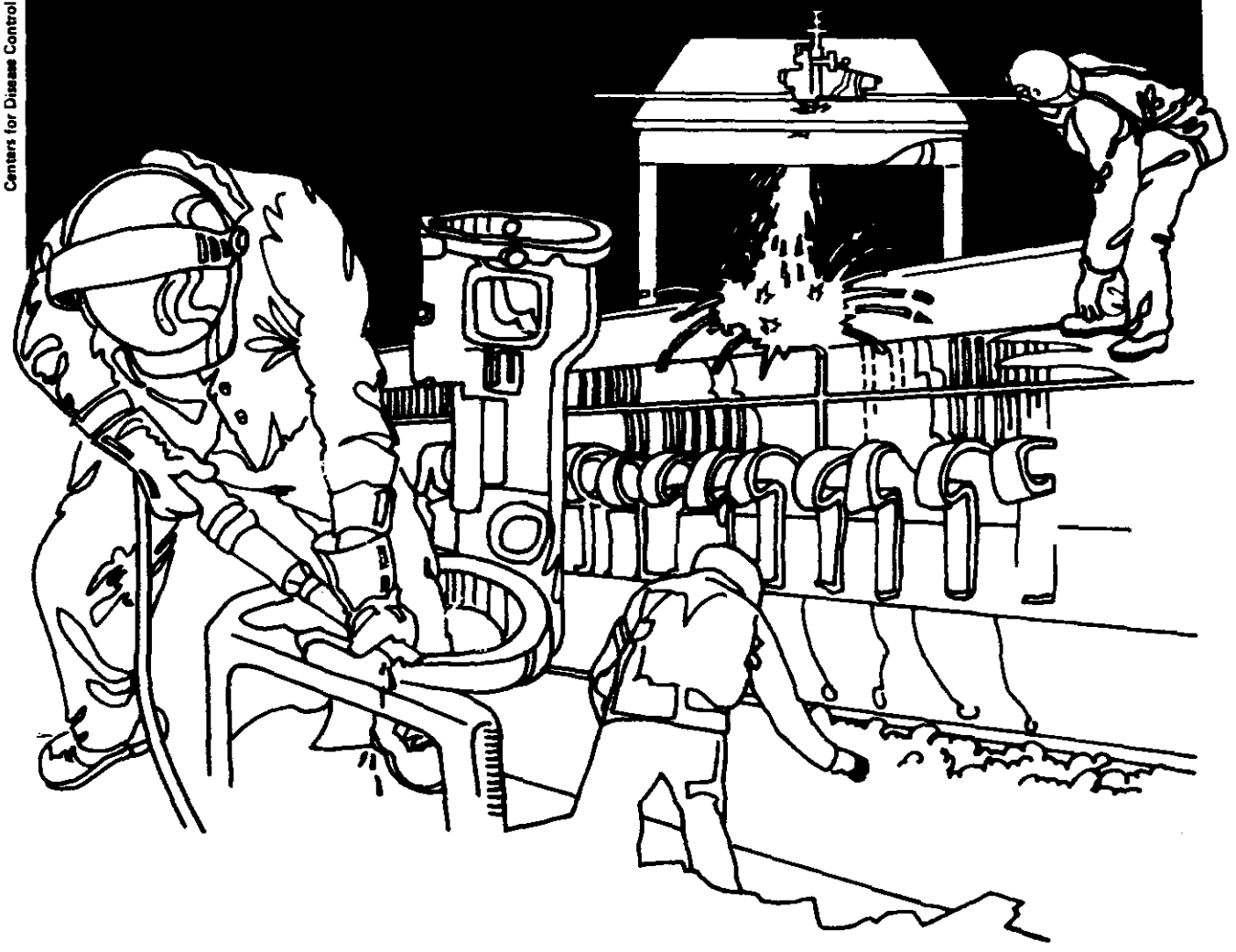
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES ■ Public Health Service
Centers for Disease Control ■ National Institute for Occupational Safety and Health

NIOSH



Health Hazard Evaluation Report

HETA 87-435-1896
WILBANKS INTERNATIONAL INC.
(ADOLPH COORS COMPANY)
HILLSBORO, OREGON

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.

HETA 87-435-1896
MAY 1988
WILBANKS INTERNATIONAL INC.
(ADOLPH COORS COMPANY)
HILLSBORO, OREGON

NIOSH INVESTIGATORS
Michael Thun, M.D., M.S.
Charles McCammon, Ph.D.
Victoria Wells, M.D., Ph.D.

I. SUMMARY

In September 1987, the Adolph Coors Company requested assistance from the National Institute for Occupational Safety and Health (NIOSH) in investigating a cluster of End Stage Renal Disease (ESRD) in workers at its Wilbanks International ceramics plant in Hillsboro, Oregon. Two current and one former worker developed kidney failure after performing similar jobs in the plant which employs approximately 70 production workers. All cases were males, ages 25-33, who began dialysis and/or received a kidney transplant between 1984-86. One of the three was diabetic.

NIOSH investigators visited Wilbanks and collected medical and employment records on the three cases. We sought additional cases of kidney disease at Wilbanks and at the five other U.S. Coors ceramics plants using medical records, insurance claims, and the U.S. ESRD registry. We inspected the industrial process at Willbanks and at a plant in Golden, Colorado, and measured several potentially nephrotoxic substances in raw materials, in workplace air, and in residues from the kilns.

All three workers with kidney failure had been hydrostatic press operators. Medical examinations by nephrologists at the University of Oregon found minor renal dysfunction in two of 12 current Wilbanks employees who had ever worked in or near the press area. Neither were current press operators. No additional cases of renal failure occurred in current or former Wilbanks production workers. No excess of ESRD occurred in workers at the Coors Porcelain Company in Golden, Colorado. No excess of other renal disorders was apparent in medical insurance claims from Wilbanks, Golden, or four other U.S. Coors ceramics plants from 1985-87. Although the three identified cases of ESRD at Wilbanks represent at least a fifteen-fold increase in prevalence over background rates in young males, this cluster appears to be localized to the Wilbanks plant.

One exposure of concern at Wilbanks is "binder burnoff" (partially combusted byproducts of polyethylene glycol) that may vent occasionally into the plant from the periodic kilns. Exhaust from the kilns could contain a variety of volatile, potentially nephrotoxic short chain glycol compounds. Although NIOSH investigators did not document exposure to these substances, the presence of a known nephrotoxin, diethylene glycol, in residue from a kiln in Golden, reinforces concern about "binder burnoff".

A potential health hazard at Wilbanks International may occur from the recirculation of the combustion byproducts of "binder burnoff" from the old periodic kilns into the workplace. Such recirculation is possible because of inadequate venting of the periodic kilns. While it is unclear whether "binder burnoff" actually contributed to the cluster of renal failure at Wilbanks, in the future such exposure should be eliminated. Section VIII of this report provides recommendations concerning medical surveillance and control of exposures.

Keywords: SIC 3297, ceramics, kidney disease, renal toxicity, nephrotoxicity

II. INTRODUCTION

In September 1987, the Adolph Coors Company requested assistance from NIOSH in investigating a cluster of End Stage Renal Disease (ESRD) in workers at its Wilbanks International, ceramics plant in Hillsboro, Oregon. Wilbanks is a wholly owned subsidiary of the Coors Ceramics Company, a Division of the Adolph Coors Company. It manufactures industrial ceramic parts, unrelated to the Coors brewing operations. The cluster of renal failure involved two (of approximately 70) current ceramic production workers and one former worker. All cases were males, ages 25-33, who began dialysis and/or received a kidney transplant between 1984-86. The Coors medical department was unaware of other cases of renal failure in any of four other U.S. Coors Ceramics plants that produce similar products.

III. BACKGROUND

A. DESCRIPTION OF THE COMPANY AND INDUSTRIAL PROCESS

Wilbanks International Inc. is one of seven "structural" (as distinct from "electronic") ceramics facilities owned by the Coors Ceramics company. Four of these "structural" ceramic plants are located in the U.S. and three are overseas. Three other U.S. Coors Ceramics plants produce ceramic parts for electronics.

Wilbanks was purchased from Wilbanks Ceramics in 1973, and the original buildings were used until 1981. Initially, it produced ceramic filters for the wood pulp industry. In 1981, operations moved to a new facility, and production diversified to include a wider variety of ceramic industrial parts.

The basic industrial process has changed little since 1973. Raw material containing a powder of aluminum oxide (Al_2O_3) and Carbowax-8000® (polyethylene glycol binder, average molecular weight 8000) arrives premixed from a central formulating plant in Golden, Colorado. This powder, or "body" is transferred into presses and molded into rigid uncured "forms" or casts of the ceramic parts. The presses operate using either hydraulic pressure from water (hydropresses) or compression without water (dry presses). The former are used to produce large forms, and the latter for smaller ready made parts. The larger "forms" from the hydropresses are machined (sanded, sawed, etc.) before being hardened or "cured" in one of several kilns. Finally, they are ground and polished to a smooth final finish.

Approximately 70 production workers are currently employed at Wilbanks, one worker per shift operating the hydrostatic press in the Forming Department. The press operation was the only job shared by all three workers with renal failure. Press operators transfer the raw "body" into molds, and operate the hydrostatic press. An assistant in the same area performs rough sawing of forms from the press. Other workers, approximately 100 feet away, perform finer milling, machining, and turning operations prior to the forms being cured. Dust exposures are highest during transfer of "body" to the molds, and during certain machining operations. Exhaust ventilation minimizes dust exposure during fine milling operations.

The Kiln Department at Wilbanks operates one large tunnel kiln, three side heated periodic kilns, and one high-temperature kiln. The tunnel kiln is approximately 60 yards from the press operators, and the periodic kilns are 120 yards away in the present plant. Prior to 1981 the kilns were only about 20 yards from the press operators.

B. DESCRIPTION OF THE CASES

The index case (Patient A) first manifest renal disease in September 1984, at age 25. A urinalysis at that time showed 3^+ proteinuria; serum creatinine was 2.3 mg/dl (upper normal 1.4 mg/dl). He continued to work, despite intermittent nausea, vomiting, flank pain, 30 pound weight loss, and swelling over the ensuing eight months. In June 1985, he was hospitalized with renal failure, a serum creatinine of 16.3 mg/dl, 3^+ proteinuria, low serum calcium (6.2 mg/dl), and high serum phosphate (7.7 mg/dl). He was maintained on hemodialysis until August 1987, when he received a cadaveric renal transplant. He has continued to work at the plant. This worker has no medical risk factors for kidney disease and no family members with renal problems. The possibility of occupationally-induced kidney disease was first explored by a physician at the occupational health clinic, University of Oregon Health Science Center. The physician learned that Patient A worked as a machinist at Wilbanks Inc., sawing and sanding uncured ceramic forms in the Forming Department (Figure 2). On visiting Wilbanks, he learned that a second worker, Patient B, had developed renal failure while working in the same area. Patient B's renal failure was attributed to diabetes. Through serendipity, the doctor subsequently encountered a third Wilbanks worker, formerly employed in the same department, who developed ESRD three years after leaving Wilbanks. All three patients had worked as press operators, and as machinists near the press (industrial process described below).

Patient B first developed nephrotic syndrome at age 32 (August 1983), while working as a press operator in the Forming Department (Figure 2). His renal disease was attributed to longstanding insulin dependent diabetes, as were retinopathy and peripheral neuropathy. In January 1985, he retired from Willbanks due to hypertension, deteriorating renal function, and the need for peritoneal dialysis. He received a cadaveric renal transplant in March 1986, but rejected the transplant. Since 1987, he successfully performed home hemodialysis. Diabetes is his only known medical risk factor for renal failure. He worked as a hydrostatic press operator for over seven years. From April to December 1984, he worked closely with patient A, who was to replace him as a press operator.

Patient C became aware of renal disease at age 33, three years after he had left employment at Wilbanks International (Figure 2). He was evaluated in September 1984, following six weeks of increasing headaches, dizziness, and nausea. Findings included 2^+ proteinuria and hypertension (212/140). Kidney biopsy yielded only a small specimen of renal tissue. Examination under light microscopy was interpreted as focal glomerulosclerosis with interstitial infiltrates, tubular vacuolization, and tubular atrophy.

Electron microscopic examination was possible for only two glomeruli, and insufficient tissue was available for immunofluroescence. The pathologist who initially examined the slides commented that the interstitial findings suggested a toxic effect, being more intense than would be expected from glomerular disease alone. A renal pathologist at the University of Oregon who subsequently reviewed the slides felt that the small amount of tissue limited interpretability. The patient began hemodialysis in February 1986, following an episode of hypocalcemia with tetany, and received a living related donor kidney transplant in August 1986. He has had borderline untreated hypertension for approximately 20 years. He has worked only in the old Wilbanks Plant (see below). Since 1981 he has owned and operated an auto repair shop.

C. EXPOSURES OF CONCERN

The NIOSH investigation focussed upon three general categories of exposure. These included: (1) glycols (potentially produced by thermal decomposition of polyethylene glycol), (2) metals, and (3) solvents. These exposures were chosen because of their presence at

Wilbanks and because all can cause renal toxicity. The toxicity of ethylene glycol, diethylene glycol, dioxane, and related glycol compounds is discussed in Section V.[1-15] Glycols have not previously been considered a potential hazard in the ceramics industry. Several heavy metals in the raw material at Wilbanks are nephrotoxic. These include arsenic, bismuth, cadmium, chromium, lead, manganese and mercury.[16] The concentration of these metals in the raw material ranges from 0.02-5 ppm by weight, suggesting that even if all of the metals were vaporized in the kilns, the resultant air concentration of individual metals would be low. From January to June 1984, Wilbanks workers processed a special ceramic material containing nickel. No measurements of nickel in air were made. Serum nickel was measured in nine exposed workers three months after exposure ceased. Only one worker (Patient B) had a detectable nickel concentration (1.1 ug/dl, normal < 3 ug/dl).

Various solvents used at Wilbanks include kerosene, lubricants, epoxy glues, and cleaning fluids. Of these, only kerosene, lubricants, and mold release agents (1,1,1-trichloroethylene) are used in the press area. Other solvents are used extensively in areas of the plant where the employees with ESRD have never worked.

IV. STUDY DESIGN AND METHODS

A. EPIDEMIOLOGIC INVESTIGATION

NIOSH investigators visited Wilbanks and collected medical and employment records on the three cases. We identified all jobs and departments in which the workers with ESRD had worked prior to the recognition of their disease. We reviewed the results of kidney function tests obtained for twelve other employees who had worked in or near the press area. To identify other workers with kidney diseases at Wilbanks and at other Coors Ceramics Plants, we counted all medical insurance claims for kidney disorders filed with the Coors medical insurance program between 1985-87. The insurance records were computerized only for these years. We reviewed the international classification of disease (ICD 9) codes 580-593.9, 599.7, 599.9, and 403-404. Insurance claims were reviewed for Wilbanks, for three other structural ceramics plants, and for two electronic ceramics plants. Coors brewery workers served as the comparison population for selected ICD codes.

We also compiled lists of current and former employees at Wilbanks (since 1973) and at the sister plant in Golden, Colorado (since 1982) and matched these lists with the U.S. ESRD Registry from 1973-86. This registry lists all persons funded by the Health Care

and Financing Administration (HCFA) for maintenance dialysis. Ninety-three percent of ESRD patients are reimbursed by this system.[16-18] The prevalence of ESRD among white males, age 20-39, at Wilbanks was compared to that of Washington County, Oregon, and the U.S. In these calculations we assumed that all 300 former Wilbanks workers and 70 current production workers were hourly white males, age 20-39, at risk over 14 years. These assumptions underestimate the increased incidence of ESRD at Wilbanks but allow some comparison with the general population.

B. MEDICAL INVESTIGATION BY THE COMPANY

Renal function had already been evaluated in twelve workers, identified by Wilbanks as having worked at or near the hydrostatic press. The testing was arranged by the company and was conducted by nephrologists at the University of Oregon Health Sciences Center. One of the workers tested was currently a press operator, five were machinists in the Forming Department, three were kiln operators, and three had not worked in either the Kiln or Forming Departments for at least three years. Tests measured creatinine clearance (a measure of overall kidney function) and the 24-hour excretion of total protein, ß-2-microglobulin, urinary oxalate, and the enzymes N-acetyl glucosaminidase (NAG) and gammaglutamyl transpeptidase (GGT). Excretion of total protein increases with glomerular injury, ß-2-microglobulin and urinary enzymes with renal tubular injury, and urinary oxalate increases following exposure to ethylene glycol. We obtained the results of these tests.

C. EXPOSURE ASSESSMENT

The Oregon Department of Accident Prevention (an OSHA-approved state occupational safety and health plan) had visited Wilbanks in 1986, after learning of the three cases of ESRD. Air monitoring focussed on ethylene glycol monomer near the isoform press and the kilns. Personal breathing zone air samples were collected on charcoal tubes and analyzed by gas chromatograph/mass spectrometry.

NIOSH investigators visited both the Wilbanks and the Golden plant in 1987. Sampling at Wilbanks included bulk and area samples to determine the concentration of potentially nephrotoxic substances in the raw materials and in dust and fumes generated at various stages of the process. Specifically, air samples were collected on silica gel for ethylene glycol and analyzed by NIOSH Method #5500[19] using a gas chromatograph (GC) equipped with a flame ionization detector (FID); trace metals were collected on

cellulose ester membrane filters and analyzed according to Method #7300[19] using atomic emission spectroscopy; solvents were collected on charcoal tubes and analyzed by CG-FID and GC-mass spectrometry (MS); and total dust levels were gravimetrically measured using pre-weighted filters. Bulk samples of ceramic body, body components, and a kiln residue were analyzed for trace metals and by GC-FID/GC-MS for glycol derivatives.

V. EVALUATION CRITERIA

A. REVIEW OF THE HEALTH EFFECTS LITERATURE

Glycols are alcohols containing two hydroxyl groups. The glycols known to be nephrotoxic include ethylene glycol, diethylene glycol, its metabolic precursor dioxane, and their metabolites (Figure 1). Ethylene glycol (antifreeze) is the most widely available of these compounds. An estimated 40-60 deaths per year occur in persons who drink ethylene glycol accidentally, as a substitute for ethanol, or as a suicidal agent.[1-7] The major toxic effects are metabolic acidosis and acute tubular necrosis (ATN). Renal failure may or may not be reversible. Diethylene glycol is a chemically related compound (Figure 1) with similar renal toxicity. It was responsible for over 100 fatalities from acute renal failure when it was ingested in sulfanilamide elixer in the 1930's.[8] The metabolites of both ethylene and diethylene glycol are believed to be more potent in inducing ATN than the parent compounds.[9-10]

Dioxane is an industrial solvent chemically and metabolically related to diethylene glycol (Figure 1). Because of its volatility, dioxane poses a greater industrial hazard than do ethylene or diethylene glycol. In 1953, five male workers in a synthetic textile factory died of acute renal failure following skin and inhalation exposure.[11-13] Although the renal pathology is poorly described, five of approximately 16 workers died of uremia within fifteen days following a change in the industrial process. The time course is consistent with acute tubular necrosis. Renal toxicity due to dioxane is believed rare at present, partly because exposures are controlled to relatively lower levels because of the potential carcinogenicity of dioxane.[13]

The principal glycol used at Wilbanks is Carbowax 8000®, a high molecular weight polymer of ethylene glycol. Intact polyethylene glycol has very low volatility and minimal potential for either skin or respiratory absorption. These polymers have been said by some to "present practically no hazards to health in industrial

handling and use."[14] It is unclear, however, whether heating or machining Carbowax® decomposes the polymer into more toxic short chain compounds. The manufacturer of Carbowax® has conducted small scale laboratory experiments to characterize its decomposition products. Such thermal degradation products vary greatly, depending upon temperature, pressure, and the availability of oxygen. It remains possible, although unproven, that under certain conditions either parent glycol compounds or their more toxic metabolites might be generated. The industrial literature does warn against exposure to heated ethylene glycol.[14] However, this warning relates to the increased vaporization and exposure potential due to heating, and refers to reported eye and skin irritation rather than renal problems.[15]

Several heavy metals found in the raw material at Wilbanks are also nephrotoxic. In particular, cadmium, chromium, bismuth, mercury and lead are all toxic to various parts of the renal tubule.[20] The effect of these metals depends upon the duration and intensity of exposure as well as the chemical form of the metal. In general, much higher concentrations of these metals than would be expected at Wilbanks are needed to induce nephropathy. Even exposure to multiple metals simultaneously has not been associated with such severe renal disease as that observed at Wilbanks. Heavy metal nephropathy due to cadmium or chromium is usually accompanied by disorders of proximal tubular function, particularly by ß-2-microglobulinuria.

A variety of solvents have been suspected of causing chronic glomerulonephritis.[21] The literature for this is far from conclusive. Originally, case reports of Goodpasture's syndrome were associated with occupational "solvent" exposure.[22] More recently a variety of chronic glomerulonephridites have been associated with mixed hydrocarbon exposure in case-control studies. The results of these studies have been conflicting, in part because exposure to solvents is common and difficult to characterize.

B. ENVIRONMENTAL STANDARDS AND RECOMMENDED LEVELS

The bulk analysis and environmental sampling conducted during the course of this investigation were undertaken for qualitative purposes only. However, since some air concentrations are given in the report, the relevant standards and recommended air levels for these contaminants are listed below. The concentrations measured by NIOSH are from area sampling, whereas the OSHA and ACGIH limits pertain to personal breathing zone exposures. The standards for

some metals (e.g., barium, chromium, etc.) vary depending on the form or solubility. For this evaluation, the metals were assumed to be insoluble and in the metal form.

Contaminant	OSHA PEL+ (mg/m^3)	ACGIH TLV++ (mg/m^3)
ethylene glycol	NA	125
nuisance dust	15	10
aluminum	15*	10*
barium	15*	10*
calcium	15*	10*
iron	15*	10*
magnesium	15*	10*
zirconium	5	5
zinc	15*	10*

+ Occupational Safety and Health Administration Permissible Exposure Limits
++ American Conference of Governmental Industrial Hygienist Threshold Limit Value
* Contaminants are considered nuisance dusts

VI. RESULTS

A. EPIDEMIOLOGIC INVESTIGATION BY NIOSH

Medical and employment records confirmed that the three cases had all worked as hydrostatic press operators prior to becoming ill (Figure 2). A fourth case of ESRD was identified from company health insurance records. However, the fourth person (whose kidney disease was hereditary) worked exclusively in an office in another state, had never visited the Hillsboro plant, and was not from Oregon. A fifth Wilbanks worker was said to have nephrotic syndrome on a medical insurance claim. We contacted the physician and learned that the diagnosis pertained to a disorder of the urinary bladder rather than the kidney. No other cases of ESRD were identified among current or former workers at Wilbanks using either medical insurance records or the ESRD registry. The prevalence of recognized ESRD in white males, age 20-39, at Wilbanks was estimated at 81.1 per ten thousand persons, compared with 4.7, 5.4, and 5.5 per ten thousand Washington County, Oregon State, and the U.S. (Table 1). The actual prevalence at Wilbanks is somewhat higher than our estimate, since not all former workers were male production workers, age 20-39. The clustering at Wilbanks represents at least a fifteen-fold increase over background prevalence.

A similar investigation at the Coors Golden plant identified one former worker with ESRD. Although this worker had served for one year in a production area of the plant, his renal dysfunction began in childhood.

Selected data from the medical insurance claims are presented in Table 2. Data on claims coded as ICD9-5997 (hematuria, benign) are included because this category, although clinically non-specific, might reflect unrecognized glomerular disease. There were 22 claims filed from workers at six ceramics plants. The three year prevalence of claims for ICD9-5997 in Coors Ceramics workers was 0.0125 (22 cases/1760 current workers). This was slightly higher than the prevalence of 0.00829 among Coors Brewery workers. The medical significance of this difference is unclear.

B. MEDICAL INVESTIGATION BY THE COMPANY

Of the twelve workers at Wilbanks who underwent medical testing, nine were completely normal. One manifest borderline hypertension (154/90) with no evidence of renal disease. Two had some evidence of mild kidney dysfunction. One worker with abnormal renal function (a machinist in the Forming Department) had transiently increased urinary excretion of total protein, ß-2-ug, NAG and GGT, and transiently abnormal liver function. All parameters returned to normal on repeat examination 4 months later. It is unclear whether these reversible abnormalities relate to occupation or some other unidentified factor. The last worker (a kiln operator) manifest mild proteinuria on three separate examinations. The nephrologist recommended tests to exclude postural proteinuria, and periodic testing of renal function in both workers with renal abnormalities.

C. EXPOSURE ASSESSMENT

The Oregon State OSHA detected no measurable levels of ethylene glycol monomer in 20 one-hour personal samples obtained on workers in the Forming Department. The detection limit was not stated.

In the NIOSH survey, no ethylene glycol was detected in any of the four silica gel samples collected throughout the forming department at Wilbanks and at the entrance to the tunnel kiln, at a detection limit of 0.03 milligrams (mg) per sample. The total dust levels ranged from 1.2 mg/m^3 near the horizontal sander to 1.5 mg/m^3 near the top sander. Trace metal analysis of the bulk samples were consistent with the ceramic body ingredient list provided by the company. The only measureable amounts of metals, in percent by

weight, were aluminum (2%), barium (0.02%), calcium (0.08%), iron (0.02%), magnesium (0.07%), and sodium (0.14%). Other heavy metals, such as arsenic, cadmium, chromium, and lead, were non-detectable at the detection limit of 0.01% by weight (100 ppm). Mercury and bismuth were not measured. The air samples analyzed for trace metals contained small quantities of the metals detected above, plus small amounts of zirconium and zinc. The metal concentrations were generally in the range of 3-12 ug/m^3 except for aluminum, which ranged from 3-60 ug/m^3. All airborne levels of metals, dusts, or solvents were well below any OSHA, NIOSH, or ACGIH exposure criteria.

The qualitative analysis by GC/MS of charcoal tube samples collected near the isopress area showed the presence of trace levels of 1,1,1-trichloroethane, toluene, and several C_{10}-C_{11} branched cyclic alkanes. Solvent extraction of the bulk samples of raw material ("body") did not reveal the presence of any glycol derivatives. The Polyox 80M bulk provided by the Golden plant contained a small amount of butylated hydroxtoluene. None of these materials were found in any toxicologically significant levels.

A waxy residue collected from the entrance to one of the tunnel kilns in Golden was analyzed to determine if any of the glycol derivatives occurred during the binder burnoff phase. The GC/MS chromatogram, shown in Figure 3, demonstrated that several glycol compounds were indeed being formed. They included diethylene glycol, triethylene glycol, and higher polyethylene glycol oligomers.

Discussions with engineers who had worked at both the Wilbanks and Golden plants suggested several reasons why exposure to "binder burnoff" might be greater and of different composition at Wilbanks. These are (1) the kilns at Wilbanks are nearer to the production workers than are the kilns at Golden (this is particularly true of the old Wilbanks plant); (2) Wilbanks uses a longer "burnout cycle" (period at temperatures between 200-400 degrees Centigrade). Since these are the temperatures at which binder burnoff occurs, differences in the rate of heating may alter the composition of the burnoff; (3) The combustion air intakes in the periodic kilns at Wilbanks are adjusted manually instead of automatically. This could affect the composition of binder burnoff if an oxygen deficiency condition results; (4) the older periodic kilns at Wilbanks use a draft instead of a forced air exhaust which, under certain weather conditions, may reflux smoke into the plant. Although several periodic kilns at Golden use a similar draft exhaust, these kilns are in a separate building that adjoins but is divided by a wall from the main production areas. It is

unknown whether these differences between Wilbanks and Golden are actually important in explaining why renal disease was observed at Wilbanks but not at Golden. They are mentioned as differences that might potentially have played a role.

Finally, we identified one potential hazard unrelated to renal toxicity. Workers producing urethane molds ("boots") use a two part system containing 25% methylenebis (2-chloroaniline) (MBOCA). This process is conducted in an uncontrolled area where exposure via skin absorption, and possibly inhalation, may occur. While unrelated to renal injury, MBOCA is increasingly suspected of causing bladder cancer in humans.[23]

VII. DISCUSSION

In summary, a cluster of ESRD has been found involving three young white male ceramic workers at a single plant. All three cases are, or were, employed in a relatively small part of the industrial process. Two of the cases have no apparent non-occupational cause for renal disease (e.g. diabetes or hypertension). The central, and unanswered, question is whether the observed cluster of renal disease is due to chance or whether some occupational exposure specific to Wilbanks has caused, or contributed to, the problem.

That all three cases have worked as hydrostatic press operators suggests that the problem may exist there. However, this investigation could not identify any particularly nephrotoxic exposures near the press. The single exception to this is the nickel oxide, processed from January to June 1984. However one of the affected workers (patient C) was not working in 1984, and a second (patient B) developed proteinuria during the preceeding year. If exposure to ordinary ceramic 'body', or unfired ceramic dust were causing the problem, we might expect some similar cases of nephropathy at the Golden, Colorado plant. The Golden plant is much larger, older and more dusty than Wilbanks.

An alternative possibility is that fumes from polyethylene glycol burnoff might recirculate from the kilns into the workplace and cause renal injury. We have identified a number of engineering reasons why exposure to "binder burnoff" might be greater at Wilbanks than at Golden. Despite these differences, it remains unclear which, if any, of these may account for the excess of ESRD at one plant and not the other.

The presence of diethylene glycol in scrapings from a tunnel kiln at the Golden plant confirms that nephrotoxic substances are produced during the firing process. Such residues were not present inside the periodic kilns at Wilbanks, because periodic kilns heat the entire interior to temperatures that vaporize burnoff. Although exhaust materials from the periodic kilns clearly do contain nephrotoxic substances under certain conditions, it is unclear how much of this material is actually vented into workplace air. It is also unclear why, if nephropathy is due to kiln fumes, the cases occurred predominantly in hydrostatic press operators rather than in kiln workers.

A final source of uncertainty involves exactly what type(s) of renal disease affected the three Wilbanks workers with ESRD. Only one of the three underwent renal biopsy. Although the biopsy in that worker shows some evidence of toxic interstitial nephritis, there was inadequate tissue for a firm diagnosis. The nature of the underlying kidney disease in these three patients is an extremely important issue. Glycols characteristically cause acute tubular necrosis, whereas the clinical picture of all three cases suggests glomerulopathy.

In conclusion, the evidence linking the renal disease to occupation in these three workers is limited. Because of the potential toxicity of the "burnoff" material and, because these cases might be work-related, it seems prudent to eliminate future exposure to binder burnoff. We also recommend periodic medical screening to detect other cases of renal dysfunction at Wilbanks.

VIII. RECOMMENDATIONS

Based on the above findings, we recommend the following;

1. Although no definite proof exists as to the cause of this problem, legitimate concern centers around a venting problem on the periodic kilns, and dust exposure from machining operations in the Forming Department. Engineering steps to control these two sources of intermittent exposure should be an important goal.

2. The company should screen Wilbanks production workers periodically (at least annually) for signs of renal disease. Screening should include at least dipstick and microscopic examination of the urine, a blood test for serum creatinine and blood urea nitrogen (BUN), and measurement of blood pressure. Testing should be offered to all production workers (not just those in the area of the press).

3. Workers with signs of renal dysfunction should be followed particularly closely. For example, the two workers with some evidence of renal dysfunction should be reexamined with 24-hour urine protein determination in 6-12 months.

4. Coors Ceramics should maintain vigilant medical surveillance for other cases of ESRD, either at Wilbanks or at other Coors facilities. Prompt recognition, reporting, and investigation of such cases may help to identify the cause of the problem.

5. As a precautionary measure, the company should consider transferring workers with documented or suspected kidney problems to jobs not involving the machining or kiln heating of polyethylene glycol.

6. If possible, a chemical other than MBOCA should be used in curing urethane. If MBOCA use is to continue, it should be handled in a well ventilated area (e.g. a laboratory hood) with proper protective equipment (e.g. butyl rubber gloves, aprons and safety glasses with sideshields). While unrelated to renal toxicity, MBOCA is increasingly suspected of causing bladder cancer in humans.[23]

IX. REFERENCES

1. Dreisbach RH. Handbook of poisoning: prevention, diagnosis and treatment. 11th ed. Los Altos, California: Lange Medical Publications, 1983:192-4.

2. Friedman EA, Greenberg JB, Merrill JP, Dammin GJ. Consequences of ethylene glycol poisoning: report of four cases and review of the literature. Am J Med 1962;32:891-902.

3. Morbidity and Mortality Weekly Report. Ethylene glycol intoxication due to contamination of water systems. 1987;36:611-614.

4. Goldsher M, Better OS. Antifreeze poisoning during the October 1973 war in the Middle East: case reports. Milit Med 1979;144:314-315.

5. Factor SA, Lava NS. Ethylene glycol intoxication: a new stage in the clinical syndrome. NY State J Med 1987;87:179-80.

6. Walton EW. An epidemic of antifreeze poisoning. Med Sci Law 1978;18:231-7.

7. Turk J, Morrell L, Avioli LV. Ethylene glycol intoxication. Arch Int Med 1986; 146:1601-1603.

8. Geiling EM, Cannon PR. Pathologic effects of elixir of sulfanilamide (diethylene glycol) poisoning. JAMA 1938;111:919-926.

9. Gabow PA, Clay K, Sullivan JB, Lepoff R. Organic acids in ethylene glycol intoxication. Ann Int Med. 1986;105:16-20.

10. Clay KL, Murphey RC. On the metabolic acidosis of ethylene glycol poisoning. Toxicol Appl Pharmacol. 1977;39:39-49.

11. Barber H. Heemorrhagic nephritis and necrosis of the liver from dioxan poisoning. Guys Hospital Reports. 1934;84:267-280.

12. Henry SA. Annual Report of Chief Inspector of Factories. HM Stationery Office. London. 1934.

13. Rowe VK. Derivatives of glycols. in Patty FA. Ed. Industrial Hygiene and Toxicology. John Wiley, New York, Volume 11c p. 3809-4052, 1982.

14. Rowe VK, Wolf MA. Glycols. in Patty FA. Ed. Industrial Hygiene and Toxicology. John Wiley, New York, Volume 11c p. 3817-3808, 1982.

15. Troisi FM. Chronic intoxication by ethylene glycol vapor. Brit J Industr Med. 1950;7:65-69.

16. Rostand SG, Kirk KA, Rutsky EA, Pate BA. Racial differences in the incidence of treatment for end-stage renal disease. NEJM 1982;306:1276-1279.

17. Mausner JS, Clark JK, Coles BJ, Menduke H. An areawide survey of treated end-stage renal disease. AJPH 1978; 68:166-169.

18. Ferguson R, Grim CE, Opgenorth TJ. The epidemiology of end-stage renal disease: the six year south-central Los Angeles experience, 1980-85. AJPH 1987;77:864-865.

19. NIOSH Manual of Analytical Methods, Third Edition, February 1984, National Institute for Occupational Safety and Health, Cincinnati, Ohio.

20. Hook JB. Toxic responses of the kidney. In Casarett and Doull's Toxicology. Casarett CD, Klaassen CD, Amdur MO Eds. McMillan, New York, 1980, 232-245.

21. Churchill DN, Fine A, Gault MH. Association between hydrocarbon exposure and glomerulonephritis. an appraisal of the evidence. (Editorial) Nephron 1983;33:169-172.

22. Beirne GJ, Brennan JT. Glomerulonephritis associated with hydrocarbon solvents. Arch Env Health. 1972;25:365-369.

23. Ward E, Smith AB, Halperin W. 4,4'-Methylenebis (2-Chloroaniline): an unregulated carcinogen. Am J Ind Med. 1987;12:537-549.

X. AUTHORSHIP AND ACKNOWLEDGEMENTS

Evaluation Conducted and Report Prepared by:	Michael J. Thun, M.D., M.S. Chief, Epidemiology II Section Industrywide Studies Branch Charles McCammon, Ph.D. Chief, Industrial Hygiene Section Industrywide Studies Branch Victoria Wells, M.D., Ph.D. Medical Epidemiologist Epidemiology II Section Industrywide studies Branch
Originating Office:	Hazard Evaluations and Technical Assistance Branch Division of Surveillance, Hazard Evaluations and Field Studies

The authors wish to acknowledge Dr. William Morton, who initially identified the common work experience ot the three workers with ESRD. We also thank Dr. Myron Harrison, Dr. William Bennett, and Dan Christianson for their help in conducting the investigation.

XI. DISTRIBUTION AND AVAILABILITY OF REPORT

Copies of this report are currently available, upon request, from NIOSH, Division of Technical Services, Publications Dissemination, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days, the report will be available through the National Technical Information Service (NTIS), Springfield, Virginia 22161.

Copies of this report have been sent to:

1. The Adolph Coors Company
2. Wilbanks International
3. Oregon State Health Department
4. Oregon Department of Accident Prevention

For the purpose of informing the "affected employees", the employer shall promptly post the report for a period of 30 calendar days in a prominent place near where the exposed employees work.

TABLE 1

PREVALENCE* OF END STAGE RENAL DISEASE IN WHITE MALES, AGE 20-39
AT WILBANKS COMPARED TO LOCAL, STATE AND U.S., 1973-86

	WILBANKS	WASHINGTON COUNTY	OREGON	UNITED STATES
# CASES	3	20	225	17,146
# PERSONS	370	42,175	416,601	30,944,000
PREVALENCE*	81.1	4.7	5.4	5.5

* PREVALENCE (PER 10,000 PERSONS) OF CURRENT OR FORMER WORKERS BEING LISTED IN ESRD REGISTRY (ASSUMES ALL PERSONS ARE AT RISK FOR ENTIRE PERIOD)

TABLE 2

PREVALENCE* OF SELECTED RENAL DISORDERS IDENTIFIED BY MEDICAL INSURANCE CLAIMS WILBANKS AND AT OTHER COORS PLANTS. (1985-87)

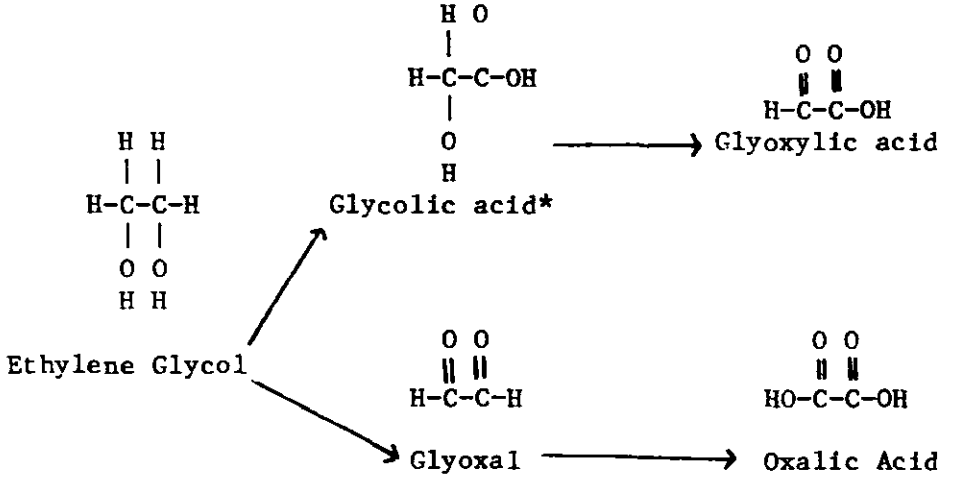
PLANT	CHRONIC RENAL FAILURE (ICD-9-585) (CASES/MALE WORKERS = PREVALENCE*)	HEMATURIA (BENIGN) (ICD-9-5997) (CASES/MALE WORKERS = PREVALENCE*)
STRUCTURAL CERAMICS		
WILBANKS, OR	3/139 = .0216	0/139 = 0
COORS PORCELAIN, CO	1/693 = .0014	11/1161 = .0095
ALUMINA CERAMICS, AS	0/118 = 0	2/118 = .0169
RI CERAMICS, OK	0/ 50 = 0	0/54 = 0
ELECTRONIC CERAMICS		
GRAND JUNCTION, CO	0/262 = 0	8/262 = .0305
CERAM, CA	0/26 = 0	1/26 = .0385
COORS BREWERY		58/7000=.00829

* PREVALENCE= PROBABILITY OF CURRENT WORKERS SUBMITTING INSURANCE CLAIM OVER A THREE YEAR PERIOD

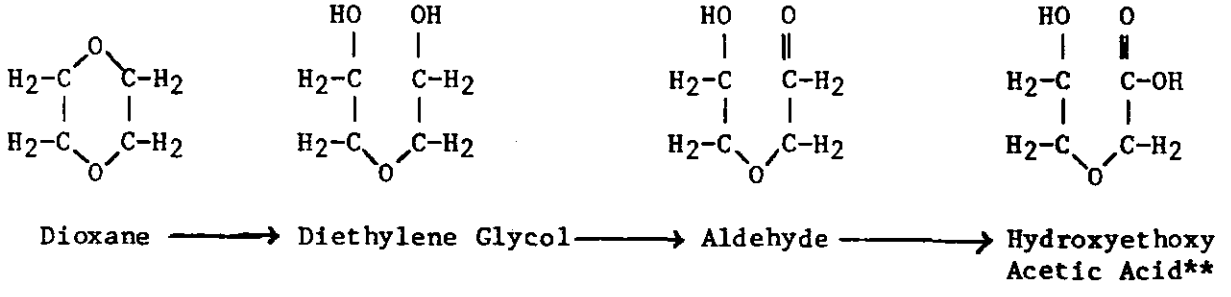
FIGURE 1

METABOLITES OF ETHYLENE GLYCOL, DIETHYLENE GLYCOL, AND DIOXANE [7-13]

ETHYLENE GLYCOL



DIOXANE AND
DIETHYLENE GLYCOL



* Major metabolite in the monkey.
** Major metabolite in the rat.

FIGURE 2

WORK HISTORIES AND CLINICAL COURSE OF THE THREE CASES OF RENAL FAILURE*

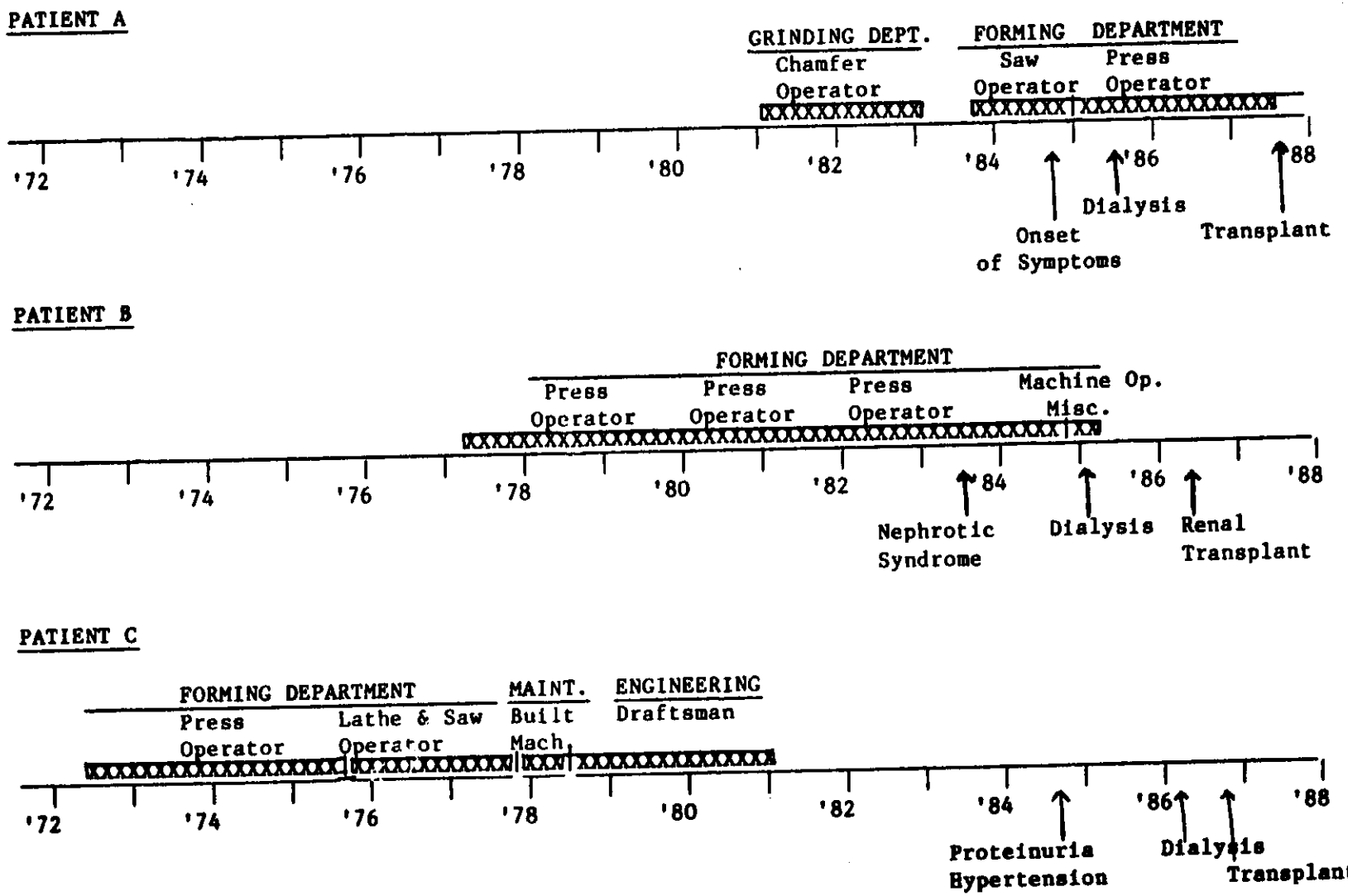
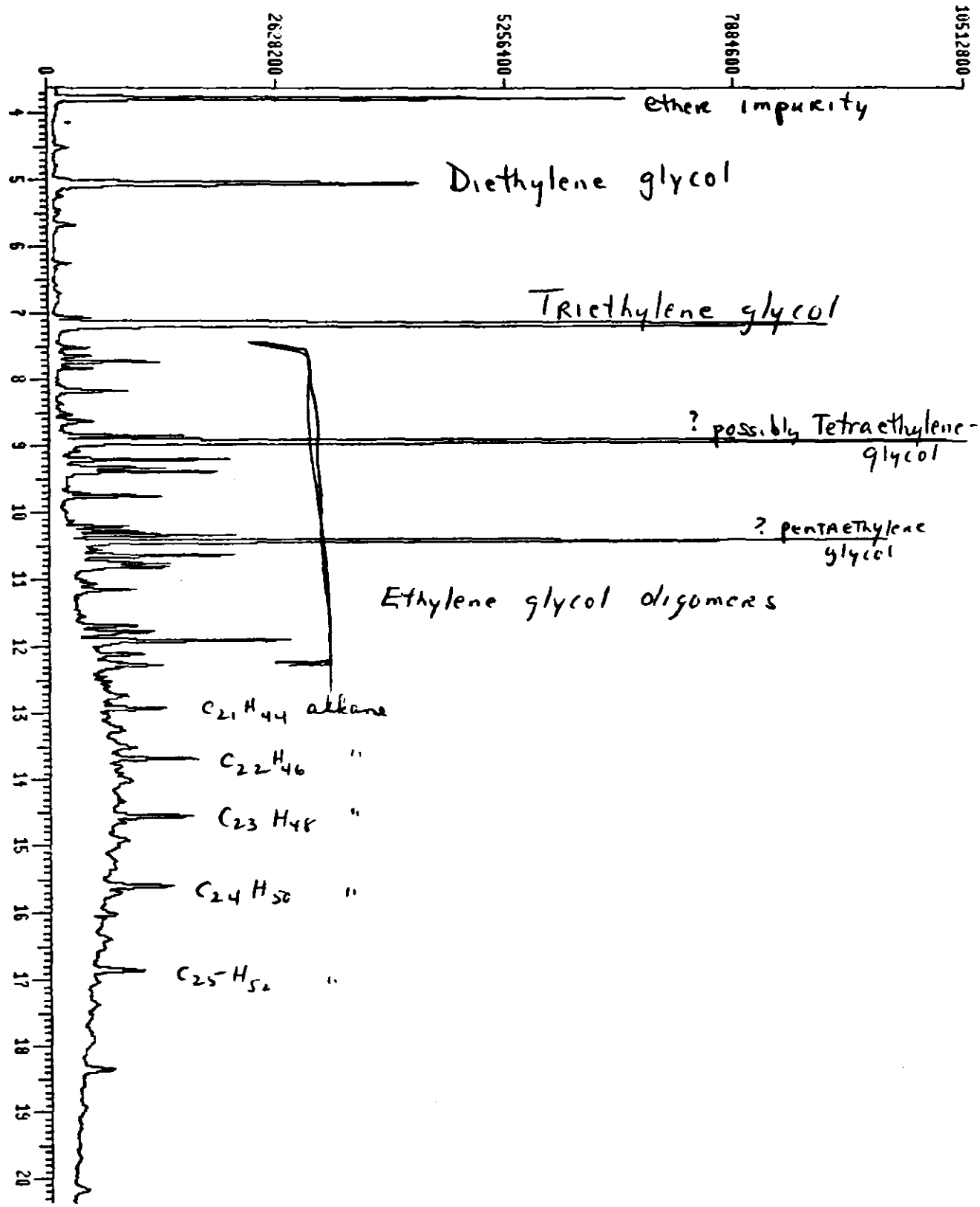


Figure 3
Gas Chromotography/Mass Spectrometry Analysis
of Kiln Residue from Golden Plant



End of plot. Time = 3.63 to 20.37 minutes Chart speed = 1.19 cm/min