RADIAN
CORPORATION

CALCIUM CARBIDE
MANUFACTURING
AP-42 Section 8.4
Reference Number
3

August 20, 1981

Mr. Douglas Cook
Project Officer
Air Programs Branch
U.S. EPA, Region IV
345 Courtland Street
Atlanta, Georgia 30365

Dear Mr. Cook:

Please find attached a draft memorandum summarizing our findings on the Airco Carbide facility located in Louisville. From our investigations we conclude that the hydrocarbon emissions from the plant are insignificant and that the source category should be dropped from further consideration. Please look over the memo and make any comments or changes you feel necessary.

Please give me or Garry Brooks a call if you have any questions.

Sincerely,

Andrew J. Miles

Andrew J. Miles
Project Director

AJM:bwj

Enclosure

cc: Mike DeBusschere
Yvonne Lewis
Garry Brooks
Bob Parks

3024 Pickett Road / Durham, North Carolina 27705 / (919) 493-4574

RADIAN
CORPORATION

September 17, 1981

Mr. Doug Cook
Project Officer
Air Programs Branch
U.S. EPA, Region IV
345 Courtland Street
Atlanta, Georgia 30365

Dear Mr. Cook:

Enclosed is the final version of Radian's memo summarizing the VOC emission situation at the Airco Carbide calcium carbide acetylene plant in Louisville, Kentucky. The only change to the original draft memo (sent to you August 20, 1981) involved a word change. All references to or descriptions of permit files and emissions inventory data as "state" files or data have been deleted. The term state has been replaced by Jefferson County district.

If you have any further questions on the memo, please give me a call.

Sincerely,

Andrew J. Miles

Andrew J. Miles
Project Director

AJM:bwj

Enclosure

cc: Y. Lewis
[redacted]
R. M. Parks
Region IV File

RADIAN
CORPORATION

MEMORANDUM

Date: August 20, 1981

To: Douglas Cook - U.S. Environmental Protection Agency (EPA)
Region IV

From: Radian Corporation

Subject: Reasonably Available Control Technology (RACT) Determination for the Airco Carbide Calcium Carbide Acetylene Plant

Purpose

The purpose of this memorandum is to brief EPA Region 4 and the Air Pollution Control District of Jefferson County (APCDJC) on Radian's current progress in developing a RACT determination for the Airco Carbide facility in Louisville, KY. All technical information learned about this facility to date will be presented, as will Radian's recommendations for further treatment of the Airco Carbide source.

Background

Calcium carbide acetylene production is one of six industrial source categories under study for EPA Region 4 and the APCDJC. The Airco Carbide Division of Airco, Inc. operates the only such process of this type that was included in the study. Preliminary definition of this source category indicated that the acetylene generation part of the process was the primary source of volatile organic compounds (VOC) emissions. To initiate its study of the Airco calcium carbide acetylene process Radian gathered together several technical descriptions of this process from the available chemical literature. Upon close examination of this information, no clear indication of a VOC emissions point could be determined. The inadvertent release of some acetylene during the acetylene generation process could not be classified as the VOC source because acetylene is non-photochemically reactive[1], and therefore should not be classified as a VOC.

Radian then received from the APCDJC, a computer printout of the Jefferson County district emissions inventory for the Airco Carbide facility. On this inventory the only source of VOC (listed as hydrocarbons on the inventory) was given as the arc furnace room vents. This source was listed as emitting 885.5 tons per year of VOC. The emission rate was determined by calculation. The description of the arc furnace room vents as the VOC emissions source was not consistent with the original

directive that the emission problem was in the acetylene generation step. Information available in the literature did not indicate the presence of any VOC emission points in the arc furnace room.

The following chemical equations are presented to better show the reactions taking place and the emissions produced in the carbide and acetylene processes. The first equation explains the process of making calcium carbide in an electric arc furnace as follows:

$$CaO + 3C \longrightarrow CaC_2 + CO$$

Calcium carbide is produced by combining lime and coke (in a ratio of 60:40) in an electric furnace with a temperature of about 3600°F. In addition to the carbide, carbon monoxide (CO) is also produced which can be used as fuel in coke dryers, lime kilns, and small boilers. No VOC emission point appears to exist in this step.

The following equation presents the basic process for producing calcium carbide acetylene:

$$CaC_2 + 2H_2O \longrightarrow C_2H_2 + Ca(OH)_2$$

In addition to acetylene, hydrated lime (calcium hydrate) and other gaseous impurties such as phosphine, ammonia, hydrogen sulfide, and organic sulfides are produced as by-products of the reaction. Gaseous by-products result primarily from impurities in the carbide raw materials. No potential for photochemically reactive VOC exists in the base reaction.

Discussion

On July 27, 1981 Radian visited the APCDJC to discuss the four industry categories in Louisville and to review state data files on these categories. Radian explained its difficulty in defining the VOC emission source at the Airco Carbide facility, and requested to speak with the APCDJC engineer assigned to this plant. The engineer was out of the office on this day. Radian reviewed the APCDJC data files on the Airco facility and determined that acetylene had been characterized as the hydrocarbon emission. Jefferson County district permit number 563-75 issued on December 16, 1980 covered acetylene hydrocarbon emissions from the electric arc furnace room.

Radian did not believe that any acetylene was being produced in the electric arc furnace. Temperatures are much too high for free moisture to exist that would be capable of generating acetylene. There are no other mechanisms for producing acetylene in the furnace room. APCDJC permit files indicated that the furnace room vents were being sent to a baghouse for particulates control. Any VOC that happened to be in the furnace room vent stream would be emitted to the atmosphere totally

uncontrolled, however, no VOC emission sources in this section of the process had been identified. Radian hypothesized that a potential cause of VOC emissions could be impurities in the coke used to produce carbide.

Radian and a representative of APCDJC visited the Airco Carbide plant on July 28, 1981 to determine what the VOC emissions at the facility were and where they were coming from. At the Airco plant Radian met with the plant manager, Ms. Sue Carney, and a plant engineer, Mr. Rick Clark. Radian explained the nature of the RACT determination study and that the Airco Carbide facility had been selected because the APCDJC emissions inventory showed that the plant emitted 885 tons per year of acetylene.

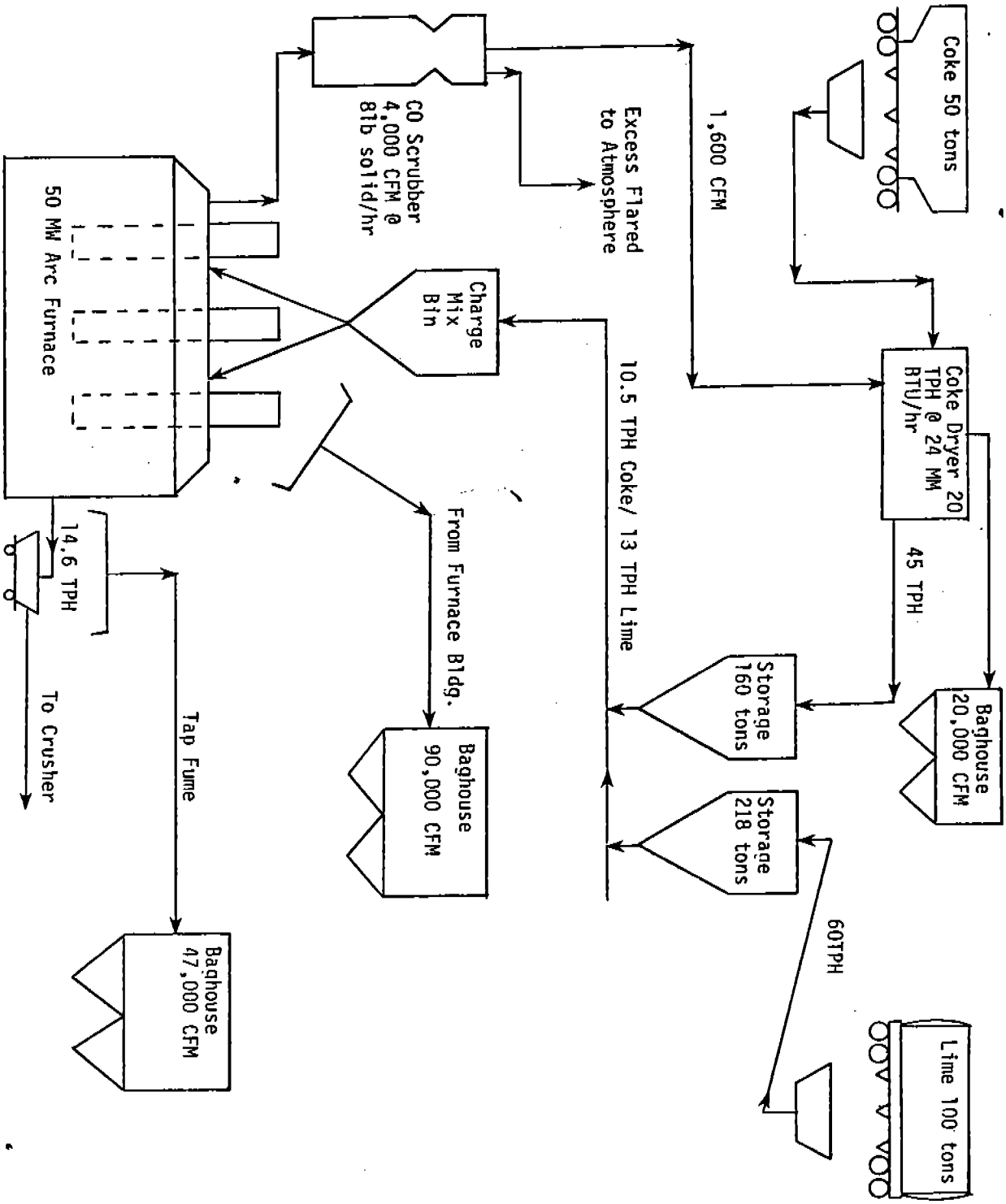
Neither Ms. Carney nor Mr. Clark believed that the 885 tons per year figure was correct. They stated that all acetylene emission points had been closed up to prevent explosion hazards from acetylene loss to the atmosphere. No acetylene was being produced or emitted in the arc furnace. Airco also discounted Radian's theory that there may be impurities in the plant's coke which is causing the VOC emissions. Airco noted that the plant no longer uses petroleum coke as listed in the APCDJC permit files. Since the plant switched to closed-top furnaces, only metallurgical coke has been used. The use of petroleum coke in a closed furnace creates an explosion hazard. Petroleum coke also produces unwanted sulfur in the carbide-generated acetylene.

The only source of potential VOC emissions that Airco Carbide could suggest was the coal-tar pitch binder used to make the furnace electrode paste. The electrode paste is composed of nine weight percent coal-tar pitch binder and 91 weight percent calcined anthracite coal. Mr. Clark indicated that the maximum volatiles content in the coal-tar pitch is 50 percent. Based on these composition figures and Airco Carbide's total paste usage in 1980 of 1948 tons, a maximum potential uncontrolled VOC emissions rate of about 88 tons per year can be calculated. Actual VOC emissions from the coal-tar pitch would be negligible because these volatiles would be burned off by heat and flames in the oxygen-rich environment surrounding the electrodes at the point which they enter the furnace.

An illustration of the Airco Carbide technique for producing calcium carbide is given in Figure 1. The Airco technique bakes the electrodes prior to entering the carbide charge furnace. The electrode paste is continuously added at the top of a large steel casing which is 62 inches in diameter. The paste is fed into the furnace through the steel casing at the rate of one inch per hour. As the paste is fed into the casing, it is baked by the intense heat generated in the 50 megawatt electric arc furnace. The baking process transforms the electrode paste into a solid electrode. The electrode exits the steel casing just inside the furnace cover. The only place VOC can escape is the one foot space (inside the furnace) between the charge hole rim and where the electrode casing ends. Any VOC released at this point are incinerated by the three to four foot flames that surround each charge hole. These flames result primarily from the burning of carbon monoxide.

The conclusion that the charge hole flames are largely the result of CO combustion was confirmed by analyzing total stoichiometric CO_2 flow (based on production data) and the maximum potential VOC flow (resulting

FIGURE 1


Coke 50 tons
CO Scrubber
4,000 CFM @
8lb solid/hr
Excess Flared
to Atmosphere
1,600 CFM
Coke Dryer 20
TPH @ 24 MM
BTU/hr
Baghouse
20,000 CFM
45 TPH
Charge
Mix
Bin
10.5 TPH Coke/ 13 TPH Lime
50 MW Arc Furnace
From Furnace Bldg.
Storage
160 tons
Storage
218 tons
Baghouse
90,000 CFM
14.6 TPH
To Crusher
Tap Fume
60TPH
Baghouse
47,000 CFM
Lime 100 tons

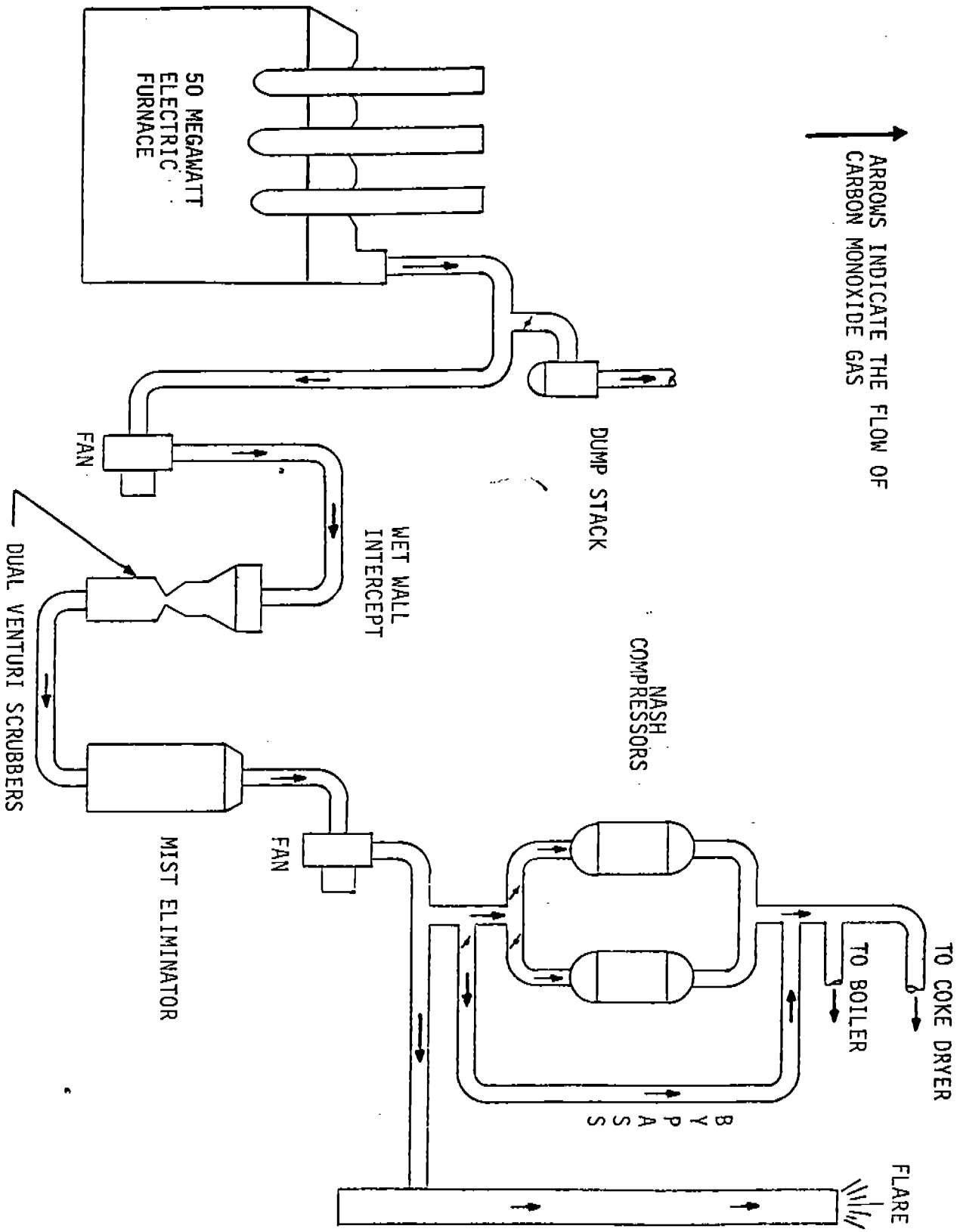
from the electrode paste). By calculating the total CO flow on a stoichemetric basis and knowing the CO flow being vented to the scrubber (see Figure 1), the resultant CO flow through the charge hole flames was determined. Dividing the maximum VOC flow by the charge hole CO flow showed that about 0.2 percent of the total flame-producing gas flow through the charge holes is VOC. Of the total CO flow, approximately 60 percent is directed through the charge holes and is destroyed. The remainder is sent to the venturi scrubber and on to the flare for final destruction.

Figure 2 illustrates the mechanism by which furnace offgasses containing coke fines, carbon monoxide, and VOC are controlled. The furnace offgas stream is first directed to dual venturi scrubbers to remove coke fines that are released during the carbide formation process. A constant nitrogen purge is maintained in the scrubber to safeguard against potential explosions. Gaseous emissions exiting the scrubber are controlled primarily by flares. The fuel value of the emissions is also utilized by burning a portion of the stream in the coke dryer and in a small steam boiler. The plant also operates an emergency flare dump stack to handle CO and VOC emissions in the event the scrubber goes down.

After the discussions with Airco Carbide and an examination of the process flowsheets, Radian concluded that the Airco facility did not have a VOC emissions problems. It appeared that the uncontrolled hydrocarbon emission rate of 885 tons per year, given in the district emissions inventory, was incorrect. Mr. Clark of Airco suggested that Radian talk with Mr. Ray Vogel of the APCDJC to determine what calculations and assumptions were made to arrive at the 885 tons per year figure. Mr. Vogel had been involved in the original work that estimated VOC emissions from the Airco Carbide facility for use in the APCDJC emissions inventory.

Radian contacted Mr. Vogel after leaving the Airco Carbide plant. Mr. Vogel indicated to Radian that the annual VOC emission rate of 885 tons had been based on an AP-42 emissions factor developed for calcium carbide manufacturing processes. The emissions factor predicted that 18 pounds of acetylene would be emitted per ton of carbide manufactured. Mr. Vogel stated that the emissions factor was based primarily on the results of an air quality study of Louisville, KY performed by the U.S. Public Health Service (PHS) in 1956.[2] The PHS study examined the operations of the Louisville Airco Carbide facility in detail. The AP-42 emissions factor, was based directly on the operations at Airco Carbide. The PHS report stated that VOC emissions had been estimated based on process data and grab samples of the furnace offgas. At the time the PHS report was done the Airco Carbide plant was using an open-top furnace and petroleum coke to produce calcium carbide. As stated earlier in this memo, the Airco plant now uses closed-top furnaces and metallurgical coke to produce its carbide. The use of a closed-top furnace alone

FIGURE 2


ARROWS INDICATE THE FLOW OF CARBON MONOXIDE GAS
50 MEGAWATT ELECTRIC FURNACE
DUMP STACK
FAN
WET WALL INTERCEPT
DUAL VENTURI SCRUBBERS
NASH COMPRESSORS
MIST ELIMINATOR
FAN
TO COKE DRYER
TO BOILER
BYPASS
FLARE

would greatly reduce any potential emissions from the facility. Essentially the process now being performed at the Airco plant is completely different from that used to form the basis for the VOC emissions presently attributed to this facility. The 18 lb per ton AP-42 factor is not representative of the current Airco closed-top furnace carbide process. Therefore, the 885 tons of VOC per year emission rate calculated using the 18 lb/ton figure is incorrect. As a result of these findings, Radian recommends that the AP-42 section on calcium carbide production be revised to say that the given emission factor for the arc furnace room is only applicable to open-top furnaces using petroleum coke.

Mr. Vogel said that the majority of the acetylene emissions generated were the result of the carbide cooling process. He noted that as the hot carbide exiting the arc furnace cooled, moisture would condense on it liberating acetylene. Radian believed that this mechanism of forming acetylene would not be occurring because the carbide would simply be too hot for moisture condensation and subsequent carbide decomposition. In addition, the plant can not afford to have acetylene spontaneously released into the atmosphere due to its explosion potential. To verify this Radian recontacted Mr. Rick Clark of Airco Carbide. Mr. Clark stated that moisture condensation on the carbide would only occur if the carbide temperature was allowed to go below its dew point, which he said was between 250°F to 280°F. The temperature of the cooling carbide is never allowed to go below 350°F at the Airco plant. Generally the hot carbide is cooled down to a range of 350°F to 500°F. Once at this temperature level, the carbide is crushed in a nitrogen atmosphere. The crushed carbide is then used in the acetylene generation part of the plant which is totally enclosed. The maintenance of a nitrogen atmosphere during crushing operations prohibits the formation of acetylene because no moisture would be present.

Airco Carbide has performed tests to determine if any acetylene losses are occurring between carbide production and crushing. Measurements taken at the furnace room gas shield showed there were 5.1 cubic feet of acetylene per pound of carbide. The same measurements taken at the crushing area indicated a level of 5.09 cubic feet of acetylene per pound of carbide. The loss is less than 0.2 percent. A loss of this magnitude is easily attributable to standard testing error.

Potential future emissions from the Airco plant will be more efficiently collected and reduced due to a planned plant modification. In 1982 Airco plans to shut down operations for two to three months to install new technology which they have purchased from Japan. The primary modifications to the Louisville facility involve the carbide furnace room. When the installation of the new technology is complete, the furnace cover and electrodes will be totally enclosed. Such a structure should facilitate even better capture and control of VOC, CO, and particulates.

Based on all available Airco Carbide plant data and APCDJC data, Radian has concluded that the Louisville, KY Airco Carbide facility does

not constitute a problem VOC emissions source. Radian recommends that the Airco plant be dropped from the list of industries being considered for a RACT determination.

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[1]Patterson, R.M., M.J. Bovnstein, and E. Garshic. Assessment of Acetylene as a Potential Air Pollution Problem, Volume I. EPA Contract No. 68-02-1337. GCA Corp., Bedford, MA. January, 1976.

[2]U.S. Department of Health, Education, and Welfare, Public Health Service. The Louisville Air Pollution Study. Technical Report A61-4. Cincinnati, OH. 1961.