FLUID CATALYTIC CRACKER
LAKE CHARLES REFINERY
STACK TEST
FEBRUARY 2, 3, 1981

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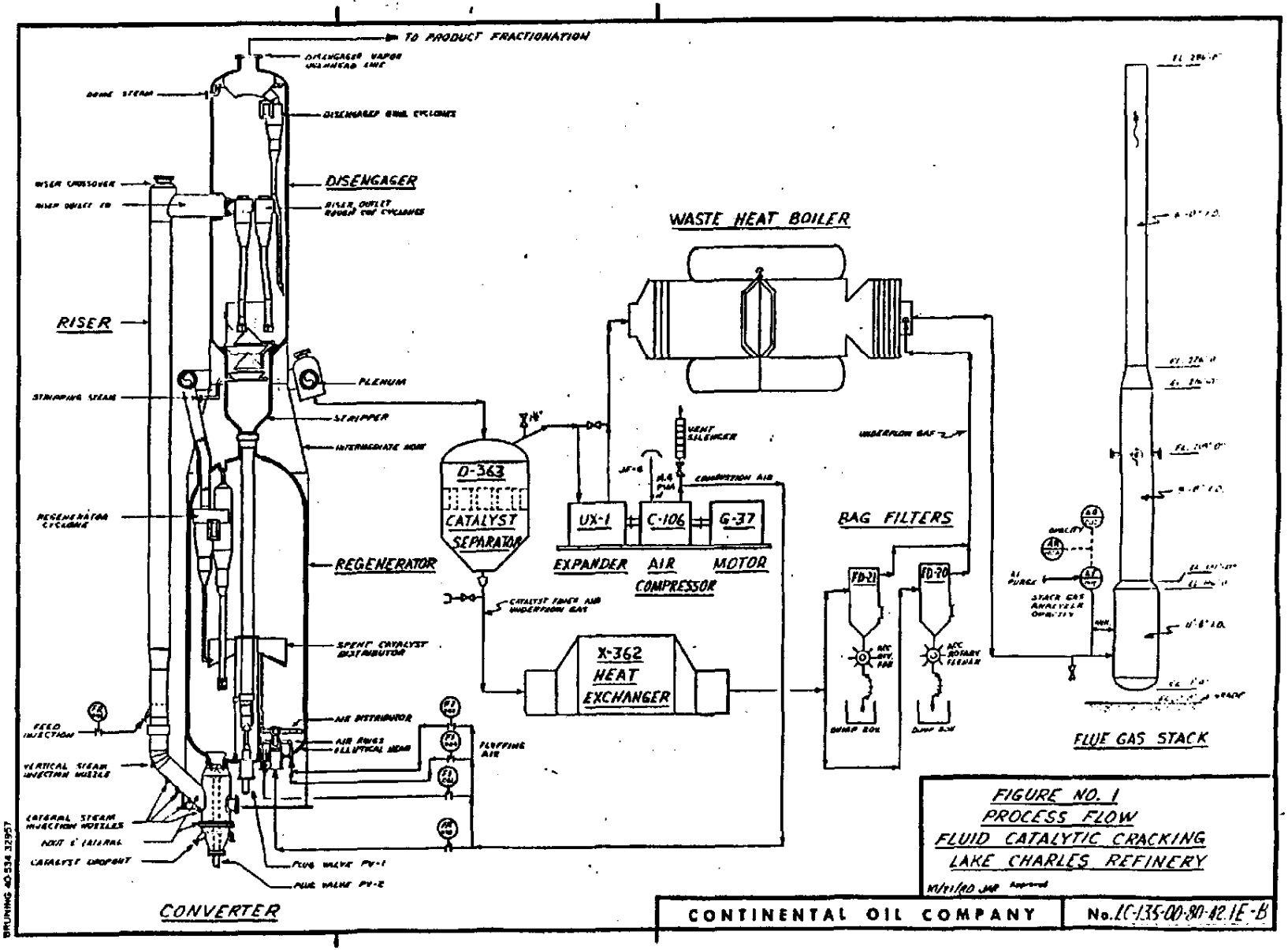
INTRODUCTION

On February 2, and 3, 1981 Kemron Environmental services and Conoco personnel conducted stack emission tests for particulate emissions, carbon monoxide emissions, and stack opacity on the Fluid Catalytic Cracker (FCC) at the Lake Charles Refinery, as required by CFR 40, part 60.8 "Performance Tests" for New Stationary Source Pollution Standards.

The FCC unit consists of a 30,600 BPSD Pullman-Kellogg Orthoflow "F" Riser Catalytic Cracker, a product fractionation section, an energy recovery section, and an emission control section. On the following page there is a process flow diagram for the FCC. The catalytic cracker is comprised of three main vessels: the riser, the disengager, and the regenerator.

Hot regenerated catalyst flows from the regenerator to the feed injection nozzle. The liquid feed is contacted with the hot catalyst, and it is instantly vaporized. The expanding vapors drive the catalyst up the riser. It is in the riser itself that the cracking reaction takes place. As a byproduct of the cracking reaction, coke is formed on the surface of and in the pores of the catalyst particles. The reaction is quenched by separating the product vapors from catalyst particles in the disengager. The product vapors go to the product fractionation section while the catalyst flows through the stripper and drops into the standpipe. The weight of catalyst in the standpipe overcomes the pressure differential between the disengager (low) and the regenerator (high). Spent catalyst from the standpipe is distributed on top of the fluidized bed in the regenerator.



Combustion air is supplied by three air distributors (95%) and three fluffing air rings (5%). The coke is burned off the catalyst, heating and regenerating it. The hot regenerated catalyst flows out the bottom of the regenerator, completing the catalyst circulation loop.

The flue gas exits the regenerator through the regenerator cyclones and enters the doughnut-shaped plenum. From there the flue gas goes to the catalyst separator which removes the catalyst fines from the bulk of the flue gas. The flue gas then goes to the energy recovery section where the expander recovers power from the hot gas to drive the combustion air compressor, then to the waste heat boiler. The catalyst fines and underflow gas leaves the bottom of the catalyst separator and flows to the flue gas cooler, X-362, where the gas is cooled to protect the bag filter fabric. In the bag filter, catalyst fines are recovered from the underflow and are disposed of into a dump box. The underflow gas passes through the bag and rejoins the flue gas leaving the waste heat boiler. The flue gas is then emitted out of the flue gas stack. On the following page is a drawing of the stack cross section at the sample port.

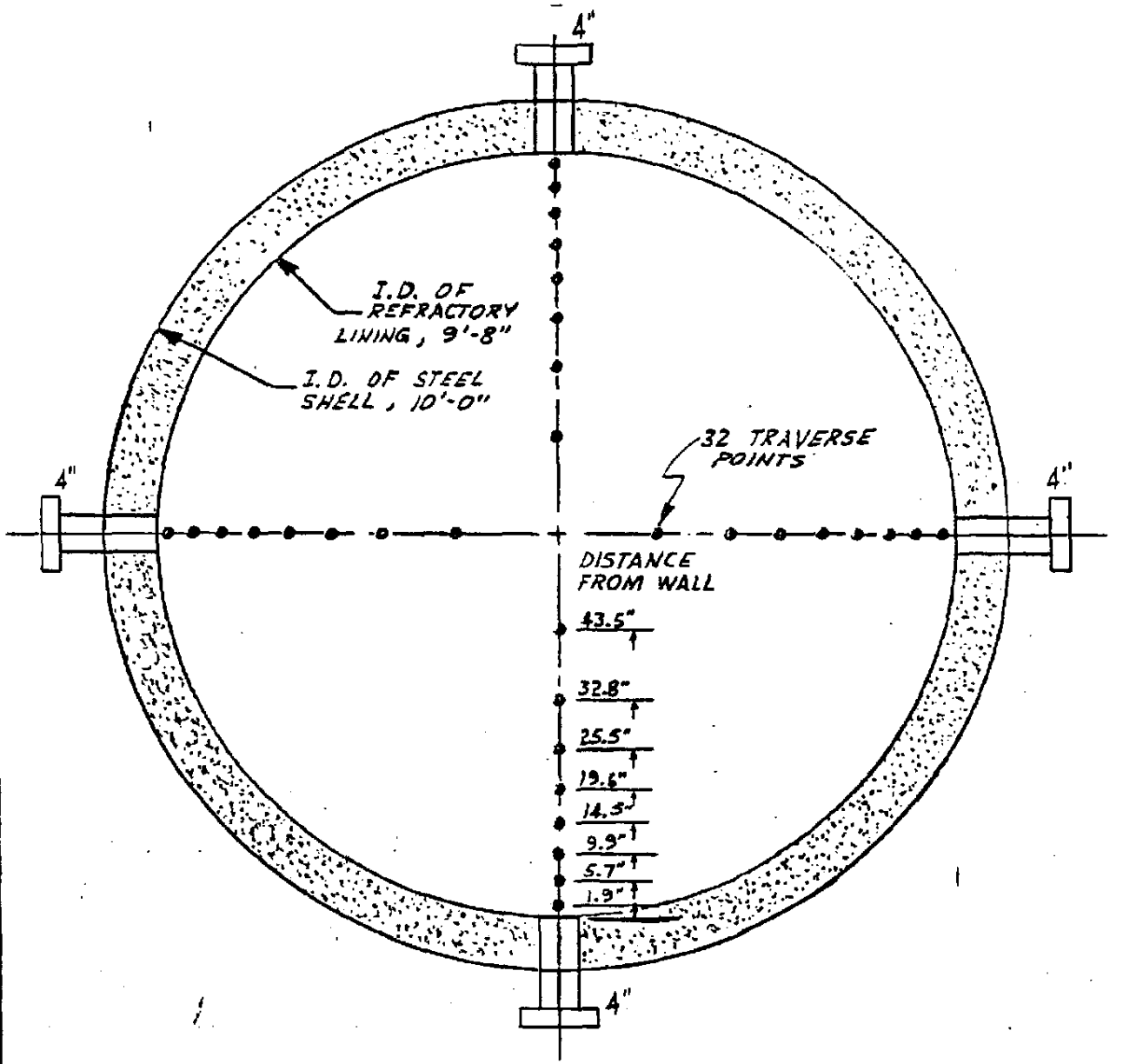


FIGURE NO. 2

STACK CROSS SECTION WITH SAMPLE POINTS DETERMINED ACCORDING TO METHOD ONE. (REFER TO METHOD ONE SECTION IV OF KEMRON REPORT)

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SUMMARY

Emissions:

A summary of emission rates, Table 1, is located on the following page. Particulate emissions exceeded the performance standard. Carbon monoxide emissions and stack opacity were within the performance standards. Stack opacity was measured with our continuous monitoring system. The stack was also visually monitored by a trained observer, Mr. Robert A. Ressl of the PEDCo Group. Mr. Ressl was under contract with Region 6 of The Environmental Protection Agency. His two sets of opacity readings averaged 16 and 15. A copy of his Visible Emission Observation Form is on page 41. The test runs were made at a feed rate of 29,050 BPD, measured with flow recorder FR-404. The design and normal maximum operating level is 30,600 BPD of feed.

Air Pollution Control Equipment:

Carbon monoxide emissions are minimized by operating the regenerator under 3% excess oxygen and using a CO combustion promoted catalyst. This causes complete combustion of carbon monoxide to carbon dioxide, without any after-burning.

The regenerator cyclones are the first level of particulate emissions control. They are meant to minimize catalyst losses from the converter. There are six first stage cyclones, Emtrol Corp. model number 46B055, and six second stage cyclones, Emtrol Corp. model number 48A033. Each first stage cyclone is paired with a second stage cyclone, with the discharge of the first stage going directly into the entrance of the second stage.

TABLE 1: A summary of emission rates for particulates and carbon monoxide, and stack opacity.

EMISSION	RUN #				PERFORMANCE STANDARD
	1	2	3	AVE.	
Particulates, lb/hr	37.6	28.7	31.4	32.6	-
Particulates, lb/1000 lb of coke burn-off	2.20	1.65	1.85	1.90	1.00
Percentage of isokinetic sampling rate, %	95.1	94.6	94.1	94.6	100 ± 10
Carbon Monoxide, ppm, run average	40.3	67.3	59.7	55.8	500
Opacity, %	13.4	13.6	13.1	13.4	30

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Air Pollution Control Equipment: (continued)

The discharge from the second stage cyclones goes into a common plenum. The recovered catalyst is returned to the regenerator through six first stage and six second stage diplegs.

The next level of particulate emissions control is given by the catalyst separator. The catalyst separator, often referred to as the "Shell separator", was manufactured under a licensing agreement with the developers, Shell Oil Co. It is meant to remove catalyst fines from the bulk of the flue gas stream, prior to the expander and waste heat boiler. It has 55 separator tubes. Figure 3, on the following page, shows a typical separator tube. Catalyst fines and flue gas pass down the outside of the tubes and across swirl vanes which impart a spin to the stream and throw the denser catalyst particles to the outside. The gas makes a turn at the bottom of a tube and flows up the inside of the tube and then out of the separator. The catalyst falls to the bottom of the separator vessel and is drawn out in a fluid flow using about three percent of the incoming flue gas as the carrier. The bottoms stream passes through critical flow nozzles (between the flue gas cooler and the bag filters). Flow through these nozzles is at sonic velocity and is therefore relatively constant and does not vary with FCC charge rate.

The temperature of the bottoms stream is 1300°F. The flue gas cooler, X-362, reduces this to 375°F, the maximum continuous operating temperature the Huyck felt bags in the bag filters can withstand, by producing steam.

The final level of particulate emissions control is given by the bag filters

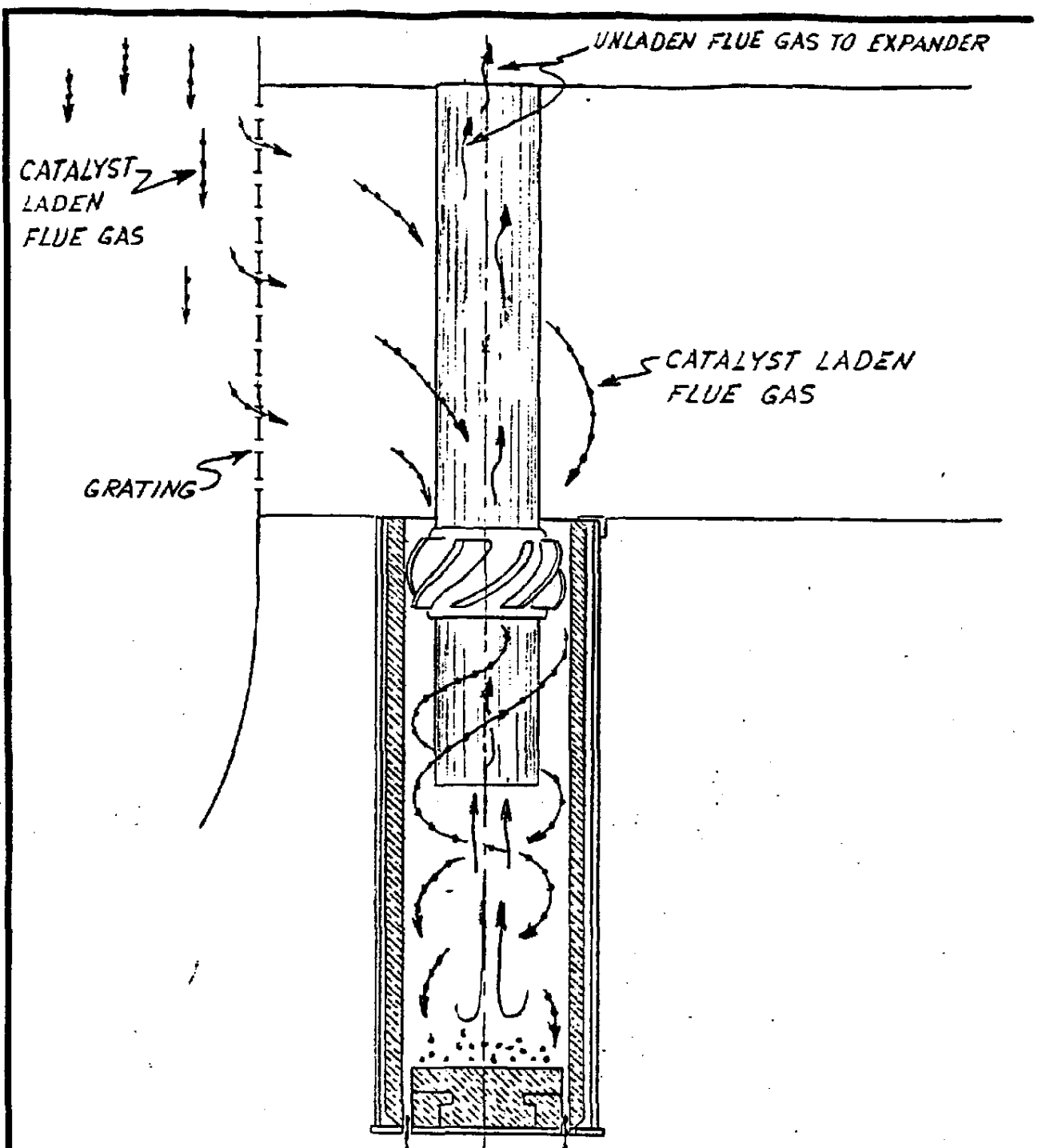

FIGURE NO. 3
INDIVIDUAL SEPARATOR TUBE IN CATALYST SEPARATOR
LAKE CHARLES REFINERY

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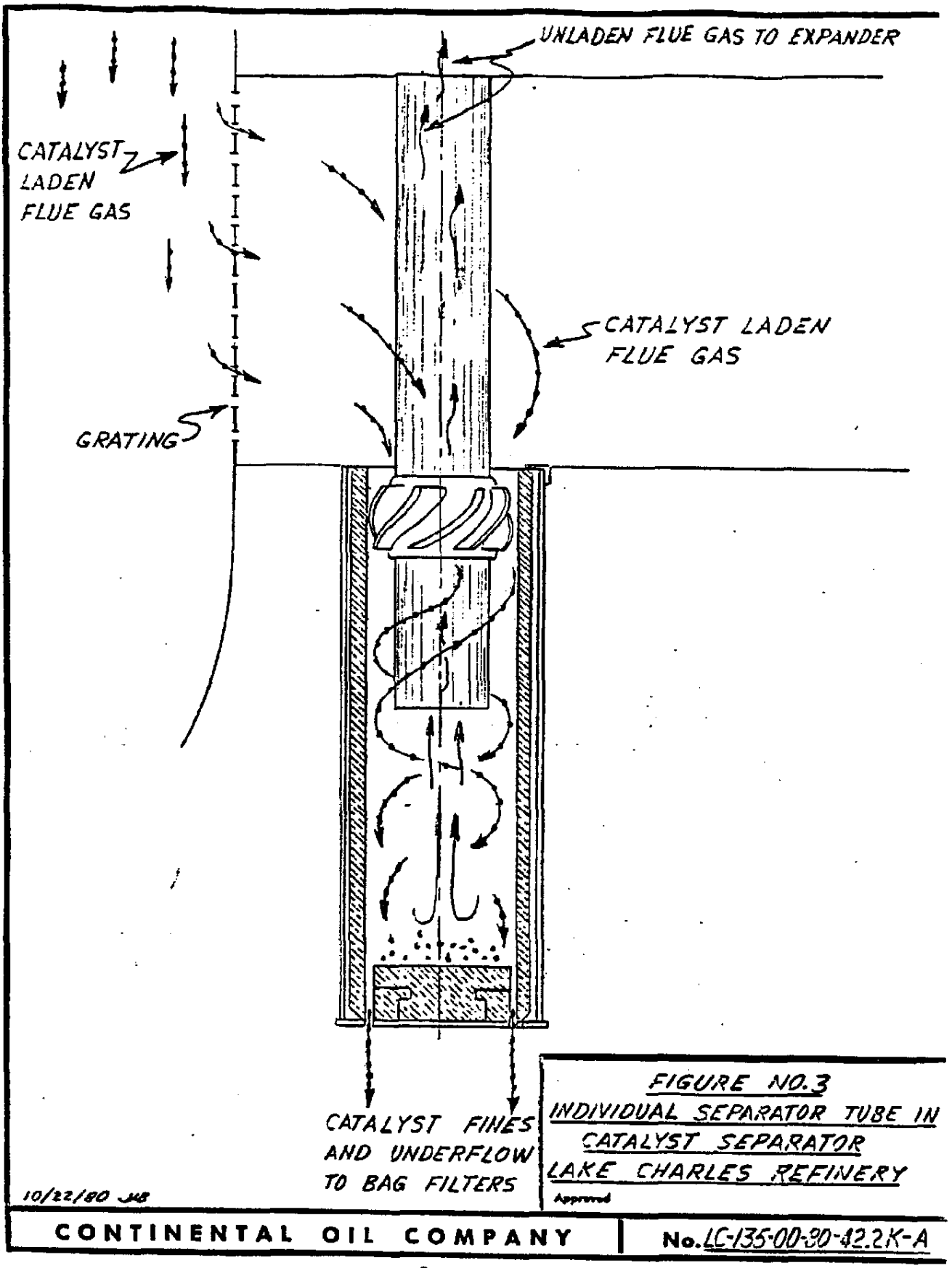

FIGURE NO. 3
INDIVIDUAL SEPARATOR TUBE IN CATALYST SEPARATOR
LAKE CHARLES REFINERY

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CONTINENTAL OIL COMPANY | No. LC-135-00-30-42.2K-A

Air Pollution Control Equipment: (continued)

which recover the catalyst fines. The underflow gas is returned to the main flue gas stream leaving the waste heat boiler. The two bag filters, American Air Filter Co. Pulse-Jet Fabric Dust Collectors, type 12-48-770, are installed in parallel. Each will handle the full gas stream, and normally only one is on stream. During the test one was on stream. Each filter has 48 Huyck felted bags, fabric weight 16 oz. The "pulse jet" type periodically uses a back flow pulse of compressed air to shake the bags to remove the recovered catalyst. The catalyst drops into a hopper at the bottom of the collector. Four gate valves remove the fines to a dump box for disposal. Only twelve of the bags are pulsed at a time, the rest remain in service. A solid state local control panel allows variation of pulse duration (0.010 - 0.500 sec.) and interval (10 - 240 sec.). During the test the pulse duration was 0.100 seconds and the interval was 1 minute.

The flue gas leaving the waste heat blower passes by the opacity monitor located in a horizontal section of pipe before exiting out the flue gas stack.

PROCEDURE

Particulate Emissions:

The test methods and procedures given in CFR 40 part 60.106(a) were used to determine particulate emissions. One deviation from the special procedure was used: Paragraph (1) specifies making a determination of the volumetric flow rates for gases released to the atmosphere; paragraph (2) specifies making a separate determination of the volumetric flow rates for exhaust gases prior to the emission control system. Only one measurement of volumetric flow rates (of gases released to the atmosphere) was made. Because of the configuration of the emission control system, with no afterburning and return of the underflow gas from the catalyst separator to the main flue gas stream, no additions to or deletions from the flue gas stream occur in the control system. Therefore, only one determination of volumetric flow rate is needed. It is much more practical to measure the flue gases after they have been cooled from 1300°F to 480°F. Because measurements are made in standard cubic feet per minute, the change in temperature will make no difference in the numerical answer.

Method 1 was used to determine the number and location of sample and velocity traverses. The calculations are found in Test Data and Calculations, pages 22-24. Method 1 is described in Appendix 4, KEMRON Report, Section IV.

Method 2, used to measure velocity and volumetric flow rate, is described in Appendix 4, KEMRON Report, Section V.

Method 5, used to measure concentration of particulate matter and moisture

PROCEDURE

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Method 2, used to measure velocity and volumetric flow rate, is described in Appendix 4, KEMRON Report, Section V.

Method 5, used to measure concentration of particulate matter and moisture

PROCEDURE

Particulate Emissions: (continued)

content, is described in Appendix 4, KEMRON Report, Section VI.

The total particulate catch was adjusted for sulfate concentration. Sulfates are in the vapor phase at stack conditions. Method 5 sampling results in them being reported as particulates. This inconsistency was corrected by analyzing the particulates for sulfates and taking an offset for any sulfates found. Sulfate emissions are shown in Appendix 4, KEMRON Report.

Carbon Monoxide:

The test methods and procedures given in CFR 40 part 60.106(b) were used to determine carbon monoxide concentration in the flue gas emitted to the atmosphere. Method 10, used to measure emissions of carbon monoxide, is described in Appendix 4, KEMRON Report, Section VII.

Opacity:

Stack opacity was measured using our continuous monitoring system. A trained observer also made visual observations in accordance with CFR 40 part 60.11(b).

ANALYTICAL TECHNIQUE

A description of the analytical technique can be found in Appendix 4, the KEMRON Report, Section II.

CHAIN OF CUSTODY

The Chain of Custody is described in Appendix 4, the KEMRON Report, Section II.

TEST DATA AND CALCULATIONS

a) Field Data Sheets

b) Process Operations Log

c) Laboratory Data

d) Emissions Calculations

Time	FI-004 Reading	FI-005 Reading	FI-006 Reading	Wet Bulb Temperature °F	Dry Bulb Temperature °F
Began	first run	9:00			
9:15 a	6.70	6.35	[illegible]	34	41
9:45 a	6.65	6.35	6.40	34	42
10:00 a	6.60	6.35	6.35	37	50
10:15 a	6.50	6.20	6.30	35	42
Ended	first run @	10:15 a			
[illegible]	6.30	6.30	6.35	35	44
Began	2nd Test @	[illegible]			
11:15 a	6.55	6.30	6.35	34	46
11:45 a	6.60	6.35	6.40	37	47
12:15 p	6.60	6.20	6.35	37	47
Ended	2nd Test @	12:30 P			
12:45 P	6.60	6.30	6.35	38	48
1:15 P	6.50	6.25	6.25	39	50
Begin	3rd Test @	1:23 P			
1:45 P	6.55	6.25	6.25	39	47
2:15 P	6.60	6.30	6.35	38	47
Ended	3rd Test @	2:35 P			
2:45 P	6.55	6.30	6.30	40	51

J. E. Blazer [illegible]

2/3/8[illegible] FCC [illegible] TEST [illegible] [illegible]

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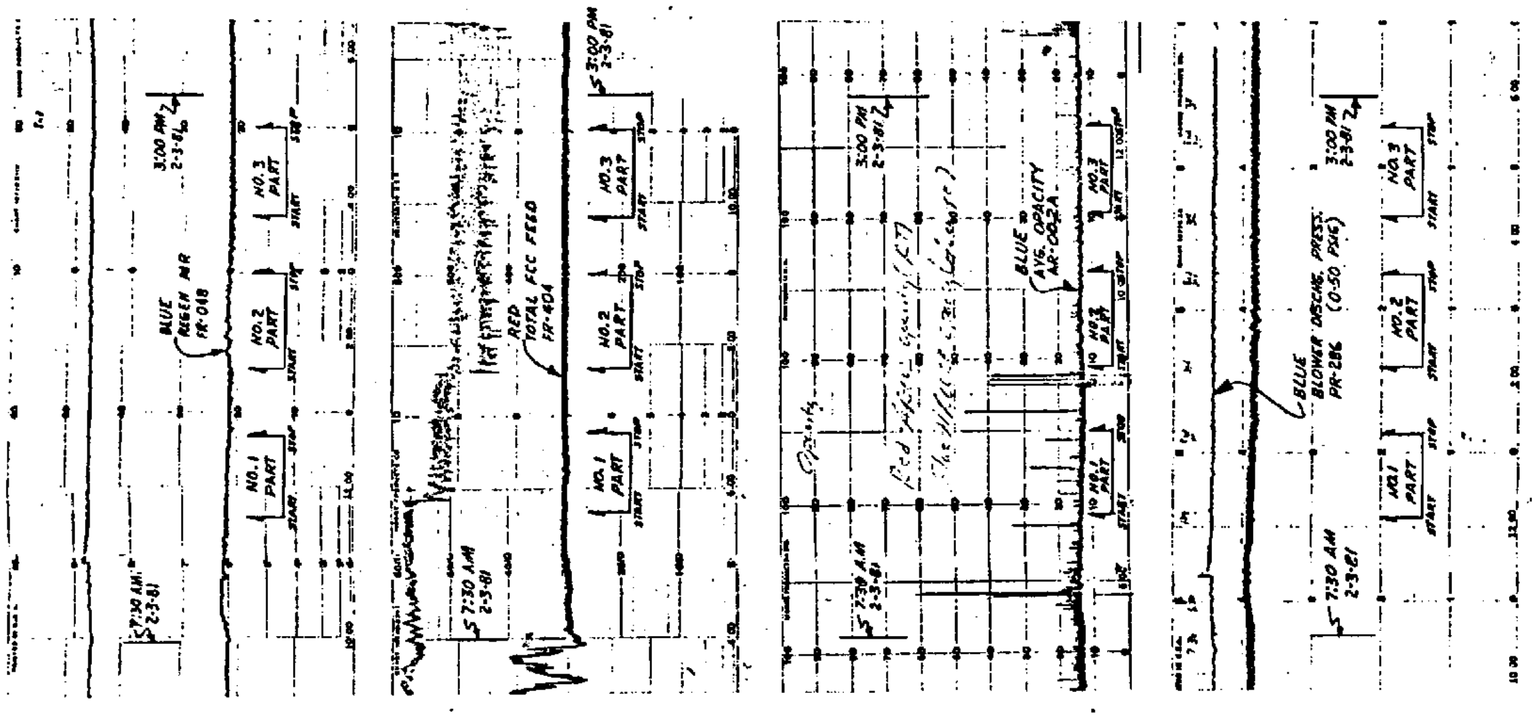
Further field data sheets for particulate and carbon monoxide emissions can be found in Appendix 4, the KEMRON Report, Section VIII, appendix.

PROCESS OPERATIONS LOG



1	3/26/81	ORIGINAL		
ISSUE NO.	DATE	DRAWN BY	CHECKED BY	APPROVED BY

CONTINENTAL OIL COMPANY
REFINERY ENGINEERING CENTER
LAKE CHARLES, LOUISIANA

CONTROL ROOM CHARTS
FCC REGENERATOR N.S.P.S. EMISSION TEST
CONOCO INC., LAKE CHARLES REFINERY

APPROVED:
DATE:
No. LC-135 06-81 42.1A-C

C) LABORATORY DATA

PARTICULATE

1. Filter Weights
2. Probe Residues
3. Blanks

Project No.

TITLE CONOCO WESTCAKE PART 2-3-81 Book No.
ECC STK

From Page No.

RUN	INT WT	FINL WT	GAIN
1	.4890	0.6686	0.1796
2	.6430	0.8023	0.1593
3	1.4844	0.6342	0.1498

To Page

Witnessed & understood by me. | Date | Invented by | Date