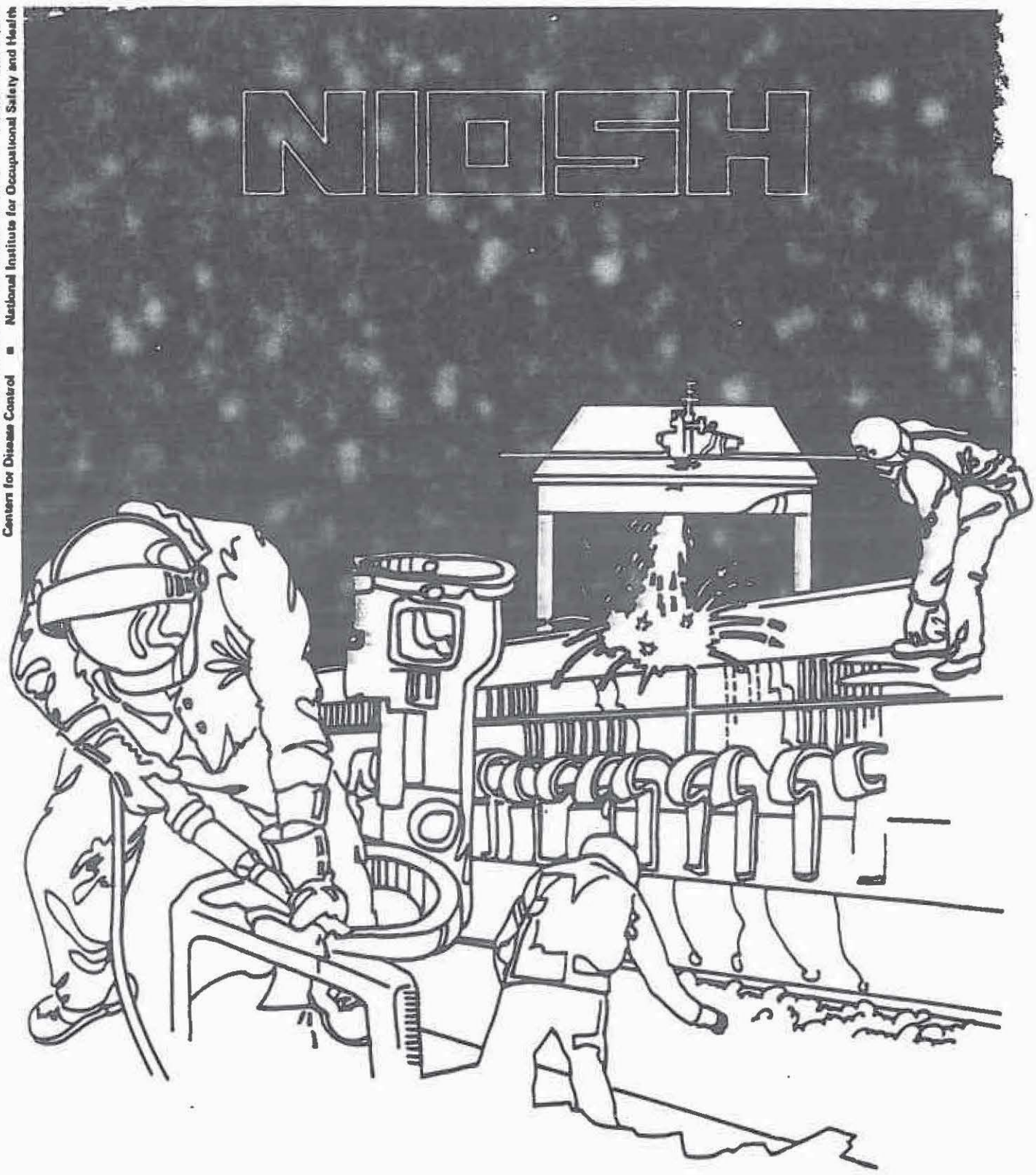
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES ■ Public Health Service
Centers for Disease Control ■ National Institute for Occupational Safety and Health



Health Hazard Evaluation Report

HETA 82-096-1259
KAISER ALUMINUM AND
CHEMICAL CORPORATION
RAVENSWOOD, WEST VIRGINIA

PREFACE

The Hazard Evaluations and Technical Assistance Branch of NIOSH conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

The Hazard Evaluations and Technical Assistance Branch also provides, upon request, medical, nursing, and industrial hygiene technical and consultative assistance (TA) to Federal, state, and local agencies; labor; industry and other groups or individuals to control occupational health hazards and to prevent related trauma and disease.

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KAISER ALUMINUM AND CHEMICAL CORPORATION
RAVENSWOOD, WEST VIRGINIA

NIOSH INVESTIGATORS:
Steven H. Ahrenholz, I.H.
Jane Lipscomb, R.N.

I. SUMMARY

On February 1, 1982, the National Institute for Occupational Safety and Health (NIOSH) received a request to evaluate reported symptoms of skin, eye, and throat irritation, and respiratory problems, possibly related to oil mist, solvent, and rolling oil exposures in the fabrication area at Kaiser Aluminum and Chemical Corporation's Aluminum Fabrication Plant in Ravenswood, West Virginia. An additional request was made to evaluate asbestos exposures around the horizontal heat treat furnace during normal operations.

The plant converts aluminum ingots into plates or coiled sheets by the use of rolling mills. There were about 700 hourly employees working in the area covered by this request at the time of the survey.

On March 31 - April 1, 1982, NIOSH investigators conducted an initial walk-through evaluation, collected bulk samples of rolling oils, and conducted informal medical questioning of workers.

Laboratory analyses of the rolling oils over temperature ranges approximating normal operating conditions indicated the potential for airborne emissions of irritants like formaldehyde, propionaldehyde, and acetaldehyde and mixtures of aliphatic compounds.

On September 21-22, NIOSH conducted a follow-up industrial hygiene survey. Concentrations of acetaldehyde and propionaldehyde were below detection limits. Mean personal breathing zone exposure to formaldehyde was 0.024 mg/M^3 (0.011-0.031 mg/M^3) and the mean concentration of area formaldehyde concentrations was 0.010 mg/M^3 (0.005-0.016 mg/M^3). NIOSH recommends that it be handled as a potential occupational carcinogen with no given exposure limit. Personal exposures to stoddard solvent had a mean of 22.2 mg/M^3 (12.3-67.1 mg/M^3) - NIOSH recommended standard 350 mg/M^3. Toluene was present but not quantifiable. Breathing zone kerosene exposures had a mean of 35.1 mg/M^3 (12.1-141 mg/M^3) - NIOSH recommended standard 100 mg/M^3. Area oil mist values had a mean of 1.31 mg/M^3 (0.29-4.36 mg/M^3) - ACGIH criterion is 5 mg/M^3. Asbestos air samples were all below 0.05 fiber per cc (NIOSH recommended standard 0.1 fiber/cc).

Eight workers from areas in the plant with the greatest oil mist exposure or those with known health complaints were interviewed during the initial walk-through. Discussions with these workers, labor representatives, management, and nursing staff indicated that the lay-off in January 1982 resulted in an older workforce, who do not appear to experience the health effects mentioned in the request. The few workers who did complain of irritant symptoms stated there were few problems when existing control measures were employed.

Based on the results of this evaluation, NIOSH has determined that a health hazard from overexposure to rolling oils, stoddard solvent, asbestos, and formaldehyde was not present at Kaiser Aluminum's Ravenswood, West Virginia, fabrication plant. High kerosene exposures were seen in the Foil Department. Recommendations to help improve conditions involve housekeeping; evaluation of existing local exhaust system effectiveness and assurance of proper operation; and the replacement of asbestos containing insulation with a less hazardous substitute.

KEYWORDS: SIC 3353 (Aluminum Sheet, Plate, and Foil), rolling oils, thermal decomposition products, formaldehyde, oil mist, stoddard solvent, asbestos.

II. INTRODUCTION

On February 1, 1982, the National Institute for Occupational Safety and Health (NIOSH) received a request from an authorized representative of Local 5668, United Steel Workers of America, to conduct a Health Hazard Evaluation (HHE) at Kaiser Aluminum and Chemical Corporation's Aluminum Fabrication Plant, Ravenswood, West Virginia. The request concerned skin, eye, and throat irritation, and respiratory problems - all possibly related to oil mist, solvent, and rolling oil exposures in the fabrication department. NIOSH conducted an initial survey March 31 - April 1, 1982, which included a walk-through survey and interviews of management and labor representatives and employees. Bulk samples of the rolling oils in use on the various fabrication mills were obtained for preliminary laboratory analyses. NIOSH conducted a follow-up industrial hygiene survey September 20-23, 1982, and sampled for selected irritant compounds (e.g. low molecular weight aldehydes) based on laboratory results of the previously obtained bulk samples which had been evaluated for decomposition products at operating temperatures. Area sampling was also conducted for oil mist levels and worker exposure to total organics (evaluated as either kerosene or stoddard solvent). Prior to NIOSH's follow-up survey, the union requested that an evaluation of asbestos exposure in the Plate Department in the vicinity of a horizontal heat treat furnace be added to the follow-up survey protocol. Results of the rolling oil bulk sample analyses along with a presentation and discussion of initial survey findings were presented in Interim Report No. 1, disseminated to the union and management in June 1982.

III. BACKGROUND

A. Workforce

Kaiser Aluminum's Ravenswood plant was constructed in 1957 as a reduction plant and fabrication mill. In January 1982, the company closed the reduction operation which resulted in the lay-off of approximately 1700 workers with less than 20 years of seniority. Approximately 50% of the current fabrication mill employees worked in the reduction plant prior to the lay-off.

Currently, there are 1418 hourly employees at the Ravenswood plant and 683 of these work in the various areas covered by the HHE request. These areas include: the Hot Rolling, Cold Rolling, Foil and Finishing Departments, as well as hot and cold roll maintenance personnel.

B. Process Description and Materials Used

The fabrication process begins in the hot roll department where ingots up to 28 inches thick and 160 inches long are run through rolling mills and converted into coiled sheets. Sheets are then

converted to a lighter gauge in the cold mill area. Coiled sheets are finally leveled, trimmed, and slit to customer's specifications in the foil and finishing areas.

Rolling ingots are currently shipped to the Ravenswood Plant from other Kaiser reduction facilities. Additionally, ingots may be formed in the Ravenswood Casting Department from reclaimed scrap, both that generated during the fabrication process and also some purchased from outside sources. The recycled aluminum purchased from outside sources may contain varying quantities of unspecified oils. Ingots pass from the furnaces through the scalping department to the tempering furnaces where they are maintained at a temperature of 427-482°C (800-900°F) prior to being run on the hot line.

The ingots, up to 28 inches thick and 285 inches long, are run through a 168 inch reversing breakdown mill, which performs the initial reduction of the ingot in the formation of plate or coils. The hot line also has a 110 inch reversing mill, a five-stand hot mill for producing coils, a six inch shear, and a three inch shear. The five-stand hot mill is not used during plate shifts. The hot rolling operation produces Ravenswood's complete stock of hot rolled plate products. All the aluminum used in the cold roll, finishing, and foil areas must pass through this line. A coolant [consisting of greater than 95 percent demineralized water, a petroleum based emulsion, and a triazine bactericide] is sprayed onto the ingots and coils during the process. The coolant is collected underneath the machines and returned to filtration systems where contaminants are removed and oil, water, and bactericides are added. Each reversing mill has one operator while the five stand mill has two controllermen, a mill operator, an assistant mill operator, and a coilerman. There are also three truck drivers in the area.

Ravenswood's cold rolling operation reduces the aluminum coil to its final gauge (thickness). Each of the five mills operates independently of the others and is connected to a coolant filtration and recirculation system. Heat exchangers present in the coolant filtration and recirculation system maintain the fluid at about 54°C (130°F). Aluminum coils are preheated using indirectly gas fired furnaces prior to being run on the cold mills. Coolants applied to the work and backup rolls on the single and multiple stand mills in cold rolling are kerosene based and local exhaust systems are present on each mill. No recirculation of exhaust air is practiced. Each mill is run by an operator, assistant operator(s), mill helper(s), and an expeditor. Coils from the cold mills are sent to either finishing or the foil department.

The foil department is responsible for further reduction of the coil in thickness to produce the finished foil. These mills may also apply a stoddard solvent to the foil by drip application during its passage through the mill in addition to the application of coolant onto the rolls. The coolants in the foil department, like the cold mills, are kerosene based and serve to cool the rolls and provide lubrication during the breakdown of aluminum sheets from one gauge to another. The coolant is collected, filtered, and thermally regulated by systems similar to those in the cold mills. Local exhaust systems are present on the foil mills. Each machine is run by an operator and mill assistant.

The surface finishing area receives coils from the cold mills and involves the use of slitters (to cut coil to specified width) and other equipment which levels, trims, and rolls coiled sheet to customer specifications. No reduction in thickness occurs here. No coolants are used in this area and a stoddard solvent application is restricted to slitting operations as an aid in cutting and to wash off the sheet. The basic slitters are run by one operator and two helpers. The high speed slitter requires three operators, one relief operator, and one trucker.

Annealing of the aluminum can be undertaken at numerous points during the processes listed. Additionally the sequence of machines and processes which a specified coil of aluminum will undergo varies with its final application and customer specifications.

An additional process addressed during the follow-up survey was heating of aluminum ingots in the Plate Department's horizontal heat treating furnace. This gas fired furnace is used to heat aluminum ingots to impart the desired properties of strength, hardness, and temper to the metal. Ingots are fed through a door into the furnace on a series of rollers. At the exit end of the furnace the ingots pass immediately into a water spray quenching unit. Ingots are then discharged from this quench unit and are removed to await further processing.

C. Plant Industrial Hygiene and Medical Resources

The Ravenswood plant's Environmental Services Department is responsible for providing industrial hygiene services. A full time industrial hygienist is on-site and, with the assistance of technicians, conducts occupational exposure monitoring of the workforce. Laboratory analyses and support are provided by Kaiser Corporation's Center for Technology.

The plant has a medical department with 24 hour nursing coverage. All prospective employees receive a pre-placement examination consisting of a medical, occupational and smoking history; a physical examination; pulmonary function test; chest x-ray;

audiometry; and blood and urine tests. Periodic examinations were offered to fabrication plant employees every three years up until 1978 when they were discontinued. Worker representatives expressed concern over discontinuation of these examinations.

Currently, medical surveillance is only provided to workers in areas of the plant where there is exposure to any substance at a level of one-half of the Occupational Safety and Health Administration (OSHA) standard. The areas of the plant covered in the hazard evaluation request do not fall into this category.

Annual audiometric testing of fabrication plant employees was recently begun.

IV. METHODS AND MATERIALS

A. Environmental

The industrial hygiene component of the HHE was conducted in two phases. During the initial survey six bulk samples of rolling oils were collected and subsequently submitted to the laboratory for a qualitative determination of potential contaminants and decomposition products released from the oils at temperatures approximating those on the mills. The primary interest was to identify compounds with known irritant properties. Based on the data generated from the initial analyses, preparations were made to conduct the follow-up survey which included sampling for low molecular weight aldehydes [specifically formaldehyde (CAS #50-00-0), acetaldehyde (CAS#75-07-0), and propionaldehyde (CAS#123-38-6)], oil mist, and total organics (i.e. as kerosene or stoddard solvent). Industrial hygiene sampling was conducted using precalibrated battery powered sampling pumps with the appropriate sampling media (described below). Personal exposure and area or process samples were obtained with sampling periods approximating the time period that production processes ran on the day shifts of September 22-23, 1982. Asbestos (CAS#12172-73-5 amosite; 12001-19-5 chrysotile) sampling was conducted September 23, 1982.

1. Bulk Sample Analyses

The six bulk samples of rolling oils (three from the hot rolling mills and three from the cold rolling and foil mills) were submitted to the NIOSH laboratory for qualitative analyses of decomposition products occurring at temperatures approximating operating conditions. Air samples from bulks obtained in the cold rolling and foil areas were generated in the lab at a temperature range of 60-70°C (140-158°F) and collected on charcoal tubes, porous polymer tubes, and, for one bulk (05) a N-benzylethanolamine coated XAD-2 tube. Identity of the bulk samples is presented in Table I. High temperature

bulks, those obtained from the hot rolling mill, were used to generate air samples while heating the oil at a temperature of 380-400°C (716-752°F). Extra steps were required to prepare the high temperature bulks due to the necessity of removing as much of the water phase as possible. Generated contaminants from the high temperature bulks were obtained on charcoal tubes and N-benzylethanolamine coated XAD-2 tubes. Detector tubes for oxides of nitrogen were also used on the effluent from the samples. All sampling periods for sorbent tubes were about 30 minutes.

Charcoal tubes and porous polymer tubes were screened by gas chromatography prior to the selection of samples for mass spectroscopic analysis. Formaldehyde tubes were analyzed for 3-benzyloxazolidine, the product resulting from the reaction of formaldehyde with N-benzylethanolamine, by gas chromatography equipped with a flame ionization detector.

A total of three charcoal tubes, one for each of the low temperature bulks, and one XAD-2 resin tube for formaldehyde generated from the low temperature bulk oils were analyzed. The high temperature bulks resulted in the analysis of only one charcoal tube by gas chromatography mass spectroscopy (GC/MS) after initial screening. Three XAD-2 resin tubes, one for each high temperature bulk, were analyzed for formaldehyde.

2. Formaldehyde, Acetaldehyde, and Propionaldehyde

Samples were obtained by bubbling air through 20 milliliters (mL) of a 1% sodium bisulfite ($NaHSO_3$) solution in a midget impinger. Breathing zone samples were obtained by placing the impinger in a holster and locating it near the worker's shirt collar. The laboratory split the impinger solution to facilitate two separate analyses: one for formaldehyde and one for acetaldehyde and propionaldehyde.

The formaldehyde analysis was done according to NIOSH Method No. P&CAM 125[1]: a modification of the method was the use of a 1% $NaHSO_3$ solution in the preparation of the formaldehyde standard solution "B" instead of distilled water. The analytical limit of detection was 2 micrograms (ug) per impinger.

Samples analyzed for acetaldehyde and propionaldehyde were done by gas chromatography using NIOSH Method No. P&CAM 127[1] with the following modifications:

Gas Chromatograph	: Hewlett-Packard Model 5731 equipped with a flame ionization detector

Column	: 4' x 2 mm internal diameter glass column packed with Chromosorb 101
Oven Conditions	: 140°C isothermal
Other	: Helium Carrier gas

The analytical limits of detection were 10 ug of analyte per mL of sample for both compounds.

3. Total Organics (ie Kerosene and Stoddard Solvent)

Personal breathing zone samples for kerosene and stoddard solvent were collected on standard charcoal tubes using pumps set at a flow rate of about 50 cubic centimeters per minute. The charcoal tubes were divided into front and back sections, desorbed in carbon disulfide, and an aliquot from each sample was injected into a gas chromatograph equipped with a 10% SP-2100 column and a flame ionization detector. Identities of analytes found were confirmed by mass spectrometry.

Bulk samples of the rolling oils and solvents used on the various equipment were obtained for preparation of analytical standards. Aliquots of the bulk samples were diluted with sufficient carbon disulfide to bring responses to within the working range of the gas chromatograph.

An additional compound identified and evaluated was toluene. The lower limits of quantitation (LOQ) and detection (LOD) are given in ug as follows:

	LOQ	LOD
Toluene	17	1
Stoddard Solvent	90	40
Kerosene	100	50

4. Oil Mist

Area samples for oil mist were collected on polyvinyl chloride filters at a sampling rate of two liters per minute. Oil mist analysis by a solvent extraction/gravimetric procedure was requested since more than one oil was in use in this operation. The oil was extracted from the filters using 1,1,2-trichloro-1,2,2-trifluoroethane ($C_2Cl_3F_3$). This method of sample collection and extraction has been documented in NIOSH Method P&CAM No. 283.[2] Each sample was transferred to scintillation vials, which had been rinsed with $C_2Cl_3F_3$ and air-dried. Ten milliliters of $C_2Cl_3F_3$ was then added and the samples were agitated. Samples were extracted for at least 30 minutes with occasional shaking. The

filters were removed and 1.00 mL was transferred to a preweighed teflon dish (approximately 15 mL capacity, approximately 50 mg total weight). After the $C_2Cl_3F_3$ had evaporated, the teflon dishes were weighed and the weight of oil on each filter was calculated. This analysis is independent of the type of oil or oils used and does not require a sample of the oil for the analysis.

5. Asbestos

Airborne asbestos concentrations were obtained in the Plate Department on open face mixed cellulose ester membrane filters using portable sampling pumps calibrated for a flow rate of 2 liters per minute. Sampling was done with the cassettes situated face down and the sample duration averaged between 5-6 hours. Two bulk samples of a gray, fibrous material adhering to the overhead beams above the furnace area and material deposited on top of the furnace itself were collected for asbestos content determination.

The filters were prepared for Phase Contrast Microscopy Analysis following a procedure published in a 1977 Millipore Corporation technical service brief. Each preparation was counted at 400x magnification on a microscope with a field area of 2.862×10^{-3} square millimeters.

The two bulk samples were prepared for Electron Microscopy Analysis by ultrasonicating portions of the sample in ethyl alcohol and evaporating aliquots of the resulting suspension onto carbon coated copper grids. Each grid was scanned at 2,000x magnification and Energy Dispersive X-ray Analysis was performed on each fiber present and on 50 particles. The two bulk samples were also prepared for Polarized Light Microscopy by immersion in several refractive index liquids. These preparations were analyzed at 400x magnification.

B. Medical

The medical component of the HHE was limited to the initial survey. A labor representative who accompanied NIOSH on the walk-through, identified 8 workers with heavy oil-mist exposure and/or health complaints. Four of these worked in the Cold Roll Department, and one worked in each of the following: Foil, Finishing, Hot Roll Departments, oil house. All were interviewed regarding health effects they experienced related to their work. These workers, their labor representatives, department foremen, and the medical department personnel were interviewed regarding reported or suspected health complaints or problems among other workers in each area. Three workers with reported chronic

respiratory problems were identified, interviewed by telephone, and their plant medical records were reviewed.

V. EVALUATION CRITERIA

The criteria used in evaluating the documented environmental levels of chemical contaminants are obtained from the following sources: NIOSH recommended occupational exposure criteria; the American Conference of Governmental Industrial Hygienists (ACGIH) recommended Threshold Limit Values®; and the Occupational Safety and Health Administrations (OSHA) General Industry Standards 26 CFR 1910:1000. The evaluation criteria are considered to be the maximum time weighted exposure limits for which most workers would not be expected to experience adverse health effects. These criteria are not intended to be interpreted as fine lines separating "safe" and "unsafe" exposure levels. Rather they are to serve as guidelines, based on industrial and experimental experience and information, in the control of health hazards. Additionally these criteria are applicable to an 8 hour workday (8-10 hours for NIOSH criteria), 40 hour workweek. Schedules deviating from this (i.e. longer workshifts and overtime) would require downward adjustment of the maximum acceptable exposure limits.

Table II presents the applicable evaluation criteria along with a listing of the target organs and a brief summary of the health effects associated with overexposures (both acute and chronic).

VI. RESULTS

A. Environmental

1. Initial Survey Bulk Sample Analyses

The chromatograms for the low temperature bulks were very similar. Compounds detected were various saturated and unsaturated nine (C_9) to sixteen (C_{16}) carbon chain aliphatics (alkanes, cycloalkanes, and/or alkenes, etc.). The most prominent peaks were the C_9-C_{16} straight chain alkanes. See Figure I. The formaldehyde analysis for the low temperature bulk did not demonstrate any peaks on the chromatograph in the region of the formaldehyde derivative.

The generated charcoal tube samples from the high temperature bulks contained hundreds of components (See Figure II).

Possibly early peaks detected prior to the solvent peak were formaldehyde, acetaldehyde, and a four carbon aliphatic compound. Peaks eluting after the solvent peak were all aliphatic type compounds including various saturated and unsaturated hydrocarbons plus some oxygenated species. These oxygen-containing compounds probably include such types as

aldehydes, ketones, alcohols, or ethers. An additional procedure performed to obtain some idea of the oxygenated species present involved acidification of the solvent solution with sulfuric acid followed by reanalysis of the solvent layer. This procedure removed oxygenated compounds such as ketones and aldehydes.

The XAD-2 tubes for formaldehyde for each of the high temperature bulks demonstrated identical chromatograms with peaks eluting in the region of the formaldehyde derivative. Only one sample was subsequently used for GC/MS peak identification and confirmation. The only major peak identified was 3-benzyloxazolidine (the formaldehyde derivative). The acetaldehyde and propionaldehyde derivatives, formed by the reaction of the aldehydes with N-benzylethanolamine, were tentatively identified. The remaining peaks could not be identified but had spectra similar to the formaldehyde derivative. Note that the XAD-2 tubes are specific for formaldehyde and the collection efficiency, stability, and desorption efficiency of other aldehydes on these tubes is unknown.

No detectable levels of oxides of nitrogen were identified by detector tube sampling of this effluent.

2. Follow-up Survey

a. Formaldehyde, Acetaldehyde, and Propionaldehyde

Table III presents formaldehyde sampling results obtained in the breathing zone of the 100 inch mill workers. Table IV presents the area or process formaldehyde sampling results. One hundred inch mill worker exposures to formaldehyde for the two day shifts sampled had the following parameters:

Arithmetic mean	: 0.024 mg/M^3 (0.029 ppm)
Standard deviation	: 0.007 mg/M^3 (0.006 ppm)
Range	: 0.011-0.033 mg/M^3 (0.009-0.027 ppm)

Area samples for the Hot Mill Department alone (from Table IV) had the following values:

Arithmetic mean	: 0.013 mg/M^3 (0.011 ppm)
Standard deviation	: 0.004 mg/M^3 (0.003 ppm)
Range	: 0.010-0.018 mg/M^3 (0.008-0.015 ppm)

All areas sampled including the hot mill department had the following parameters:

Arithmetic mean	: 0.010 mg/M^3 (0.008 ppm)
Standard deviation	: 0.004 mg/M^3 (0.003 ppm)
Range	: 0.005-0.016 mg/M^3 (0.004-0.013 ppm)

Note that all formaldehyde results are conservative, since values below detection limits are not included. Tables III and IV give the arithmetic mean and standard deviation for all samples in the footnotes.

All samples obtained for acetaldehyde and propionaldehyde were below the analytical limits of detection.

b. Kerosene, Stoddard Solvent, Toluene

The results of personal exposure monitoring for total hydrocarbons (i.e. kerosene, stoddard solvent, and toluene) are presented in Table V. Twenty-one of the twenty-nine total organic samples were analyzed for kerosene, eight for stoddard solvent, and all twenty-nine for toluene. The kerosene exposures were low with the exception of one exposure of 141 mg/M^3 occurring on a foil mill which exceeded the NIOSH recommended evaluation criteria for kerosene of 100 mg/M^3. Kerosene exposures are summarized below:

Arithmetic mean	: 35.1 mg/M^3
Standard deviation	: 31.5 mg/M^3
Range	: 12.1-141 mg/M^3

Stoddard solvent exposures were very low and presented the following results:

Arithmetic mean	: 22.2 mg/M^3
Standard deviation	: 18.4 mg/M^3
Range	: 12.3-67.1 mg/M^3

Toluene levels were extremely low with twenty-three below the analytical limit of quantitation and four below analytical limits of detection. The remaining two values were below 5 mg/M^3.

c. Oil Mist

All oil mist concentrations were below the OSHA standard of 5 mg/M^3. Sample results were as follows for the 10 samples having concentrations above analytical limits of detection.

Arithmetic mean	:	1.31 mg/M^3
Standard deviation	:	1.23 mg/M^3
Range	:	0.29-4.36 mg/M^3

Table VI presents the oil mist sampling data and results.

d. Asbestos

The results of airborne asbestos sampling conducted in the Plate Department are presented in Table VII. All three samples (two areas and one breathing zone) were below 0.05 fibers per cubic centimeter, less than half the NIOSH recommended exposure limit of 0.1 fibers per cubic centimeter.

Both of the bulk samples (one from a rafter near the overhead crane stairway and one from on top of the horizontal heat treat furnace) contained amosite and chrysotile asbestos. Both optical and electron microscopy showed that the amounts of both species were less than one percent of the total sample volume used in the analysis.

The major fibrous constituent present in both bulk samples was an isotropic material composed of aluminum and silicon. No further identification of the material was undertaken. Although the asbestos fibers were present in dimensions of less than five micrometers long and approximately one to two micrometers (um) wide, these major fibers ranged from less than one to approximately 15 um wide and approximately 2 um to millimeters in length. Another fibrous material suspected to be present was cotton.

The major mineral constituent present in both bulk samples was an anisotropic material composed of aluminum and silicon. The most abundant minor mineral constituent was composed of sulfur and calcium and was positively identified by polarized light microscopy as gypsum.

Other minor constituents identified were particles composed of aluminum and silicon compounded with sodium and/or potassium in varying ratios and silicon particles positively identified as quartz. Present in trace amounts were particles containing aluminum, silicon, and magnesium and magnesium-containing particles. No attempts were made at further identification of these particles.

B. Medical

There were few complaints of skin, eye or throat irritation, or respiratory problems among the eight workers interviewed. Two

persons in the cold roll department stated that noise was the biggest problem in their work area. Two employees in this area complained of dry skin with occasional redness and cracking. Several stated they heard occasional complaints of eye and throat irritation from fellow workers, but that these were uncommon.

Workers in the cold roll department stated that in the recent past, some of the ventilation was not working properly, resulting in eye and skin irritation. The installation of new fans in this areas has improved the situation. In general, when ventilation is working properly, oil mist did not appear to cause irritant symptoms.

Workers, their labor representatives and medical department personnel interviewed by NIOSH identified three workers with known chronic respiratory problems. Their medical records were reviewed and they were interviewed by telephone. These workers worked in the foil department (as operators or assistant operators) for 21-25 years. Two have emphysema, both diagnosed by their local physicians six years ago. One currently smokes two packs of cigarettes per day (ppd); the second worker has been an ex-smoker (2 ppd) for eight years. According to both workers, their personal physicians stated that their work exposures may have contributed to their condition. One was placed on permanent physical capability restriction in 1981 and is to avoid exposure to dust, smoke and oil mist. The plant physician evaluated his current job and feels his work does not constitute a hazard to his health.

The third worker was diagnosed as having intrinsic asthma in 1973. He was placed on permanent physical capability restriction in 1981 with the same restrictions mentioned above.

VII. DISCUSSION

A. Environmental

Contaminant levels of all compounds for which sampling was conducted September 21 and 22, 1982, were (with two exceptions) below the applicable evaluation criteria by a factor of two or more.

Sampling for low molecular weight aldehydes was conducted subsequent to preliminary laboratory analyses demonstrating their presence as potential contaminants generated from the decomposition of rolling oils at operating temperatures. Only a fraction of the substances coming off of the bulk samples were considered possible environmental contaminants. Levels of acetaldehyde and propionaldehyde in the area and personal exposure samples were negligible (below detection limits). The formaldehyde levels in the Fabrication Department and specifically the Hot Mill were all below 0.05 mg/M^3 (0.041 ppm). No formaldehyde use was observed

or reported to be used in the various mill lubricants or supporting mill processes addressed in the HHE.

A discrepancy noted in the formaldehyde exposure data, even though the time-weighted average concentrations are very low, is that some personal (breathing zone) samples (Table III) are higher than those considered area or process samples (set up in, or on equipment). For Hot Mill values, this difference was statistically significant (two sample t test, $p<0.01$). A possible explanation for the higher personal exposure values is that the samples picked up formaldehyde associated with cigarette smoking in the workers' break rooms. Workers wore the personal monitors during the entire sampling period which would have included breaks and lunch hours. Smoking was restricted to these areas. Estimates of the formaldehyde concentrations generated by burning cigarettes in a confined area have been given a range of 1.84-2.57 mg/M^3 (1.5-2.1 ppm).[13] Another report places formaldehyde concentration in a 30 cubic meter chamber subsequent to the smoking of five cigarettes at 0.282 mg/M^3 (0.23 ppm).[14]

Toluene and stoddard solvent exposures were sufficiently below the evaluation criteria to eliminate their consideration in addressing irritant effects. Kerosene exposures were also low except for samples obtained on the 402 foil mill. On the first day of sampling at this mill, the operator's exposure exceeded the NIOSH recommended exposure limit of 100 mg/M^3. On the second day, this worker's exposure fell back below the recommended level. At the time of the medical evaluation, workers in this department did not demonstrate or complain of symptoms associated with kerosene exposure (i.e. dermatitis, mucous membrane irritation). The operators on both foil mills sampled had the higher exposures when compared to the assistant operators. This is most likely due to the fact that the operator's station is on the uptake side of the mill. On this end of the mill, the aluminum has had rolling oils applied to it as it passed through the mill, prior to being coiled on a roll.

Oil mist levels were low with only one sample approaching the exposure limit. This one sample was obtained immediately adjacent to and between two of the mill stands of the 100" mill. This was an area where workers spent very little time during the operations but was expected to present a maximum level for comparison purposes.

Airborne asbestos concentrations were below the recommended exposure limits; however, concern was expressed about the collection of asbestos containing dust on structural and equipment surfaces in the area and the potential for re-entrainment of this material in the air. Efforts were reportedly being taken to replace asbestos containing insulation in the furnace. During normal furnace operations there did not appear to be an

overexposure potential. Additionally the plates coming out of the furnace discharged directly into a water spray quench unit.

Concern over the representative nature of operations during the NIOSH survey was expressed by the union. NIOSH investigators inquired about the level of operations during the follow-up survey and were provided with machine performance data for the days sampling was conducted in addition to selected month and year machine performance values. This information indicated that operating conditions during the survey, with the exception of one machine being brought on line, were representative of normal operating conditions. Other variables were mentioned by workers which could contribute to higher or lower contaminant levels than those found during the survey, although many of the documented values are low enough that overexposures would still be considered unlikely. These other factors included: gauge reduction; mill speed; coolant temperature; age of coolant and ratio of additives; equipment down time; metal being run; and metal temperature.

B. Medical

The hazard evaluation request was submitted before the lay-off of approximately 50% of production workers in January 1982. The remaining workforce had at least 20 years of seniority and did not appear to have the health complaints stated in the request. Although only eight production workers were interviewed during the initial survey, they were asked about general working conditions in their areas and any health complaints among fellow workers. From the information gathered during these interviews, it appeared that few of the remaining workforce had (or were known to have) health complaints related to work.

The three workers interviewed by telephone had chronic respiratory problems which were documented in their plant medical records. Two of these suffer from emphysema and have cigarette smoking histories of 2 ppd (one current smoker and one ex-smoker). Although dusty work environments may contribute to the development or progression of emphysema, cigarette smoking continues to be the factor most commonly associated with the development of this condition.[15] More importantly, the inhalation of oil mist has not been associated with the development of emphysema. Based on this information and the fact that neither the union, company, or medical department were able to identify additional workers with chronic respiratory problems, further medical investigation was not indicated.

VIII. CONCLUSIONS

Industrial hygiene sampling did not discern the presence of a health hazard during the NIOSH survey except for an overexposure to kerosene

on the foil mills, indicating a need for additional evaluation of the ventilation and work practices on those two units (specifically 402 mill). Irritant effects, although few in number, could be associated with a high level of kerosene exposure as well as raising additional concerns about housekeeping and potential safety and fire problems.

IX. RECOMMENDATIONS

NIOSH recommends that formaldehyde be considered a suspect human carcinogen and that levels be maintained at the minimum level possible. Therefore, although no recommendations for additional control of formaldehyde exposures are being made concerning formaldehyde levels present during this study, the local exhaust systems present on the mills should be closely monitored to assure continued effective removal of rolling oil decomposition products including formaldehyde.

Resampling of the workers on the 402 mill should be conducted to further evaluate kerosene exposures. This would be most appropriate following an inspection and possible cleaning or repair of the exhaust system on the mill. Continued high exposure levels would indicate a need for increased air movement into the hoods or modification of the existing exhaust system configuration.

The concern over asbestos containing dust in the Plate Department, while not demonstrating a health hazard during the NIOSH survey, should be addressed by increased housekeeping efforts to reduce the potential for re-entrainment of asbestos containing dusts. This may involve regular hosing down of high activity areas or vacuuming with industrial vacuums[16] suitable for the collection of asbestos waste. Continuation of efforts to replace asbestos containing materials with less hazardous substitutes is encouraged.

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IX. AUTHORSHIP AND ACKNOWLEDGEMENTS

Evaluation Conducted and Report Prepared by:	Steven H. Ahrenholz, M.S., C.I.H. Industrial Hygienist Industrial Hygiene Section
Medical Evaluation:	Jane Lipscomb, R.N., M.S. Epidemiologist Medical Section
Environmental Evaluation:	Richard Hartle, M.S., C.I.H. Industrial Hygienist Kenneth Wallingford, M.S. Industrial Hygienist Industrial Hygiene Section
Laboratory Analyses:	Ardith A. Grote, Chemist Marilyn Hawkins, Chemist Karen J. Schulte, Chemist George Williamson, Chemist Measurement Support Section Measurements Research Support Branch Division of Physical Sciences and Engineering UBTL Salt Lake City, Utah
Originating Office:	Hazard Evaluations and Technical Assistance Branch Division of Surveillance, Hazard Evaluations, and Field Studies
Report Typed By:	Pat Lovell Clerk-Typist Industrial Hygiene Section

X. DISTRIBUTION AND AVAILABILITY OF REPORT

Copies of this report are currently available upon request from NIOSH, Division of Standards Development and Technology Transfer, 4676

Columbia Parkway, Cincinnati, Ohio 45226. After 90 days, the report will be available through the National Technical Information Service (NTIS), 5285 Port Royal, Springfield, Virginia 22161. Information regarding its availability through NTIS can be obtained from NIOSH Publications Office at the Cincinnati address. Copies of this report have been sent to:

1. United Steel Workers of America, Local 5668
2. Kaiser Aluminum and Chemical Corporation, Ravenswood, West Virginia
3. United Steel Workers of America International
4. NIOSH, Region III
5. OSHA, Region III

For the purpose of informing the 683 affected employees, copies of this report shall be posted by the employer in a prominent place accessible to the employees for a period of 30 calendar days.

TABLE I

Bulk Rolling Oil Samples

Kaiser Aluminum & Chemical Corporation
Ravenswood, West Virginia
HETA 82-096

Low Temperature Bulks: Sample #	Identified Components*	Reference Figures
04	mixed petroleum hydrocarbons; petroleum and fatty derived products	I
05	mixed petroleum hydrocarbons; petroleum and fatty derived products	I
06	mixed petroleum hydrocarbons; fatty alcohols and acids	I

High Temperature Bulks: Sample #	Identified Components*	Reference Figures
01	water; water soluble oil; bactericide	II
02	water; petroleum and petroleum byproducts; bactericide	II
03	water; water soluble oil; bactericide	II

* Identified components are listed in order of decreasing quantity. The low temperature bulks were generally considered kerosene based whereas the high temperature bulks are emulsions containing about 95% or more water.

TABLE II

Evaluation Criteria and Health Effects Summary

Kaiser Aluminum and Chemical Corporation
Ravenswood, West Virginia
HETA 82-096

Contaminant	Recommended Exposure Limit mg/M^3 (ppm)[1]	Source[2]	OSHA[3] Standard mg/M^3 (ppm)	HEALTH EFFECTS* Symptoms	Target Organs	Reference
Asbestos	0.1 fiber/cc (>0.5 um length)	NIOSH	2 fibers/cc (>0.5 um length)	Restrictive pulmonary function; shortness of breath, dry cough, finger clubbing	Lungs, digestive tract (human carcinogen)	4
Formaldehyde	See Note**	NIOSH	3.7(3)	Dermatitis; mucous membrane irritation of the respiratory tract and eyes; cough, shortness of breath and pulmonary edema if inhaled in high concentrations	Respiratory system, eyes, skin. Animal carcinogen (nasal)	5
Kerosene (C_9-C_{16})	100	NIOSH	-	Skin irritation, dermatitis, inhalation of high concentrations may cause headache, nausea, confusion, drowsiness, and coma; extensive lung damage if aspirated	Skin; lungs	6 7
Oil Mist	5	ACGIH	5	Pulmonary effects rare, possible irritation; lipoid pneumonia possible following aspiration; dermatitis from direct contact with liquid oil	Skin, lungs	9 10
Stoddard Solvent (C_7-C_{12})	350	NIOSH	2900 (500)	Eyes, nose, throat irritation; dizziness, dermatitis	Skin, eyes, respiratory system, central nervous system	6
Toluene	27 (100)	NIOSH	53 (200)	Fatigue, muscle weakness; incoordination, confusion, euphoria, dizziness, headache; irritation of eyes, respiratory tract, dermatitis	Central nervous system, liver, kidneys, skin	11

1. Exposure limits are given in milligrams per cubic meter (mg/M^3) and parts per million (ppm) where applicable. Volume per volume (ppm) values not given for kerosene or stoddard solvent since each is of variable composition, not having a specific molecular formula or weight. Asbestos limits are given in fibers per cubic centimeter (cc) for fibers greater than (>)0.5 micrometers (um) in length.
2. NIOSH: the National Institute for Occupational Safety and Health (NIOSH). See References 3, 5, 6, and 11.
   ACGIH: American Conference of Governmental Industrial Hygienists - Threshold Limit Values®, 1982. Reference 8.
3. OSHA: the Occupational Safety and Health Administration (OSHA). Reference 12.

* Health Effects present symptoms which may result from acute and/or chronic exposure; the target organs; and the reference.

** The NIOSH recommended exposure limit was originally based on the prevention of the irritant effects of formaldehyde. More recent toxicity data has produced evidence (chronic exposure studies in rats and mice) which implicates formaldehyde as an animal carcinogen. NIOSH therefore recommends that formaldehyde be considered a suspect human carcinogen and that exposures be maintained at the lowest level feasible. See reference 5.

TABLE III

Breathing Zone Formaldehyde Exposure Levels: 100 Inch Mill

Kaiser Aluminum and Chemical Corporation
Ravenswood, West Virginia
HETA 82-096

September 21-22, 1982

Sample Description				Formaldehyde Concentration **	
Date	Job Title	Sample Duration (minutes)	Sample Volume (M^3)*	mg/M^3	PPM
9/21	Operator	453	0.453	0.011	0.009
9/22	Operator	289	0.289	0.021	0.017
9/21	Assistant Operator	445	0.445	<0.004***	<0.003
9/22	Assistant Operator	307	0.307	0.029	0.024
9/21	Coiler Operator	415	0.415	0.022	0.018
9/22	Coiler Operator	294	0.273	0.026	0.021
9/21	Stacker Bander	450	0.450	0.022	0.018
9/22	Stacker Bander	289	0.289	0.017	0.014
9/21	Trucker	420	0.420	0.031	0.025
9/22	Trucker	301	0.301	0.033	0.027
Analytical Limit of Detection (mg per sample):				0.002	
Sample Statistics (sample size =9):					
	Arithmetic mean			0.024	0.029
	Standard deviation			0.007	0.006
	Geometric mean			0.022	0.018
	Median value			0.022	0.18
	Range			0.011-0.033	0.009-0.027
	95% confidence interval			0.021±0.005	0.017±0.004
Evaluation Criteria:			NIOSH[1]	1.22	1
			OSHA[2]	3.67	3

* M^3 = cubic meters

** Concentrations are given both in milligrams per cubic meter (mg/M^3) and parts per million (ppm). Values are a time weighted average (TWA) over the respective sample duration. Analytical limit of detection was 2 micrograms (ug) per sample or 0.002 mg per sample.

*** Value given is the calculated environmental limit of detection for this sample. Formaldehyde exposure for this worker was below the analytical limits of detection. Value excluded from mean calculation. With indicated value included, the arithmetic mean is 0.022 mg/M^3 (0.018 ppm) and the standard deviation is 0.009 mg M^3 (0.007 ppm).

1 The NIOSH recommended exposure limit cited was originally based on the prevention of the irritant effects of formaldehyde. More recent toxicity data has produced evidence (chronic exposure studies in rats and mice) which implicates formaldehyde as an animal carcinogen. NIOSH therefore recommends that formaldehyde be considered a suspect human carcinogen and that exposures be maintained at the lowest level feasible. See reference 5.

2 OSHA General Industry Standards, reference 12.

TABLE IV

Area and Process Formaldehyde Sampling Results

Kaiser Aluminum and Chemical Corporation
Ravenswood, West Virginia
HETA 82-096

September 21-22, 1982

Sample Description*						Formaldehyde Concentration **	
Date	Department	Machine	Location	Sample Duration (minutes)	Sample Volume (M^3)	mg/M^3	PPM
9/21	Hot Mill	168" reversing mill	top catwalk	422	0.271***	0.018	0.015
9/22	Hot Mill	168" reversing mill	top catwalk	292	0.292	0.013	0.011
9/21	Hot Mill	110" reversing mill	top catwalk	410	0.410	0.010	0.008
9/22	Hot Mill	110" reversing mill	top catwalk	293	0.293	0.010	0.008
9/21	Hot Mill	100" mill	operator's desk	429	0.429	<0.005	<0.004
9/22	Hot Mill	100" mill	scrap bin	286	0.286	<0.007	<0.006
9/21	Hot Mill	100" mill	between mill 2 & 3	420	0.420	<0.005	<0.004
9/22	Hot Mill	100" mill	delivery end	323	0.323	<0.006	<0.005
9/21	Hot Mill	100" mill	stacker/bander booth	443	0.443	<0.004	<0.003
9/21	Cold Mill	384 mill	delivery end	391	0.391	0.008	0.006
9/21	Cold Mill	386 mill	feed end	385	0.385	<0.005	<0.004
9/21	Cold Mill	386 mill	delivery end	389	0.389	<0.005	<0.004
9/22	Cold Mill	381 mill	delivery end	421	0.394	0.005	0.004
9/21	Foil	402 mill	delivery end	396	0.396	0.008	0.006
9/22	Foil	402 mill	delivery end	425	0.425	0.009	0.007
9/21	Foil	403 mill	delivery end	388	0.388	0.008	0.006
9/22	Finishing	Hi-speed slitter	feed roll	424	0.424	0.016	0.013
Analytical Limit of Detection (mg per sample):						0.002	
Sample Statistics (sample size = 10)							
					Arithmetic mean	0.010	0.008
					Standard deviation	0.004	0.003
					Geometric Mean	0.010	0.008
					Geometric Standard Deviation	1.46	
					Median value	0.008	0.006
					Range	0.005-0.016	0.004-0.013
					95% Confidence interval	0.010±0.002	0.008±0.002
Evaluation Criteria:					NIOSH [1]	1.22	1
					OSHA [2]	3.67	3

* Sample descriptors: Machines: 100" mill is a 5 stand mill; 384 and 386 mills are single stand mills; 381 is a five stand mill. Sample volume is given in cubic meters (M^3)

** The formaldehyde concentrations are time weighted average for the sampling period. Values are given both in milligrams per cubic meter (mg/M^3) and parts per million (ppm). < indicates values were below the calculated environmental limit of detection. The analytical limit of detection was 2 micrograms per sample.

*** Sample volume is an estimate due to sampling train problems.

**** The arithmetric mean and standard deviation for all samples (n=17: using calculated environmental limits of detection for samples with nondetectable values) is 0.008 mg/M^3 (0.007 ppm) and 0.004 mg/M^3 (0.003 ppm), respectively.

1 The NIOSH recommended exposure limit cited was based on the prevention of the irritant effects of formaldehyde. More recent toxicity data has produced evidence (chronic exposure studies in rats and mice) which implicates formaldehyde as an animal carcinogen. NIOSH therefore recommends that formaldehyde be considered a suspect human carcinogen and that exposures be maintained at the lowest level feasible. See reference 5.

2 OSHA General Industry Standards, reference 12.

TABLE V

Breathing Zone Exposure for Total Hydrocarbons*

Kaiser Aluminum and Chemical Corporation
Ravenswood, West Virginia
HETA 82-096

September 21-22, 1982

Sample Description*						Contaminant Concentration in mg/M^3***		
Date	Department	Location	Job Title	Sample Duration (minutes)	Sample Volume (liters)	Toluene	Stoddard Solvent	Kerosene
9/21	Hot Mill	100" mill	mill operator	456	22.3	(0.583)**	-	12.1
9/22	Hot Mill	100" mill	mill operator	290	12.5	<0.08***	-	36.0
9/22	Hot Mill	100" mill	assistant operator	307	11.4	<0.088	-	16.7
9/21	Hot Mill	100" mill	trucker	424	23.0	(0.652)	-	6.52
9/22	Hot Mill	100" mill	trucker	300	13.6	<0.074	13.97	-
9/21	Cold Mill	384 mill	assistant operator	392	21.4	(0.093)	-	19.2
9/21	Cold Mill	384 mill	assistant operator	395	7.6	4.87	-	21.0
9/21	Cold Mill	386 mill	mill operator	391	18.0	(0.111)	-	17.8
9/21	Cold Mill	386 mill	assistant operator	382	19.2	(0.104)	-	33.8
9/22	Cold Mill	381 mill	mill operator	432	7.6	(0.789)	-	13.2
9/22	Cold Mill	381 mill	assistant operator	427	13.9	(0.432)	-	15.8
9/22	Cold Mill	381 mill	assistant operator	429	22.9	(0.480)	-	16.6
9/22	Cold Mill	382 mill	mill operator	391	15.9	(0.692)	-	16.4
9/22	Cold Mill	385 mill	assistant operator	386	6.0	(0.833)	-	20
9/21	Foil	402 mill	mill operator	392	7.1	(0.563)	-	141
9/22	Foil	402 mill	mill operator	421	22.2	(0.450)	-	76.6
9/21	Foil	402 mill	assistant operator	332	10.8	(0.185)	-	26.8
9/22	Foil	402 mill	assistant operator	421	22.7	(0.308)	-	35.7
9/21	Foil	403 mill	mill operator	390	13.0	(0.231)	-	76.2
9/22	Foil	403 mill	mill operator	422	6.5	(1.69)	-	64.6
9/21	Foil	403 mill	assistant operator	387	13.9	(0.288)	-	39.6
9/22	Foil	403 mill	assistant operator	423	21.9	1.096	-	32.4
9/21	Finishing	CPL****	operator	392	13.0	<0.078	12.3	-
9/21	Finishing	66" slitter	operator	378	14.9	(0.134)	67.1	-
9/21	Finishing	60" slitter	operator	366	16.5	(0.121)	12.7	-
9/22	Finishing	HS slitter[1]	operator	417	26.6	(0.150)	14.3	-
9/22	Finishing	HS slitter	operator	411	19.3	(0.259)	21.1	-
9/22	Finishing	HS slitter	operator	413	12.5	(0.32)	19.2	-
9/22	Finishing	HS slitter	operator	407	21.5	(0.372)	16.7	-

(continued)

TABLE V (continued)

Analytical Limits of Detection (in mg):			0.001	0.04	0.05
Analytical Limits of Quantitation (in mg):			0.017	0.09	0.10
Sample Statistics*****					
	Arithmetic mean			22.2	35.1
	Standard deviation			18.4	31.5
	Geometric mean			19.0	26.6
	Median			15.5	21
	Range			12.3-67.1	12.1-141
	95% confidence interval			22.2±15.4	35.1±14.3
Evaluation Criteria[2]:		OSHA	751	2900	-
		NIOSH	376	350	100

*Total Hydrocarbons is interpreted as either kerosene or stoddard solvent depending on the substance in use at the sampling location and results of the subsequent laboratory analyses. Toluene was identified as being a specific compound present at detectable levels.
Toluene concentrations are estimated since sample concentrations fell between the limit of detection and the limit of quantitation.
***Concentrations are given in milligrams per cubic meter (mg/M^3).
( ): Toluene concentrations given in parentheses are estimated from sample concentations occurring above the anlaytical limit of detection but below the analytical limit of quantitation.
< : Denotes calculated environmental limit of detection for specified sample (i.e. non detected)
****CPL: continuous Process Line
[1] HS slitter: High Speed Slitter
[2] Evaluation Criteria: OSHA: General Industry Standards, reference 12.
NIOSH: Criteria for a recommended standard, references 11 (toluene); 6 (kerosene and stoddard solvent).
*****Sample number = 8 for stoddard solvent; 21 for kerosene. Statistics not calculated for toluene.

TABLE VI

Oil Mist Sampling Results

Kaiser Aluminum and Chemical Corporation
Ravenswood, West Virginia
HETA 82-096

September 21-22, 1982

Sample Description*					Oil Mist Concentration **
Date	Department	Machine	Location	Sample Duration (minutes)	mg/M^3
9/21	Hot Mill	168" reversing mill	top catwalk	422	0.96
9/22	Hot Mill	168" reversing mill	top catwalk	292	2.12
9/21	Hot Mill	110" reversing mill	top catwalk	410	1.35
9/22	Hot Mill	110" reversing mill	top catwalk	293	1.02
9/21	Hot Mill	100" mill	stacker/bander booth	443	<0.09
9/21	Hot Mill	100" mill	operator sample window	429	0.29
9/21	Hot Mill	100" mill	main aisle side	419	4.36
9/22	Hot Mill	100"mill	scrap bin	288	1.20
9/22	Hot Mill	100" mill	SW corner catwalk	323	1.33
9/21	Cold Mill	384 mill	delivery end	391	<0.10
9/21	Cold Mill	386 mill	feed end	385	0.29
9/21	Cold Mill	386 mill	operator station	389	0.15
9/22	Cold Mill	381 mill	operator station	421	<0.10
9/22	Cold Mill	383 mill	delivery end	385	<0.10
9/21	Foil	402 mill	delivery end	396	<0.10
9/22	Foil	402 mill	delivery end	425	<0.09
9/21	Foil	403 mill	delivery end	389	<0.10
9/21	Foil	403 mill	delivery end	389	<0.10
9/22	Finishing	Hi-speed slitter	feed roll	424	<0.09
9/22	Finishing	Hi-speed slitter	uptake roll	424	<0.09

Analytical Limit of Detection (LOD/per filter): 0.08mg

Sample statistics (Sample size 10):***

Arithmetic Mean	1.31
Standard Deviation	1.23
Geometric Mean	0.87
Median Value	1.11
Range	0.29-4.36
95% confidence interval	1.31±2.78

Evaluation Criterion: OSHA**** 5 mg/M^3

* All samples are area or process samples

** mg/M^3: milligrams per cubic meter; <denotes concentration was below calculated environmental limit of detection for the sample.

*** The arithmetic mean and standard deviation for all values (n=20: using calculated environmental limits of detection for nondetectable sample values) are 0.70 mg/M^3 and 1.05 mg/M^3, respectively.

**** OSHA General Industry Standards: see reference 12.

TABLE VII

Plate Department Airborne Asbestos Sampling Results

Kaiser Aluminum and Chemical Corporation
Ravenswood, West Virginia
HETA 82-096

September 22, 1982

Sample Description*			Asbestos Fiber Concentration in Fibers/cc**
Location - Area Samples	Duration (minutes)	Volume (M^3)	
Entry, horizontal heat treat furnace	341	0.682	0.015
Exit end, prior to water quench	332	0.664	0.031
Furnace Operator - Breathing Zone	353	0.706	0.004
Evaluation Criteria:		NIOSH[1]	0.1
		OSHA[2]	2

*Includes two area and one personal exposure samples. Volume is given in cubic meters (M^3)
**Concentration of asbestos fibers longer than 5 micrometers is given in fibers per cubic centimenter (cc)
To convert to fibers/M^3, multiply given value by 1000000.
1 NIOSH recommended occupational exposure limit is for an 8- to 10- hour Time-Weighted Average (TWA) for asbestos fibers greater than 5 micrometers in length. See reference 3.
2 The OSHA 8-hour TWA for concentrations of airborne asbestos fibers longer than 5 micrometers is applied. See reference 12.

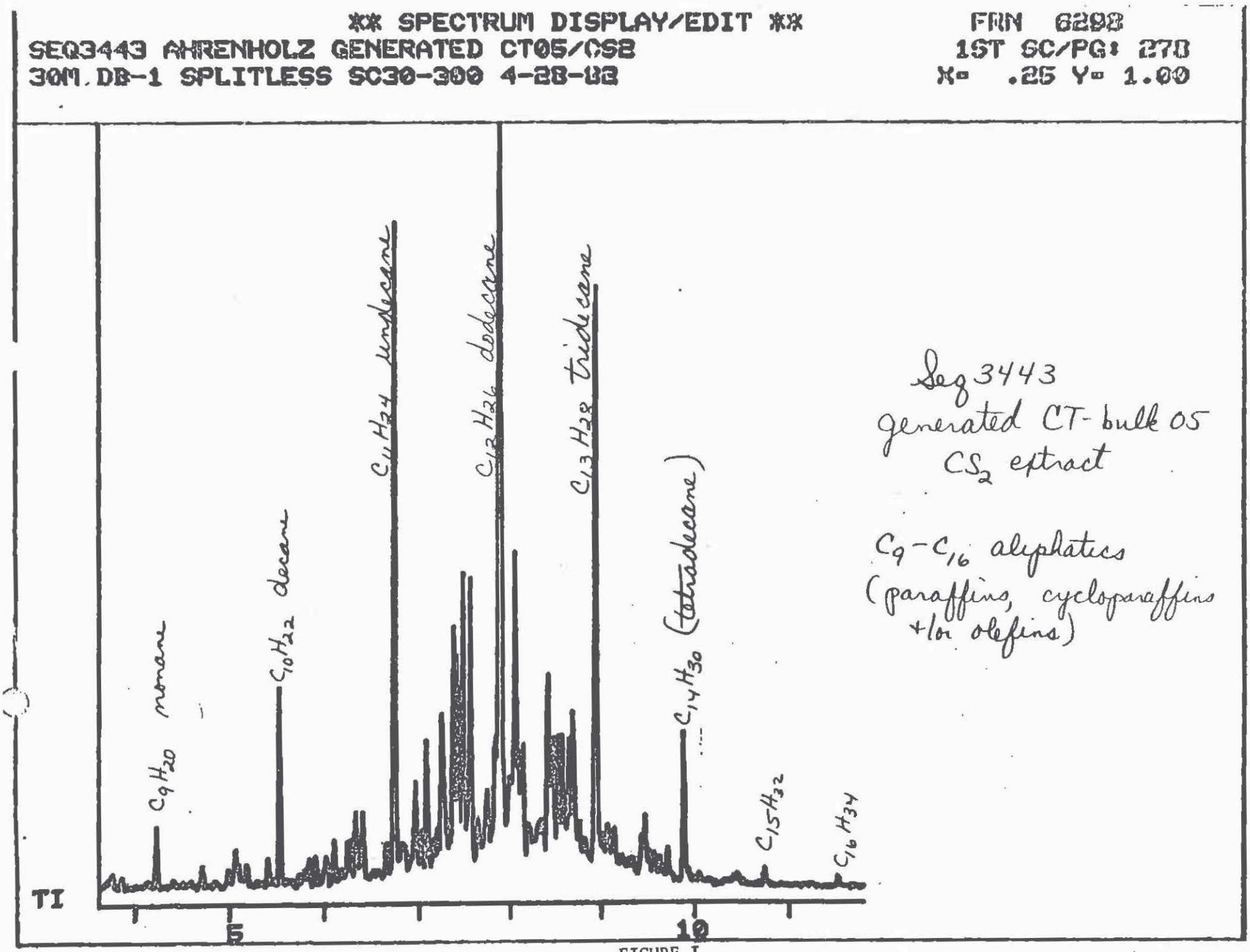
** SPECTRUM DISPLAY/EDIT **
SEQ3443 AHRENHOLZ GENERATED CT05/CS2
30M. DB-1 SPLITLESS SC30-300 4-28-93
FRN 6298
1ST SC/PG: 270
X= .25 Y= 1.00
C9H20 nonane
C10H22 decane
C11H24 undecane
C12H26 dodecane
C13H28 tridecane
C14H30 (tetradecane)
C15H32
C16H34
TI
5
10
Seq 3443
generated CT- bulk 05
CS2 extract
C9 - C16 aliphatics
(paraffins, cycloparaffins
+/or olefins)

FIGURE I

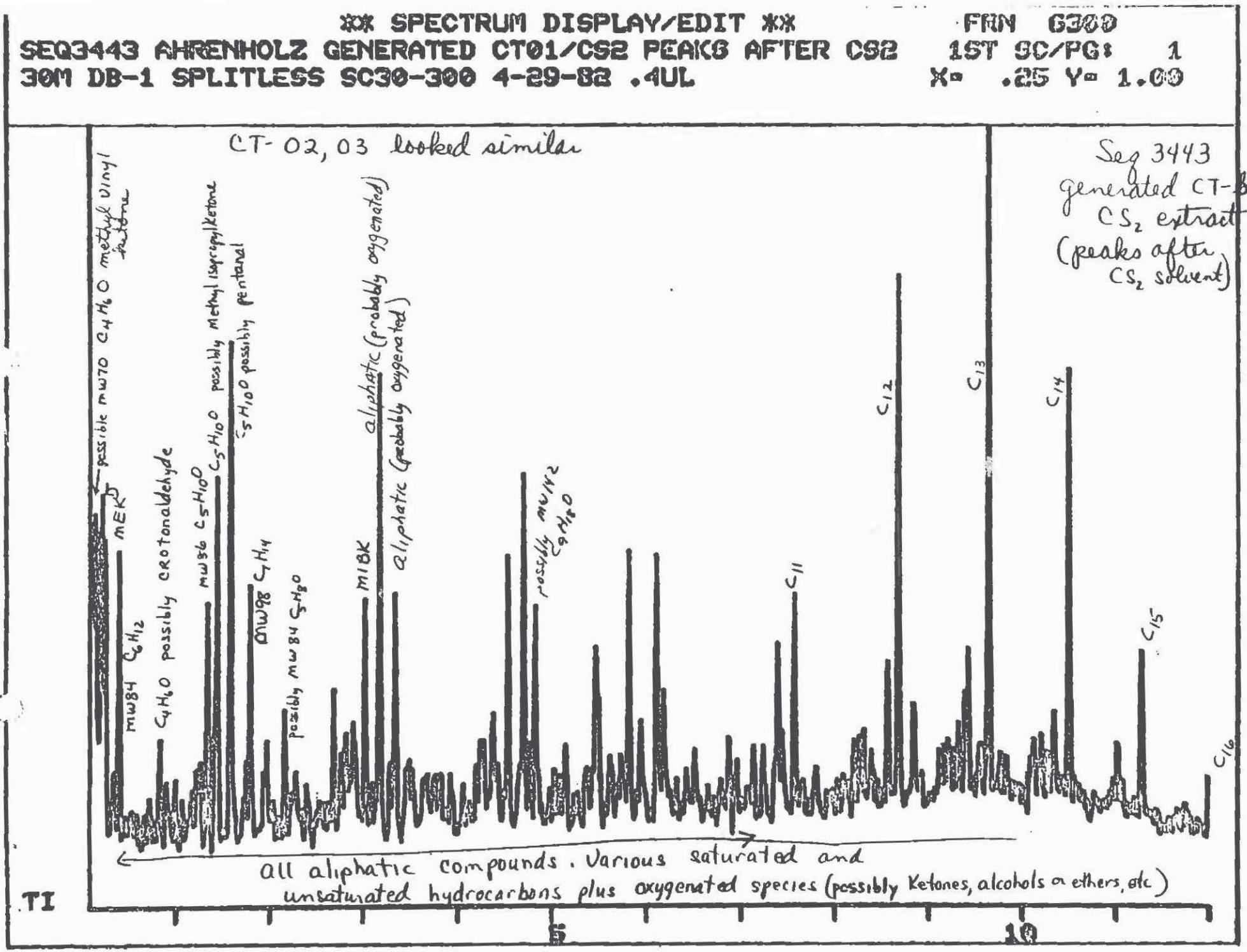
** SPECTRUM DISPLAY/EDIT **
FRN 6300
SEQ3443 AHRENHOLZ GENERATED CT01/CS2 PEAKS AFTER CS2
1ST SC/PG: 1
30M DB-1 SPLITLESS SC30-300 4-29-82 .4UL
X= .25 Y= 1.00
CT-02,03 looked similar
Seq 3443 generated CT-Bulk01 CS2 extract (peaks after CS2 solvent)
possible mw70 C4H6O methyl vinyl ketone
MEK
mw84 C6H12
C4H6O possibly crotonaldehyde
mw86 C5H10O
C5H10O possibly methyl isopropylketone
C5H10O possibly pentanal
mw98 C7H14
possibly mw84 C5H8O
MIBK
aliphatic (probably oxygenated)
aliphatic (probably oxygenated)
possibly mw142 C9H18O
C11
C12
C13
C14
C15
C16
all aliphatic compounds. Various saturated and unsaturated hydrocarbons plus oxygenated species (possibly Ketones, alcohols or ethers, etc)
TI
5
10

FIGURE II

DEPARTMENT OF HEALTH AND HUMAN SERVICES
PUBLIC HEALTH SERVICE
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