REF# 5

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Refinery improves particulate

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PHILLIPS Petroleum Co., in its latest attempt to control particulate emissions, has added a voltage controller to an electrical precipitator. Installed on a cat cracker in the Avon refinery near Martinez, Calif., the controller is described as very effective in helping to reduce emissions.

Addition of the new mechanism is the latest in a long line of improvements to control particulate emissions at this plant.

Other challenges are being met at the plant's fluid coker, boiler house, and at the coker hopper.

Improvements over the years have netted new efficiencies on the above units. Latest test reports show particulate-emission-control efficiency to be 94.6% at the cat cracker, 98.7% at the coker, 99.3% at the boiler house, and 99.7% at the coker hopper, Table 1.

Paper presented at the NPRA Annual Meeting in San Francisco.

As it happened. In 1956, a 42,000-b/d fluid coker was built at the Avon plant. Particulate coke from the burner was largely held in the unit by use of 18 pairs of two-stage cyclones in the burner.

Fines which carried past the cyclones were designed to be burned in the CO steam generator. Even with the large firebox on the CO boiler, it was not possible to burn 100% of the coke carried over from the regenerator cyclones.

A 500,000-lb/hr boiler, constructed to burn gas, fuel oil, or coke, went on stream in 1958. When burning a solid fuel of 0.5% ash content, a yellow plume of fly ash and some SO_3 was usually present. This fly ash was mostly unburned coke and was returned to the firebox where the coke content was reduced.

By 1960, generation of stack plumes and loss of particulates to atmosphere became socially and politically unacceptable. So contracts were let for four Buell Engineering precipitators.

One of the new precipitators was small and removed coke fines from a carrying-air stream formerly vented at the top of two large coke silos. Each silo had a capacity of 6,000 tons.

While the amount of gas and fines handled is not large, this unit is included since it fills a need and does so under conditions quite different from the other three precipitators.

CO boiler. The second precipitator was added to the fluid-coker CO boiler. This device handles 7-15 tons/day of fine coke of less than 2% ash at full charge rate. Gas stream is 437,000 cfm at 476° F. at essentially atmospheric pressure with a superficial velocity of 3.8 fps, Fig. 1.

Flow is distributed into four parallel passes by ductwork. But partitions are not complete in the precipitator and no part can be shut down separately. It is two-stage with 16 hoppers with dimensions of 27 x 24 x 77 ft.

Composition of the gas handled is essentially 13.9% CO_2, 22% H_2O, 3.8% excess O_2, and the balance is nitrogen.

Table 1

Avon refinery precipitators

Unit	Rate	ACF/min @ °F.	Area sq ft	Length	Velocity, fps	Particulate loading lb/hr In	Particulate loading lb/hr Out
Cat cracker	44,300 b/d	220,000 @ 609°	988	25'10"	3.7	500	27
Coker	42,000 bbl f.f.	437,000 @ 476°	1,920	27'½"	3.8	915	12
Boiler house	400,000 lb/hr 600# stm.	210,000 @ 390°	1,020	27'10"	3.44	983	6.6
Coker hopper	46 tons/hr	8,160 @ 282°	144	16'	1.0	507	2.5

GAS COMPOSITION

Unit	CO_2, % (Remainder N_2)	CO, % (Remainder N_2)	O_2, %	H_2O, %
Cat cracker	10	8.5	0.5	20.1
Coker	13.9	0	3.8	22
Boiler house	14.1	0	5.25	3.7
Coker hopper	← Air →			

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control

There is no CO as the preceding afterburner has eliminated it effectively. Stack losses are less than 25 lb/hr for a fines recovery of better than 98%.

This is the first year that we have consistently achieved this degree of efficiency. There is no visible plume at the stack. Fines were originally combined with balance of product coke but are now returned to the burner for combustion.

This precipitator was not altogether successful at first due to difficulty with the screw pumps handling recovered fines. Air leaked in through the hoppers causing internal fires. And occasionally, emitter wires broke and resulted in short circuits.

This precipitator is provided with ductwork. The ducts permit bypassing of the CO boiler and precipitator, the precipitator alone, or operation of the CO boiler with the precipitator down.

Blinds and water seals are used. But in units of this size, the time and manpower required to make any of the above transitions and return constitute a major effort. Change from bypassed to on-line status is a matter of several hours at each end.

Cat cracker. Cat-cracker precipitator, built in 1962, is two-stage with eight fines hoppers. Four sets of rappers are synchronized on 15-sec intervals for collector plates. Ductwork distributes flow into two passes which are not separated by a partition, Fig. 2.

Precipitator is located ahead of the CO boiler so that typical gas composition differs from that handled in the coker. There is some CO present. There is an absence of excess O_2 and it lacks products of the secondary combustion in the following afterburner.

Total volume of gas handled varies with operating conditions but at typical rates would be 200,000 actual cfm. Recovery of 5 to 7 tons/day of catalyst fines is made for an efficiency of about 95%.

The last six particulate tests have shown less than 10 lb/hr carryover to the stack. There is no stack plume visible as a rule but we show up to a Ringelmann 1 when loading fresh catalyst.

Fines recovered are dumped from the eight cat-cracker-precipitator hoppers on level control to a fines-storage hopper. Carrying air is discharged through a baghouse which is also used when unloading fresh catalyst. The fines are removed by a commercial scavenger company to a land-fill solids-disposal site.

Boiler house. The third major precipitator is on the main boiler-house firebox. It collects 5-10 tons/day of a fly ash which is 70% unburned carbon. This two-stage, two-pass installation handles 210,000-cfm vapors at 390° F. Vapors contain 14.1% CO_2, 3.7% water, and 5% excess O_2. The balance is nitrogen.

This precipitator operates at over 99% efficiency. Velocity is 3.44 fps. Fly ash from the boiler-house firebox contains enough vanadium and nickel to be marginally attractive for recovery when firing any substantial amount of solid fuel.

This fly ash is at present discarded. When firing gas or solid fuel, the disposal problem is negligible.

The 2,800 multiclones ahead of the precipator are original equipment and have never shown enough wear to warrant any renewals to date.

Fig. 1

Flue gas—coker

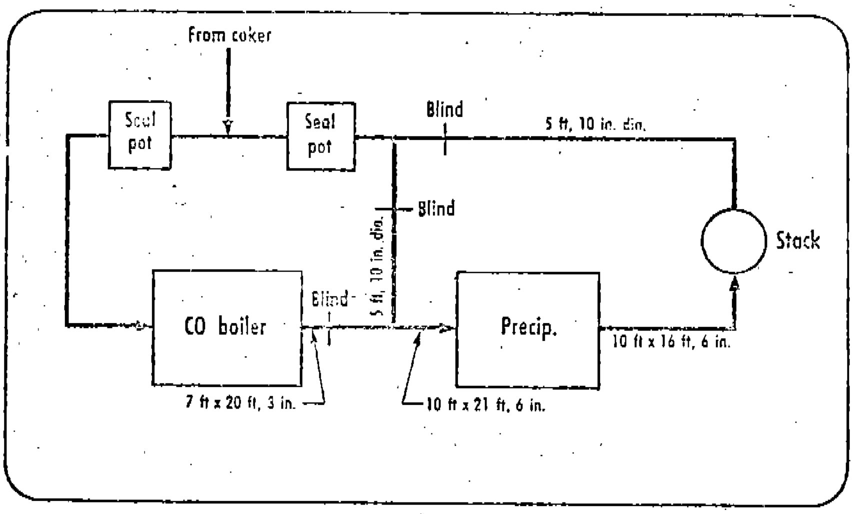
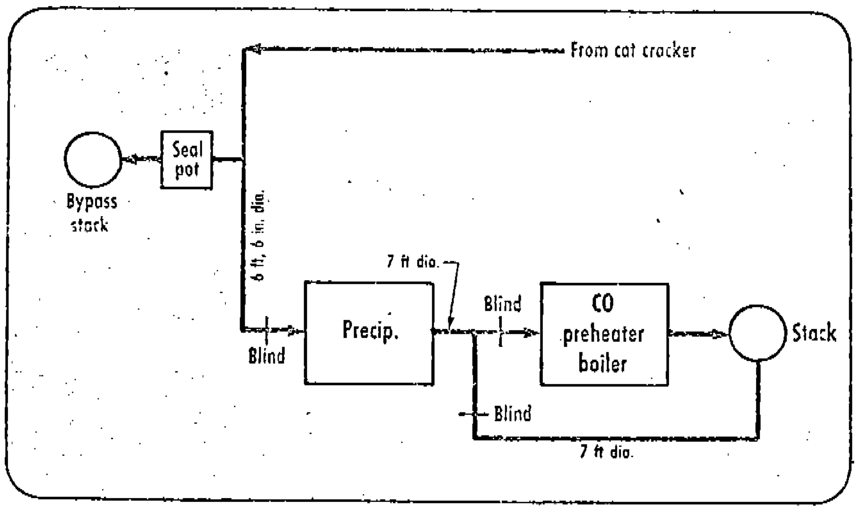


Fig. 2

Flue gas—cat cracker



Increasingly stringent regulation of particulate emissions and visible smoke demand extreme reliability on the part of this equipment. The first years of operation saw many equipment failures, mostly due to the accessory hardware.

The two-pass boiler-house-precipitator hopper had trouble the first year with the ash conveyor. This was repeated in Dec. 1967, and this in turn led to a mudded-up hopper and a short circuit in one quarter of the precipitator.

It is possible to take half of this precipitator off at a time by inserting blinds and this was done on this occasion. The stack is remarkably clean with no visible plume at full rates. We have had no citations on it in the last 4 years. Precipitator and accessories have had no serious problems for many years.

Coker. The coker precipitator has had one or two failures of emitter wires per run. But after the initial problems with fines-handling equipment and faulty collecting plates, operation has been fairly dependable. The present run is into 9 months with one shorted section to date.

No visible plume shows at this time and recent particulate tests are well within the allowable 40 lb/hr. On one of the occasions of an electrical short, it was possible to destroy the offending wire using a welding machine. On another occasion, this technique was tried but it failed.

During one run, a quarter of the precipitator had both sections shorted out. The stack plume became visible but did not exceed a Ringelmann 2 which was acceptable at that time. Repair would require full shutdown of the unit.

Maintenance. The cat-cracker precipitator has been a more frequent source of trouble. Citations were received for discharge of Ringelmann 2 or over for periods longer than 3 min 10 times in 1969 and 4 times in early 1970.

However, it has been necessary to report equipment breakdowns or electrical shorts on this unit on 35 occasions in 1969 and 45 occasions up to Sept. 1970. While not all of these resulted in excessive dust emission or long upsets, they do show a high degree of unreliability.

Failures were due to loss of electrical power, instrumentation, loss of rapper hammers, burned-out motor on rapper arms, seams opening in the precipitator wall, and breakage of emitter wires. This has required planned maintenance such as cleaning of insulators and servicing of rapper motors.

Increasing demands have been made for reduction in particulate levels by the State Air Resources Board and Bay Area Air Pollution Control District. This has made it necessary to prepare to meet not only a particulate maximum of 40 lb/hr, but also an opacity below Ringelmann 1.

With the 1969 or early 1970 performance record of our cat-cracker precipitator, these goals seemed unattainable. Even installation of a parallel precipitator would not guarantee compliance except with both units on stream.

Moreover, the difficulty of blind installation slows the utilization of the spare equipment and makes for periods of visible emission and the problems of public reaction. Anything which can improve reliability of this equipment is of great interest to the industry.

New controller. In Sept. 1970, a new and highly effective control mechanism was installed by Buell on "A" bank of the cat-cracker precipitator. This system is called "Anacomp" and in this a silicon control rectifier replaces the original saturable core reactor for voltage control.

Since its installation, we have had no occasions when breakdown or stack duct originated in the electrical system of A section. The only problem since September has been with a false hopper level and alarm circuit which finally shorted out the A section and led to burnout of a rectifier.

We had no spare and were in jeopardy for 4 days while a new one was flown from Pennsylvania. Since that time, we have had neither electrical breakdowns nor citations. However, a casing failure, due to a pressure surge, required a precipitator shutdown for entry and repairs on Jan. 15.

Virtue of the latest Anacomp voltage control lies in its extreme speed of 100 ms. It can sense a sparking buildup, reduce voltage to interrupt the spark, and restore it to the maximum intensity below the danger of arc.

This avoids the problem of the older voltage regulator which frequently permitted arcing at an insufficiently reduced electromotive force. This often completely shorted out a section and resulted in stack emissions until a manual correction could be made.

The A bank of this precipitator, which formerly did well to maintain a fairly steady 500 ma on the secondary, is now operating at close to 1,000 ma steadily.

The stack, which showed occasional puffs up to Ringelmann 2, is now rarely as high as Ringelmann 1. This efficiency continues even when loading catalyst and at coke-burning rates of 37,000 lb/hr and 4,000-b/d charge.

Challenges. A baghouse eliminates dust from carrying air used to unload catalyst and to move recovered catalyst fines from the precipitator to a reject hopper. This baghouse contains 44 Dacron bags and is designed for an air rate of 1,800 scfm.

Bag change is dependent on moisture content of the air and the catalyst. In general, 40-50 bags per year are replaced. A broken bag in this installation can make an immediate dust cloud more opaque than Ringelmann 2.

Bags usually begin leaking because of chafing while being filled with catalyst which may not drop during the shaking cycle. Causes include moisture content as previously cited.

Some of the stricter environmental demand 100% elimination of dust emissions. The construction and maintenance of duplicate precipitators and baghouse facilities offers many operational problems in addition to the expense involved.

Inlet ducts to precipitators are several feet in diameter and under the conditions of the inlet it is difficult to maintain the very large-diameter valves in working condition.

Attempts to control the flow by means of large blinds involves a substantial time element to switch precipitators. During this time, emissions to the air are substantial and unacceptable to most regulating agencies.

We believe that the selection of the most reliable type of equipment and the maintenance of this to the point of highest reliability represents the most practical method of meeting the requirements.

Some structural improvements are to be made at the next turnaround. But with the improved Anacomp control system on both stages of the cat-cracker and coker precipitators, we hope to be able to meet the latest particulate and opacity limits consistently. END