DOE/PC/90545--T8

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DE92 018420

Full-Scale Demonstration

Low-NOx Cell™ Burner Retrofit

Quarterly Report No. 6

for the period - January 1, 1992 through March 31, 1992

DOE Agreement No.: DE-FC22-90PC90545

B&W CRD Agreement No.: CRD-1250

Patents Cleared by Chicago on May 22, 1992

Prepared by:

Babcock & Wilcox
a McDermott Company

May 11, 1992
Rev 1 June 11, 1992

DISCLAIMER

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1.0 EXECUTIVE SUMMARY

The Full Scale Demonstration Low-NOx Cell™ Burner (LNCB™) Project (DOE Agreement No. DE-FC22-90PC90545) progress from January 1, 1992 through March 31, 1992 identified in this, the Sixth Quarterly Report. The Report centers on Phase III - Operation status.

The LNCB™ project involves retrofitting the two-nozzle cell burners at Dayton Power & Light's, 605 MWe J.M. Stuart Unit #4 Boiler near Aberdeen, Ohio with LNCB™ (a burner and intregal NOx port). Previous pilot-scale tests have shown such an arrangement to achieve 50% reduction in NOx emission levels. This full-scale project will determine the commercial applicability of this technology.

Monthly reports covering the time period of this report and final copies of the Technical Progress Reports #3 and #4 were completed and issued to DOE PETC. The draft of a LNCB™ project technical paper for the June 1992 Seminar in Kansas City has been forwarded to the Air & Waste Management Association for review and approval.

The fourth Advisory Committee meeting was held in Cincinnati, Ohio on Feb. 11, 1992. The next Advisory Committee Meeting is scheduled for the late summer 1992.

Based on results from the two weeks of preliminary in November 1991 (refer to Appendix A), a switch to a shallower angled impeller to achieve project NO_x reduction goals was agreed to by DOE, Dayton Power & Light (DP&L), Electric Power Research Institute (EPRI), and Babcock & Wilcox (B&W). All Advisory Committee members agreed that inversion (swapping burner and NOx port locations) of every other lower burner provided the best results to mitigate CO levels in the lower furnace (refer to Appendix B). Engineering and fabrication work on both the burner inversion and the shallower angled impeller, has been initiated. Refer to 4.3.2 Task 2 for further details.

Dayton Power & Light is soliciting firm price bids from four installation contractors to do the burner inversion and impeller modification work. DP&L is doing this work as part of their in-kind costs. Installation is scheduled to begin April 27, 1992.

Laboratory Corrosion test results were presented at the Advisory Committee meeting. As can be seen in Appendix C, tube metal temperature is the more critical factor to corrosion rate than is %H_2S levels, when the levels are below 0.3% (3000 ppm). We do not anticipate the Low NOx Cell™ burners producing H_2S levels any higher than 1000 ppm.

The schedule for parametric and optimization testing was finalized. A chart of the test plans is shown in Appendix A.

2.0 INTRODUCTION

As per the Cooperative Agreement No. DE-FC22-90PC90545 dated October 11, 1990, the following quarterly report has been prepared for Phases I, IIA, IIB and III of the Full-Scale Demonstration of Low-NOx Cell™ Burner Project. The period covered by this quarterly report is January 1, 1992 througł March 31, 1992. This report is the sixth quarterly prepared for the project.

All Phase I - Design, Phase IIA - Procurement & Fabrication, and Phase IIB - Installation work was concluded in prior quarters.

Under Phase III Operation, Task 1 - Management & Reporting work accomplished during this quarter involved hosting the Fourth Advisory Committee meeting. Final copies of the Technical Progress Reports #3 and #4 were completed and issued to DOE PETC. An LNCB™ project technical paper for the June 1992 Air & Waste Management Association Seminar in Kansas City has been drafted.

Task 2 - Preliminary Testing, saw analysis work completed for the preliminary test results, numerical modelling of the furnace hopper CO mitigation, redesign of a shallower angled impeller for lower NOx, and laboratory corrosion testing.

Task 3 - Parametric and Optimization Testing, saw the finalization of the testing schedule.

3.0 PROJECT DESCRIPTION

3.1 PROJECT OVERVIEW

The current energy policy of the United States includes the expanded use of coal in utility and industrial applications. However, the increased use of coal must not conflict with environmental goals and thus requires development of cost-effective technology to control the pollutants resulting from coal combustion. Of major concern is the problem of oxides of nitrogen in the Northeastern United States and portions of Canada.

U.S.-installed steam generating units (ie. boilers) equipped with pulverized-coal-fired, cell-type burners account for approximately 26,000 MW of electric power generating capacity. Ten thousand MW of generating capacity is located in Ohio. The balance is located primarily in the Midwest and Northeast, but also in the South and West. coal-fired generating units equipped with cell-type burners produce about 20% of the Pre-New Source Performance Standards (NSPS) utility NOx emissions with an uncontrolled emission rate of approximately 1,000,000 t/yr NOx as NO2. Replacement of the standard cell burners with Low-NOx Cell™ Burners (LNCB™) can potentially reduce NOx emissions by 50% per boiler, or 500,000 - 600,000 tons per year if applied to all pre-NSPS boilers of this type.

Currently there is no other commercially-available technology that can achieve NOx emission reductions on the order of 50% in cell-fired utility boilers without resorting to pressure part modifications. The unique cell burner configuration precludes the use of commercially-available low-NOx burner designs. This is due to the proximity of the burner throats and the relatively small burner throat openings typical of the pre-NSPS cell burner design. Low-NOx burner designs operating on the principle of delayed combustion require larger throat openings, i.e., lower burner air velocities, to inhibit the formation of volatile NOx in the early stages of combustion. Furthermore, optimum NOx reduction with unit volume is minimized. The existing cell burner configuration does not lend itself to either of these requirements.

Realizing the need, Babcock & Wilcox and the Electric Power Research Institute (EPRI) have invested a large amount of resources in the research and development of an unique, "plug-in" Low-NOx Cell™ Burner for retrofitting these existing boilers equipped with standard cell burners.

3.2 PROJECT BACKGROUND

The Low-NOx Cell™ Burner operates on the principle of staged combustion. The lower burner of each two-nozzle cell is modified to accommodate all the fuel input previously handled by two nozzles. Secondary air, less than theoretically required for complete combustion, is introduced to the lower burner. The remainder of secondary air is directed to the upper "port" of each cell to complete the combustion process.

B&W/EPRI have thoroughly tested the LNCB™ at two pilot scales (6 million Btu per hour and 100 million Btu per hour), and tested a single full-scale burner in a utility boiler. Combustion tests at two scales have confirmed NOx reduction with the low-NOx cell on the order of 50% relative to the standard cell burner at optimum operating conditions. The technology is now ready for full unit, full-scale demonstration.

From the standpoint of cost-effective NOx reduction technology the Low-NOx Cell™ Burner is, by design, ideally suited for retrofit to existing two-nozzle cell burner installations. The "plug-in" design will fit existing wall tube openings eliminating outage time and material/labor expense associated with pressure part modifications and burner relocations. Potentially, this burner can be installed on all utility boilers currently equipped with two-nozzle cell burners, and can be adapted to units with three-nozzle cell burners.

Since pressure part changes are not required for the replacement, Low-NOx Cell™ Burners are the most cost-effective NOx control alternative for boilers equipped with standard cell burners. The cost effectiveness (dollars per ton NOx removal) for the Low-NOx Cell Burners™ is about one-half of that for conventional low-NOx burners, and one-tenth that for selective catalytic reduction.

The Low-NOx Cell™ Burner retrofit is expected to be compatible with all U.S. Coals currently being burned in the original cell burners. No loss to domestic coal sourcing will be recognized. Utilities representing 70% of the potential Low-NOx Cell™ Burner retrofit market (capacity basis) are participating in the project.

To accelerate commercialization of this promising technology in controlling NOx levels in pre-NSPS power plants, a full-scale retrofit of a complete boiler system is to be performed. This project at Dayton Power & Light's J.M. Stuart Unit #4, located along the Ohio River between Manchester and Aberdeen, Ohio, will permit actual full-scale NOx levels to be quantified and demonstrate the ability of the equipment to reliably meet conservative utility industry standards.

Unit No. 4 is a supercritical Universal Pressure, single-reheat, Carolina-type boiler, fired with pulverized coal. The unit is designed for a maximum continuous capacity of 4,400,000 lbs steam/hr delivered to a 3500 psig (nominal) General Electric turbine-generator for a maximum gross generating capacity of 605 MWe.

Existing combustion equipment consists of 24 two-nozzle cell burners, 6 MPS-89K pulverizers, and 6 gravimetric feeders. The burners are arranged in an opposed-fired configuration with 12 cell burners on each wall, 2 high by 6 wide. The existing burner throat openings are 38 inches in diameter.

3.3 PROJECT OBJECTIVES

The overall objectives of the full-Scale Low-NOx Cell™ Burner (LNCB™) Retrofit project is to demonstrate the cost-effective reduction of NOx generated by a large, base-loaded (70% capacity factor or greater), coal-fired utility boiler. Specific objectives include:

- At least 50% NOx reduction over standard two-nozzle cell burners, without degradation of boiler performance or life.
- Acquire and evaluate emission and boiler performance data before and after the retrofit to determine NOx reduction and impact on overall boiler performance.

- Demonstrate that the LNCB™ retrofits are the most cost-effective alternative to emerging, or commercially-available NOx control technology for units equipped with cell burners.

The focus of this demonstration is to determine maximum NOx reduction capabilities without adversely impacting plant performance, operation and maintenance. In particular, the prototype evaluations will resolve many technical issues not possible to address fully in the previous pilot-scale work and the single full-scale burner installation. These include low-NOx combustion system impact on:

(1) boiler thermal efficiency
(2) furnace temperature and heat absorption profiles
(3) slagging and fouling
(4) waterwall corrosion
(5) gaseous and particulate emissions
(6) boiler operation considerations

3.4 HOST SITE BOILER

The host site is an existing utility boiler owned by Dayton Power & Light Company, Cincinnati Gas & Electric Company, and Columbus Southern Power Company. The following is a summary of pertinent information.

- OPERATING UTILITY: The Dayton Power & Light Company

- UNIT ID: J.M. Stuart No. 4

- LOCATION: Route 52, P.O. Box 468
  Aberdeen, Adams County, Ohio 45101

- NAME PLATE RATING: 605 MW NDC

- TYPE: Tandem Steam Turbine

- PRIMARY FUEL: Eastern Bituminous Pulverized Coal
  from Ohio, West Virginia, and Kentucky

- OPERATION DATE: 1974

- BOILER ID: Babcock & Wilcox UP No. 106

- BOILER GENERAL CONDITION: Commercial Operation/Good Condition

- BOILER TYPE: Supercritical, Once-Through

- DEMONSTRATION FUEL: Eastern Bituminous Pulverized Coal

- BURNERS: 24 Two-Nozzle Cells, to be replaced with
  Low-NOx Cell™ Burners

- PARTICULATE CONTROL: Electrostatic Precipitators

- PAST EMISSIONS MONITORING: Precipitators - 99+% collection
  efficiency NOx (full load) -
  1.2 lb/10^6 Btu

3.5 PROJECT TEAM

The Low NOx Cell™ Burner Project Team consists of the U.S Department of Energy, The Babcock & Wilcox Company, Dayton Power & Light, the Electric Power Research Institute (EPRI).

Team members from B&W represent the Research and Development Division (R&DD), the Fossil Power Division (FPD), the Energy Services Division (ESD) and the Contract Research Division (CRD).

Major subcontractors are Acurex and Enerfab. Acurex has been designated to perform continuous emissions monitoring activities as well as various analytical requirements during the testing program. The installation subcontractor is Enerfab. They are the Dayton Power & Light - J.M. Stuart Station maintenance contractor. They will perform pre-outage, outage, and start-up work necessary to install the Low-NOx Cell™ Burners and its associated equipment.

A summary of the overall project organization is as follows:

<u>Project Organization</u>

- Department of Energy - 48.4% funding co-sponsor
- Babcock & Wilcox - Prime contractor, project manager, and funding co-sponsor
- Dayton Power & Light - Host site utility and funding co-sponsor
- EPRI - Technical advisor and funding co-sponsor
- Ohio Coal Development Office - Advisory committee member and funding co-sponsor
- Utility advisory committee members and funding co-sponsors

  Allegheny Power System
  Centerior Energy Corporation - Funding thru EPRI
  Duke Power Company - Funding thru EPRI
  New England Power Company - Funding thru EPRI
  Tennessee Valley Authority - Funding thru EPRI

- Acurex Corporation - testing subcontractor
- DP&L Stuart Station Maintenance Contractor - LNCB™ installation

3.6 PROJECT PHASES

The LNCB™ project, which is a $10 million project, consists of four separate phases which are planned to occur over a 38-month period. These are:

- Phase I - Design

  During this phase, the Low-NOx Cell™ Burner (LNCB™) System will be designed based upon B&W's pilot-scale combustion tests, and experience/knowledge of full-scale burner/OFA port/control system retrofits. Additionally, collection of baseline emissions and performance data, along with performance of general boiler system assessment, will be completed at DP&L's J.M. Stuart Unit #4 prior to the LNCB™ retrofit.

- Phase IIA - Procurement & Fabrication

  In order to meet the construction schedule, long lead-time equipment will be ordered and fabricated during the first budget period. To facilitate the funding of this procurement activity, Phase II is divided into two parts, Phase IIA and Phase IIB.

- Phase IIB - Installation

  The LNCB™ system will be installed and started up to provide a fully operational system prior to testing.

- Phase III - Operation

  Parametric/optimization and long term performance tests will assess the potential of the technology from both the resulting emission reductions and boiler performance capability aspects. both full-load and reduced-load operations will be evaluated for the LNCB™ technology. Finally, readiness for commercialization will be determined from both a technical and economic viewpoint.

4.0 PROJECT STATUS

The time period covered by this project quarterly report #6 is January 1, 1992 through March 31, 1992. Progress will be discussed on a task basis for Phase III activities. Phase I, Phase IIA, and Phase IIB are complete.

4.1 PHASE I - DESIGN

Activities in Phase I include the following tasks: Management and Reporting, Test Plan Development, Pre-Retrofit Testing, Functional Engineering, Detailed Design Engineering, and Permitting.

PHASE I WORK IS COMPLETE!

4.2A PHASE IIA - PROCUREMENT AND FABRICATION

Activities in Phase IIA include the following tasks: Management and Reporting, Procurement, and Manufacturing and Fabrication.

PHASE IIA WORK IS COMPLETE!

4.2B PHASE IIB - INSTALLATION

Activities in Phase IIB include the following tasks: Management & Reporting, Pre-Outage Construction, Installation of LNCB™ Equipment, and Start-up & Shakedown.

PHASE IIB WORK IS COMPLETE!

4.3 PHASE III - OPERATION

Activities in Phase III include the following tasks: Management & Reporting, Preliminary Testing, Optimization Testing, Long Term Testing, Data Analysis, Final Report, and Disposition.

4.3.1 <u>Task 1- Management and Reporting</u>

Monthly reports covering the time period of this report were completed and issued to DOE PETC. Final copies of the Technical Progress Reports #3 and #4 were also submitted to DOE.

The draft of a LNCB™ project technical paper for the June 1992 Seminar in Kansas City has been forwarded to the Air & Waste Management Association for review and approval. B&W is also working on technical papers for an EPRI workshop in July 1992, the Pittsburgh Coal Conference and the ASME International Joint Power Generation Conference both of which are in October 1992.

The fourth Advisory Committee meeting was held in Cincinnati, Ohio on Feb. 11, 1992. The agenda for the meeting was to review the preliminary testing results and to discuss findings regarding design changes improve NOx reduction and to mitigate CO levels in the lower furnace. All Advisory Committee members agreed that inversion (swapping burner and NOx port locations) of every other lower burner provided the best results. Engineering and fabrication work on the burner inversion has been initiated. Installation is scheduled to begin April 27th. Refer to 4.3.2 Task 2 for further details.

The next Advisory Committee Meeting is scheduled for late August or early September 1992.

4.3.2 Task 2 - Preliminary Testing

Based on results from the two weeks of preliminary in November 1991 (refer to Appendix A), a switch to a shallower angled impeller to achieve project NOx reduction goals was agreed to by DOE, Dayton Power & Light (DP&L), Electric Power Research Institute (EPRI), and Babcock & Wilcox (B&W). Engineering and fabrication work was initiated in January such that shipment could be made to meet the planned April 27, 1992 outage date.

The sub-stoichiometric operation of the LNC™ burners, like any staged combustion system, is forming high levels of Carbon Monoxide (CO) in the furnace hopper area below the lowest burner level. CO levels as high as 8% to 12% have been sampled in the furnace just above the bottom ash system while CO out the stack is less than or equal to baseline levels.

The Low NOx Cell™ burner system design was reviewed for methods to mitigate CO levels in the lower furnace. Numerical modeling shows that either air injection into the hopper zone, or burner rearrangement can mitigate the CO. Refer to Appendix B for Numerical analysis results. Burner rearrangement would involve swapping the components of the lower elevation of LNC™ burners, i.e. switch positions of the NOx port and the burner assembly. Air injection would likely involve pressure part changes and ductwork equipment. Air injection analysis was performed at full boiler load only. The effectiveness of such a system at reduced loads is somewhat suspect. In a commercial application, B&W as well as the Advisory Committee members felt that rearrangement would prove to be the least costly and most effective method to mitigate the CO.

Dayton Power & Light is soliciting firm price bids from four installation contractors to do the burner inversion and impeller modification work. DP&L is doing this work as part of their in-kind costs.

Laboratory Corrosion test results were presented at the Advisory Committee meeting. As can be seen in Appendix C, tube metal temperature is the more critical factor to corrosion rate than is $\%H_2S$ levels, when the levels are below 0.3% (3000 ppm). We do not anticipate the Low NOx Cell™ burners producing H_2S levels any higher than 1000 ppm.

4.3.3 Task 3 - Parametric & Optimization Testing

The schedule for this phase of the testing was finalized. A chart of the test plans is shown in Appendix A.

5.0 PLANNED ACTIVITIES

Planned activities for the next quarter, April, May, and June 1992 will focus on the following:

Management & Reporting will include submittal of the Management Plan - Phase III Update, and the Post Retrofit Test Plan. Technical papers for the EPRI Workshop, July 7-9, 1992 and the ASME International Joint Power Conference, October 18-22, 1992 will be drafted during this time frame.

Phase III, Task 2 - Complete fabrication & installation of materials for shallower angled impellers and burner inversion.

Phase III, Task 3 - Preform parametric and optimization testing.

Phase III, Task 4 - Begin long term testing.

Appendix A

FULL SCALE DEMONSTRATION OF LOW NOx CELL BURNER™

APPROXIMATE START-UP & PRELIMINARY TESTING RESULTS

TEST REFERENCE	STANDARD CELL	LOW NOx CELL BURNER™ OPERATION		
	BASELINE TEST 1	IMPELLER NORMAL POS.	IMPELLER RETRACTED	FURNACE MINIMUM CO
DATE	10/22/90	11/25/91	11/27/91	12/04/91
NOx REDUCTION	N/A	35%	45%	30%
STOICHIOMETRY	N/A	0.59 – 0.66	0.54 – 0.68	0.8
WINDBOX-FURNACE PRESS. DROP	1.93 in. Wg.	2.24 in. Wg.	2.62 in. Wg.	3.69 in. Wg.
CO IN LOWER FURNACE*	0 – 0.1% #	10 – 12%	8 – 10%	3.5 – 4.5%
H2S IN LOWER FURNACE**				
EAST (LEFT HAND) SIDEWALL	0 PPM	NO SAMPLE	400 PPM	0 PPM
WEST (RIGHT HAND) SIDEWALL	100 PPM	NO SAMPLE	1000 PPM	400 PPM
O2 AT ECONOMIZER OUTLET				
EAST (LEFT HAND) SIDE	3.4%	3.6%	3.2%	3.5%
WEST (RIGHT HAND) SIDE	3.7%	3.9%	3.7%	4.7%
CO AT ECONOMIZER OUTLET	29 – 30 PPM	27 – 32 PPM	21 – 29 PPM	20 – 26 PPM
LOI – BOTTOM ASH	1.0 – 7.6% ##	5.01%	NOTE 2	NO SAMPLE
LOI – 1ST FIELD OF PRECIPITATOR				
EAST (LEFT HAND) SIDE	NOTE 1	1.22%	NOTE 2	NO SAMPLE
WEST (RIGHT HAND) SIDE	NOTE 1	1.64%	NOTE 2	NO SAMPLE

* TAKEN THROUGH AN OBSERVATION DOOR OPENING AT ELEVATION 564'-10".
** TAKEN THROUGH AN OBSERVATION DOOR OPENING AT ELEVATION 556'-2".
# DATA TAKEN ON STUART UNIT # 2 ON 11/19/91.
REFERANCE TABLE IV OF BASELINE TEST REPORT.

NOTE 1: BASELINE TEST REPORT DOES NOT DIFFERENTIATE BETWEEN LEFT AND RIGHT. BASELINE TEST RESULTS RANGED FROM 1.14% TO 2.53% LOI.

NOTE 2: ASH SAMPLES WERE TAKEN ON 12/02/91 UNDER THE SAME BURNER SETTINGS AS 11/27/91. LOI RESULTS FOR 12/02/91 WERE BOTTOM = 3.02%, LEFT = 2.41%, AND RIGHT = 1.94%.

LNCB OUTAGE & TEST PLANNING

APRIL '92

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
26	27	28	29	30		
<UNIT OUTAGE FOR LOWER BURNERS/ IMPELLERS>						

MAY '92

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
					1	2
					< OUTAGE CONT'D >	
3	4	5	6	7	8	9
<--- OUTAGE CONTINUED ---->			<#4 STARTUP / SHAKEDOWN >			
	<--- TEST EQUIPMENT SETUP - ACUREX & B&W ---->					
10	11	12	13	14	15	16
	<-- LNCB PARAMETRIC TESTING - ACUREX & B&W -->					
17	18	19	20	21	22	23
	<-- LNCB PARAMETRIC TESTING - ACUREX & B&W -->					
24	25	26	27	28	29	30
	<-- LNCB PARAMETRIC TESTING - ACUREX & B&W -->					
31	NOTE: LONG-TERM TESTING COMMENCES ON MAY 11, 1992					

JUNE '92

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
	1	2	3	4	5	6
	<-- LNCB PARAMETRIC TESTING - ACUREX & B&W -->					
7	8	9	10	11	12	13
	<--- DIGEST DATA - SELECT OPTIMUM SETTINGS --->					
14	15	16	17	18	19	20
	<--- LNCB OPTIMIZED TESTING - ACUREX & B&W --->					
21	22	23	24	25	26	27
	<--- LNCB OPTIMIZED TESTING - ACUREX & B&W --->					
28	29	30				
	<-- OPTIM. TESTS -->					

JULY '92

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
			1	2	3	4
			<---- OPTIMIZED TESTING ---->			
5	6	7	8	9	10	11
	<-------- LNCB CONTINGENCY TEST DAYS --------->					

Appendix B

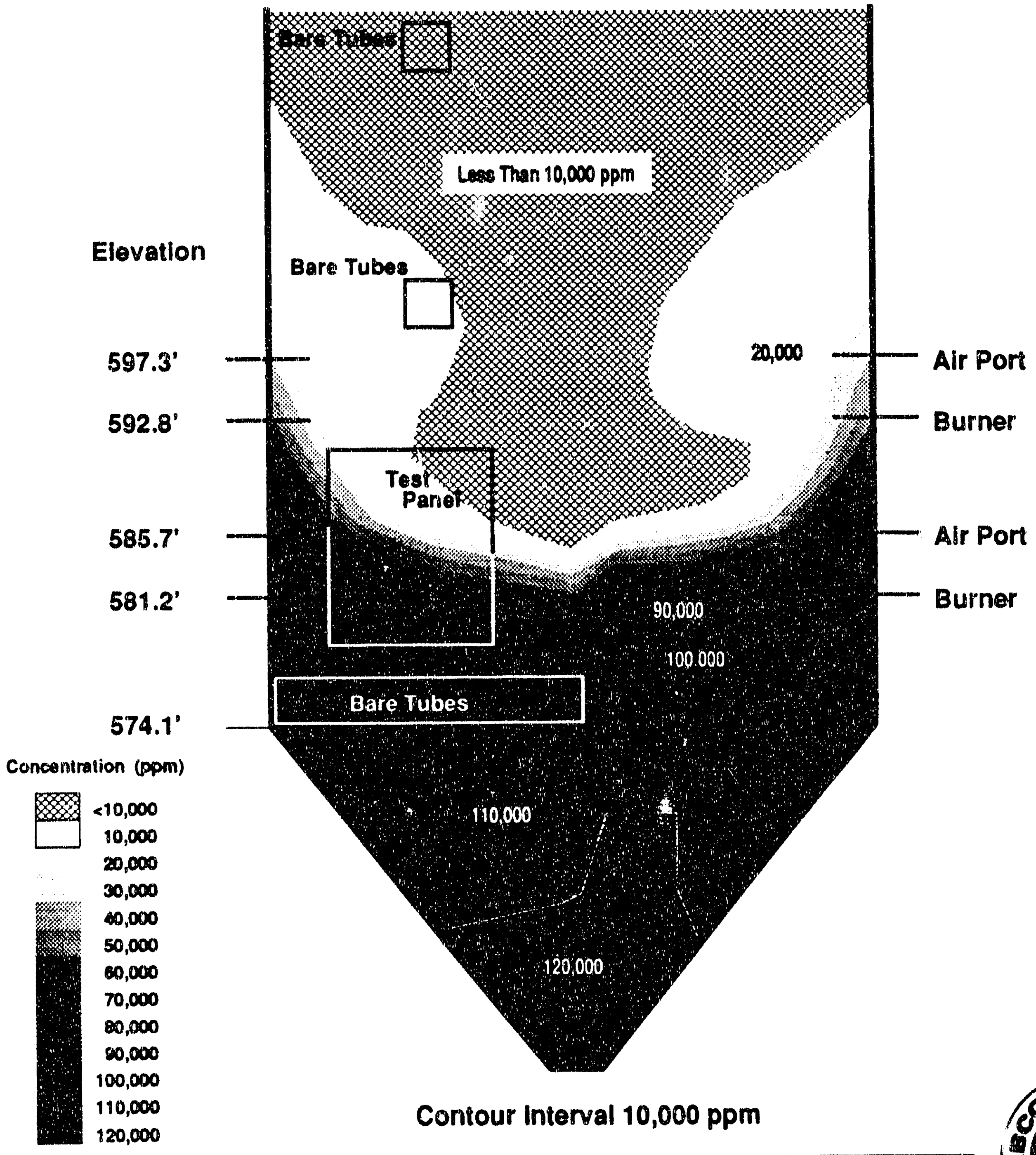
Hopper CO Mitigation Numerical Modeling

- Problem Definition
- Modeling Analysis
- Summary of Potential Solutions

Problem Definition

CO Concentrations Near the Right (West) Side Wall with the LNCBs at Full Load with all Mills in Service

Corrosion Testing Locations Shown



Modeling Analysis

- Burner and air port flow control variations of current installation
- Comparison with CO measurements
- Inverting lower row of cells
  - All
  - Paired - four outer cells on each firing wall
  - Alternating - adjacent and front-to-rear
- Hopper air injection
  - Hopper throat
  - Side wall ports
- Load and mill-out variations
- Heat transfer analysis

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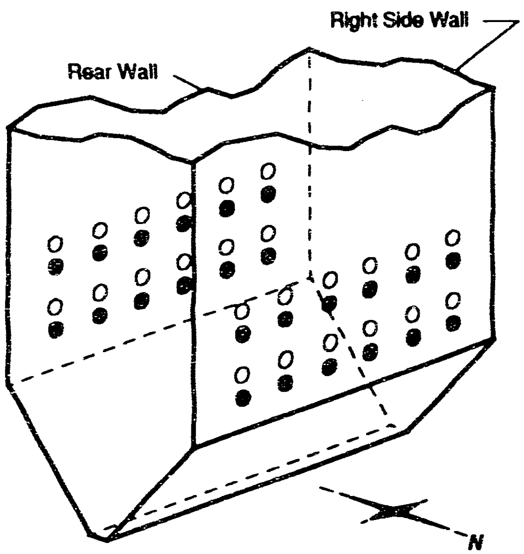
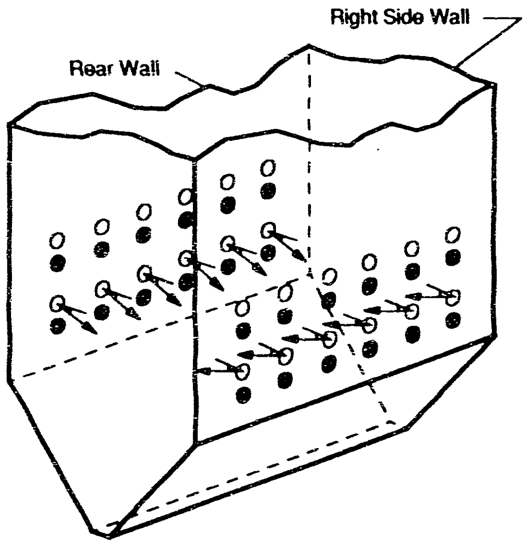
Burner and Air Port Flow Control

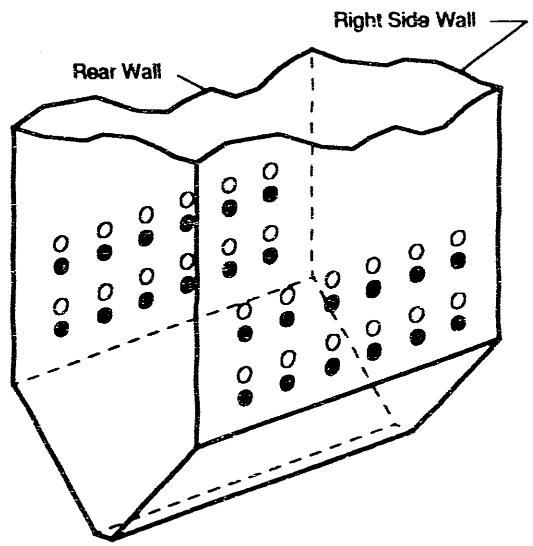
Normal Operation



Air Port Dampers 20 degrees Down



Lower Row Burner Stoichiometry 0.8



O Air Port
● 0.6 Stoichiometry
● 0.8 Stoichiometry

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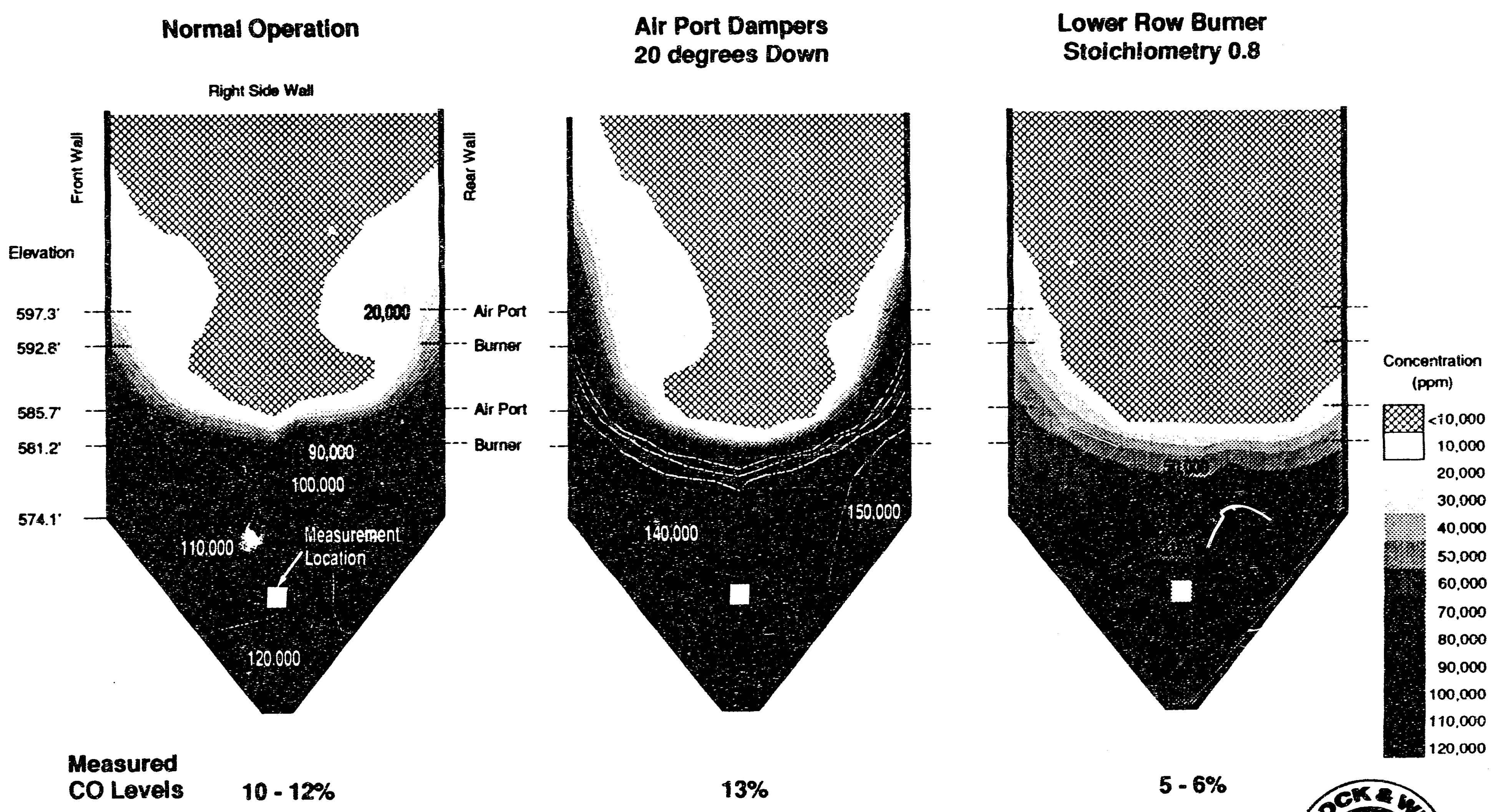
ARC 02/05/92

Burner and Air Port Flow Control



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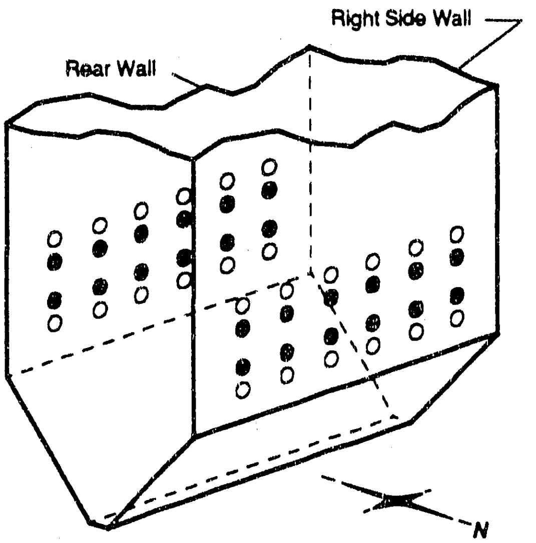
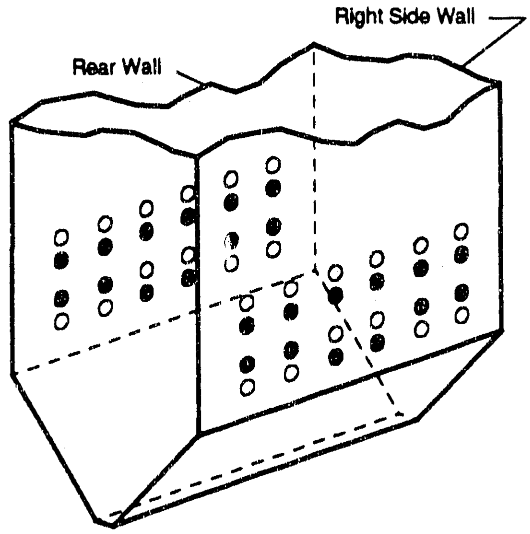
Inverted Cells

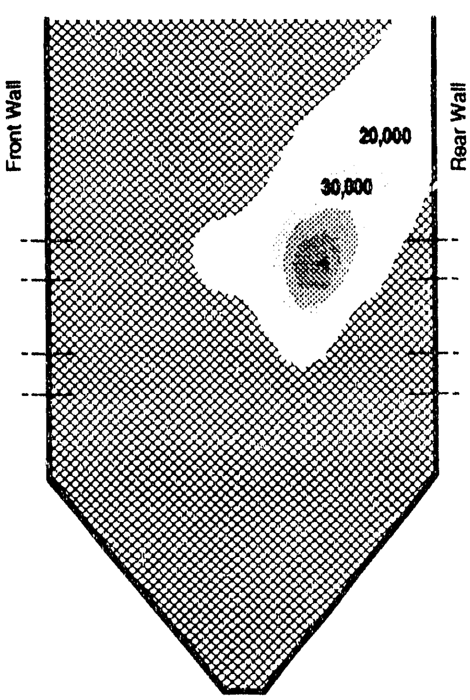
All Lower Cells Inverted

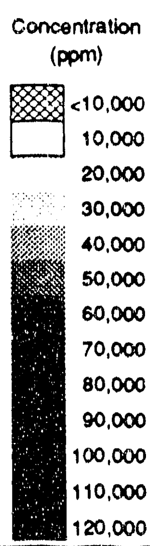


Outer 4 Cells on Lower Row Inverted

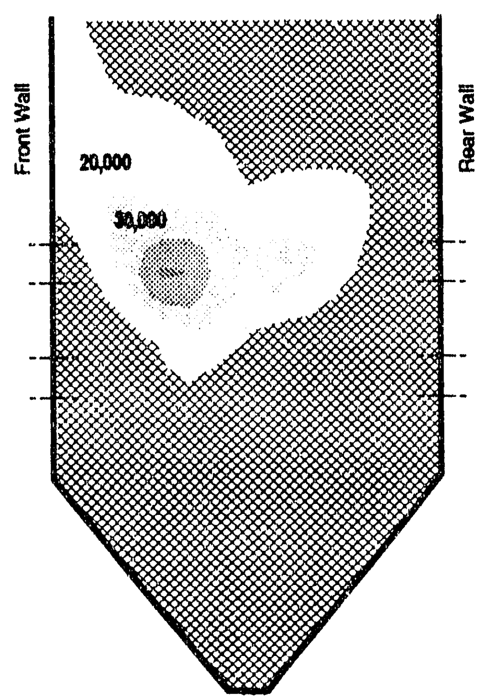


Right Side Wall





Right Side Wall



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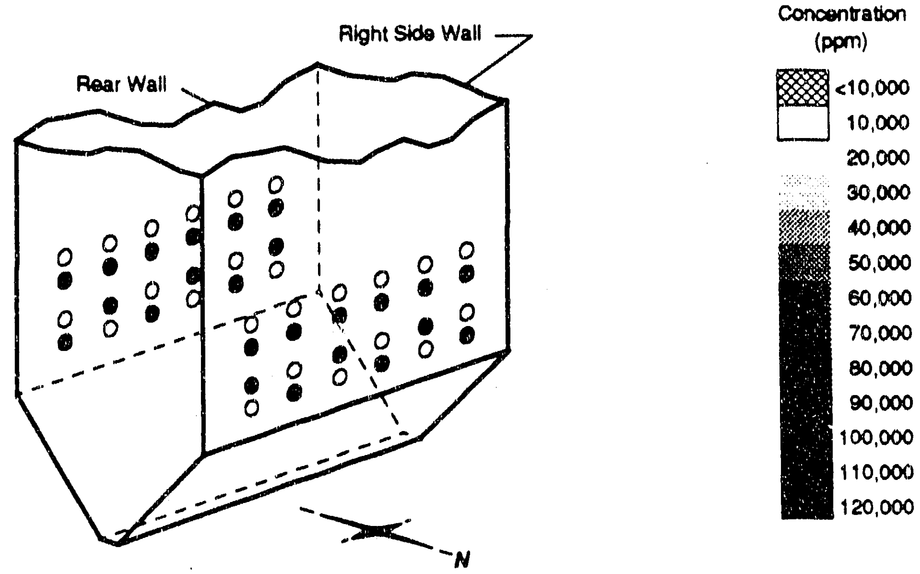
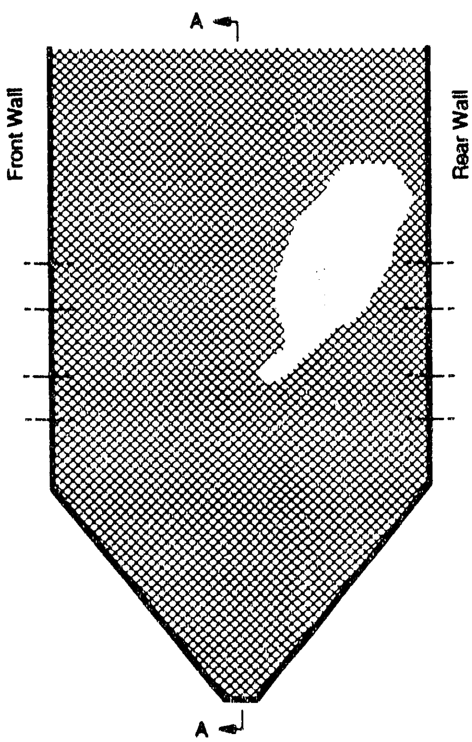
Inverted Cells

Alternating Lower Cells Inverted



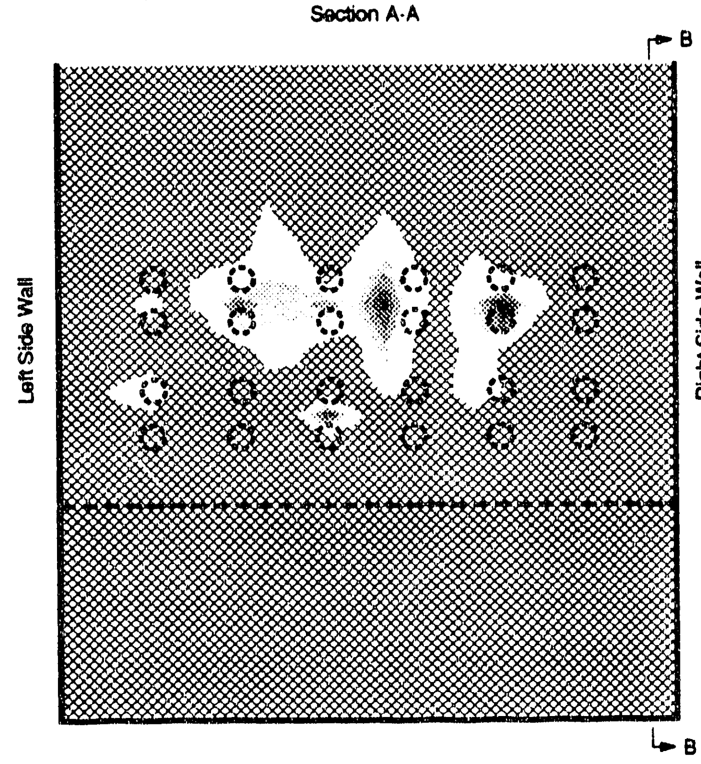
Right Side Wall

Section B-B



Furnace Centerline

Section A-A



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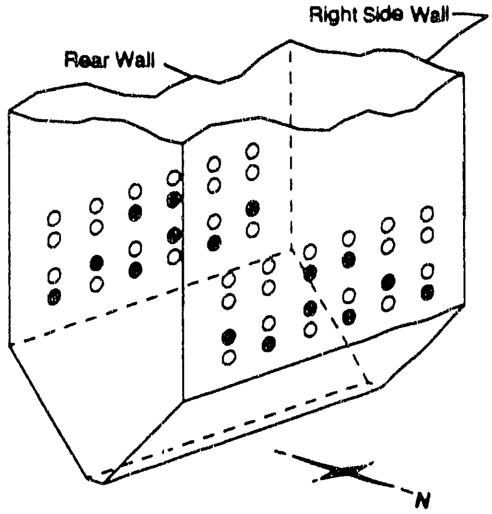
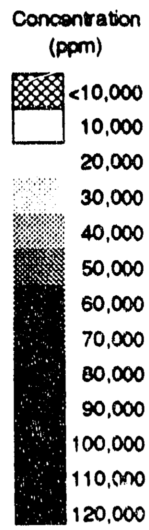
Inverted Cells

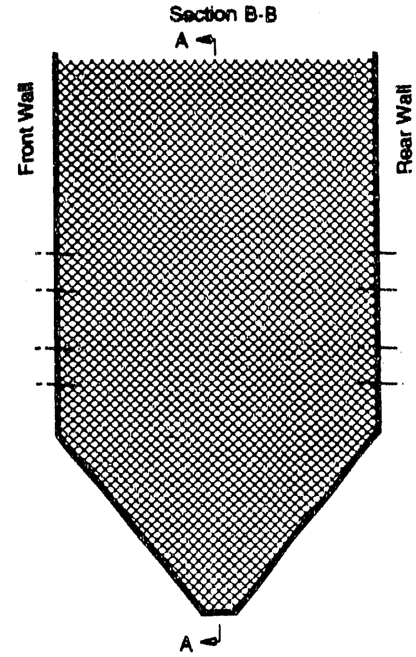
Alternating Lower Cells Inverted

50% Load, A and F Mills Out

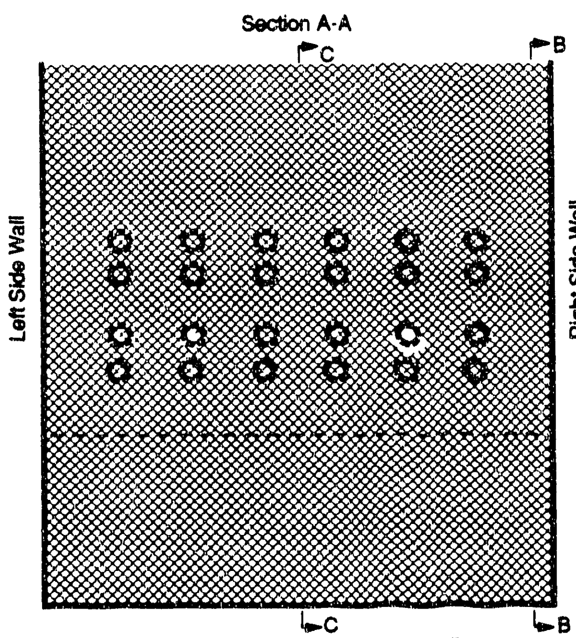




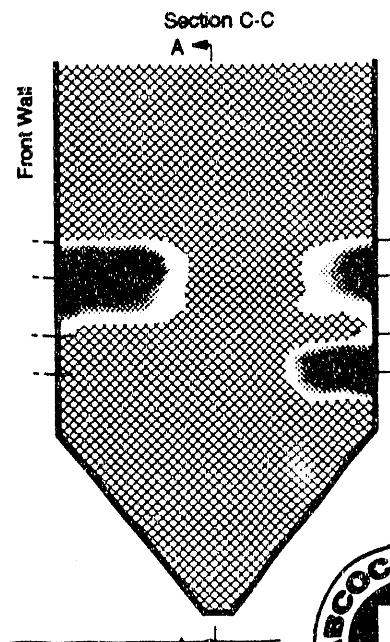
Right Side Wall



Furnace Centerline



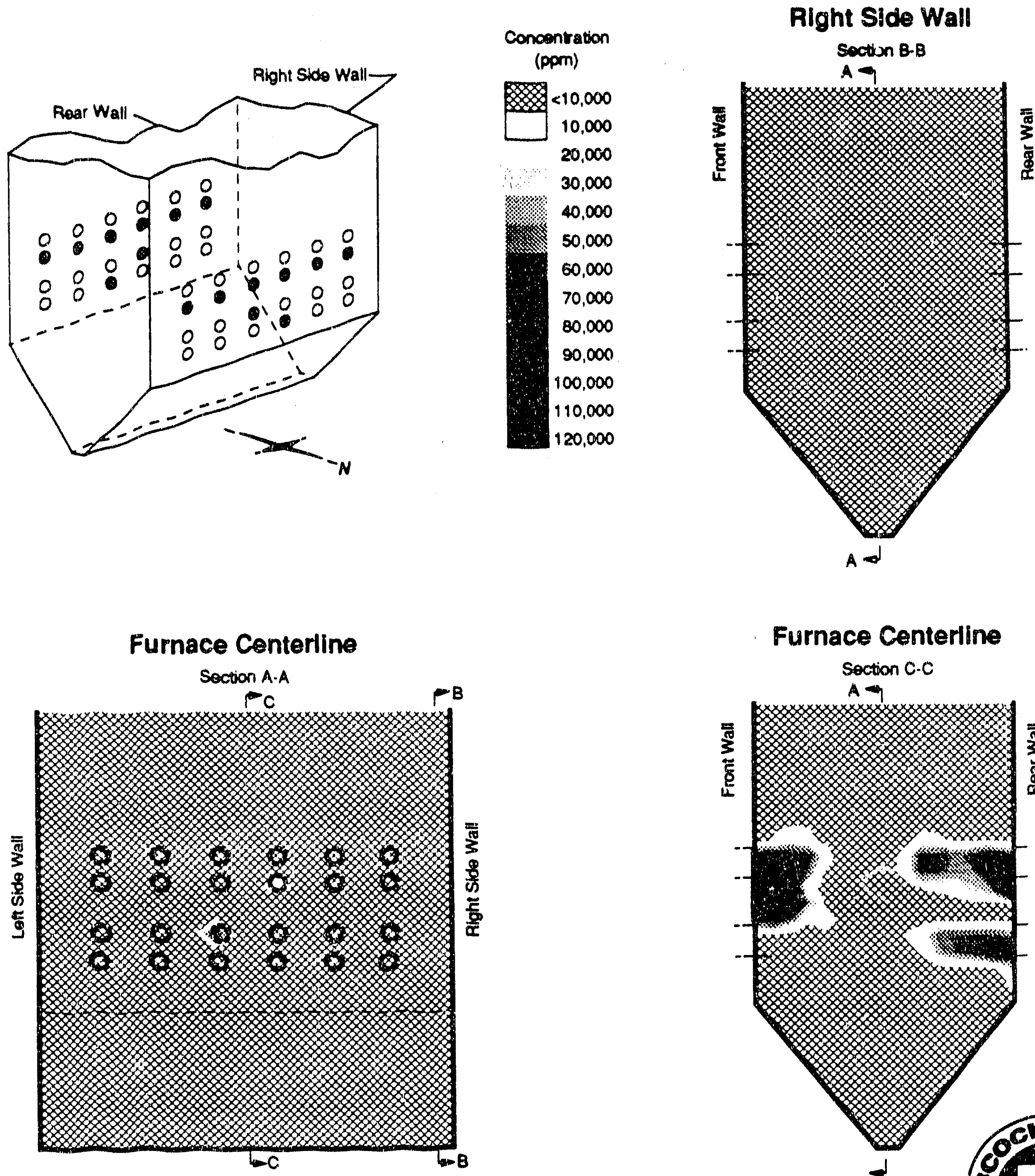
Furnace Centerline



Inverted Cells

Alternating Lower Cells Inverted

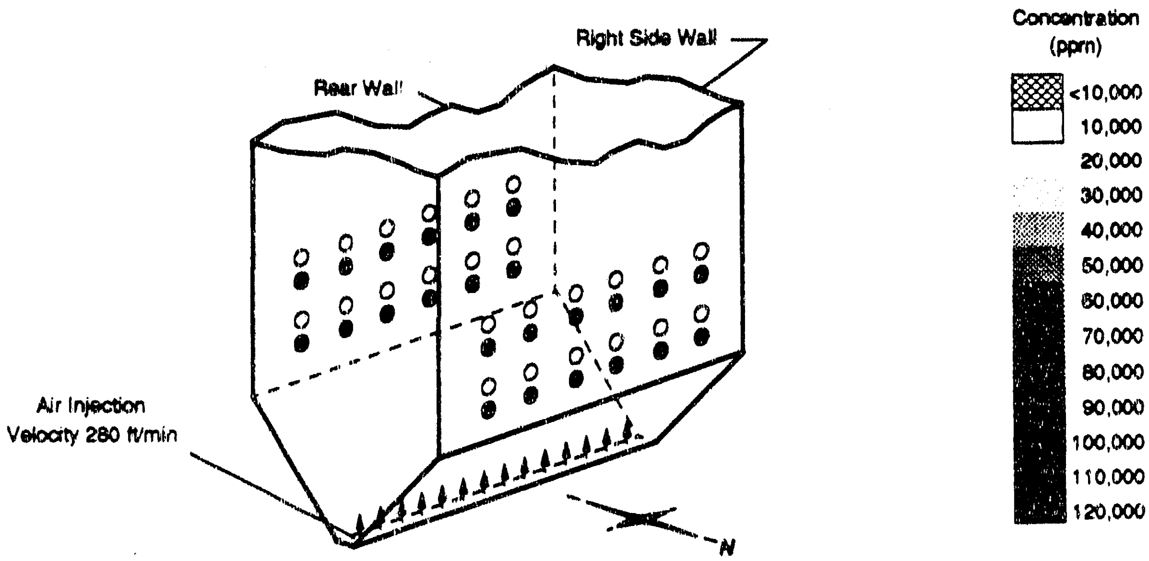
50% Load, C and D Mills Out



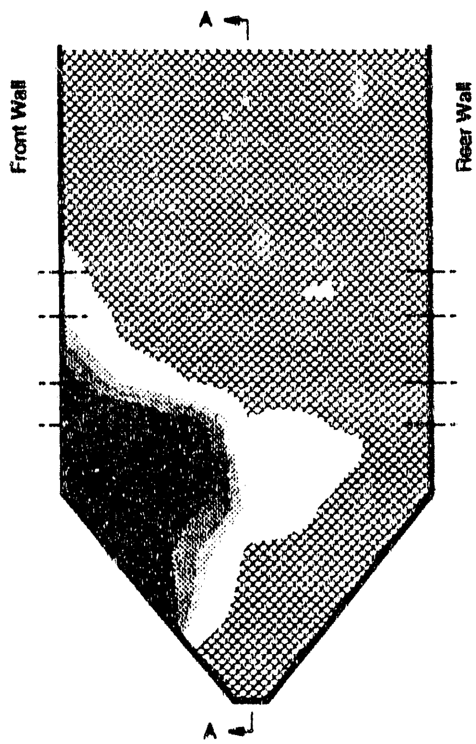
BABCOCK & WILCOX

Hopper Air Injection

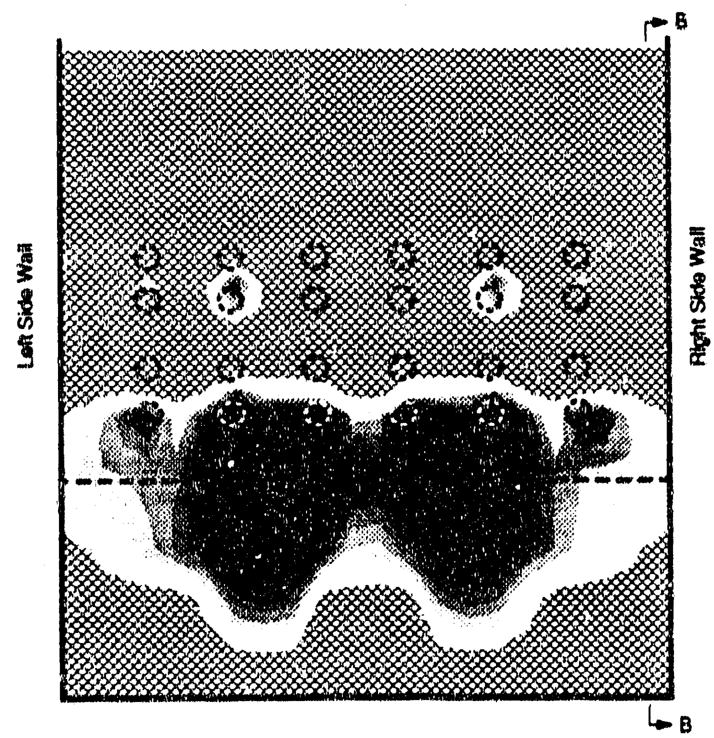
3% Excess Air Injected Through Hopper Throat



Right Side Wall
Section B-B

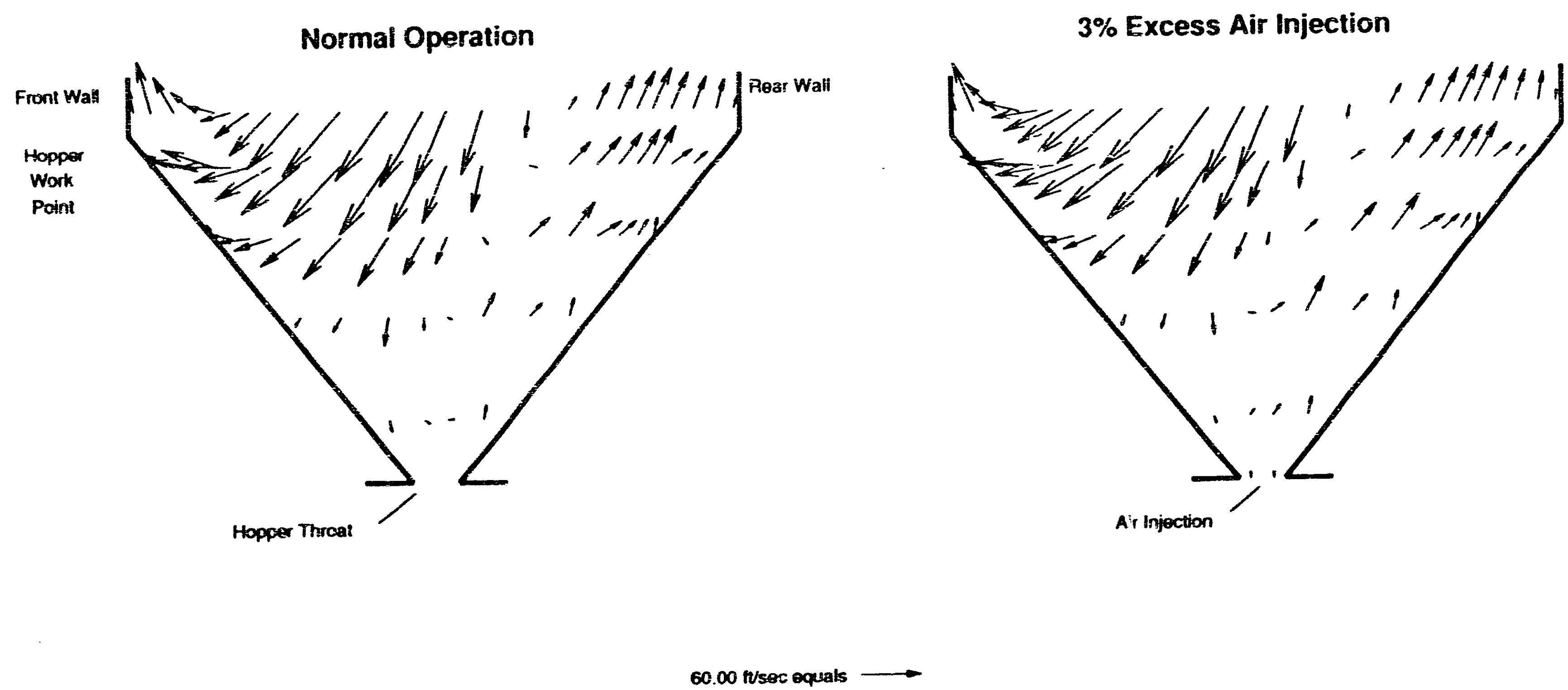


Furnace Centerline
Section A-A



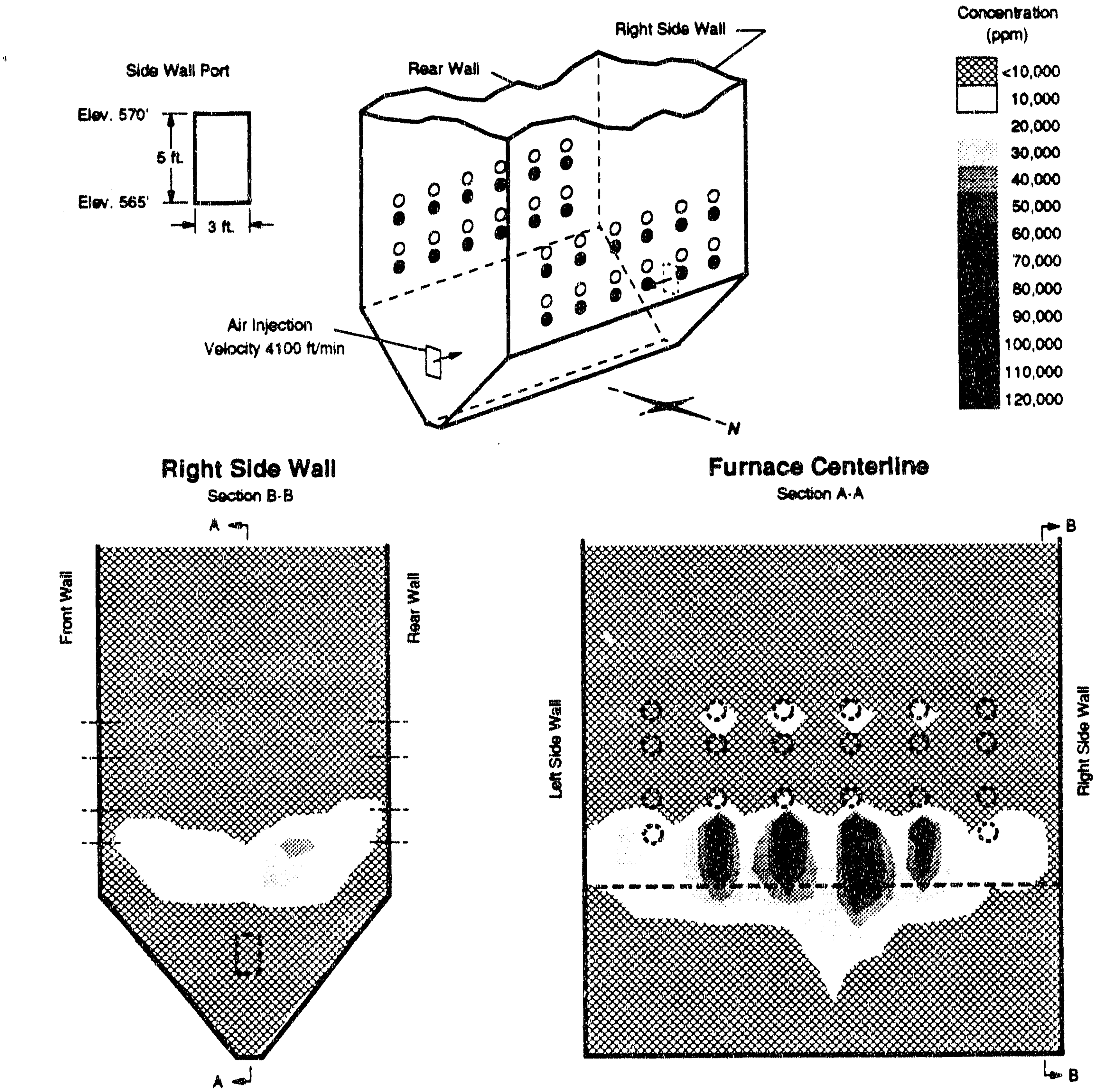
BABCOCK & WILCOX

Hopper Flow Fields



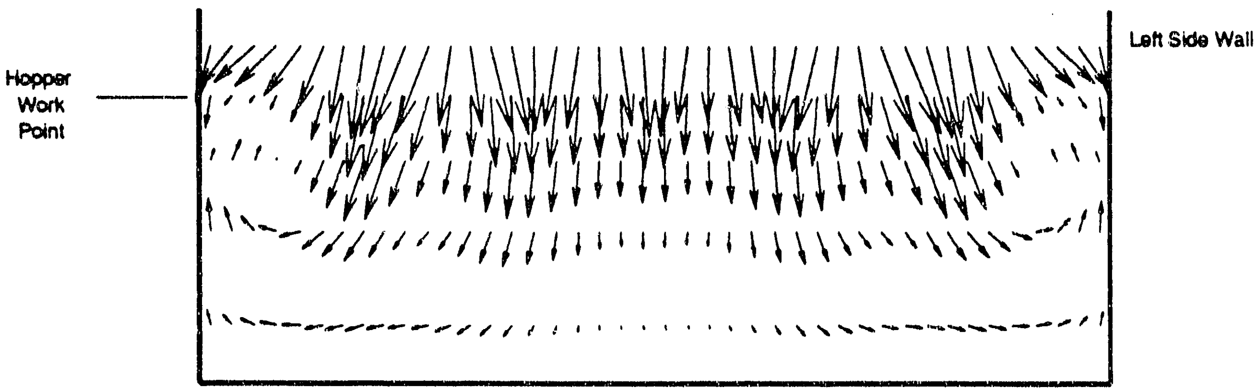
Hopper Air Injection

7% Excess Air Injected Through Side Wall Ports

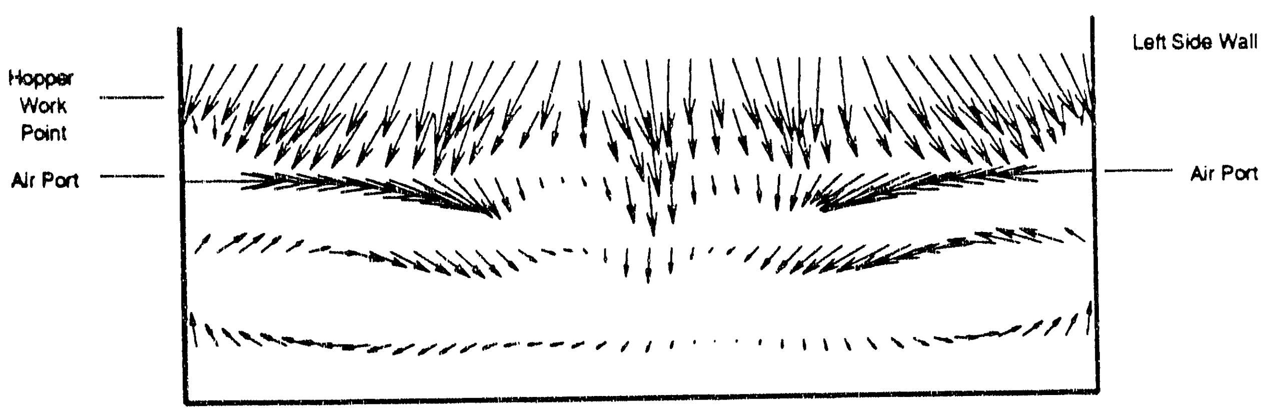


Velocity Vectors At Furnace Centerline

Normal Operation



Side Wall Air Ports

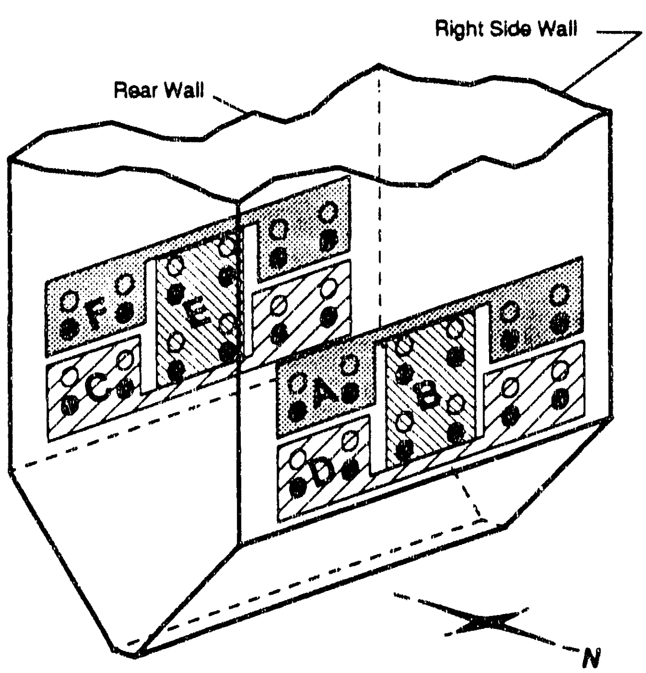


60 00 ft/sec equals ⟶

RDD 4009
ARC 02/05/92

Heat Transfer Analysis

Case	Full Load Mills Out of Service	Full Load FEGT (F)	25% Load Mills Out of Service	25% Load FEGT (F)
Standard Cell	None	2510	C,D & E	1748
LNCB				
Current	None	2509	C,D & E	1670
All Inverted	None	2588	C,D & E	1721
	B	2533		
Alternating	None	2515	C,D & E	1715
	B	2488		



Summary of Potential Solutions

Option	Advantages	Disadvantages
Current	No changes	High hopper CO High corrosion potential
Inverting Cells on Lower Row	Low hopper CO Reduced NOx Potential	Depends on number inverted Large increase in FEGT
Alternating Cells on Lower Row	Low hopper CO Little change in FEGT	Unknown impact on NOx
Air Injection	Low hopper CO No changes to burners	Pressure part changes Penetration at reduced load Additional controls required Fan limitations

Appendix C

Full Scale Demonstration
of
Low-NOx Cell Burner Project

Laboratory Corrosion Test

Fourth Advisory Committee Meeting

LOW NO_x CORROSION TESTING (4009)

I Test Matrix

H_2S%	Isothermal T (°F)	Time (hours)
0.05	500, 700, 900	1000
0.25	700	1000
0.50	700	1000

II Materials

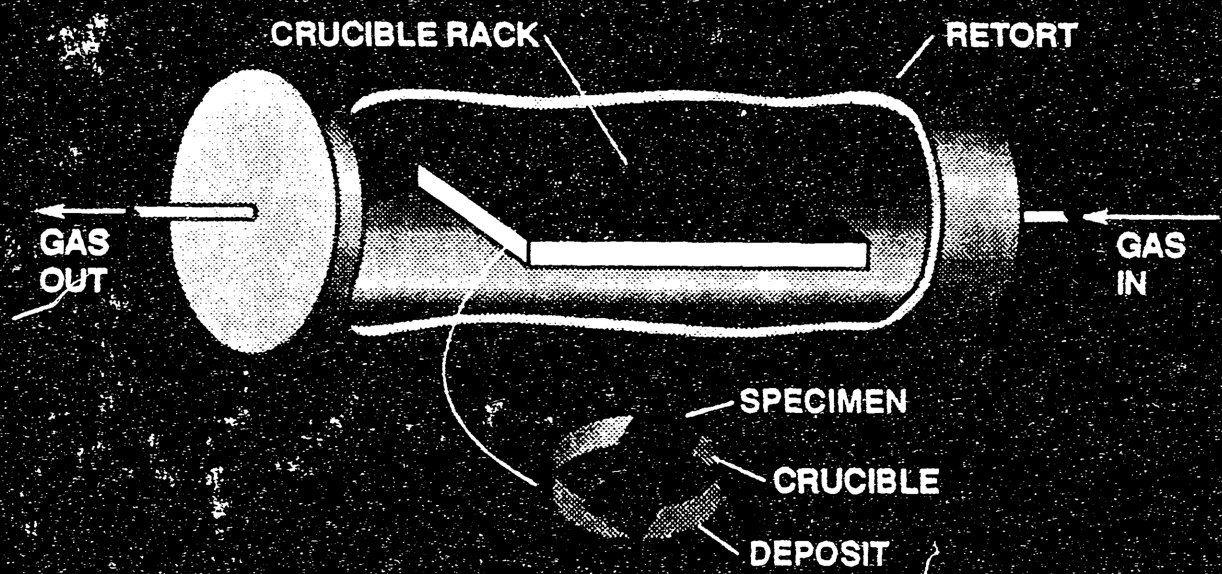
(1) Alloy

Steels	Stainless Steels	Other Alloys	Coatings
SA178-A	SA213-TP304L	253MA	Al-sprayed T2
SA213-T2	SA213-TP309	Fe-16Cr-5Al	FeCrAl-T2
SA213-T11	SA213-TP310	FeNiCrAl	Cr/Si-T2
SA213-T22	SA213-TP321		
SA213-T9			

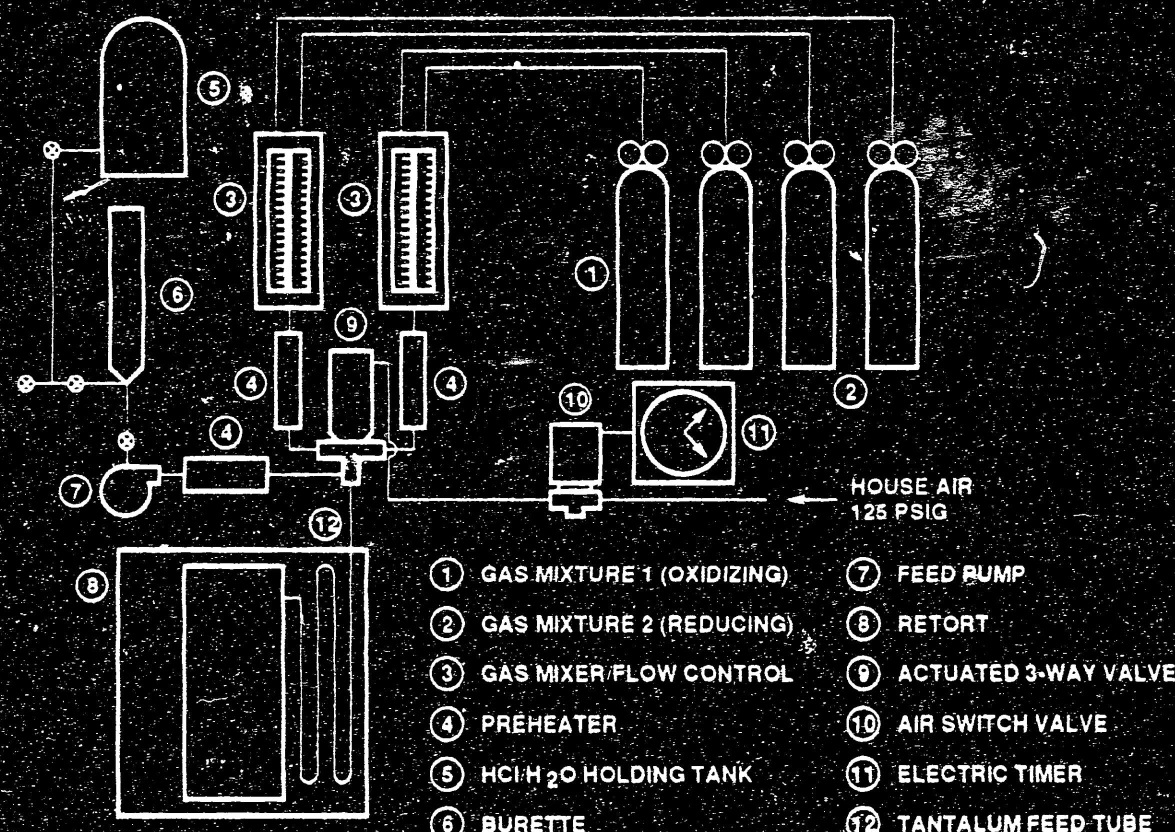
(2) Simulated Ash Deposit

Chemical	wt.%
SiO_2	38
Al_2O_3	16
FeS	19
CaS	18
K_2S	2
Na_2S	1
MgS	1
Coal	5

Schematic Representation of Retort Containing the Test Specimens



Schematic Representation of the Test System

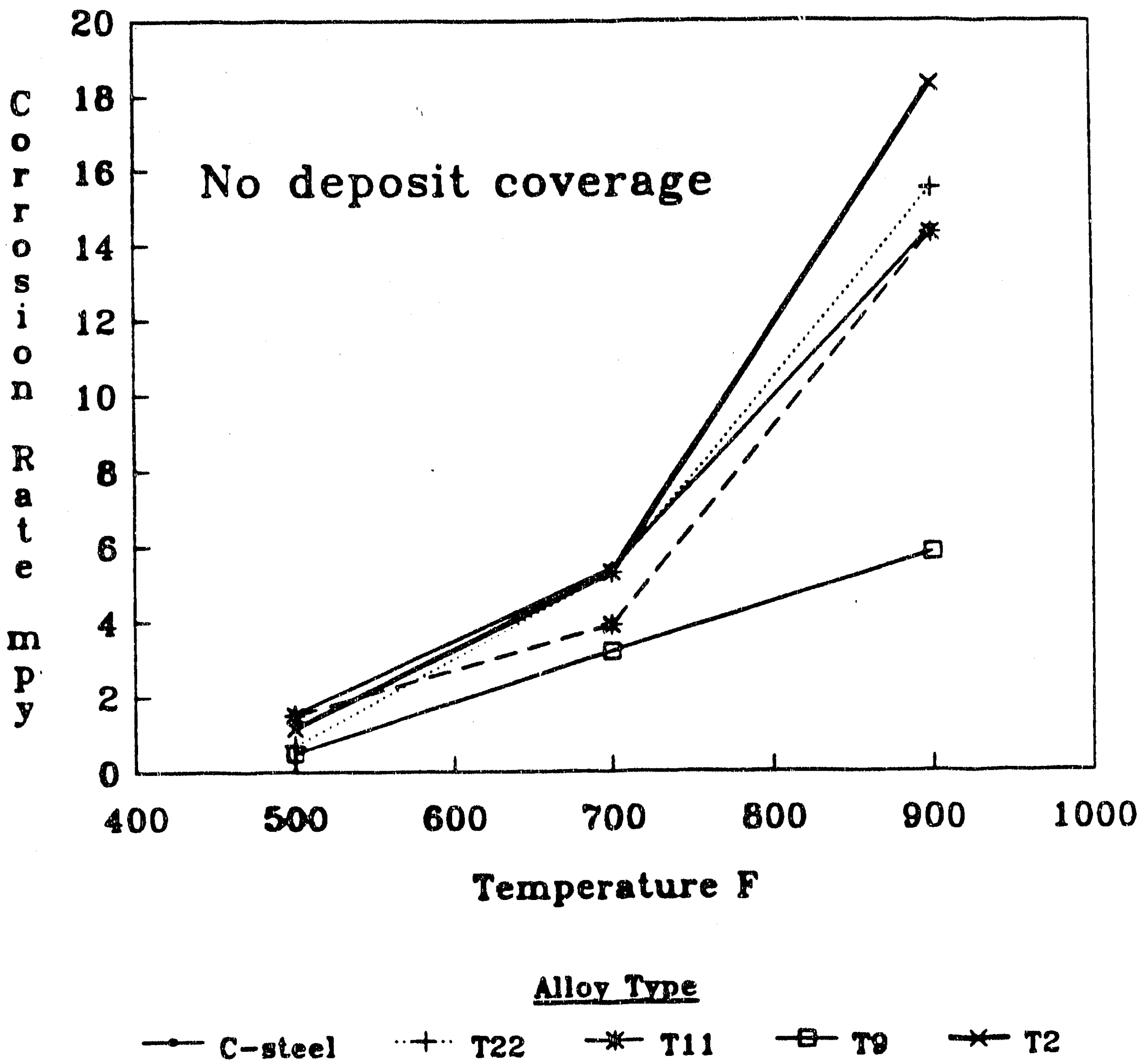


Determination of Critical Corrosion Rate

- For a service life of 20 years.
- Lower limit is 5 mpy.
- Upper limit is 10 mpy.
- An intermediate value of 7.5 mpy is used.

CORROSION RATE vs. TEMPERATURE

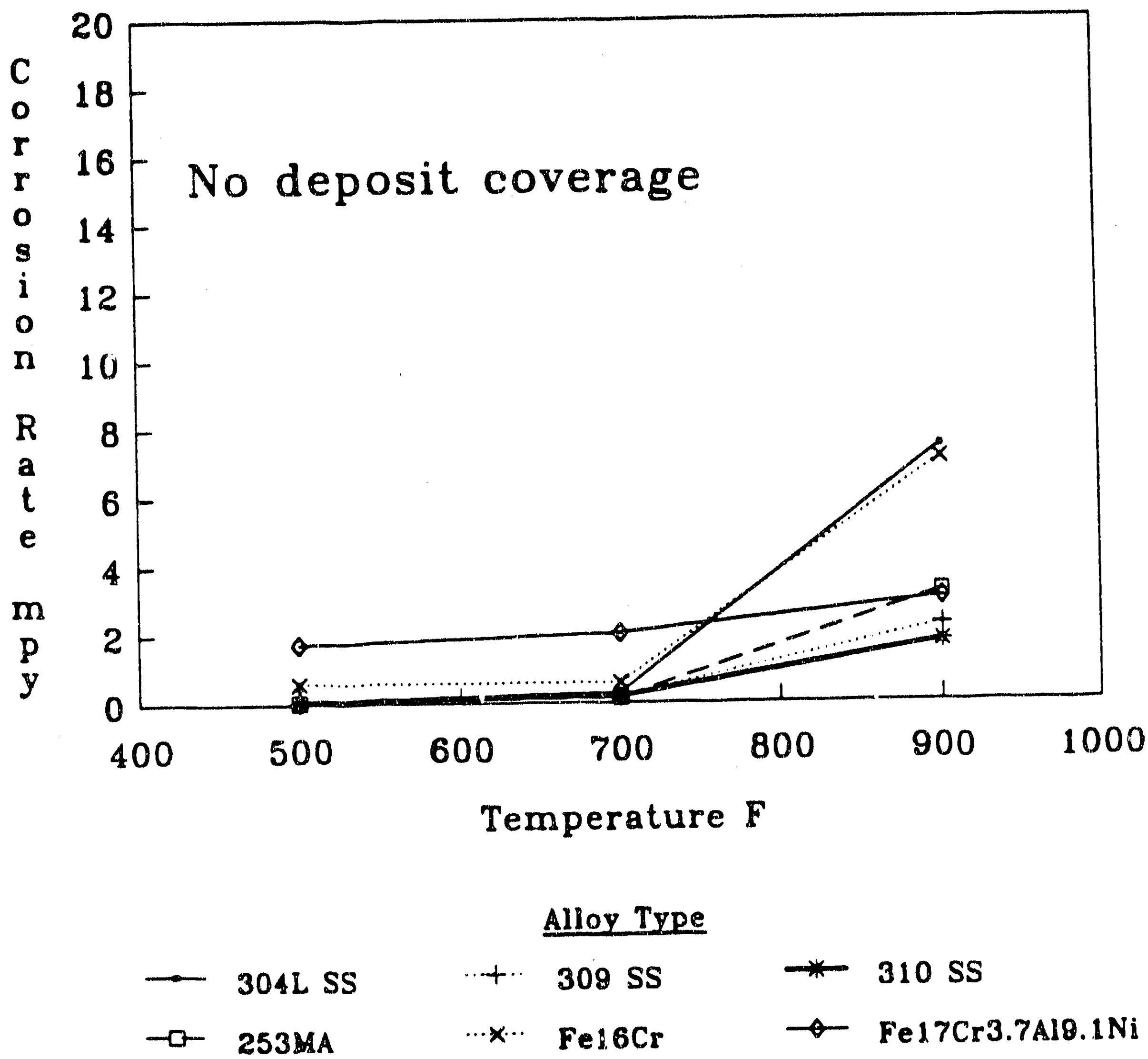
Carbon and low-alloy steels in mixed gas with 0.05% H2S after 1000 hours



Average corrosion rates are extrapolated to one year based on the 1000-hour metal wastage data from the retort tests.

CORROSION RATE vs. TEMPERATURE

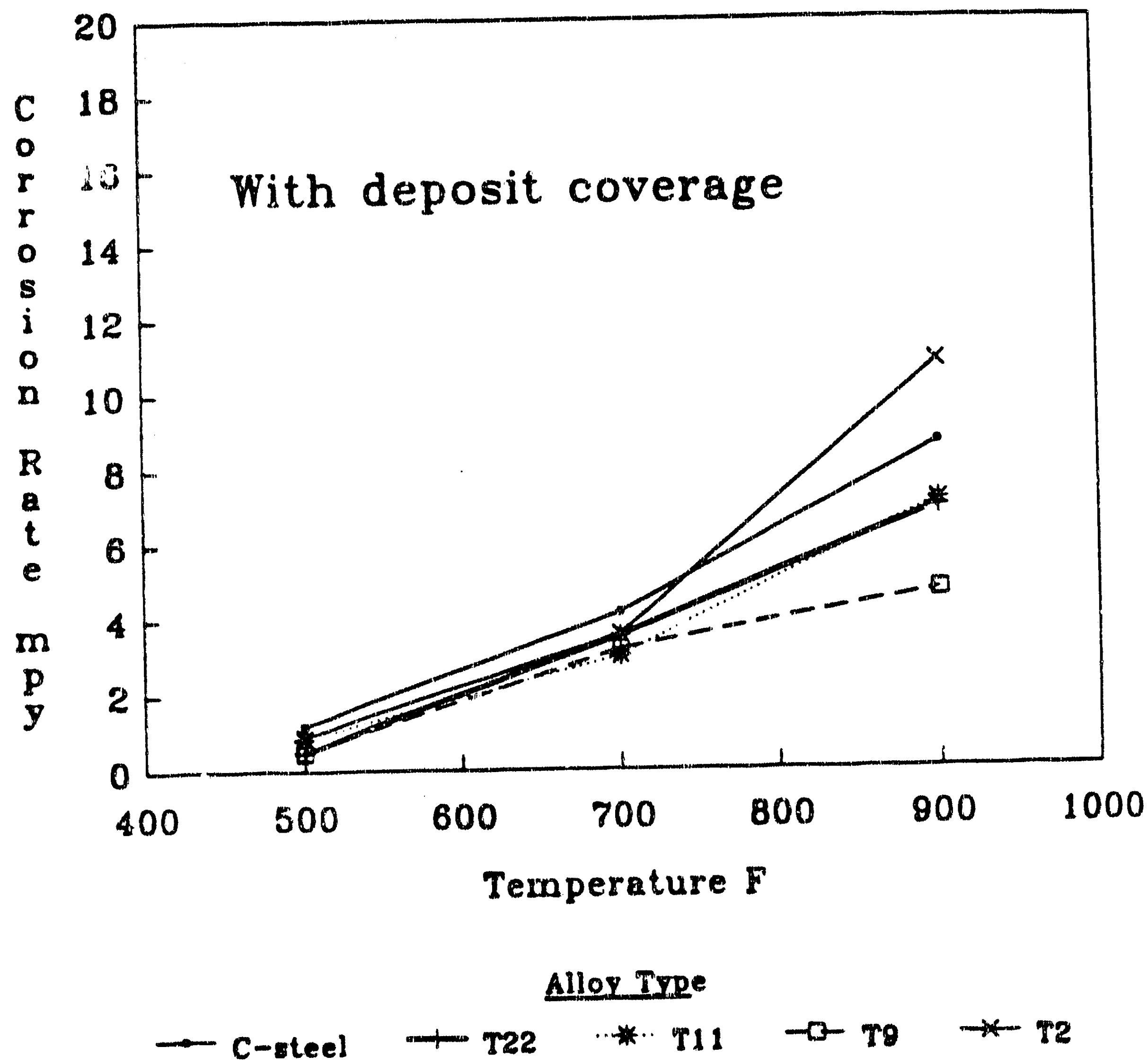
High-alloy steels in mixed gas with 0.05% H2S after 1000 hours



Average corrosion rates are extrapolated to one year based on the 1000-hour metal wastage data from the retort tests.

CORROSION RATE vs. TEMPERATURE

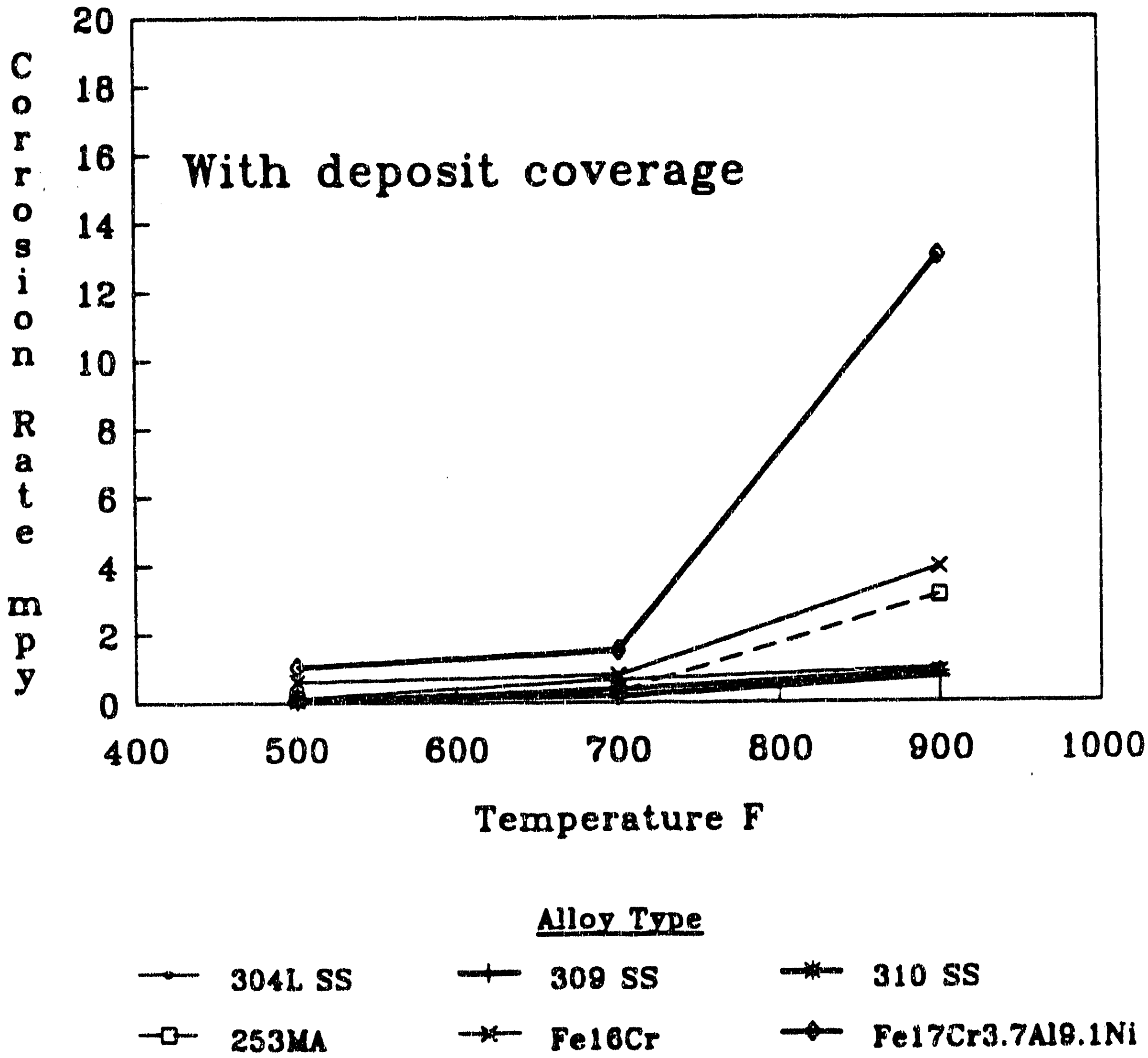
Carbon and low-alloy steels in mixed gas with 0.05% H2S after 1000 hours



Average corrosion rates are extrapolate to one year based on the 1000-hour metal wastage data from the retort tests.

CORROSION RATE vs. TEMPERATURE

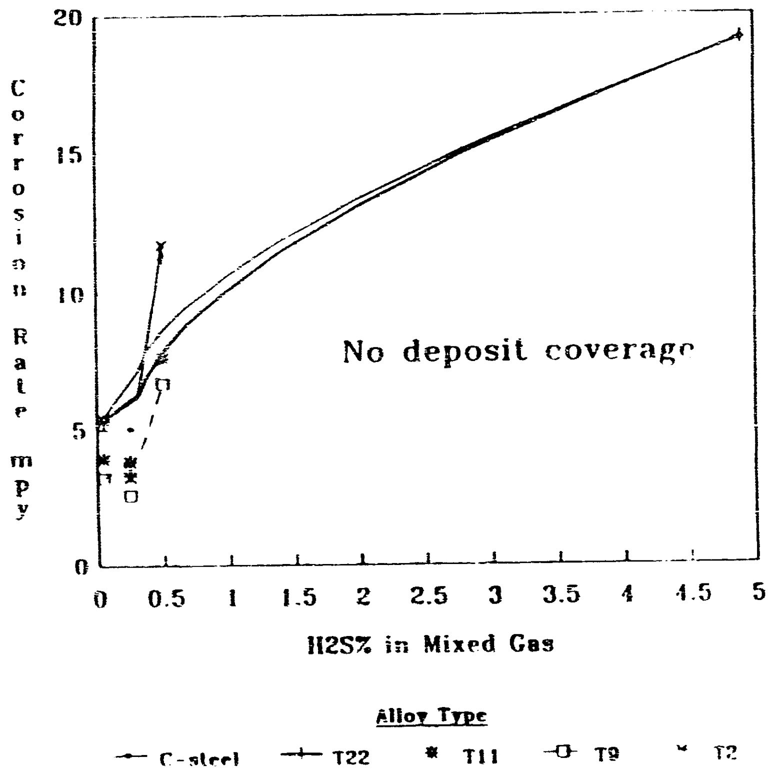
High-alloy steels in mixed gas
with 0.05% H2S after 1000 hours



Average corrosion rates are extrapolated to one year based on the 1000-hour metal wastage data from the retort tests.

CORROSION IN LOW-NOx ENVIRONMENT

Alloys exposed to a H2S-containing mixed gas at 700 F for 1000 hours



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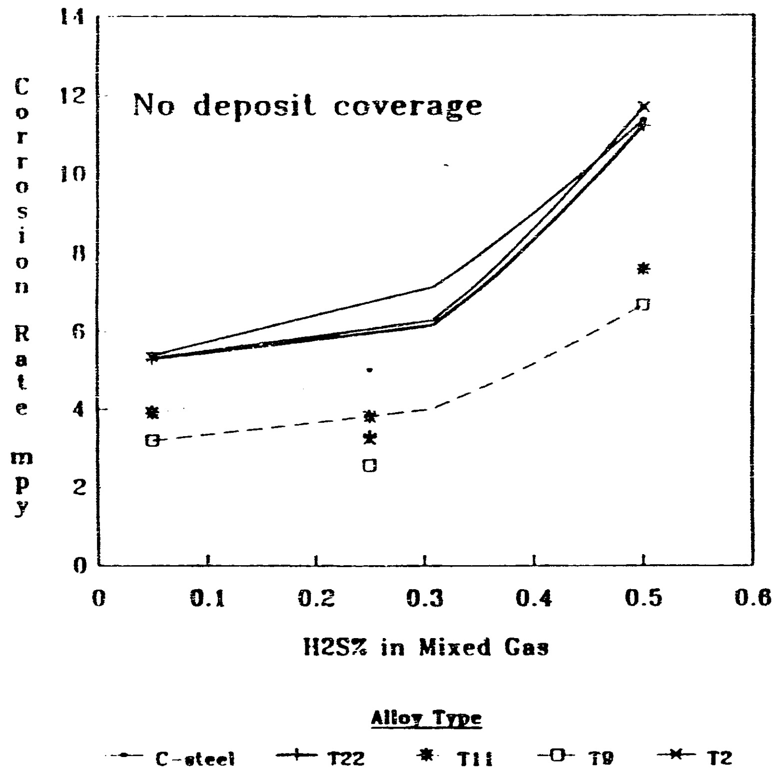

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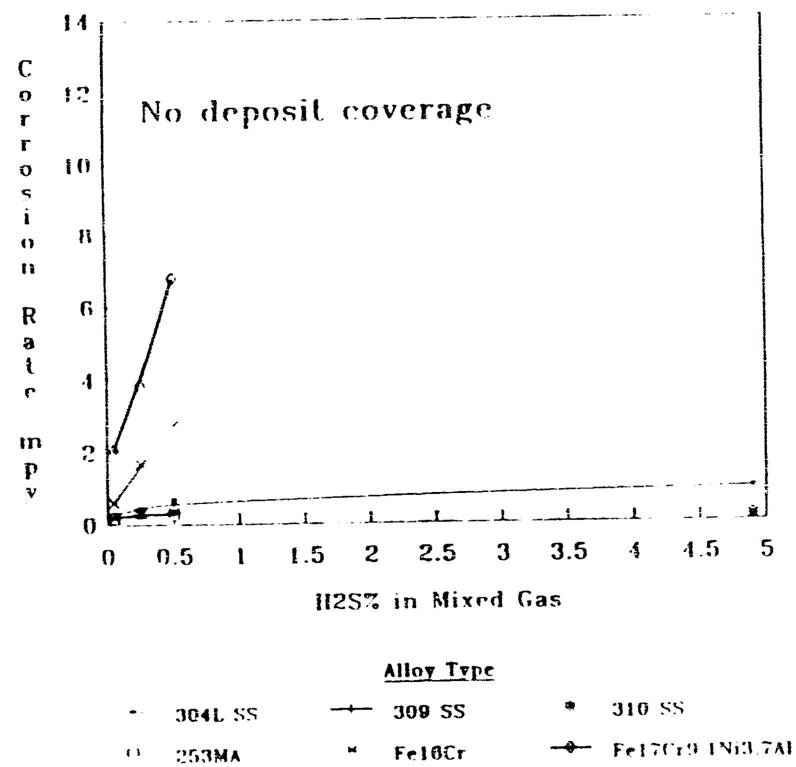

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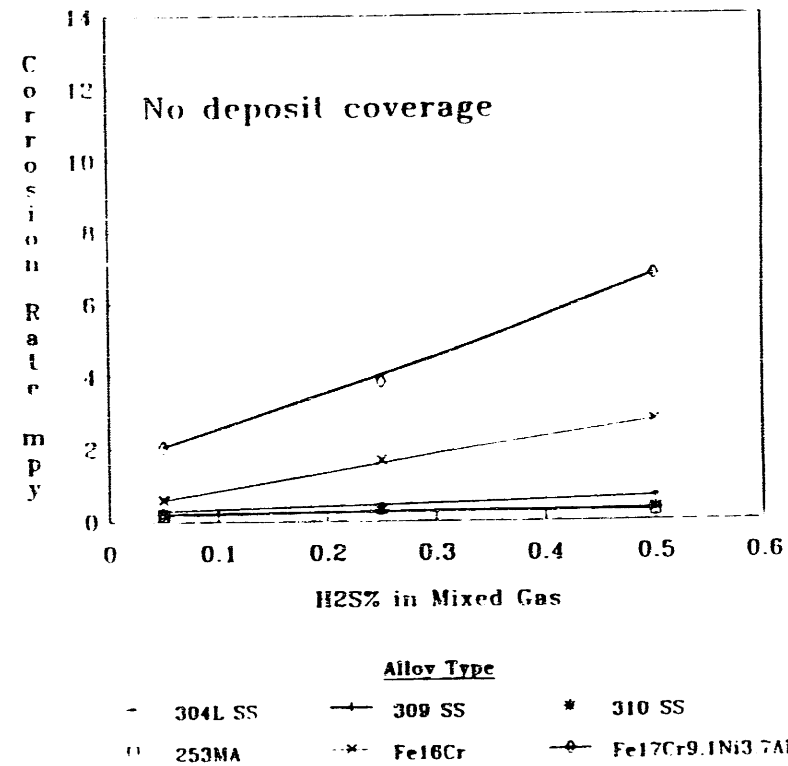

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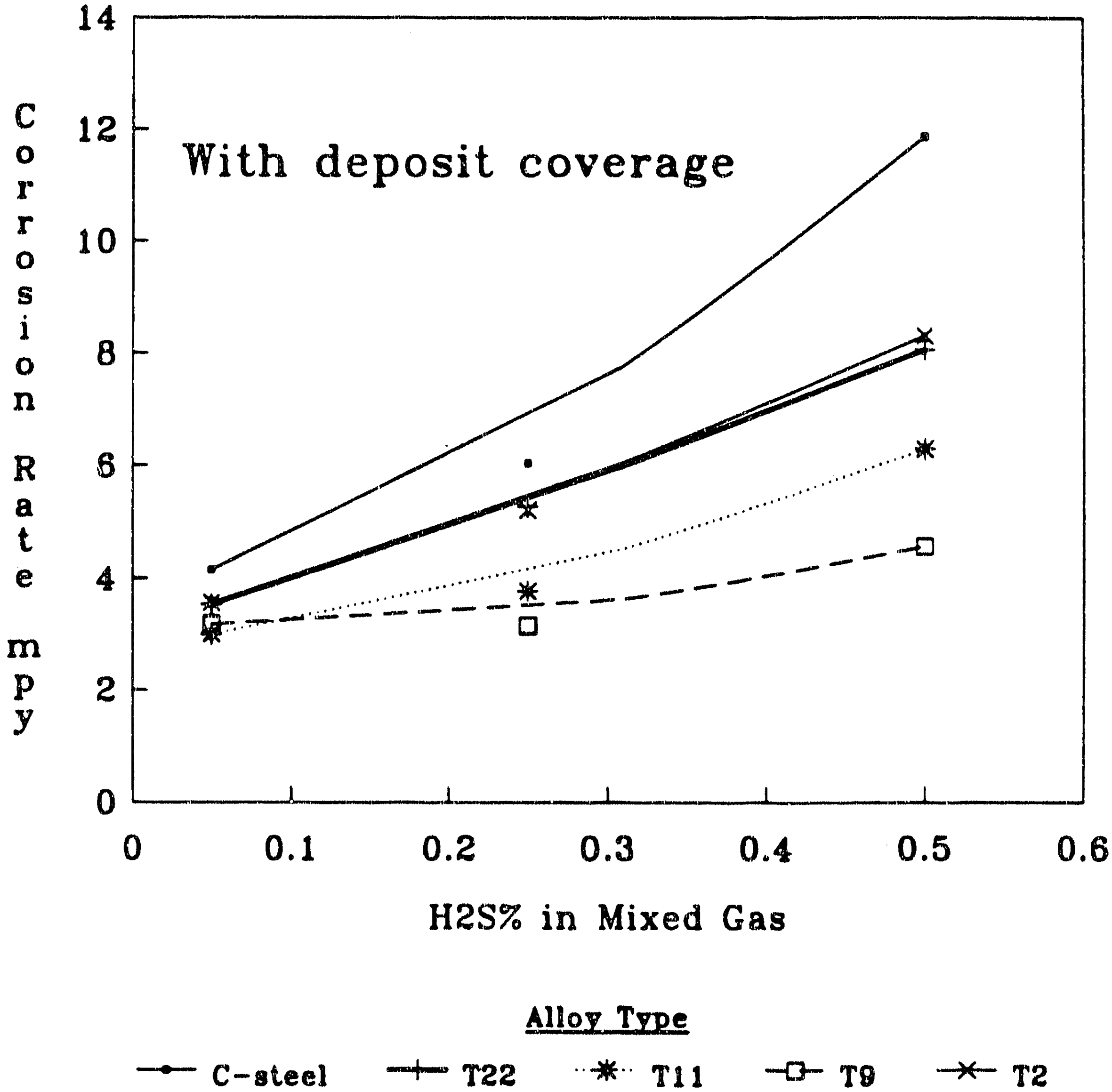
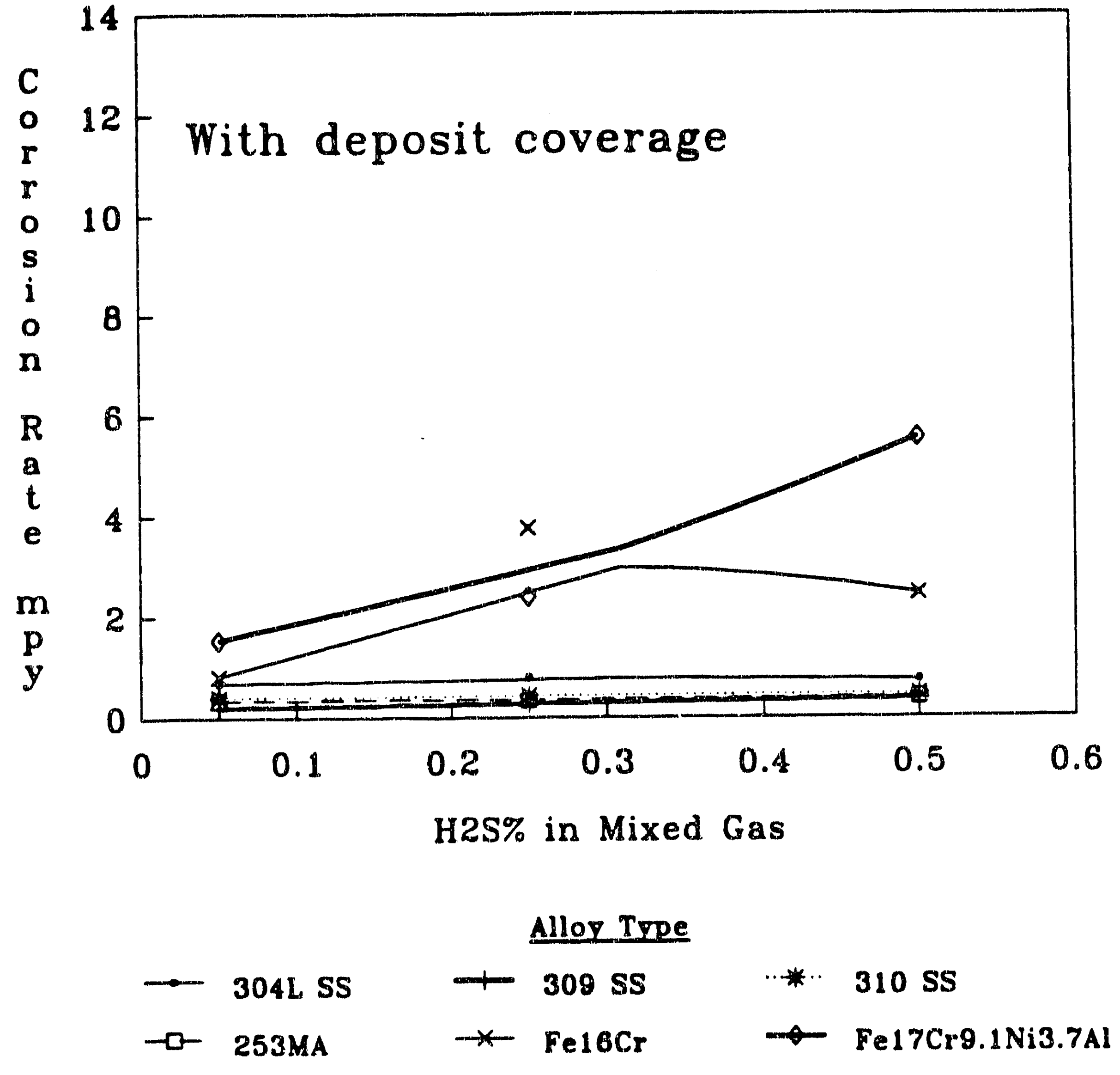


Average corrosion rates are extrapolated to one year based on the 1000-hour metal wastage data from the retort tests.

CORROSION IN LOW-NOx ENVIRONMENT

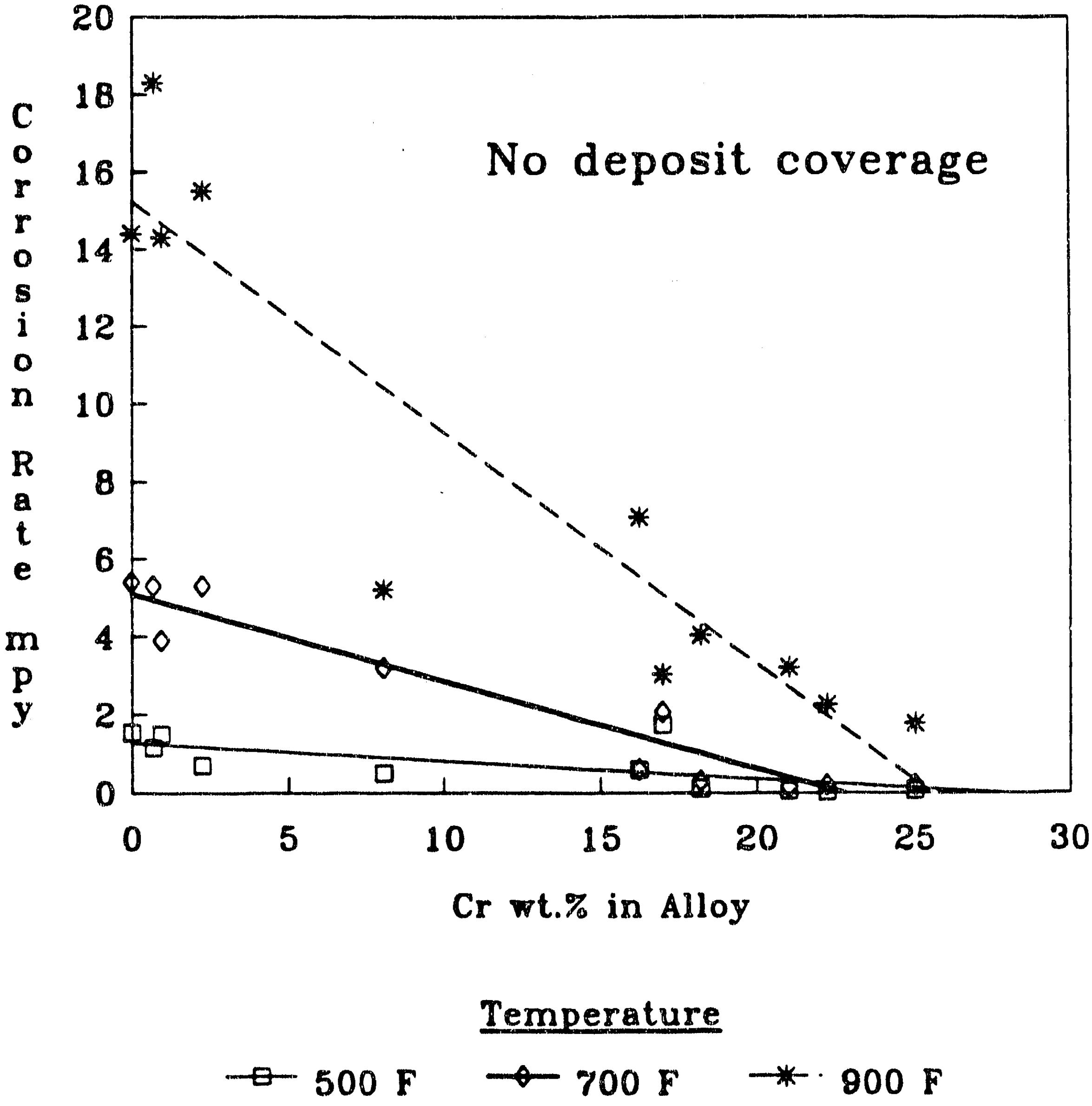
Alloys exposed to a H_2S-containing mixed gas at 700 F for 1000 hours



Average corrosion rates are extrapolated to one year based on the 1000-hour metal wastage data from the retort tests.

CORROSION RATE vs. Cr%

Exposure to mixed gas containing 0.05% H2S for 1000 hours



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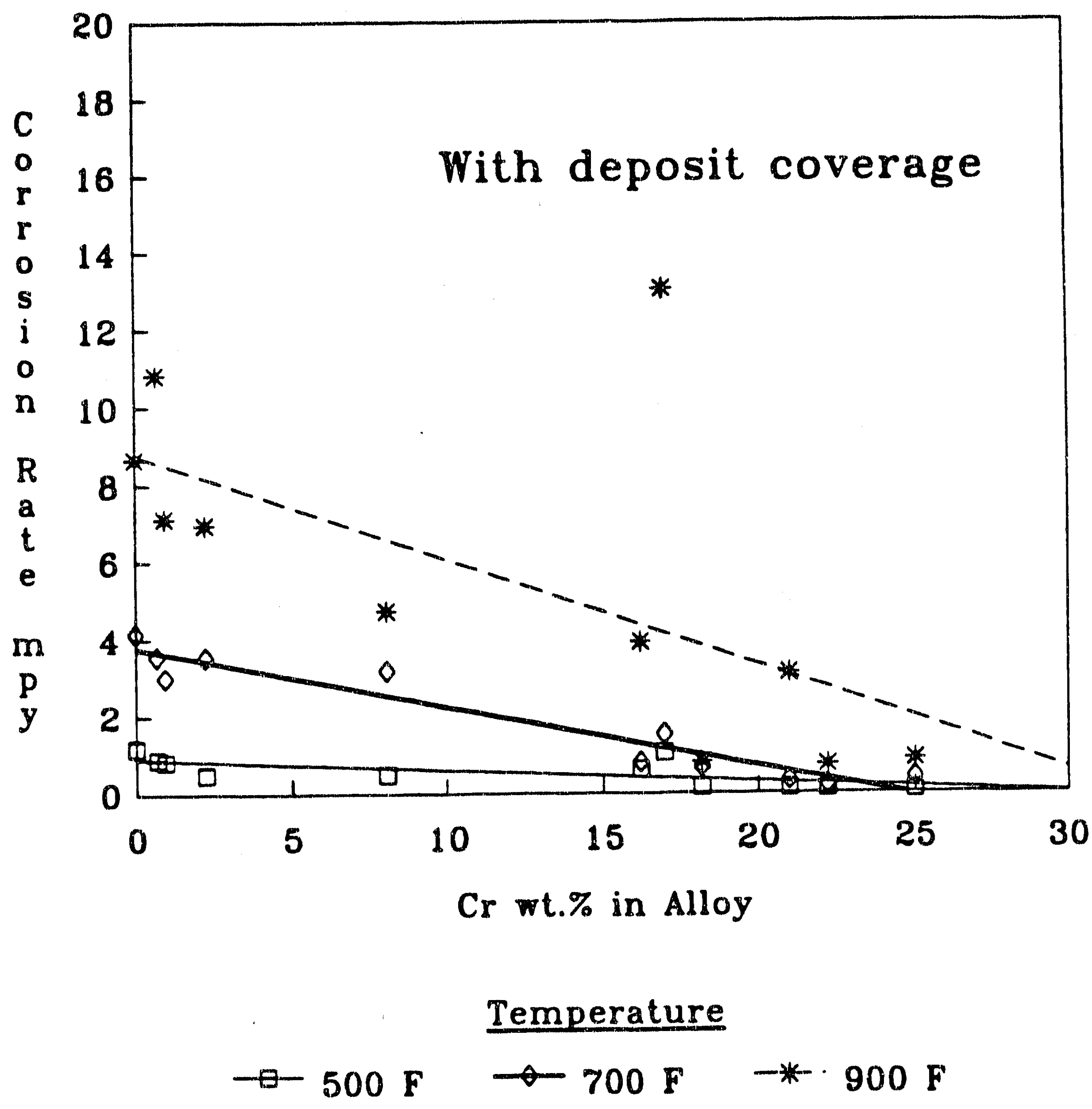
CORROSION RATE vs. Cr%

Exposure to mixed gas containing 0.05% H2S for 1000 hours



Average corrosion rates are extrapolated to one year based on the 1000-hour metal wastage data from the retort tests.

CONCLUSION OF CORROSION TEST

- The corrosion rates of carbon and low-alloy steels are too high for 900F and 0.5% H_2S.
- Chromia-forming high-alloy steels are corrosion resistant to the LNCB environments.
- The critical Cr content in alloy is about 15%.
- Coating characteristics are important.
- Metal temperature affects the corrosion rates more than H_2S concentration in the mixed gas.

END

DATE FILMED

9/17/92