NEIC EMISSIONS INVENTORY CALCULATIONS

NEIC EMISSION INVENTORY

(JUNE, JULY, AUGUST, 1976)

Coke Plant

Coal charged (TONS)

Battery	June	July	August
1	40,595	41,679	41,959
2	40,450	41,531	41,906
3	40,291	41,321	41,961
4	40,172	41,340	42,020
Totals (Tons/Month)	161,508	165,871	167,846
Average (Tons/Day)	5,384	5,351	5,414

Emissions:

Coal handling

factor: 0.4[3] lb/ton of coal charged

June (5384 tons/day)	0.4 lb/ton) =	2153 lbs/day =	1.08 tons/day
July (5351 (0.4) =		2140 lbs/day =	1.07 tons/day
August (5414) (0.4) =		2166 lbs/day =	1.08 tons/day
		AVERAGE =	1.08 tons/day

Charging

factor: (1.5[3] lb/ton of coal charged) (0.4[1]) = 0.6 lb/ton

June (5384 tons/day)	(0.6 lb/ton) =	3230 lbs/day =	1.6 tons/day
July (5351) (0.6) =		3210 lbs/day =	1.6 tons/day
August (5414 (0.6) =		3248 lbs/day =	1.6 tons/day
		AVERAGE =	1.6 tons/day

Oven/Door Leaks

factor: 0.1[3] lb/ton of coal charged

June (5384 ton/day) 0.1 lb/ton = 538 lbs/day = 0.27 ton/day

July (5351) (0.1) = 535 lbs/day = 0.27 tons/day

August (5414) (0.1) = 541 lbs/day = 0.27 tons/day

AVERAGE = 0.27 tons/day

Pushing

factor: 0.78[4] lb/ton of coal charged

June (5384)tons/day (0.78 lb/ton) = 4200 lbs/day = 2.10tons/day

July (5351) (0.78) = 4173 lbs/day = 2.08 tons/day

August (5414) (0.78) = 4223 lbs/day = 2.10tons/day

AVERAGE = 2.09 tons/day

Quenching

factor: 0.45[4] lb/ton of coal charged

June (5384 ton/day) (0.45 lb/ton) = 2423 lbs/day = 1.21 tons/day

July (5351 (0.45) = 2402 lbs/day = 1.20 tons/day

August (5414) (0.45 = 2436 lbs/day = 1.22 tons/day

AVERAGE = 1.21 tons/day

Combustion

factor: 0.069[4] lb/ton of coal charged

June (5384 tons/day (0.069 lb/ton) = 371 lbs/day = 0.19 tons/day

July (5351 (0.69) = 369 lbs/day = 0.18 tons/day

August (5414) (0.069) = 374 lbs/day = 0.19 tons/day

AVERAGE = 0.19 tons/day

Coke Handling

factor: 0.023[4] lb/ton of coal charged

June (5384 tons/day) (0.023 lbs/ton)	= 124 lbs/day	=	0.06 tons/day
July (5351) (0.023)	= 123 lbs/day	=	0.06 tons/day
August (5414) (0.023)	= 124 lbs/day	=	0.06 tons/day
	AVERAGE	=	0.06 tons/day

Coke Plant Total:

Coal Handling	1.08
Charging	1.60
Oven/Door Leaks	0.27
Pushing	2.09
Quenching	1.21
Combustion	0.19
Coke Handling	0.06
TOTAL	6.50 tons/day

Blast Furnaces

Production	(tons/month)	(average tons/day)
June	126,178	4,206
July	130,820	4,220
August	125,342	4,043

Emissions:

Material Loading

Factor: 0.37[4] lb/ton of hot metal produced

June (4,206 tons/day (0.37 lbs/ton = 1556 lbs/day = 0.78 tons/day

July (4,220) (0.37 = 1561 lbs/day = 0.78 tons/day

August (4,043) (0.37) = 1496 lbs/day = 0.75 tons/day

AVERAGE = 0.77 tons/day

Material Dumping

Factor: 0.73[4] lb/ton of hot metal produced

June (4,206 ton/day (0.73 lb/ton = 3,070 lbs/day = 1.54 tons/day

July (4,220 (0.73) = 3,081 lbs/day = 1.54 tons/day

August (4,043) (0.73) = 2,951 lbs/day = 1.48 tons/day

AVERAGE = 1.52 tons/day

Leaks

Factor: 1.1[4] lb/ton of hot metal produced

June (4,206 ton/day (1.1 lb/ton = 4,627 lbs/day = 2.31 tons/day

July (4,220) (1.1) = 4,642 lbs/day = 2.32 tons/day

August (4,043) (1.1) = 4,447 lbs/day = 2.22 tons/day

AVERAGE = 2.28 tons/day

Building Monitor

Factor: 1.1[4] lb/ton of hot metal produced

June (4,206 ton/day) (1.1 lb/ton	= 4,627 lbs/day	=	2.31 tons/day
July (4,220) (1.1)	= 4,642 lbs/day	=	2.32 tons/day
August (4,043) (1.1)	= 4,447 lbs/day	=	2.22 tons/day
	AVERAGE	=	2.28 tons/day

Off Gas Combustion

Factor: 0.38[4] lb/ton of hot metal produced

June (4,206 tons/day) (0.038 lb/ton	= 160 lbs/day	=	0.08 tons/day
July (4,220) (0.038)	= 160 lbs/day	=	0.08 ton/day
August (4,043) (0.038)	= 154 lbs/day	=	0.08 ton/day
	AVERAGE	=	0.08 ton/day

Blast Furnace Total:

Material Loading	0.77
Material Dumping	1.52
Leaks	2.28
Buildup Monitor	2.28
Off Gas Combustion	0.08
TOTAL	6.93 tons/day

Open Hearth Furnaces

Production (Tons/Month)

Furnace	June	July	August
90	678	28,350	25,161
91	9,674	20,037	18,741
92	24,188	19,933	--
93	15,768	24,143	26,510
94	19,106	23,974	17,236
95	11,495	18,005	10,643
96	27,575	12,662	--
97	28,274	22,104	16,762
98	26,485	--	--
99	12,284	6,946	26,452
TOTALS (Tons/Month)	175,527	176,154	141,505
Average Tons/Day	5,851	5,682	4,565

Emissions

Stack

Factor: 0.73[4] lb/ton of steel produced

June (5851 ton/day (0.73 lb/ton) = 4271 lbs/day = 2.1 tons/day

July (5682 (0.73 = 4147 lbs/day = 2.07 tons/day

August (4565 (0.73) = 3332 lbs/day = 1.67 tons/day

AVERAGE = 1.95 tons/day

Fugitive

Factor: 0.87[4] lb/ton of steel produced

June (585/ton/day) (0.87 lb/ton)	= 5090 lbs/day	=	2.5 tons/day
July (5682 (0.87)	= 4943 lbs/day	=	2.47 tons/day
August (4565) (0.87)	= 3972 lbs/day	=	1.99 tons/day
	AVERAGE	=	2.32 tons/day

Open Hearth Furnaces Total:

Stack	1.95
Fugitive	2.32
TOTAL	4.27 tons/day

Sintering Plant

Production (tons/month)

June	July	August
52,245	45,693	47,442
(tons/day)		
1,742	1,474	1,530

Emissions

Stack

Factor: 1.0[3] lb/ton of sinter produced

June (1,742 ton/day) (1.0 lb/ton) = 1,742 lbs/day = 0.87 ton/day

July (1,474)(1.0) = 1,474 lbs/day = 0.74 ton/day

August (1,530) (1.0) = 1,530 lbs/day = 0.76 ton/day

AVERAGE = 0.79 ton/day

Fugitive

Factor: 2.1[3] lb/ton of sinter produced

June (1,742 ton/day (2.1 lb/ton) = 3,658 lbs/day = 1.83 tons/day

July (1,474) (2.1) = 3,095 lbs/day = 1.55 tons/day

August (1,530) (2.1) = 3,213 lbs/day = 1.61 tons/day

AVERAGE = 1.66 tons/day

Sintering Plant Total:

Stack	0.79
Fugitive	1.66
TOTAL	2.45 tons/day

Rolling Mills

Production	(tons/month)	(average tons/day)
June	126,486	4,216
July	127,479	4,112
August	112,567	3,631

Combustion (mixed gas @ 500 BTU/ft^3)

	(MCF/month)	(Gal/month)	(Gal/day)
June	1,297,986	26,079	869
July	1,198,123	78,347	2,527
August	1,121,774	113,520	3,662

Natural Gas Equivalents

	(MCF/month)	(MCF/day)
June	648,993	21,633
July	599,062	19,325
August	560,872	18,093

Emissions

Scarfing Factor: 0.2[5] lb/ton of metal scarfed

June (4,216 ton/day (0.2 lb/ton) = 843 lbs/day = 0.42 ton/day

July (4,112) (0.2) = 822 lbs/day = 0.41 ton/day

August (3,631) (0.2) = 726 lbs/day = 0.36 ton/day

AVERAGE = 0.40 ton/day

Gas Factor: 18^3 lb/10^6 ft^3 of gas burned

June (21.63×10^6 ft^3/gas) (18 lb/10^6 ft^3 of gas	= 389 lbs/day	= 0.19 ton/day	
July (19.32×10^6) (18 lb/10^6)	= 348 lbs/day	= 0.17 ton/day	
August (18.09×10^6) (18 lb/10^6)	= 326 lbs/day	= 0.16 ton/day	
	AVERAGE	= 0.17 ton/day	

Fuel Factor: 23^3 lb/10^3 gallons of fuel = 20 lbs/day

June (0.869×10^3 gal/fuel) (23 lb/10^3 gal fuel	= 20 lbs/day	= 0.01 ton/day
July (2.527×10^3) (23 lb/10^3)	= 58 lbs/day	= 0.03 ton/day
August (3.662×10^3) (23 lb/10^3)	= 84 lbs/day	= 0.04 ton/day
	AVERAGE	= 0.03 ton/day

Rolling Mill Total:

Scarfing	0.40
Gas Combustion	0.17
Oil Combustion	0.03
TOTAL	0.60 tons/day

Boilers

Fuel consumption per month (CF for gas, tons for coal)

	June	July	August
NG	180,242,000	122,282,000	65,587,000
MG	894,344,000	809,570,000	884,928,000
BF	3,911,369,000	4,530,655,000	4,206,414,000
Coal		206	

(NG = natural gas, MG = mixed gas @ 500 BTU/Ft^3, BF = blast furnace gas @ 100 FTU/Ft^3)

Natural Gas Equivalents

	June	July	August
NG	180,242,000	122,282,000	65,587,000
MG	447,172,000	404,785,000	442,464,000
BF	391,137,000	453,065,500	420,641,400
Total (Ft^3/month)	1,018,551,000	980,132,500	928,692,400
Avg. (Ft^3/day)	33,951,700	31,617,177	29,957,819

Emissions

Factor: 18^3 lb/10^6 ft^3 gas burned

June $(33.95 \times 10^6\ ft^3)$ $(18\ lb/10^6\ ft^3)$ = 611 lbs/day = 0.30 ton/day

July $(31.62 \times 10^6\ )$ (18) = 569 lbs/day = 0.28 ton/day

August (29.96×10^6) (18) = 539 lbs/day = 0.27 ton/day

AVERAGE = 0.28 ton/day

Factor: $(16)^3 (8)^2$ lb/ton coal burned

128 lb/ton coal burned

July (128 lb/ton (6.65 tons/day) = 0.42 ton/day

Three month average = 0.14 ton/day

Boiler Total:

Gas	0.28
Coal	0.14
TOTAL	0.42 ton/day

Nitrogen Plant

Production tons/month

June	July	August
9,395	7,355	11,181
tons/day		
313	237	361

Emissions

Prilling

Factor: 0.9^3 lb/ton of product

June (313 ton/day) (0.9 lb/ton) = 282 lbs/day = 0.14 ton/day

July (237 (0.9) = 213 lbs/day = 0.11 ton/day

August (361) (0.9) = 324 lbs/day = 0.16 ton/day

AVERAGE = 0.14 ton/day

Dryers and Coolers

Factor: 3.6^3 lb/ton of product

June (313 ton/day) (3.6 lb/ton) = 1127 lbs/day = 0.56 ton/day

July (237) (3.6) = 8532 lbs/day = 0.43 ton/day

August (361) (3.6) = 1300 lbs/day = 0.65 ton/day

AVERAGE = 0.55 ton/day

Nitrogen Plant Total:

Prilling	0.14
Dryers and Coolers	0.55
TOTAL	0.69 ton/day

EXPERIMENTALLY DETERMINED FUGITIVE DUST EMISSION FACTORS[6,7]

Source category	Measure of extent	Emission factor[a/] (lb/unit of source extent)	Correction parameters
Aggregate storage (sand and gravel; crushed stone)	Tons of aggregate put through storage cycle	$\frac{0.33}{(PE/100)^2}$	PE = Thornthwaites Precipitation-Evaporation Index
Unpaved roads	Vehicle-miles traveled (light duty)	$0.49\ (s_u)\ \frac{S}{30}\ \frac{d}{365}$	s_u = road surface silt content (%) S = average vehicle speed (mph) d = dry days per year
Paved roads	Vehicle-miles traveled (light duty)	$9 \times 10^{-5}\ L\ s_p$	L = surface loading (lb/mile) s_p = fractional silt content of road surface material
Wind erosion	Acre-years of exposed land	$18\ \frac{esf}{(PE/50)^2}$	e = soil erodibility (tons/acre-yr) s = silt content of surface soil (%) f = fraction of time wind exceeds 12 mph PE = Thornthwaites Precipitation-Evaporation Index

a/ Annual average emissions of dust particles smaller than 30 micrometers in diameter based on particle density of 2.5 g/cm^3.

ROAD EMISSIONS[7]

	Source Extent			Correction Factors				Emissions*		
Roads	Road Length	Vehicle Miles Traveled	Vehicle Class	Vehicle Weight Correction	Vehicle Speed	Road Surface Silt Content	Surface Loading	Emission Factor	Daily Emissions	Yearly Emissions
	Miles[a]	Miles/Day[b]	Light Duty A Medium Duty B Heavy Duty C	Based on Observation	mph[b]	% or fraction	Lbs. Material per Mile	Lbs/VMT	Tons/Day	Tons/Year
Unpaved										
Slag Hauling	1.3	90	C	8.0	25	7[c]	--	4.3[e]	0.19	69.4
Hot Strip	0.9	72	A&B	1.3	25	10[d]	--	4.0	0.14	51.1
Slag Plant	3.0	288	C	8.0	10	13[c]	--	12.8	1.84	671.6
Coke Pile	0.3	28	C	8.0	25	4[c]	--	9.8	0.14	51.1
Total	5.5	478							2.31	843.2
Paved										
Coal Storage	0.7	56	A&B	1.3	25	0.10[d]	> 15,000[d]	4.0[f]	0.11	40.2
Coke Plant	0.8	120	B	3.5	25	0.10[d]	> 15,000[d]	5.4[g]	0.32	116.8
Other Paved	12.8	1,030	A&B	1.3	25	0.07[d]	5,000[d]	0.04	0.02	7.3
Total	14.3	1,206							0.45	164.3

a Determined from plant map.
b Data obtained from plant personnel.
c Determined by means of dry sieving.
d Assumed value based on observation.
e Factor has been reduced by 75% to account for road surface oiling.
f Calculated as an unpaved road due to its high surface loading.
g Same as f, but reduced by 50%.
* All emissions are based on particulates less than 30 microns in diameter.

OPEN AREA EMISSIONS[7]

Wind erosion	Source extent: Total plant area acres	Total open area acres	Effective open area fraction	Correction factors: Soil erodibility	Surface silt soil content (%)	Wind speed	PE	Emissions: Emission factor lb/acre year	Daily emissions tons/day
Plant A Open Areas	1,502	376	0.5[a]	86[b]	20[c]	0.19[d]	45[e]	3,631	1.87

a/ Effective open area fraction: That area which is unsheltered by nearby buildings (effective open area = total ope 0.5).

b/ Tons of material eroded/acre-year.

c/ Assumed value based on known nearby agricultural land silt content.

d/ Fraction of the time the wind speed is greater than 12 mph.

e/ Thornthwaites Precipatation-Evaporation Index.

STORAGE PILE EMISSIONS[7]

Material in Storage	Source extent: Amount in Storage (tons)a/	Source extent: Annual thruput (million tons)b/	Correction factors: Silt content (%)	Correction factors: Duration of storage (days)b/	Emission factors*: Load in (lb/ton stored)	Emission factors*: Vehicular traffic (lb/ton stored)	Emission factors*: Wind erosion (lb/ton stored)	Emission factors*: Load out (lb/ton stored)	Emission factors*: Total storage cycle (lb/ton stored)	Emissions (tons/day)	Emissions (tons/yr)
Medium volatility coal	42,500	0.5	6c/	30	0.16	f/	0.72	0.79	1.67	1.15	420
High volatility coal	127,000	1.5	2c/	30	0.05	f/	0.24	0.26	0.55	1.14	415
Iron ore pellets	125,000	1.5	13c/	30	0.35	0.43	0.31	f/	1.09	2.25	820
Lump iron ore	242,333	2.9	9c/	30	0.24	f/	1.09	f/	1.33	5.30	1,935
Coke	185,000b/	1.0	1d/	Surge basis	0.03	0.16	0.12	0.16	0.47	0.64	235
Slag	129,000	1.5	1.5e/	30	0.04	g/	0.18	0.25	0.47	1	365
Total	851,333	8.9								11.48	4,190

a/ Calculated as 1/12 the annual thruput.
b/ Data obtained through plant personnel.
c/ Determined by means of dry sieving.
d/ Assumed value based on pile observation.
e/ Conservative average based on incomplete plant data obtained at the plant.
f/ Determined negligible.
g/ Considered in the unpaved road calculations.
* All emissions are expressed on a pound of particulates less than 30 μ diameter basis.

ADDENDUM E

USSC EMISSIONS INVENTORY CALCULATIONS (1974)

ADDENDUM E
USSC EMISSIONS INVENTORY
CALCULATIONS (1974)

Emission Inventory for Year of 1974

Coke Plant - EPA Emission Factors

Discharging -

.6#/T coal charged
.6# x 1,939,000 tons coal charged
= 582 tons part. per year

Unloading

.4#/T coal charged
.4# x 1,939,000 tons coal
= 388 tons part. per year

Charging

1.5#/T coal charged
1.5# x 1,939,000 tons coal
= 1,454 tons part. per year
1,454 x .40* = 582 tons part. per year
* At 60% reduction due to using stage charging.

Coke Cycle

.1#/T coal charged
.1# x 1,939,000 tons coal
= 97 tons part. per year
97 x .40* = 39 tons part. per year
* At 60% reduction in emissions from no control due to rehabilitation of coke ovens and replacement of all doors and frames.

Quenching

.9#/T coal charged
.9# x 1,939,000 tons coal
= 873 tons part. per year
873 x .25* = 218 tons part.
* 75% reduction in emissions from no controls due to installation of baffles.

Open Hearth

Average volume = 450,000 SCFM
Average GR/CF = .026

$$450{,}000\ \frac{SCF}{Min} \times \frac{.026\ GR/CF}{7{,}000\ GR/\#} \times 1{,}440\ \frac{Min.}{Day}\quad 365\ D/Y \quad 2{,}000\frac{\#}{T} = \underline{439} \text{ tons part. per year}$$

Sinter Plant

Wind Box both Machines

Average volume = 354,000 SCFM
Average GR/CF = .03 GR/CF

$$354{,}000\ \frac{SCF}{Min.} \times \frac{.03\ GR/CF}{7{,}000\ GR/\#} \times 6027\ \frac{Oper.\ Hrs.}{Yr.} \times 60\ \frac{Min}{Hr.} \times \frac{1}{2{,}000\#/T} =$$

274 tons part. per year.

North End Discharge

Average volume = 80,000 SCFM
Average GR/CF = .03 GR/CF

$$80{,}000\ \frac{SCF}{Min} \times \frac{.03\ GR/CF}{7{,}000\ GR/\#} \times 6027\ \frac{Oper.\ Hrs.}{Yr.} \times 60\ \frac{Min.}{Hr.} \times \frac{1}{2{,}000\ \#/Yr} =$$

62 tons part. per year.

Total Sinter Plant

274	Wind Box
62	Discharge End
336	Tons/Year Total

Blast Furnace Stoves

Rated capacity 144 M BTU/Hr/Stove
Based on EPA emission factor for natural gas 15# part./MCF

$$144{,}000\ \frac{CF}{HR} \times \frac{15\#}{1{,}000{,}000\ CF.\ NG} = 2.1\#\ part./Hr./Stove$$

2.1#/HR x 24 Hrs. x 3 fces. x 365 D/YR = 27.6#/Yr for all 3 fces.

1974 - One furnace down 2 months for a total of 34 fce. months out of a possible of 36 months.

$$27.6\#/YR \times \frac{34}{36} = 26.1\ tons\ part.\ per\ year.$$

Power House

Fuels

Coal - 57,894 tons
B.F. gas - 75,000,000 MCF @ 100 BTU/CF
Natural Gas - 1,800,000 MCF @ 1,000 BTU/CF
Mixed Gas - 3,200,000 MCF @ 570 BTU/CF

Coal - EPA emission factor 1.6#/ton coal burned

$$57{,}894\ \frac{NT\ Coal}{Yr.} \times 16\#/T \times 6.7\%\ Ash \times \frac{1}{2{,}000}\ \#/T = 3{,}103\ tons\ part.\ per\ year$$

Gaseous Fuels @ 1,000 BTU

Based on EPA emission factor for natural gas - 18# per MCF.

B.F. Gas = 7,500 MMCF
Nat. Gas = 1,800 MMCF
Mixed Gas = 1,824 MMCF

Total 11,124 MMCF

11,124 MMCF x 18#/MCF x $\frac{1}{2,000\#/T}$ = 100 Tons part. per year

Rolling Mill

Coke Oven Gas - 6,500,000 MCF @ 570 BTU
Nat. Gas - 3,700,000 MCF @ 1,000 BTU
Fuel Oil - 7,000 Gals.

Gaseous Fuels

Based on natural gas @ 1,000 BTU and EPA emission factor of 18#/MMCF

7,405 MMCF X 18# MMCF = 66.6 tons.

Fuel Oil

EPA emission factor 23#/M Gals.

7,000 M gals. X 23#/M gals. = 80.5 tons.

Total 66.6
80.5

147.1 Tons Part. Per Year

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