

## XII. APPENDIX II

### PROCESS DESCRIPTION: LOW- OR MEDIUM-BTU COAL GASIFICATION UTILIZING BITUMINOUS COAL OR LOWER RANKED FEEDSTOCKS

The gasification of bituminous coal produces tars, which must be removed before the product gas can be utilized. The sulfur content ranges from 0.3 to over 5.5% by weight, and hence in many cases sulfur recovery units must be included for the treatment of the product gas. The analysis of a typical bituminous coal is shown in Table XII-1 [15].

TABLE XII-1  
ANALYSIS OF A TYPICAL BITUMINOUS COAL

Constituent	Concentration (wt %)
Ash	3.6
Carbon	57.4
Moisture	3.1
Volatile matter	35.9
<u>Heating Value</u>	<u>14,070 BTU/lb</u>

Adapted from reference 15

Gas cleanup systems may vary from a simple cyclone to remove particulates when the product use can tolerate both tar and sulfur to the sophisticated system shown previously in Chapter III (Figure III-5) [102].

Low-BTU, low-pressure processes use an interlocking disc valve system or rotary barrel valve as part of the coal feed system. These feed systems result in the loss of only a small quantity of product gas to the atmosphere above the coal storage bin [15].

The raw product gas that comes off the top of the gasifier passes through a lined cyclone where elutriated coal dust is removed. The gas then passes through a water spray tower where the oils and tars are condensed and removed. The gas then passes through electrostatic precipitators where particulates and the remaining tar

are removed. Sulfur is then removed from the gas by a Holmes-Stretford desulfurization system. In the system shown, the clean product gas (Table XII-2) is stored for future use [102].

TABLE XII-2  
TYPICAL PRODUCT GAS ANALYSIS

Constituent	Concentration (vol %)
Carbon dioxide	4.2
Carbon monoxide	26.6
Ethane	0.3
Ethylene	0.2
Hydrogen	16.0
Methane	1.9
Nitrogen	50.9
Heating value	164 BTU/scf
Adapted from reference 15	

Excess water from the water seal on the gas pipe in the primary, secondary, and high-pressure scrubbers is collected in a single decanter. A portion of the decanter water (gas-liquor) is sent to the cooling tower and then recycled to the tertiary high-pressure scrubber and used to maintain a gas temperature of 50 C (120 F). The decanter water is recycled from the decanter to all sprays, both in the primary and secondary scrubbers, the water seal, and the gas lines. Water condensed from steam used in gasifying the coal is collected in two 5,000-gallon tanks. When the water level becomes too high, steam coils are activated and the excess water is evaporated to the atmosphere [15]. In no case should any of the water in the process be sent to the sewer or otherwise discharged. Thus, the water should always contain an equilibrium quantity of contaminants including phenols and suspended tars and oils, and lesser amounts of ammonia, cyanide, phosphorus, nitrate, and trace metals [15]. It is assumed that any volatile contaminant in the water is discharged to the atmosphere with the evaporated water or, if above the saturation limits, is condensed into the tar at the bottom of the decanter. This tar is pumped to a nearby steam plant, where it is burned in a boiler.

Because of the products generated in the bituminous gasifier, the operator is exposed to hazardous substances when testing the bed through pokeholes (see Chapter XIII for detailed procedure). In one installation, a ring around the inside of the pokehole directs a steam jet downward into the gasifier and thus reduces emission through the pokehole [124].

The operation is generally run by one man per shift. The operator is located on the operating floor at the top of the gasifier but under the coal feed bins. Because the coal feed operation is automatic, the actual duration of direct exposure to producer gas is generally approximately 2-3 hours per shift [16].

XIII. APPENDIX III

PROCESS DESCRIPTION: COAL GASIFICATION (LOW- or MEDIUM- BTU)  
UTILIZING ANTHRACITE FEEDSTOCK OR VERY HIGH TEMPERATURES

Plants Utilizing Anthracite Coal Feedstock

A typical analysis of anthracite coal is shown in Table XIII-1 [14]. The low content of both sulfur and volatile matter significantly reduces the hazard of exposure to hydrogen sulfide, sulfur oxides, and tars in plants using anthracite feedstock as compared with exposures in plants using bituminous or lower ranked feedstocks.

TABLE XIII-1  
ANALYSIS OF ANTHRACITE COAL--WASHED AND SIZED

<u>Constituent</u>	<u>Content</u> <u>(Wt %)</u>
Ash	12.00
Carbon	78.32
Moisture	5.44
Sulfur	0.47
Volatile matter	4.23
<u>Heating value</u>	<u>12,190 BTU/lb</u>
Adapted from reference 14	

Figure XIII-1 is a diagram of the fixed-bed process at a plant [14] that uses anthracite feedstock. The gasifier has operated at levels varying from as low as 3 tons of coal per day, producing approximately 60,000 scf of natural gas equivalent, to as high as 24 tons of coal per day, producing 500,000 scf of natural gas equivalent [14].

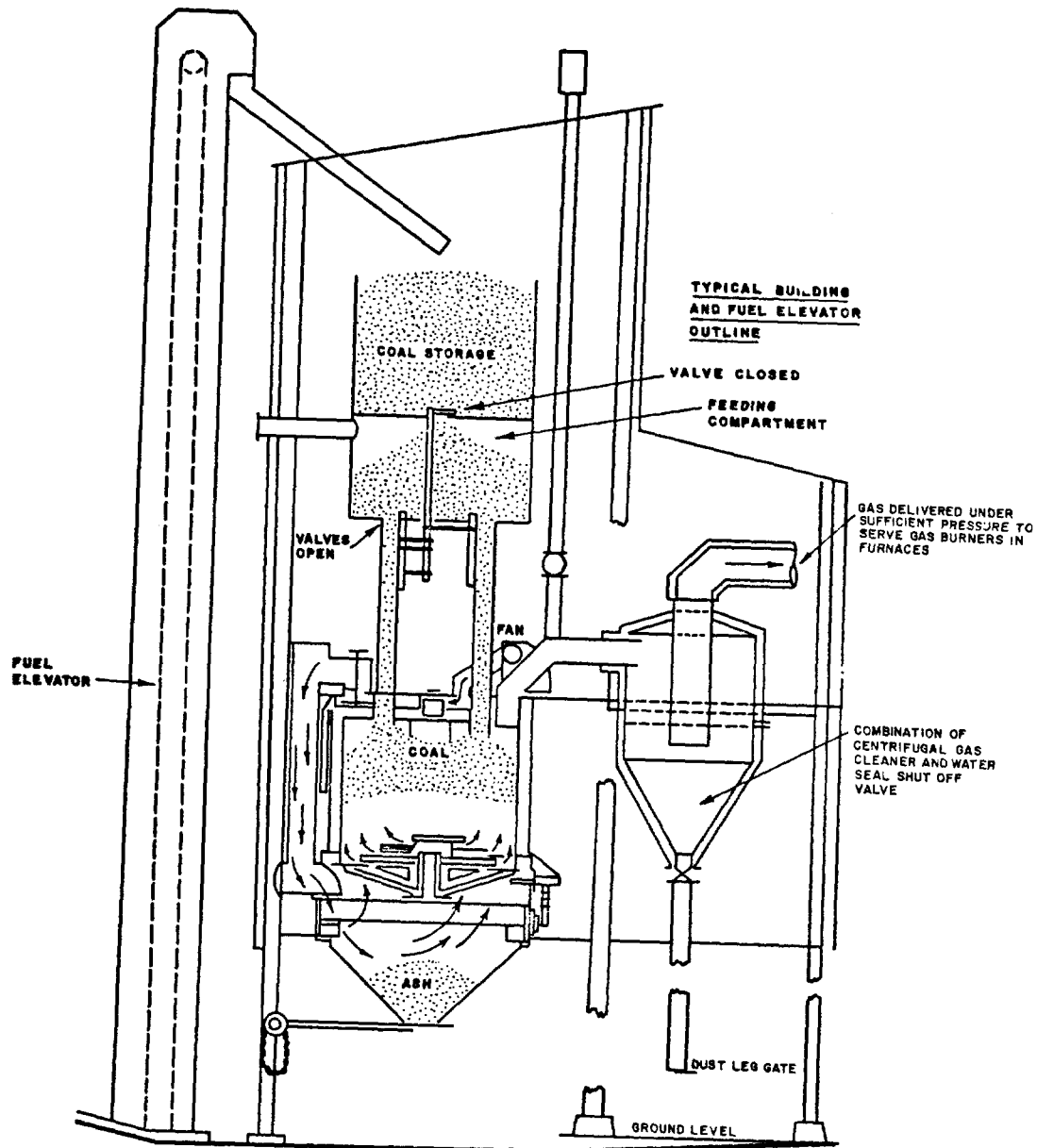


Figure XIII-1

Wellman-Galusha Standard Type Producer

Adapted from Reference 14

A fuel elevator is used to move the coal into the coal storage bin (capacity approximately 25 tons), which is the upper section of a two-compartment bin. The lower section, the feeding compartment (capacity approximately 5 tons), is separated from the coal storage bin by disc valves. Similar disc valves cover the openings to each of the heavy-steel feedpipes (approximately 1 foot in diameter and 12 feet long) connecting the feeding compartment to the gasifier. A simple interlocking mechanism prevents the opening of the upper valves unless all the lower valves are tightly closed, and vice versa.

The coal feed system is operated manually as needed. Coal fills the feeding compartment, the feed pipes and the gasifier via an automatic gravity feed system. To fill the coal feeding compartment, the disc valves between the coal storage bin and the feeding compartment are opened, and the disc valves between the feeding compartment and the gasifier are closed. To fill the feedpipes and the gasifier, the operator reverses the procedure, opening the disc valve between the feeding compartment and the gasifier, and closing the valves between the coal storage bin and the feeding compartment. The escape of product gas is minimized because of the coal in the feed system and the low operating pressure (5-7 inches water column) in the gasifier. The operating pressure decreases to 3 inches water column when a gas compressor is used.

The product gas fills the voids in the feed pipes. When the disc valves between the feeding compartment and the gasifier are opened, some of this gas escapes into the feeding compartment. When the disc valves between the feeding compartment and the coal storage bin are opened, some of the product gas escapes through the coal storage bin into the upper-floor work area.

The gas-making chamber is completely water jacketed. The inner wall is 1-inch-thick steel plate and requires no brick lining. Waste heat in the water jacket generates the process steam [actually water vapor at about 180 F (82 C)]. A direct-drive fan supplies the air required by the gasifier. On its way to the firebed, this air acquires moisture from the steaming water at the top of the jacket. Saturation is automatically controlled by regulating the rate of supply of jacketed water to maintain the desired saturation temperature of 140-150 F (60-66 C).

Startup can be performed with the gasifier either cold or hot. For cold startup, wicker boxes are located at various positions on the grate, and an ashbed is built on the grate and around the wicker boxes. An oil-saturated wick is inserted into the wicker boxes, so that it may be lighted from the ash bin. Oil-saturated charcoal is placed on the ashbed and on the wicker boxes. The gasifier is then loaded with anthracite. The blower is started, at a rate that produces a very low air flow through the bed. The ash-pit door is closed, the wicks are lighted, and the ashpit slide valve is closed. The air flowrate is set at a 1.0-inch water column for 1.5 hours and

then increased to a 3.0-inch water column for 1 hour; the gasifier product is exhausted to the atmosphere [14]. After 3 hours, the exhaust is regulated to put pressure on the system. If the firebed is burning properly and the product gas meets specifications, the gas is fed to the distribution system.

For temporary shutdowns, the fire is banked by reducing the air flow, and the gasifier is vented to the atmosphere. To return the unit to full operation (hot startup), the air flow is increased, the exhaust valve is closed, and the gas flow is directed to the distribution system.

When the proper operating conditions have been established, the product gas is directed to the centrifugal gas cleaner to remove coal fines. The cleaned gas is delivered with sufficient pressure to serve the gas burners in the distribution system.

Slowly revolving grates remove the ash to an uninsulated hopper. Water from a 2-inch water line around the inside circumference at the top of this hopper is used to flush out a 24-hour accumulation of ash as a slurry. The ash is dumped into a truck, an operation that takes about 5 minutes, and removed to a landfill area. Gas production is not affected during this operation.

The product gas passes from the gasifier to a cyclone lined with refractory bricks and insulated on the outside. If the product-gas offtake line and the cyclone are not insulated, the operator would be potentially exposed to burns and to heat stress if required to work in the immediate area for long periods. The product gas (see Table XIII-2) leaves the cyclone at 315 C (600 F) [14].

TABLE XIII-2

TYPICAL PRODUCT-GAS ANALYSIS

<u>Constituent</u>	<u>Concentration (Vol %)</u>
Argon	0.52
Carbon dioxide	6.95
Carbon monoxide	24.03
Hydrogen	16.97
Methane	0.25
Nitrogen	51.12
Oxygen	0.16
<u>Heating value</u>	<u>130/140 BTU/scf</u>
Adapted from reference 14	

The particulates collected in the cyclone, usually less than a wheelbarrow full, are removed once per week and sent to a landfill with the ash. The particulate material collected in the cyclone is 40-50% carbon [14].

Approximately every 4 hours, an operator checks the firebed depth by inserting a steel rod through pokeholes, which are normally closed by covers tightened by slide dogs. There are eight such holes over the outer grate, two over the inner grate, and one over the center. For the checking operation, the operator opens the pokehole and inserts a steel rod through the firebed and ashbed to the grate. This operation is repeated for all eight pokeholes, each with its own steel rod. The operator then sequentially closes and tightens the cover over each of the pokeholes after measuring and recording the ashbed and firebed depths (each rod remains in the gasifier between 3 and 5 minutes). The entire operation takes approximately 20 minutes. During the checking operation, small quantities of product gas escape into the operating area. On one occasion a carbon monoxide monitor located at the control station (approximately 10 feet away) registered a level of 40 ppm [14]. After the pokeholes were closed, the carbon monoxide level at the monitor decreased to a level of 1-2 ppm [14].

Both the gasifier and the coal feeding compartment are fitted with a direction-controlled blowout patch to minimize any danger that would result from the ignition of product gas. In 30 years of operation, there has been no reported incident of product gas igniting in any unit burning anthracite coal [14].

Normal maintenance, including lubrication, requires an average of 2 hours/week. During minor maintenance, the fire is banked. Major maintenance is done once a year and includes the following tasks [14]:

- \* The slide dogs and pokehole covers are resurfaced.
- \* The grates are refurbished.
- \* The insulation of the gasifier and the cyclone is repaired as needed.
- \* Any particulate matter that has accumulated at bends, dead ends, and at the end of the pipeline near the distribution system is raked out through cleanout ports.



The buildings housing the gasifiers are totally enclosed, with windows for ventilation. However, after experiencing levels of carbon monoxide as high as 500 ppm above the coal storage bin, one company installed push-out panels with controllable openings to increase the natural draft in the building [14]. At another plant [14], fans were installed on the top floor to increase air flow through the building and reduce the potential for carbon monoxide and product-gas accumulation. The level of carbon monoxide registered on the top floor was below 10 ppm.

### Very High Temperature Coal Gasification

The operating temperature, at least 1816 C (3300 F), destroys most or all of the tars that would be produced in lower temperature processes, regardless of the coal feedstock used. This significantly reduces the hazard of exposure to tar and tar oil.

At one such plant [24], feedstock coal is dried to a moisture content of 2-8% and pulverized in a wind-swept closed system using a ball, rod, or roller mill until 70% of the coal can pass through a 200 mesh screen and 8-10% is smaller than 7 microns [24]. A classifier returns the oversized particles to the mill and allows the finer particles to continue to a cyclone. The properly sized coal is stored in a surge bunker, from which it is pneumatically conveyed with nitrogen to a service bin above the gasifier. Pressure switches control the feed to the service bin. The nitrogen is separated by a cyclone for reuse.

From the service bin the coal is fed to the feedbin. A control system using a screw feeder and metering head insures a continuous coal feed of uniform density.

At the mixing head, which is designed to prevent gas backflow and explosions, a mixture of steam and oxygen entrains the pulverized coal leaving the metering head, accelerates the coal particles, and projects them into the gasifier at velocities sufficiently high (approximately 300 ft/second) to prevent flashback.

The gasifier, shaped like two spheroidal cones joined at their bases, is of double-wall construction. The annulus between the inner and outer walls is water cooled and connected to a steam separator. The low-pressure steam generated is used as process steam and enters the gasifier through the mixing head.

Each gasifier cone contains two adjacent burners mounted in line with the opposing set. The sets of burners are designed to provide turbulence and to insure continuous ignition if one burner should become temporarily blocked.

The advantages of opposing burners are that particles passing through one flame region unburned are gasified in the opposing flame, and the problems associated with refractories at high temperature are minimized because the flame is directed into a gaseous medium.

The carbon in the entrained oxygen-steam stream is exothermically oxidized, producing a flame temperature of approximately 1925 C (3500 F). Steam production in the water jacket and endothermic reactions between the carbon and steam reduce the temperature to about 1650 C (3000 F). Theoretical equilibrium calculations show that essentially all hydrocarbons, phenols, tars, and ammonia are dissociated and oxidized [24]. In practice, the gas contains no complex hydrocarbon molecules and only small amounts of methane [24]; it is essentially carbon monoxide, hydrogen, and carbon dioxide, with relatively small quantities of nitrogen. Hydrogen sulfide, carbonyl sulfide, ammonia, and hydrogen cyanide concentrations depend on the sulfur and nitrogen content of the coal. There are only trace quantities of other compounds.

The gasifier is a completely enclosed unit and is monitored by 28 instruments [18]. If any parameter deviates from established limits, the gasifier automatically shuts down and is vented to the atmosphere.

Ash in the feedstock is liquefied in the high-temperature flame. Up to 50% of the ash flows down the walls as molten slag and draws into a slag quench tank; the remainder of the ash (50-80%) leaves the gasifier as fine fly ash entrained in the gas [18,24].

Molten particulates in the product gas, (1200 C, 2192 F) are solidified at the entry to the waste-heat boiler, which is usually a radiant-surface boiler, followed by a fin-tube boiler. The gas leaves the waste heat boiler at 205 C (400 F) and is washed and cooled in refractory-lined spray washers which remove approximately 90% of the heavy particulates. Subsequent cleaning is done downstream with disintegrators and electrostatic precipitators when the gas is to be compressed for subsequent use as a synthesis gas for chemical feedstock or pipeline gas.

After the clean product gas has been compressed, sulfur is removed by the Claus, Rectisol, Stretford, or other commercially available processes.

#### XIV. APPENDIX IV

##### SAFETY

The fault-tree analysis method of safety assurance is recommended as a useful technique in the design and operation of coal gasification plants. Fault-tree analyses tend to insure that all variables have been considered and provide a logical, systematic approach to identifying safety problems, assisting in their solution, and determining whether corrective action has been sufficient within the constraints of operation, time, and cost. This approach affords the opportunity to identify many accident situations that might be missed by less detailed investigations.

Several procedures for such analyses are currently available. The following are useful references:

- \* Chemical Industrial Safety and Health Council: Guide to Hazard and Operational Studies. London, England, Chemical Industries Association, Ltd
- \* Grose VL: System Safety in Rapid Rail Transit. Santa Barbara, California, Justin Institute of Technology
- \* Kolodner HJ: The Fault Tree Technique of System Safety Analysis as Applied to the Occupational Safety Situation, Monograph #1, Park Ridge, Illinois, American Society of Safety Engineers, 1971
- \* Lambert HE: Systems Safety Analysis and Fault Tree Analysis. Lawrence Livermore Laboratories, California, 1973

The Occupational Safety and Health Administration's Standards and Interpretations, 29 CFR 1910 [XIV-5], are the Federal regulations governing plant safety. These standards prescribe a useful minimum of safety practices in certain general plant situations, specifying adequate egress from plant areas (29 CFR 1910.37), provision of proper guards for machines (29 CFR 1910.219), positive electrical lockout of machinery during maintenance (29 CFR 1910.145), adequate fire extinguishing equipment (29 CFR 1910, Subpart L), and hearing protection in noisy areas (29 CFR 1910.95). Each state has safety laws and regulations applicable to large chemical plants; a compilation of these is available [129].

The applicable state and Federal standards are, however, of necessity very general and of minimal utility in designing a safe workplace in the coal gasification industry. They would be useful in implementing a "retrofit type" of safety program in existing unsafe work areas but fall short of providing sufficiently detailed technical data for insuring safety in the design of the very large and complex facilities foreseen for coal gasification at the commercial scale.

Handbooks and codes used by various industries can provide a greater degree of technical specificity for analyzing the hazards in coal gasification. Since these publications are generally applicable throughout industry, a detailed presentation is beyond the scope of this document on unique aspects of coal gasification. However, some of these documents are listed here and referenced. Of special interest is National Bureau of Standards Special Publication 329, An Index of US Voluntary Engineering Standards [129], which is a very comprehensive compilation of design standards used in industry. Other applicable standards are the following:

- \* American Standard Codes for Pressure Piping, ASA B31.1-1955 and B31.8-1958
- \* The American Society of Mechanical Engineers Boiler and Pressure Vessel Code, Section 8, "Unfired Pressure Vessels," New York, 1965
- \* Battelle-Northwest Laboratories: Battelle-Northwest Pressure Systems Manual, BNWL-MA-21. Richland, Washington
- \* Hanford Engineering Standards (HWS-10000, "Architectural-Civil Standards"; HWS-10001, "Mechanical Standards"; "Mechanical Standards"; HWS-10002, "Electrical Standards"; HWS-10003, "Guides," Vol 1, and HWS-10002, "Guides," Vol 2; HWS-10004, "Welding Standards"; HWS-10005, "Instrument Standards"; HWS-10006, "Standard Design Criteria"; and HWS 10007, "Protective Clothing Standards")
- \* National Fire Codes, the National Fire Protection Association (Vol 1, "Flammable Liquids"; Vol 2, "Gases"; Vol 3, "Combustible Solids, Dust, and Explosives"; Vol 4, "Building Construction and Facilities"; Vol 5, "Electrical" (the National Electrical Code); Vol 6, "Sprinklers, Fire Pumps, and Water Tanks"; Vol 7, "Alarm and Special Extinguishing Systems"; Vol 8, "Portable and Manual Fire Control Equipment"; Vol 9, "Occupancy Standards and Process Hazards"; and Vol 10, "Transportation")

- \* United States of America Standards Institute: Safety Code for Cranes, Derricks, and Hoists, 1943, Reaffirmed, 1952. ASA B30.2, USA 51., 1952
- \* United States of America Standards Institute: Safety Code for Elevators, Dumbwaiters, and Moving Walks, 1965
- \* United States of America Standards Institute: Uniform Building Code, Vol 1. ASA A17.1, Pasadena, California, 1964

## XV. APPENDIX V

### SAMPLING AND ANALYSIS FOR POLYCYCLIC AROMATIC HYDROCARBONS

To determine the concentrations of polycyclic aromatic hydrocarbons in the occupational environment, samples should be collected on 0.8 micrometer pore size silver membrane filters (37 mm diameter) preceded by Gelman type A or equivalent glass fiber filters encased in 3-piece plastic (polystyrene) field monitor cassettes. The cassette face cap should be on and the plug removed.

#### Equipment

- (a) Personal sampling pump suitable for exhausting at least 1.6 liters/minute
- (b) Thermometer
- (c) Manometer
- (d) Stopwatch
- (e) Tubing

#### Calibration

Since the accuracy of an analysis can be no greater than the accuracy with which the volume of air is measured, accurate calibration of sampling devices and flowmeters is essential. Frequency of calibration depends on the use, care, and handling of the sampling system. Pumps should be recalibrated if they have been abused or if they have just been repaired or received from the manufacturer. When sampling highly polluted or dusty environments, frequent cleaning and calibration may be necessary because the orifices of flowmeters and other equipment may become contaminated.

Ordinarily, pumps should be calibrated in the laboratory both before they are used in the field and after they have been used to collect a large number of field samples. The accuracy of calibration depends on the type of instrument used as a reference. The choice of calibration procedure depends largely on where the calibration is to be performed. For laboratory testing, a 1-liter buret or wet-test meter is recommended, although other standard calibrating instruments, such as spirometer, Marriot bottle, or dry-gas meter, can be used. The actual setup will be similar for all calibration systems used. The calibration instrument should be connected to the sampling train, followed by the sampler pump. In this way, the calibration instrument will be at atmospheric pressure. Each personal sampling pump must be calibrated separately. If a buret is used for calibration, it should be set up so that the flow is toward the narrow end of the unit.

Assemble the calibration setup carefully to ensure that seals at the joints are airtight and that the length of connecting tubing is minimized. Calibration should be performed at the same conditions of pressure and temperature as those under which sampling will occur. A calibrated pump rotameter should be used to establish flow rate in the field.

#### Collection of Samples on a Glass Fiber Filter

Because of the large air volume to be sampled and the limited capacity of air movers available for personal monitoring, long sampling periods are required. Inspect the filter and air mover periodically and terminate sampling if either the filter or air mover are malfunctioning.

Submit the filters in the field monitors for analysis along with three blank filters from each lot.

#### Principal of the Analytical Method

The cyclohexane-soluble material in the particulates on the glass fiber filters is extracted ultrasonically. Blank filters are extracted along with, and in the same manner as, the samples. After extraction, the cyclohexane solution is filtered through a fritted glass funnel. The total material extracted is determined by weighing a dried aliquot of the extract.

#### Range and Sensitivity

When the electrobalance is set at 1 mg, this method can detect 75-2,000 (u)g/sample.

#### Precision and Accuracy

When nine aliquots of a benzene solution from a sample of aluminum-reduction plant emissions containing 1,350 (u)g/sample were analyzed, the standard deviation was 25 (u)g. Experimental verification of this method using cyclohexane is not yet complete.

#### Advantages and Disadvantages of the Method

##### (a) Advantages

This procedure is much faster and easier to run than the Soxhlet method.

(b) Disadvantages

If the whole sample is not used for cyclohexane-extraction analysis, small weighing errors make large errors in final results.

Apparatus

- (a) Ultrasonic bath, 90 Kc, 60 watts, partially filled with water
- (b) Ultrasonic generator, Series 200, 90 Kc, 60 watts
- (c) Electrobalance capable of weighing to 1 (u)g
- (d) Stoppered glass test tube, 150 x 16 mm
- (e) Teflon weighing cups, 2 ml, approximate tare weight 60 mg
- (f) Dispensing bottle, 5 ml
- (g) Pipets, with 0.5 ml graduations
- (h) Glass fiber filters, 37 mm diameter, Gelman Type A or equivalent
- (i) Silver membrane filters, 37 mm diameter, 0.8 micrometer pore size
- (j) Vacuum oven
- (k) Tweezers
- (l) Beaker, 50 ml
- (m) Glassine paper, 3.5 x 4.5 inches
- (n) Wood application sticks for manipulating filters
- (o) Funnels, glass-fritted, 15 ml
- (p) Graduated evaporative concentrator, 10 ml

Reagents

- (a) Cyclohexane, ACS nanograde reagent
- (b) Dichromic acid cleaning solution
- (c) Acetone, ACS reagent grade



## Procedure

(a) All extraction glassware is cleaned with dichromic acid cleaning solution, rinsed first with tap water, then with deionized water followed by acetone, and allowed to dry completely. The glassware is rinsed with nanograde cyclohexane before use. The Teflon cups are cleaned with cyclohexane, then with acetone.

(b) Preweigh the Teflon cups to one hundredth of a milligram (0.01 mg).

(c) Remove top of cassette and hold over glassine paper. Remove plug on bottom of cassette. Insert end of application stick through hole and gently raise filters to one side. Use tweezers to remove filters, and loosely roll filters around tweezers. Slide rolled filters into test tube and push them to bottom of tube with application stick. Add any particulates remaining in cassette and on glassine paper to test tube.

(d) Pipet 5 ml of cyclohexane into test tube from dispensing bottle.

(e) Put test tube into sonic bath so that water level in is above liquid level in test tube. Do not hold tube in hand while sonifying. A 50-ml beaker filled with water to level of cyclohexane in tube works well.

(f) Sonify sample for 5 minutes.

(g) Filter the extract in 15-ml medium glass-fritted funnels.

(h) Rinse test tube and filters with two 1.5-ml aliquots of cyclohexane and filter through the fritted-glass funnel.

(i) Collect the extract and two rinses in the 10-ml graduated evaporative concentrator.

(j) Evaporate down to 1 ml while rinsing the sides with cyclohexane.

(k) Pipet 0.5 ml of the extract to preweighed Teflon weighing cup. These cups can be reused after washing with acetone.

(l) Evaporate to dryness in a vacuum oven at 40 C for 3 hours.

(m) Weigh the Teflon cup. Use counterweighing techniques on electrobalance with full scale range of 1 mg to determine weight of aliquot to nearest microgram. The weight gain is due to the cyclohexane-soluble residue.

### Calculations

The amount of cyclohexane-extractable fraction present in the sample (in mg) may be determined according to the following equation:

$$\text{mg/sample} = 2 \times [\text{wt sample aliquot (mg)} - \text{wt blank aliquot (mg)}]$$

The amount of cyclohexane-extractable fraction present in the air may then be determined according to the following equation:

$$\text{mg/cu m} = \frac{\text{mg/sample}}{\text{air volume collected (cu m)}}$$

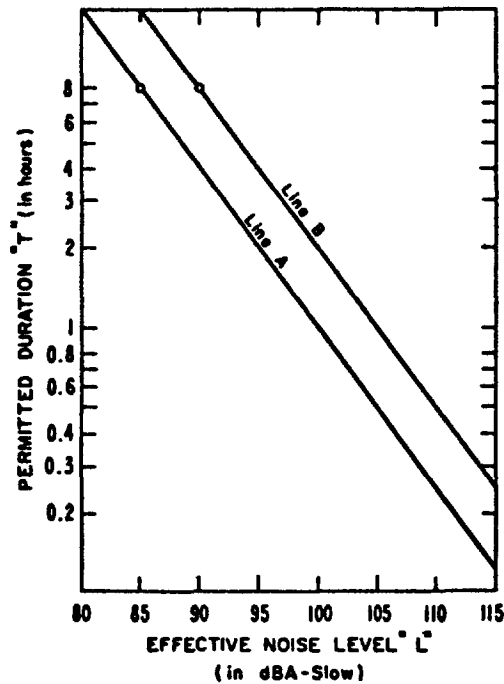
XVI. APPENDIX VI

NOISE TABLE

Occupational noise exposure shall be controlled so that no worker shall be exposed in excess of the limit described as line B in Figure XVI-1. New installations shall be designed with noise control so that the noise exposure does not exceed the limits described as line A in Figure XVI-1. For noise exposures consisting of two or more periods of exposure at different levels, the Daily Noise Dose, D, shall not exceed unity. Line A or line B, as applicable, shall be used in computing the Daily Noise Dose [72].

LINE A  
 FORMULA:  $T = 16 + 2(L-80)/5$   
 RANGE: 80 to 115 dBA-Slow

LINE B  
 FORMULA:  $T = 16 + 2(L-85)/5$   
 RANGE: 85 to 115 dBA-Slow



Adapted from Reference 72

Figure XVI-1

Permitted Duration vs Noise Level (a)

(a) The indicated duration limits which exceed 8 hours are to be used for purposes of computing Daily Noise Dose and are not to be regarded as defining noise exposure limits for work days which exceed 8 hours.

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