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IH CHARACTERIZATION OF COAL LIQUEFACTION FACILITIES

INTRODUCTION

COAL LIQUEFACTION REPRESENTS A TECHNOLOGY THAT MAY DECREASE OUR DEPENDENCE ON IMPORTED PETROLEUM. RESEARCH IN THIS AREA HAS BEEN CONDUCTED WITHIN THE UNITED STATES SINCE 1934. HOWEVER, IN SPITE OF THE TIME AND EFFORT EXPANDED ON THESE PROCESSES MANY QUESTIONS STILL REMAIN TO BE ANSWERED BEFORE LIQUEFACTION BECOMES AN ESTABLISHED TECHNOLOGY. ONE OF THE QUESTIONABLE AREAS NOW UNDER INVESTIGATION IS THAT OF OCCUPATIONAL HEALTH. WORK IN THIS AREA WAS INITIATED SEVERAL YEARS AGO BY THE NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH (NIOSH) THROUGH A SERIES OF STUDIES DESIGNED TO IDENTIFY POTENTIAL HEALTH HAZARDS IN THE COAL LIQUEFACTION ENVIRONMENT.

THIS PAPER IS A REVIEW OF THE RESULTS OF ONE OF THESE NIOSH STUDIES. THIS STUDY ENTITLED "A STUDY OF COAL LIQUEFACTION PROCESSES" IS DESIGNED TO CHARACTERIZE THE OCCUPATIONAL ENVIRONMENT OF DIFFERENT LIQUEFACTION PROCESSES IN TWO STAGES:

1. THE IDENTIFICATION OF CONTAMINANT CLASSES, AND
2. THE DETERMINATION OF EXPOSURE LEVELS FOR SELECTED CONTAMINANTS.

THE RESULTS REPORTED HERE ARE BASED ON COMPLETED SURVEYS IN THREE OF THE FIVE FACILITIES UNDER STUDY. ALTHOUGH THE PHYSICAL AGENTS AND PARTICULATES WERE INVESTIGATED, THE FINDINGS FOR THE ORGANIC CONTAMINANTS ARE EMPHASIZED IN THIS PAPER.

PROCESS

THE FACILITIES INVOLVED IN THIS STUDY UTILIZED THE DIRECT LIQUEFACTION PROCESS IN WHICH COAL IS CONVERTED DIRECTLY INTO A LIQUID PRODUCT AS OPPOSED TO THE INDIRECT PROCESS WHERE COAL IS FIRST GASIFIED AND THEN CATALYTICALLY CONVERTED TO A LIQUID FUEL. BRIEFLY, THE DIRECT PROCESS INVOLVES THE FORMATION OF A SLURRY OF FINE-MESHED COAL IN A COAL-DERIVED LIQUID. THIS SLURRY IS THEN SUBJECTED TO ELEVATED TEMPERATURES AND PRESSURES TO DISSOLVE, DEPOLYMERIZE, AND HYDROGENATE THE CARBONACEOUS MATERIAL IN COAL TO FORM THE LIQUID PRODUCT. GASES AND SOLIDS ARE BY-PRODUCTS OF THE PROCESS.

THE STUDY WAS DIVIDED INTO TWO STAGES. THE FIRST STAGE IS QUALITATIVE ANALYSIS; THE SECOND IS QUANITATIVE ANALYSIS OF THOSE COMPOUNDS IDENTIFIED IN STAGE 1.

SLIDE 1 GIVES THE OPERATING SIZE AND OPERATING PARAMETERS FOR THE DISSOLVER/REACTOR STAGE OF THE PROCESS FOR THE THREE FACILITIES DISCUSSED IN THIS PAPER. FACILITY II DIFFERS FROM THE OTHER FACILITIES BY HAVING A CATALYTIC HYDROGENATION STEP. AS CAN BE SEEN FROM THE COAL PROCESSING RATE, ALL THE PLANTS STUDIED WERE PILOT PLANT FACILITIES.

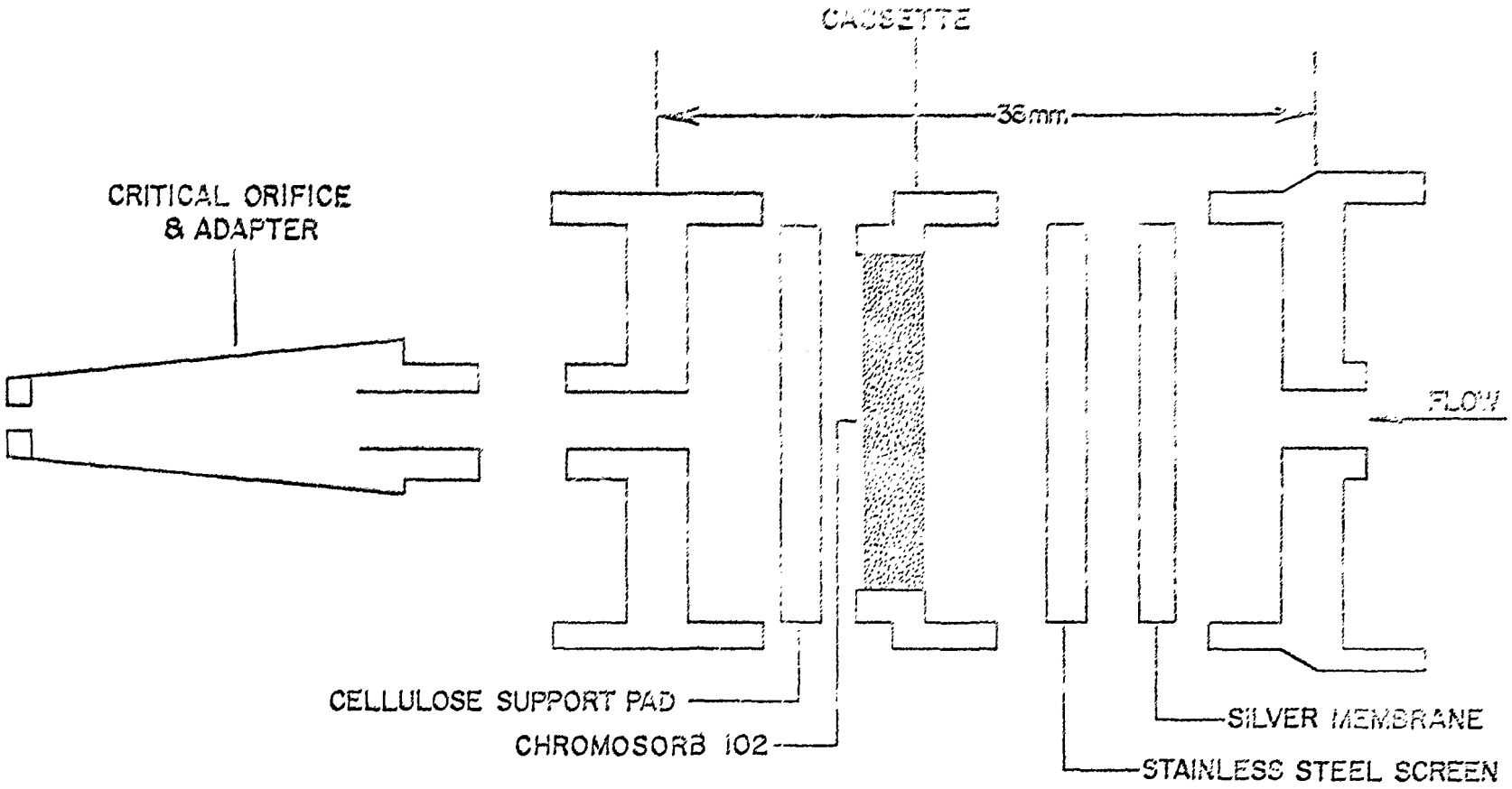
PROTOCOL AND RESULTS/STAGE 1

THE CONTAMINANT CLASSES PRESENT WITHIN THE COAL LIQUEFACTION WORKING ENVIRONMENT OF THE TWO FACILITIES WERE IDENTIFIED THROUGH AN ANALYSIS OF 8-HOUR AREA AIR SAMPLES. SAMPLES WERE COLLECTED ON

SLIDE 1

OPERATING PARAMETERS AT THREE FACILITIES

FACILITY	SIZE (TONS COAL/DAY)	PRESSURE	TEMPERATURE
I	50 (150 BBL/D)	1500-2000	800-875
II	20	150-400	500-750
III	6 (18 BBL/D)	1400-2500	800-875



Slide 2. HIGH-VOLUME SAMPLING DEVICE FOR PNA

600MG CHARCOAL TUBES AND 875MG SILICA GEL TUBES FOR THE IDENTIFICATION OF HYDROCARBONS AND AROMATIC COMPOUNDS, E.G. AMINES, PHENOLS. THESE SAMPLES WERE COLLECTED AT A FLOW RATE OF 100 ML/MIN.

A SPECIAL SAMPLING CASSETTE CONSISTING OF A SILVER MEMBRANE FILTER AND CHROMOSORB 102 WAS DESIGNED FOR COLLECTING POLYNUCLEAR AROMATICS (PNAS). THIS CASSETTE SHOWN IN SLIDE 2 INCLUDES:

- A SILVER MEMBRANE FILTER
- STAINLESS-STEEL SCREEN
- CHROMOSORB 102 - 3 GRAMS
- SUPPORT PAD

A GLASS FILTER WAS NOT USED IN THIS SAMPLING DEVICE BECAUSE PARTICULATE LEVELS AT THE SURVEYED FACILITIES WERE NOT EXPECTED TO CLOG THE SILVER MEMBRANE FILTER. IN OPERATION, THIS ASSUMPTION PROVED CORRECT. THE CHROMOSORB ADSORBENT WAS ADDED TO THE SYSTEM TO CAPTURE VAPOR PHASE PNAS AND SPECIES EVAPORATING FROM THE FILTER COLLECTED PARTICULATES. AREA SAMPLES WERE COLLECTED AT A FLOW RATE OF 9.2 LPM.

A GENERAL SCAN OF CHARCOAL AND SILICA GEL TUBE AREA SAMPLES FROM VARIOUS PROCESSING UNITS WAS CONDUCTED FOR MORE THAN 25,000 COMPOUNDS USING A GAS CHROMATOGRAPH/MASS SPECTROMETER (GC/MS) WITH QUALITATIVE IDENTIFICATION BY A COMPUTER DATA BASE. CHARCOAL AND SILICA GEL SAMPLES WERE ALSO ANALYZED BY GAS CHROMATOGRAPHY FOR BENZENE, TOLUENE, AND XYLENE, AND THE AROMATIC AMINES AND AROMATIC

ALCOHOLS LISTED IN SLIDE 3. THE COMPOUNDS IN SLIDE 3 ARE REPRESENTATIVE OF TWO CLASSES OF CHEMICAL WHICH HAVE BEEN ASSOCIATED WITH THE LIQUEFACTION PROCESS. THE SAMPLE CASSETTES WERE QUANTITATIVELY ANALYZED FOR THE CYCLOHEXANE-SOLUBLE FRACTION WHICH IS IN LIEU OF THE BENZENE-SOLUBLE FRACTION. ALL ANALYSES WERE PERFORMED ACCORDING TO THE APPROPRIATE NIOSH ANALYTICAL METHOD, WHERE AVAILABLE.

THE PNA SAMPLE CASSETTES WERE ALSO QUANTITATIVELY ANALYZED FOR THE 30 PNAs LISTED IN SLIDE 4 FOR WHICH ANALYTICAL STANDARDS WERE AVAILABLE. ANALYSES FOLLOWED THE GC/MS AND HIGH PERFORMANCE LIQUID CHROMATOGRAPHY METHODOLOGY DEVELOPED BY THE UNIVERSITY OF IOWA HYGIENIC LABORATORY, IOWA CITY, IOWA. IN THIS METHOD THE SILVER MEMBRANE FILTER IS ULTRASONICLY EXTRACTED WITH CYCLOHEXANE; THE CHROMOSORB 102 IS EXTRACTED IN A SOXHLET EXTRACTOR USING A 50:50 MIXTURE OF METHYLENE CHLORIDE-METHANOL. SENSITIVITY OF THE METHOD FOR EACH OF 30 PNAs IS IN THE LOW NANAOGRAM RANGE PER SAMPLE.

STAGE 1 RESULTS AND DISCUSSION

A TOTAL OF 86 COMPOUNDS WERE IDENTIFIED IN THE 23 SAMPLES TAKEN AT FACILITY I. AND 68 WERE IDENTIFIED IN 21 SAMPLES TAKEN AT FACILITY II (SLIDE 5). FACILITY III WAS NOT INVOLVED IN THE STAGE 1 SURVEY. FROM THE QUALITATIVE ANALYSIS, MORE DIFFERENT KINDS OF AROMATIC THAN ALIPHATIC WERE FOUND AMONG THE COMPOUNDS WHICH COULD BE DETECTED.

SLIDE 3

LIST OF SELECTED COMPOUNDS

AROMATIC AMINES

ANILINE

N, N.-DIMETHYLANILINE

2, 4-DIMETHYLANILINE

P-NITROANILINE

O-TOLUIDINE

O-ANISIDINE

P-ANISIDINE

AROMATIC ALCOHOLS

PHENOL

P-PHENOL

O-ETHYLPHENOL

P-ETHYLPHENOL

O-CRESOL

M-CRESOL

P-CRESOL

2, 3-XYLENOL

2, 5-XYLENOL

3, 5-XYLENOL

SLIDE 4

POLYNUCLEAR AROMATICS (PNAs)

- Naphthalene
- Quinoline
- 2-Methylnaphthalene
- 1-Methylnaphthalene
- Acenaphthelene
- Acenaphthene
- Fluorene
- Phenanthrene
- Anthracene
- Acridine
- Carbozole
- Fluoranthene
- Pyrene
- Benzo(a)Fluorene
- Benzo(b)Fluorene
- Benz(a)Anthracene
- Chrysene
- Triphenylene
- Dimethylbenz(a)Anthracene
- Benzo(e)Pyrene
- Benzo(a)Pyrene
- Dibenz(a,j)Acridine
- Dibenz(a,i)Carbazole
- Indeno (1,2,3-c,d)Pyrene
- Dibenzanthracene
- Benzo(g,h,i)Perylene
- Anthanthrene
- Coronene
- Dibenzpyrene

SLIDE 5

BREAKDOWN OF COMPOUNDS IDENTIFIED AT FACILITIES I AND II

FACILITY	ALIPHATIC	AROMATIC	TOTAL
I	5	81	86
II	1	67	68

THE PREDOMINANCE OF THE AROMATICS AMONG THE IDENTIFIED COMPOUNDS IS BELIEVED TO BE DUE TO THE GREATER STABILITY OF THE AROMATICS RELATIVE TO THE ALIPHATICS AT THE OPERATING TEMPERATURES AND PRESSURES OF THE PROCESS.[10] THIS PATTERN OF RELATIVE STABILITY IS ALSO APPARENT AMONG THE AROMATICS AS CAN BE SEEN IN SLIDE 6 WHICH GIVES A BREAKDOWN OF THE AROMATICS BY THE NUMBER OF AROMATIC RINGS WITHIN THE COMPOUND. IT IS APPARENT THAT THE MORE STABLE CLASS OF AROMATICS, THE SINGLE-RING AND FUSED TWO-RING COMPOUNDS, ACCOUNT FOR A MAJORITY OF THE COMPOUNDS IDENTIFIED AT THE TWO FACILITIES WITH AN AVERAGE DISTRIBUTION OF 52.3% AND 66.8%, RESPECTIVELY, FOR FACILITIES I AND II.

THESE FINDINGS SUGGEST THAT COMPOUND STABILITY IS A FACTOR IN DETERMINING THE TYPES OF COMPOUNDS BEING FORMED UNDER THE LIQUEFACTION PROCESS. OTHER FACTORS WOULD BE THE TYPE OF PROCESS, OPERATING PARAMETERS, CATALYST, ETC.

THE BENZENE-SOLUBLE FRACTION HAS BEEN USED AS AN INDIRECT MEASURE OF PNA LEVELS IN THE WORKING ENVIRONMENT.[11] FOR EACH SAMPLE CASSETTE THE CYCLOHEXANE SOLUBLE FRACTION WAS DETERMINED SEPARATELY FOR THE FILTER AND ADSORBENT TO EVALUATE THE APPLICABILITY OF THIS METHOD TO THE COAL LIQUEFACTION ENVIRONMENT. THESE RESULTS ARE GIVEN IN SLIDE 7 ALONG WITH MEASURED PNA LEVELS FOR THESE SAMPLES. THE PNA VALUES REPRESENT THE SUM OF THE CONCENTRATION OF THE 30 PNAS UNDER STUDY. AS CAN BE SEEN SOME CONSISTENCY IS SUGGESTED AMONG THE SOLUBLE FRACTION VALUES BUT A HIGH VARIABILITY WAS NOTED WITHIN THE PNA VALUES. NO APPARENT RELATIONSHIP WAS NOTED BETWEEN THE CYCLOHEXANE-SOLUBLE FRACTION

SLIDE 6

% BREAKDOWN OF AROMATIC COMPOUNDS AT FACILITY I AND II

STRUCTURE	(No. OF COMPOUNDS) FACILITY I	FACILITY II	REPRESENTATIVE COMPOUNDS
NONFUSED RINGS	37.2 (32)	2.9 (20)	
ONE RING	31.4 (27)	26.1 (18)	INDENE TOLUIDINE ANISIDINE THIOPHENE BENZENE SUBSTITUTED BENZENES TOLUENE XYLENE ANILINE SUBSTITUTED ANILINE
TWO RINGS	4.6 (4)	2.9 (2)	BIPHENYL SUBSTITUTED BIPHENYLS BIPYRAZOLE
THREE RINGS	1.2 (1)	0	TRIPHENYL ESTER
FUSED RING	56.9 (49)	69.6 (48)	
TWO RINGS	20.9 (13)	40.7 (28)	NAPHTHALENE SUBSTITUTED NAPHTHALENES QUINOLINE ACENAPHTHALENE ACENAPHTHENE FLUORENE AZULENE
THREE RINGS	17.4 (15)	13.0 (9)	PHENANTHRENE SUBSTITUTED PHENANTHRENES ANTHRACENE HERIDINE CARBAZOLE
FOUR RINGS	12.3 (11)	7.2 (5)	BENZANTHRACENE TRIPHENYLENE CHRYSENE
FIVE RINGS	5.8 (5)	8.7 (6)	BENZPYRENE PERYLENE

SLIDE 7

CYCLOHEXANE-SOLUBLE FRACTION vs. TOTAL PNAs

Sample Number	Cyclohexane-Soluble Fraction (mg/m^3)			Total PNAs ($\mu g/m^3$)		
	Filter	Adsorbent	Total	Filter	Adsorbent	Total
001	0.2	1.6	1.8	0.9	8.3	9.2
002	0.4	0.6	1.0	0.4	45.0	45.4
003	0.3	0.9	1.2	19.4	1727	1746.
004	0.1	0.7	0.8	13.6	260.1	273.7
016	0.3	1.2	1.5	0.07	30.0	30.1
021	0.07	0.8	0.9	67.4	127.	194.

Correlation Coeff. Filter 0.06 N = 6

Absorbent + 0.01

Total - 0.12

VALUES AND THE MEASURED PNA LEVELS INDICATING THAT THE SOLUBLE FRACTION MAY NOT BE AN EFFECTIVE TOOL FOR MEASURING WORKER EXPOSURE TO PNAs.

ON THE BASIS OF THESE QUALITATIVE RESULTS, STAGE 2, QUANITATIVE SAMPLING AT THE THREE FACILITIES WAS LIMITED TO BENZENE, TOLUENE, XYLENE, AROMATIC AMINES, AND PNAs; COMPOUNDS AND COMPOUND CLASSES IDENTIFIED IN STAGE 1. A PANEL OF NIOSH RESEARCHERS HAD PREVIOUSLY PRIORITIZED THE LIST OF CHEMICALS. THE ONES LISTED ABOVE WERE IN THE HIGHEST PRIORITY GROUPING.

STAGE 2 SAMPLING PROTOCOL

THREE MAJOR JOB CATEGORIES WERE IDENTIFIED IN WHICH WORKERS MAY BE EXPOSED TO PROCESS CONTAMINANTS BECAUSE OF ASSIGNED DUTIES. THESE CATEGORIES INCLUDE THE PLANT OPERATORS, LABORATORY TECHNICIANS, AND THE MAINTENANCE STAFF. THE SAMPLING PROGRAM EMPHASIZED SAMPLING TO DETERMINE EXPOSURE OF THE PLANT OPERATORS BECAUSE THEIR EXPOSURE IS BELIEVED TO BE MORE REPRESENTATIVE OF THE PROCESS THAN THE OTHER JOB CATEGORIES. THE RESULTS REPORTED HERE FOR THE THREE FACILITIES ARE THERFFORE PRIMARILY CONCERNED WITH THE FIELD OPERATORS.

IN STAGE 2, OPERATOR EXPSOURE WAS DETERMINED FOR EACH OF THE CONTAMINANTS IDENTIFIED IN STAGE 1. THESE CONTAMINANTS ARE LISTED IN SLIDE 8. SAMPLES TAKEN WERE OF 8-HOUR DURATION WITH FLOW RATES OF 100 ML/MIN FOR CHARCOAL AND SILICA GEL TUBE SAMPLES AND 1.5

SLIDE 8

CONTAMINANTS STUDIED IN STAGE II

- BENZENE
- TOLUENE
- XYLENE

- ANILINE
- N,N-DIMETHYLANILINE
- 2,4-DIMETHYLANILINE
- P-NITROANILINE
- O-TOLUIDINE
- O-ANISIDINE
- P-ANISIDINE
- ALPHA-NAPHTHYLAMINE

- NAPHTHALENE
- QUINOLINE
- 2-METHYLNAPHTHALENE
- 1-METHYLNAPHTHALENE
- ACENAPHTHALENE
- ACENAPHTHENE
- FLUORENE
- PHENANTHRENE
- ANTHRACENE
- ACRIDINE
- CARBAZOLE
- FLUORANTHENE
- PYRENE
- BENZO(A)FLUORENE
- BENZO(B)FLUORENE
- BENZ(A)ANTHRALENE
- CHRYSENE/TRIPHENYLENE
- DIMETHYLBENZ(A)ANTHRACENE
- BENZO(E)PYRENE
- BENZO(A)PYRENE
- PERYLENE
- DIBENZ(A,J)ACRIDINE
- DIBENZ(A,I)CARBAZOLE
- INDENO(1,2,3-CD)PYRENE
- DIBENZANTHRACENE
- BENZO(G,H,I)PERYLENE
- ANTHANTHRENE
- CORONENE
- DIBENZPYRENE

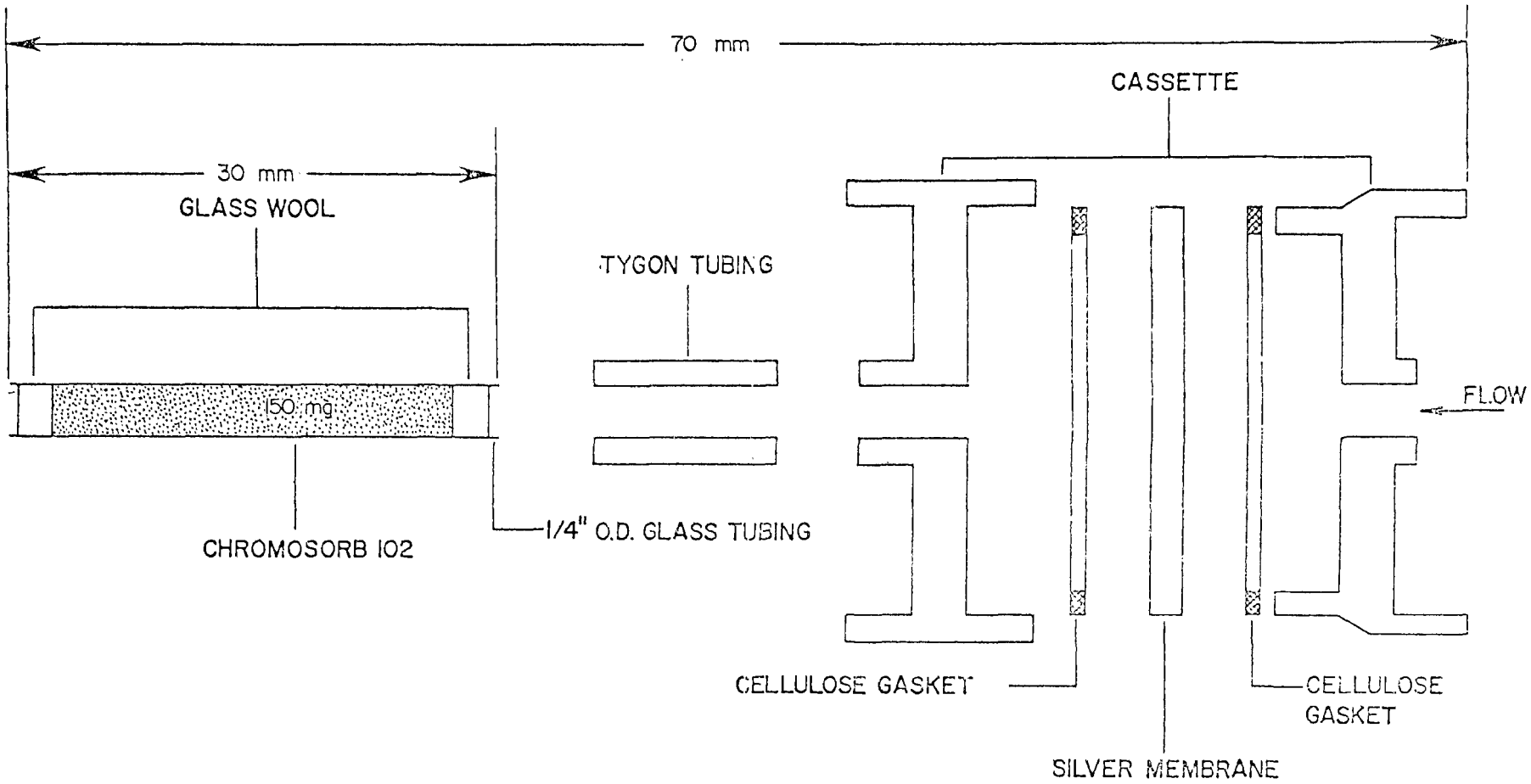
LPM FOR THE PERSONAL PNA SAMPLE CASSETTE. PERSONAL MONITORING SAMPLES WERE SUPPLEMENTED AT EACH FACILITY WITH 8-HOUR AREA SAMPLES. THE AREA SAMPLES ARE UNIT EXPOSURES.

A DIFFERENT SAMPLING DEVICE HAS BEEN DESIGNED TO MONITOR WORKERS FOR PERSONAL PNA EXPOSURE. THIS SAMPLING DEVICE IS SHOWN IN SLIDE 9. IT CONSISTS OF A 37MM CASSETTE WITH A SILVER MEMBRANE FILTER SANDWICHED BETWEEN TWO GASKETS AND A 7MM INNER DIAMETER GLASS TUBING (BORON SILICATE) CONTAINING 150 MG OF CHROMOSORB 102. THE TWO SECTIONS WERE JOINED WITH INERT ¼-INCH TYGON TUBING. THIS CHANGE WAS NECESSARY DUE TO PUMP WEIGHT RESTRICTIONS.

SAMPLES TAKEN IN STAGE 2 WERE ANALYZED USING THE PROCEDURES DESCRIBED FOR STAGE 1; THAT IS GAS CHROMATOGRAPH FOR CHARCOAL AND SILICA GEL TUBE SAMPLES, AND GC/MS AND HIGH PERFORMANCE LIQUID CHROMATOGRAPHY USING A FLUORESCENT DETECTOR FOR THE PNA SAMPLE CASSETTES.

STAGE 2 RESULTS AND DISCUSSION

THE RESULTS FOR BENZENE, TOLUENE, XYLENE AND THE EIGHT AROMATICS STUDIED ARE SUMMARIZED IN SLIDE 10. THE RANGES GIVEN REPRESENT A COMPOSITE OF THE RESULTS FOR THE THREE MAJOR JOB CATEGORIES. AS CAN BE SEEN MEASUREABLE QUANTITITES WERE OBTAINED PRIMARILY AT FACILITY I WITH THE HIGHER END OF THE RANGE BEING ASSOCIATED WITH THE PERFORMANCE OF MAINTENANCE ACTIVITIES. AT FACILITY II ONLY TOLUENE WAS FOUND AT



Slide 9.. PERSONAL MONITORING DEVICE FOR PNA

SLIDE 10

RESULTS IN PPM FOR BENZENE, TOLUENE, XYLENE, AND EIGHT AROMATIC AMINES AT THREE LIQUEFACTION FACILITIES

Compound	Facility I		Facility II		Facility III	
	No. of Samples	Range	No. of Samples	Range	No. of Samples	Range
Benzene	16	0.01 - 0.08	3	0.02 - 0.04	10	ND
Toluene	16	0.01 - 0.4	3	0.02 - 0.03	10	ND
Xylene	16	0.01 - 0.07	3	0.01	10	ND
Aniline	21	0.02	27	ND - 0.05	12	ND
N, N-Dimethylaniline	21	0.01	27	ND - 0.05	12	ND
2,4-Dimethylaniline	21	0.01 - 0.04	27	ND - 0.05	12	ND
P-Nitroanaline	2	-	27	ND - 0.05	12	ND
O-Toluidine	21	0.01 - 0.02	27	ND - 0.05	12	ND
O-Anisidine	21	0.02	27	ND	12	ND
P-Anisidine	21	0.02	27	ND	12	ND
1-Naphthylamine		-		-	12	ND

MEASUREABLE LEVELS WHILE NONE OF THESE CONTAMINANTS WERE DETECTABLE AT FACILITY III. THE DETECTION LIMIT FOR BENZENE, TOLUENE AND XYLENE WAS 0.01 PPM AND FOR THE AROMATIC AMINES RANGED FROM 0.02 TO 0.05 PPM DEPENDING ON THE COMPOUND AND ON SAMPLE VOLUME. THE HIGHEST VALUE RECORDED WAS FOR TOLUENE AT 0.4 PPM AT FACILITY I INDICATING THAT WORKER EXPOSURE TO THESE CONTAMINANTS WERE WELL BELOW CURRENT OCCUPATIONAL HEALTH STANDARDS.

WORKER EXPOSURE TO THE PNAS IS SUMMARIZED IN SLIDE 11. VALUES GIVEN ARE FOR TOTAL PNAS AND REPRESENT THE SUM OF THE MEASURED CONCENTRATION OF THE 30 PNAS STUDIED. AS CAN BE SEEN WORKER EXPOSURE TO THE PNAS WAS IN THE MICROGRAM-PER-CUBIC-METER RANGE. A COMPARISON OF THE THREE FACILITIES SHOWS THAT FACILITY I HAD HIGHER EXPOSURE LEVELS THAN THE OTHER FACILITIES. IT IS ANTICIPATED THAT USING APPROPRIATE INDUSTRIAL HYGIENE TECHNIQUES AND CONTROL TECHNOLOGY, THESE VALUES WILL BE QUITE LOW.

AN EVALUATION OF THE RESULTS INDICATES THAT THE TWO- AND THREE-RING PNAS ACCOUNTED FOR MORE THAN 97 PERCENT BY WEIGHT OF THE TOTAL PNAS IDENTIFIED AT THE THREE FACILITIES AS SHOWN IN SLIDE 12. THESE INCLUDED NAPHTHALENE, QUINOLINE, 2-METHYLNAPHTHALENE, 1-METHYLNAPHTHALENE, ACENAPHTHENE, FLUORENE, PHENANTHRENE AND ANTHRACENE. THE REMAINING THREE PERCENT WAS COMPOSED PRIMARILY OF FOUR-RING PNAS.

SLIDE 11

FIELD OPERATOR EXPOSURE TO TOTAL PNAs IN MG/M^3

	FACILITY I	FACILITY II	FACILITY III
NUMBER OF SAMPLES	12	12	4
AVERAGE	62.8	0.2	9.9
RANGE	3.5-264.3	0.02-0.3	0.05-21.4
STANDARD DEV.	72.2	0.1	8.8
GEOMETRIC MEAN.	35.6	0.1	3.1
GEOMETRIC STD. DEV.	3.3	22.8	16.0

SLIDE 12

BREAKDOWN BY WEIGHT OF PNAs FOUND AT THREE LIQUEFACTION FACILITIES

	FACILITY I		FACILITY II		FACILITY III	
TWO RING COMPOUNDS	AREA	PERSONAL	AREA	PERSONAL	AREA	PERSONAL
MEAN (ug/m^3)	27.2	52.8	52.9	0.2	7.2	14.2
(PERCENT)	(49.3)	(72.8)	(97.5)	(100)	(68.8)	(86.1)
RANGE (ug/m^3)	0.12 - 72.7	0 - 244.5	14.8 - 72.2	0.02 - 0.5	0 - 18.4	0 - 42.0
(PERCENT RANGE)	(20 - 78.4)	(0 - 94.5)	(89.3 - 99.8)	(100)	(0 - 94.1)	(0 - 97.1)
NO. OF SAMPLES	8	19	12	25	13	14
THREE RING COMPOUNDS						
MEAN (ug/m^3)	26.5	7.8	0.6	0	1.0	0.8
(PERCENT)	(46.0)	(24.8)	(1.7)	-	(28.1)	(13.5)
RANGE (ug/m^3)	0.4 - 119.	0.6 - 19.8	0.08 - 1.5	-	0.01 - 4.6	0.05 - 1.5
(PERCENT RANGE)	(18.7 - 73.3)	(6.2 - 100.0)	(0.3 - 7.2)		(2.9 - 100)	(2.6 - 10(
NO. OF SAMPLES	8	19	12	25	13	14
FOUR PLUS RING COMPOUNDS						
MEAN (ug/m^3)	0.7	0.9	0.4	0	0.1	0.04
(PERCENT)	(2.1)	(3.3)	(0.9)		(2.6)	(0.4)
RANGE (ug/m^3)	0.02 - 2.4	0 - 4.5	0.01 - 1.0	-	0 - 0.8	0 - 0.09
(PERCENT RANGE)	(0.7 - 4.7)	(0 - 25.4)	(0.02 - 3.5)		(0 - 16.7)	(0 - 1.1)
NO. OF SAMPLES	8	19	12	25	13	14

CONCLUSION

BASED ON THE RESULTS OF SURVEYS CONDUCTED AT THE THREE FACILITIES, A PRELIMINARY ASSESSMENT CAN BE MADE WITH REGARD TO THE COAL LIQUEFACTION WORKPLACE ENVIRONMENT. THE STAGE 1 RESULTS INDICATE THAT THE SPECTRUM OF ORGANIC CONTAMINANTS FOUND IN THE LIQUEFACTION WORKPLACE ENVIRONMENT FOR THAT PLANT ON THOSE DAYS UNDER THOSE CONDITIONS IS NOT AS DIVERSE AS WOULD BE EXPECTED, CONSISTING OF THE LOW-MOLECULAR WEIGHT AROMATICS WITH ONE TO THREE RINGS APPARENTLY PREDOMINATE IN THIS ENVIRONMENT. HOWEVER, NOT ALL LOW-MOLECULAR WEIGHT SPECIES WERE PRESENT. NOTABLY ABSENT WERE THE PHENOLS AND CRESOLS WHICH, ALTHOUGH BELIEVED TO BE PRESENT IN THE LIQUID EFFLUENTS WERE NOT DETECTED IN ANY OF THE AIRBORNE SAMPLES.

STAGE 2 PERSONAL MONITORING RESULTS INDICATE THAT EXPOSURE TO THESE LOW-MOLECULAR WEIGHT AROMATICS WAS IN THE PARTS PER MILLION RANGE AND FOR THE PNAs, IN THE MICROGRAM-PER-CUBIC-METER RANGE. AT THE PPM LEVEL, COMPARISON OF BENZENE, TOLUENE, XYLENE AND THE AROMATIC AMINES WITH CURRENT OCCUPATIONAL HEALTH STANDARDS INDICATE THAT THESE COMPOUNDS ARE WELL BELOW THE OSHA LIMITS.

THERE IS AN ABSENCE OF TOXICOLOGICAL DATA TO ASSESS THE HEALTH HAZARD OF PROLONGED PNA EXPOSURES AT THE MICROGRAM-PER-CUBIC-METER RANGE. HOWEVER, TOXICOLOGIC STUDIES HAVE SHOWN THAT PROCESS STREAM EXTRACTS OBTAINED FROM THE PROCESS STREAMS OF DIFFERENT COAL CONVERSION PROCESSES EXHIBITED CARCINOGENIC PROPERTIES WHICH WERE ATTRIBUTED TO THE PNA CONSTITUENTS (2-7). SINCE A NUMBER OF PNAs HAVE EXHIBITED

CARCINOGENIC PROPERTIES IN ANIMAL TOXICOLOGY STUDIES (8,9), IT COULD BE ASSUMED THAT THE PNA CONSTITUENTS FOUND IN THESE PROCESSES MAY BE POTENTIAL CARCINOGENIC HAZARDS AS WELL. THIS SUGGESTS THAT WORKERS WITHIN THESE FACILITIES MAY HAVE AN ADDED RISK OF DEVELOPING CANCER BECAUSE OF PNA-INDUCED CANCER RELATIVE TO WORKERS WITHOUT SUCH EXPOSURE. WHAT REMAINS UNDEFINED IS THE QUANTIFICATION OF THE RISK FACTOR.

COMPARISON OF NIOSH CONTRACTOR AND DOE INDUSTRIAL HYGIENE DATA

THE DATA COLLECTED BY OUR CONTRACTOR AT THE COMPREHENSIVE SURVEY WAS OBTAINED DURING OPERATION OF THE SRC-II PROCESS. FOR MEANINGFUL EVALUATION THIS DATA IS BEING COMPARED WITH DOE RESULTS OBTAINED DURING SRC-II OPERATIONS. BECAUSE OF DIFFERENCES IN SAMPLING AND ANALYTICAL PROCEDURES, THE COMPARISON OF DATA FROM THE TWO SURVEYS IS CONCERNED WITH MAGNITUDE OF THE OBSERVED CONCENTRATIONS FOR EACH PROCESS AREA.

BENZENE, TOLUENE, AND XYLENE

A COMPARISON OF THE LEVELS FOR BENZENE, TOLUENE, AND XYLENE IN THE COAL PREPARATION, MINERAL SEPARATION, AND SOLVENT RECOVERY AREAS SHOWED SIMILAR LEVELS FOR BOTH AREA SAMPLES AND PERSONAL SAMPLES. HOWEVER, IT SHOULD BE NOTED THAT ONLY ONE SAMPLE WAS TAKEN IN EACH AREA BY OUR CONTRACTOR.

THE DOE DATA TAKEN OVER A PERIOD OF 12 MONTHS SHOWED LITTLE VARIATION AMONG SAMPLES WITHIN PROCESS AREAS TESTED: MORE THAN 90 PERCENT OF THE SAMPLES HAD VALUES BETWEEN 0.01 AND 0.05 PPM FOR BENZENE, TOLUENE, AND XYLENE. OUR CONTRACTOR'S DATA TAKEN 8 MONTHS LATER FALLS WITHIN THIS RANGE, WHICH SUGGESTS A UNIFORMITY IN PROCESS EMISSIONS FOR THESE COMPOUNDS IN THE SRC-II PROCESS.

PNAs

WITH REGARD TO THE PNAs, DOE SAMPLES WERE ANALYZED ONLY FOR BENZO(A)PYRENE (BaP). AN EVALUATION OF CONTRACTOR PERSONAL SAMPLES SHOWED SIMILAR LEVELS FOR BaP IN ALL TESTED PROCESS AREAS EXCEPT THE PRODUCT SOLIDIFICATION AREA. FOR THE TWO SURVEYS, LEVELS RANGED FROM NONDETECTABLE TO LESS THAN 0.01 UG/M^3, WHEREAS DOE HAD LEVELS ONE TO TWO ORDERS OF MAGNITUDE HIGHER (0.13 - 0.99 UG/M^3). THIS DISCREPANCY IN THE PRODUCT SOLIDIFICATION AREA CANNOT BE PROPERLY EVALUATED BECAUSE PLANT OPERATING STATUS INFORMATION DURING THE DOE SURVEY WAS NOT AVAILABLE.

THE DATA ARE COMPARABLE. BOTH DOE AND OUR CONTRACTOR RESULTS AGREE, OR AT LEAST ERR IN THE SAME DIRECTION.

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Dr. Weisburger (NCI): I have one or two comments. First, what was this coal-derived liquid that was used for the process you mentioned?

Dr. Berardinelli: It is a mixture of aromatics, i.e., anthracene oil in which the coal is then slurried. At facility number 2, I think, methyl-naphthalene is probably one of the biggest constituents.

Dr. Weisburger (NCI): Also, you have compared the extent of exposure to the polycyclics with -- I mean, between these people and people, say, who are out standing on the street corner in some busy city, you know, where there are lots of automobiles going by and lots of combustion taking place; what is the relative extent of exposure?

Dr. Berardinelli (NIOSH): Okay, that is a very valid question. This is something that I think we will pursue further. The big problem here is analysis. I think EPA was the first one to point out that we cannot use just a silver membrane filter. If you look at the NIOSH methods of sampling analysis for PNA's, a silver membrane filter is recommended. Well, we know that this is not entirely suitable because we are missing the whole vapor phase. A sorbent resin is needed to catch the vapor phase PNA's.

But what I am saying is that some of the old data really cannot be compared to our data because the techniques are different. In addition, we have some problems as to analytical capabilities. Most people have used the cyclohexane-soluble fraction and tried to use that as a PNA indicator. EPA has done work where they have looked extensively at BAP.

I would say that BAP is in the high nanogram per cubic meter range for ambient levels, I think in the Pittsburgh area. I believe more important would be to compare PNA's to other work places. One thing we can do there is to look at some Scandinavian data, which I do not have with me. However, they looked at coke oven emissions using an analytical scheme which analyzed 40 PNA's, and found total PNA's in the milligram per cubic meter range.

So to answer your question fully, I really have to kibitz a bit, because I will say that PNA's seem to be worse than the rural environment.

NIOSH

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SHERATON/POTOMAC, ROCKVILLE, MARYLAND

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