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DALLAS & MAVIS FORWARDING CO.
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I. SUMMARY

On February 5, 1991, the National Institute for Occupational Safety and Health (NIOSH) received a request from employees of the Dallas and Mavis Forwarding Company (DMFC) in Seattle, Washington, to conduct a health hazard evaluation. DMFC employees transport newly manufactured trucks across the United States, Canada, and Mexico. The workers were concerned about potential occupational exposures causing moderate to severe skin rashes, upper respiratory symptoms, and frequent nose bleeds.

On June 16, 1991, the NIOSH investigators met one of the truck drivers whose delivery route passed through the Denver area. An occupational and medical history was taken, and the driver's skin was examined by the NIOSH physician. On September 10-12, 1991, NIOSH investigators traveled to Seattle, Washington, to inspect the DMFC grounds and the truck manufacturing plant, meet with various state and academic professionals who were already involved with an investigation, and interview DMFC employees.

On October 11, 1991, a NIOSH symptom and exposure questionnaire was administered to DMFC employees. On March 2-4, 1992, area air samples and wipe samples were collected inside three truck cabs while they were idling in the parking lot. The air samples were analyzed for aldehydes, isocyanates, total hydrocarbons, organic dusts, fibers, carbon monoxide, temperature, and humidity. Wipe samples were analyzed for organic compounds. On March 3, one of the investigators boarded one of the new Kenworth (KW) trucks bound for Denver, Colorado, and collected a variety of area environmental air samples in the truck cab over the next two days.

Qualitative analysis of air samples identified over 100 organic compounds. Nine compounds were chosen for quantitative analysis. Levels of these compounds range from non-detected up to 2.0 parts per million (ppm) for xylene. All chemical concentrations were at least a factor of 10 below their respective evaluation criteria. Total hydrocarbon levels ranged from less than detectable to 8.5 milligrams of hydrocarbons per cubic meter of air sampled (mg/M^3). Only trace levels of carbon monoxide (1 ppm), aldehydes (<0.1 mg/M^3), fiberglass (0.13 fibers/cubic centimeter) and isocyanates (<2 micrograms [ug]/M^3) were found. Wipe samples did not contain any measureable levels of organic compounds.

All eight of the deckers (who stack the truck cabs), and 30 of 35 drivers (80%) reported symptoms temporally associated with driving new KW trucks over the one-year period November 1990 through October 1991. Skin symptoms were reported by over two-thirds of the drivers and deckers for this same time period, most of whom had objective evidence of some type of skin rash. The face was the area most frequently affected; however, the arms, legs, chest, and neck were also affected. Other symptoms, such as headache and mucous membrane (nose and throat) irritation, were also common among DMFC employees. Twenty-six of the 38 (68%) symptomatic employee reported seeing a physician for their symptoms, with 12 being prescribed some type of medication. Conditions exacerbating these symptoms were operating the heater, sleeping in the cab of the truck, and keeping the truck closed-up. Opening the windows alleviated symptoms. Over one-third of employees reported an improvement of symptoms, particularly the skin symptoms, for the one year period October 1990 to October 1991.

No single contaminant or set of conditions was identified to explain the truck drivers' health complaints. The symptoms experienced by DMFC employees appear related to the driving of new KW trucks. Many symptomatic employees were diagnosed by occupational medicine physicians as having a skin rash consistent with an irritant contact dermatitis. A number of specific chemicals, some of which are known skin irritants, were identified from air samples inside the trucks, but at levels not known to cause health effects.

On the basis of this evaluation, NIOSH investigators concluded that a variety of symptoms, including skin rashes and mucous membrane irritation, appeared related to driving newly manufactured trucks. The skin rashes probably represented an irritant contact dermatitis. This evaluation could not pinpoint the specific substances responsible for these health effects.

KEYWORDS: SIC 4731 (Truck Transportation Brokers) skin rashes, contact dermatitis, mucous membrane irritation, truck drivers, total hydrocarbons, plasticizers.

II. INTRODUCTION

Dallas and Mavis Forwarding Company (DMFC) employees transport newly manufactured trucks across the United States, Canada, and Mexico. In 1989 several employees noted skin rashes, upper respiratory symptoms, and nose bleeds while driving the trucks, particularly during the winter months. After preliminary investigations by a number of consultants, in February 1991, employees requested the National Institute for Occupational Safety and Health (NIOSH) evaluate their working conditions.

On June 16, 1991, the NIOSH investigators interviewed and examined one of the truck drivers as he was passing through Denver. Subsequent site-visits to the DMFC offices on September 10-12, 1991, October 11, 1991, and March 2, 1992, allowed NIOSH to conduct an environmental and medical survey. On March 3-4, 1992, one of the NIOSH investigators boarded one of the new trucks bound for Denver, Colorado, and collected a variety of area environmental air samples.

III. BACKGROUND

The Dallas and Mavis company transports new (and sometimes old) trucks from the manufacturing site to the customer. These trucks could be delivered anywhere in the continental United States, Mexico, and Canada. As the new trucks are rolled off the assembly line, the manufacturer, Kenworth (KW), inspects and test drives the vehicles. KW test mechanics and drivers spend approximately 40 to 60 minutes in each truck. After the KW inspection, shop employees at DMFC drive the trucks three miles to the DMFC's stacking garage. In general, for delivery efficiency, two new trucks are stacked in a "piggy-back" manner behind the main cab. Trucks delivered from KW in the morning are stacked and ready for transport the following day.

On Monday through Friday at the DMFC offices, drivers are dispatched to delivery locations. Delivery assignments are determined by driver seniority; drivers with the most seniority have the first selections. A trip's length, and consequently, the number of days inside the truck cab, are determined by delivery location. Typically, trips last three to five days with 10 to 14 hours per day spent in the cabs. Sometimes drivers sleep in the sleeper component of the cab, increasing the total number of hours spent in the cab area per day. Upon delivery of the trucks, the drivers return to Seattle via commercial aircraft or "back-hauling" a new truck manufactured by another company.

Demand for new trucks determines the number of employed drivers. At the time of this survey, DMFC employed 38 truck drivers and ten shop employees to stack the trucks ("deckers"). The turn-over at DMFC is less than 5% per year, and there is very little transferring from shop employee to driver or visa versa. The last transfer involved three drivers switching to shop employees in the mid 1980s.

Skin rashes were first noted by drivers during the winter of 1989 (January-February), but the possible relationship to the work environment was not recognized until the winter of 1990, when drivers waiting for dispatch related similar skin conditions. After notifying their employers, DMFC informed the truck's manufacturer (KW), and KW's parent company (PACCAR) of the potential problem and began investigating.

Several occupational physicians, a private environmental health firm, the Washington State Division of Industrial Hygiene, and the Department of Environmental Health at the University of Washington became involved in the investigation.

HISTORY OF ENVIRONMENTAL INVESTIGATION PRIOR TO NIOSH INVOLVEMENT

In March 1990 PACCAR hired an environmental consulting firm, R.L. Schumacher & Associates. The firm conducted air sampling inside truck cabs for known or suspected skin irritants identified from material safety data sheets (MSDSs) of materials used in the truck manufacturing. Two settings were selected for air samples: 1) inside closed truck cabs while sitting in the DMFC lot, and 2) while the trucks were being driven on the road. Several bulk materials were tested for residual chemicals to determine if appreciable amounts of any chemicals could be identified. Lastly, Schumacher distributed log sheets to all drivers to determine specific conditions that existed when the drivers were experiencing difficulties. No specific chemicals or conditions could be identified which would explain the symptoms drivers were experiencing. Schumacher recommended the University of Washington further investigate the problem in a "more rigorous and controlled manner."[1]

The University of Washington (UW) operates a state supported Field Research and Consultation Group which provides occupational consultation by request. One of the University's specialties is qualitative analysis of unknowns. The UW directed their effort in four areas: 1) a review of Schumacher's questionnaire data to look for patterns which might lead to the source of exposure, 2) a review of MSDSs to compile a complete chemical inventory, 3) laboratory testing of bulk materials to determine offgassing chemicals, and 4) field sampling in the trucks to determine the identity and levels of chemicals on surfaces and in the air.

From the Schumacher questionnaire data, the UW concluded that there was a) a non-statistical association between symptoms and the number of trips taken (the greater the number of trips, the greater the prevalence for symptoms), and b) an association with certain types and colors of fabric used to finish the interior of the truck. Review of MSDSs provided the UW with a list of major chemicals probably present inside the trucks. They also looked at any new products being used as the result of a new truck model being introduced around the time of the rash outbreak (Model T-600-IIA was introduced in Summer 1989). To determine the offgassing of chemicals, bulk samples were tested by putting raw fabrics, adhesives, finished components (such as a dash assembly), etc. into an enclosed container (sometimes with heat added) and conducting an analysis of the headspace above the material. Dozens of chemicals were identified, but significant quantities were found only for toluene and xylenes. Finally, the UW also conducted sampling inside the cabs of new trucks upon delivery to DMFC. The trucks were started and allowed to run with the throttle advanced to 1500 RPM and the heaters placed on "high" before samples were collected. Qualitative analysis using gas chromatography/mass spectrometry (GC/MS) was used to identify specific chemicals. Numerous organic chemicals were found, but none in levels high enough to be of concern. The highest levels were 6.9 parts per million (ppm) of toluene and 2.9 ppm of methyl chloroform. These levels are at least a factor of ten below what is considered safe in occupational settings.

In May 1991, WISHA's investigation found at least four KW employees medically evaluated for skin problems, and one of these was recorded onto KW OSHA 200 logs. WISHA also investigated the company supplying KW with the cab's dash, console, and glove box components. Some of the supplier's employees reporting similar symptoms, with two workers filing compensation claims for skin disorders since October 1989. The report did not state if these cases represented an increase (or decrease) from previous years. The WISHA report also noted the supplier changed the mold release agent for polyurethane parts in late 1989.

IV. MATERIALS AND METHODS

A. MEDICAL

NIOSH reviewed medical consultant's reports provided to them by the company and employees. In addition, on October 11, 1991, a NIOSH symptom and exposure questionnaire was administered to DMFC employees. Thirty-five of the 38 (92%) current truck drivers, and 8 of the 10 (80%) of the current decking employees completed the questionnaire.

B. ENVIRONMENTAL

On March 2-4, 1992, area environmental air samples were collected inside the truck cabs for aldehydes, isocyanates, qualitative and quantitative analysis of total hydrocarbons and organic dusts, fibers, carbon monoxide, temperature, and humidity. Wipe samples were also collected on various areas inside the cabs. All air samples were collected with Gilian portable, battery-operated sampling pumps, model LFS 113D for flow rates of 20-200 cubic centimeters per minute (cc/min) and model HFS-513A for flow rates of 1000-4000 cc/min.

Air samples for aldehydes (acetaldehyde, formaldehyde, valeraldehyde, crotonaldehyde, butyraldehyde, benzaldehyde, hexanal, and heptanal) were collected at 20-50 cc/min on treated XAD-2 sorbent tubes and analyzed by a gas chromatograph equipped with a nitrogen-phosphorus detector according to NIOSH Method 2539.[2] Air samples for isocyanates (2,4- and 2,6-toluene diisocyanate and hexamethylene diisocyanate) were collected at 200-1000 cc/min on coated glass wool in a sorbent tube and analyzed by high performance liquid chromatography according to NIOSH Method 2535.[2]

Air samples for qualitative hydrocarbon analysis were collected at 20-50 cc/min on specially prepared thermal desorption tubes which contained a front layer of 350 mg of Carbotrap C, a middle layer of 175 mg of Carbotrap, and a back section of 150 mg of Carboxen 569. The samples were thermally desorbed from the tubes and analyzed by gas chromatography-mass spectrometry (GC-MS). Wipe samples collected in the truck cabs were on glass fiber filters which were wetted with distilled water. The samples were extracted with 3 mL methylene chloride, screened by gas chromatography (FID) and selected extracts were analyzed by GC-MS. Air samples for organic dusts were collected on glass fiber filters and analyzed as described above for the wipe samples.

Air samples for quantitative analysis of hydrocarbons were collected at 20-1000 cc/min on 150-mg charcoal tubes, extracted with a 2% ethanol-carbon disulfide solution, and analyzed by gas chromatography (FID) using a 30-meter capillary column. Eleven major hydrocarbons had been qualitatively identified from the thermal desorption tubes and then requested for quantitative analysis. Standards for each of these eleven chemicals were prepared on charcoal prior to the analysis.

Air samples for fibers were collected at 2.3 liters per minute on 25-mm cellulose ester filters mounted in a conductive cowled cassette. The samples were submitted for fiber counts using phase contrast microscopy according to NIOSH Method 7400.[2]

Temperature and humidity were measured periodically while air samples were being collected using an Extech Instruments Digital Humidity and Temperature Meter. Carbon monoxide (CO) was measured continuously using a Draeger Model 190 Datalogger which used a passive electrochemical cell for CO.

V. EVALUATION CRITERIA

A. MEDICAL

Occupational skin diseases account for approximately 40 - 50% of all occupational illnesses, and approximately 80 - 90% of these skin diseases may be classified as contact dermatitis.[3] Contact dermatitis refers to the induction of changes in the skin, usually accompanied by inflammation, from direct skin exposure to a wide variety of chemical or physical substances. The inflammation of contact dermatitis is caused by irritation (80 - 90% of cases), allergy, or both. Regardless of the mechanism (allergy or irritation), the clinical result typically a red, itchy, rash with vesicles, cracking, excoriations, and occasionally secondary infections.

The development of allergic contact dermatitis involves the affected individual becoming sensitized to the offending substance.[3,4] Once sensitized, the affected individual will react within several hours or days following re-exposure to even very small amounts of the substance. Allergic contact dermatitis may extend to other body surfaces, and massive exposures may lead to immediate reactions such as urticaria. The prognosis for those who develop occupational contact dermatitis, both irritant and allergic types, is generally poor. Only approximately 25% of those who develop occupational contact dermatitis experience complete clearing of their skin condition, despite measures such as changing jobs to decrease exposure to the offending agent(s).[3] This is why primary prevention of exposure to potentially causative agents is so important.

B. ENVIRONMENTAL

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 10 hours per day, 40 hours per week, for a working lifetime, without experiencing adverse health effects. It is important, however, to note that not all workers will be protected from adverse health effects if their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a preexisting medical condition, and/or a hypersensitivity (allergy).

In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled at the level set by the evaluation criterion. These combined effects often are not considered in the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes and, thus, potentially increase the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent becomes available.

The primary sources of environmental evaluation criteria for the workplace are: 1) NIOSH Criteria Documents and recommendations, 2) the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLVs), and 3) the U.S. Department of Labor/Occupational Safety and Health Administration (OSHA) occupational health standards [Permissible Exposure Limits (PELs)]. Often, the NIOSH recommendations and ACGIH TLVs are lower than the corresponding OSHA standards. In evaluating the exposure levels and the recommendations for reducing these levels found in this report, it should be noted that the company is required by the Occupational Safety and Health Administration to meet those levels specified in an OSHA standard. A time-weighted average (TWA) exposure refers to the average airborne concentration of a substance during a normal 8- to 10-hour workday.

A list of Evaluation Criteria for the substances of interest is included in Table 1.

VI. RESULTS

A. MEDICAL

1. REVIEW OF MEDICAL CONSULTANTS REPORTS

Harborview Medical Center

In the winter-spring of 1990, Harborview Medical Center evaluated at least seven DMFC drivers with upper respiratory tract symptoms and pruritic skin lesions with a strong temporal association with truck delivery. The evaluating physician felt the symptoms were consistent with mucous membrane irritation by some unidentified airborne chemical substance and the skin changes may represent an irritant contact dermatitis.

Virgina Mason Medical Clinic (VMMC)

In April 1990 PACCAR hired an occupational medicine specialist at VMMC to evaluate the DMFC drivers and Kenworth (KW) test mechanics and drivers for symptoms associated with new KW trucks. In April-May 1990, a VMMC symptom questionnaire was completed by 39 of the 45 (80%) DMFC drivers (Table 2). Over 70% of surveyed drivers reported an itchy skin rash distributed over their arms, legs, face and chest (Table 3).

Two VMMC physicians (one occupational medicine specialist and one dermatologist) evaluated 16 DMFC drivers. Based on these 16 evaluations, the physicians made the following generalizations. The skin rashes typically began after several hours in the truck, were exacerbated by the cab heater or sleeping in the cab's "sleeper" compartment, began to resolve after delivering the truck, and continued to improve when returning to Seattle either by air or back-hauling other types of trucks. Eight of the rashes were described as nonspecific erythematous patches with evidence of excoriations but no primary lesions, two appeared to have classic reactions to an airborne allergen or irritant, and six drivers were not mentioned. Skin biopsies were obtained on seven DMFC drivers (Table 4). Results of routine screening blood tests, pulmonary function tests, and chest x-rays were reported as "normal."

A symptom questionnaire was not distributed to KW employees, however seven KW test mechanics and 3 KW test drivers were evaluated by VMMC physicians. KW test mechanics and drivers typically spend 40-60 minutes in the cab or sleeper compartment on each truck. Five KW employees were noted to have red itching rashes with a temporal association to the workplace beginning in the Summer/Fall of 1989. Skin biopsies were obtained on two KW employees (Table 4). The VMMC physicians stated that "no symptoms associated with the new trucks have been reported from 1) the purchasers or distributer of the new KW trucks, 2) DMFC drivers of new KW trucks from Chilicothe, Ohio, or 3) KW production line employees," although none of these groups were surveyed in a systematic manner.

Oregon Health Sciences University (OHSU)

In June 1990, PACCAR consulted with a dermotologist specializing in occupational cases at OHSU. Fifteen cases were reviewed; seven via photographs (Table 5), and eight via skin biopsies reviewed in conjunction with a OHSU dermatopathologist (Table 4). Although none of the employees were interviewed or examined directly by the OHSU physicians, they concluded that the majority of employees had minor skin conditions "in rates consistent with the general population." "Twelve of the 15 had skin conditions which could be exacerbated by low humidity (<35%) found in the trucks."

Providence Medical Center (PMC)

Finally, in September 1991, an occupational medicine specialist at PMC, reviewed the medical records of 22 DMFC employees who filed workers compensation claims (WCC). The PMC report found the majority of DMFC workers described symptoms in very specific circumstances. "Symptoms were most prominent when driving newly manufactured KW trucks on outbound trips of several days duration, in the winter, with the heater on, and the windows closed." "Driving other makes of trucks rarely produced symptoms, and symptoms usually resolved on return trips or after several days of not driving."

Although few claimants have had objective findings of respiratory tract or eye irritation, approximately one-third had objective evidence of skin rash by photographs or physician examination reports consistent with contact dermatitis. Three or four claimants had symptoms and signs of contact dermatitis of primary occupational origin. The remaining claimant's conditions were probably exacerbated by any of the following conditions in the KW truck cabs: a) airborne skin irritants, b) direct skin irritants, c) low humidity, or d) a potential skin sensitizer. "For most claimants, there was no permanent impairment of skin, respiratory tract, or other systems anticipated." Few, if any, characteristics of this "outbreak" had few, if any, features suggestive of "mass psychogenic illness."

2. NIOSH QUESTIONNAIRE SURVEY

The mean age of participants was 41 years. Only one of the 43 (2%) participants was female, and only 1 (2%) was an ethnic minority (hispanic). The mean seniority of both drivers and deckers was 10 years (range 2-20). The drivers averaged 3.8 trips per month (range 3-6) over the past year.

All eight of the deckers, and 30 of the 35 drivers (80%) reported symptoms temporally associated with KW trucks over the one-year period November 1990 through October 1991. Skin symptoms were reported by over two-thirds of the drivers and deckers for this same time period (Table 2). The face was the area most frequently affected, but the arms, legs, chest, and neck were also affected (Table 3). Other symptoms, such as headache and mucous membrane (nose and throat) irritation, were also common among DMFC employees (Table 2). Eighty-two percent of the symptomatic employees noted their symptoms within six hours after being in the truck (range=1-72, mean=7, median=2, mode=1). Sixty-seven percent reported their symptoms resolved within a week, but a few employees noted that their symptoms continued for months despite not driving the trucks. Twenty-six employees reported seeing a physician for their symptoms, and twelve (55%) reported being put on some type of prescription medication. Twenty-one employees reported filing a workers compensation claim.

All of the deckers, and 82% of the drivers reported that their symptoms were exacerbated by operating the heater. The air conditioner, which utilized the same air ducts as the heater, exacerbated symptoms in 71% of the deckers and 32% of drivers (Table 6). Other conditions which seemed to exacerbate the symptoms included sleeping in the trucks, and keeping the truck closed-up overnight (Table 6). There was not a clear relationship between symptom exacerbation and the type of interior matting (carpet or rubber) or the type of truck driven (Table 6). Keeping the windows open alleviated symptoms among 100% of the deckers and 57% of the drivers.

Only twelve drivers (10 symptomatic and 2 asymptomatic) responded to the question regarding "average number of trips taken per month over the past year." The ten symptomatic drivers reported a mean of 3.6 trips per month [(Standard deviation (SD) 0.70], while the two asymptomatic drivers reported a mean of 5.0 trips per month (SD 1.4). For this sample of twelve drivers, there was no association between the average number of trips taken and symptoms (Kruskal-Wallis p-value for non-normally sample distribution = 0.11). Over one-third of employees reported an improvement of symptoms, particularly the skin symptoms, during the one-year period Octobert 1990 to October 1991 (Table 7).

B. ENVIRONMENTAL

The results of the qualitative analysis of air samples for organic compounds are included in Attachment 1. Over one hundred compounds were identified and seventy were considered to be present in sufficient quantity to consider further. Based on the identity of these compounds, their relative abundance, their ability to cause dermal problems, and the relative toxicity of the compounds, nine were identified for quantitative analysis. These were tetrahydrofuran (THF), methyl isobutyl ketone (MIBK), methyl ethyl ketone (MEK), 1,1,1-trichloroethane (TCE), xylene (XYL), styrene (STY), 1-methyl-2-pyrrolidinone (MPD), 2-ethylhexanoic acid, 2-ethylhexyl acrylate (EHA), plus total hydrocarbons. Table 1 contains a summary of the analytical results for these compounds, except 2-ethylhexanoic acid. This compound could not be recovered from the charcoal tubes and so could not be quantitated. The concentrations varied from less than detectable levels to 2.0 ppm for all xylene isomers. Total hydrocarbon levels were as high as 8.5 mg/M^3. Wipe samples collected for organics contained no measurable levels.

Samples for aldehydes were below the limit of detection [0.5 - 2 micrograms (ug) per sample] except for benzaldehyde where trace levels (at the limit of detection; 2 ug/sample) were found in most of the samples. This equates to a minimum detectable concentration of 0.1 mg/M^3.

All samples for isocyanates were below the limit of detection; 0.3 ug/sample for 2,4-TDI and HDI, and 0.6 ug/sample for 2,6-TDI. This equates to a minimum detectable concentration of 2 ug/M^3.

No carbon monoxide levels were measured above 1 ppm. One of four air samples collected for fibers contained detectable amounts of fiberglass fibers, between the limit of detection and the limit of quantitation (thus reducing the certainly of the analysis). Based on the small sample volumes, this sample equates to a fiber concentration of 0.13 fibers per cubic centimeter (cc).

VII. DISCUSSION

Few of the skin rashes were observed by NIOSH investigators, but many were documented by occupational physicians in the Seattle area. The three occupational medicine specialists who examined these employees felt the skin conditions were at least exacerbated by the workplace, with several cases being primarily occupational. On the other hand, the occupational dermatologist at OHSU concluded the skin disorders found among DMFC drivers were typical of any cohort of that age, and that the low humidity in the trucks, particularly during the winter months with increase use of the heater exacerbated these underlying conditions.

The symptom prevalences reported by DMFC employees (84%) is probably higher than expected in the general population, and the temporal patterns are consistent with a work-related etiology. Two employees had an allergic contact dermatitis by clinical diagnosis or biopsy (spongiotic dermatitis). Another seven employees had objective evidence of skin rash by examination, photograph, or biopsy consistent with contact dermatitis. The relatively high prevalence of skin condition/symptoms is most consistent with an irritant, rather than an allergic contact dermatitis. Although over one-third of the employees reported an improvement of symptoms during 1991, a slow recovery, despite removal of the causal agent, is characteristic of a contact dermatitis.[5] The small number of rashes visualized by NIOSH investigators appears inconsistent with the slow recovery of contact dermatitis, however many of the workers were not examined due to the drivers being on the road at the time of the NIOSH site-visit.

A temporal association was noted by PACCAR during the course of the NIOSH investigation with the onset of symptoms (Summer/Fall 1990) and a change in the cleaning solvent used to clean the heater coils. When the heater was first turned on, residual mineral spirits (and perhaps other solvents) emitted a visible smoke and odor. This problem was corrected in all trucks by December 1991. PACCAR has speculated that the decomposition products from the residual solvents on the heater coils produced a chemical irritant causing the drivers' skin problems. The fact that the heater coil problem was resolved in December 1991, with the majority of employees still having skin problems in 1992, is not inconsistent with a contact dermatitis.[5]

Another event temporally associated with the onset of symptoms was a change in truck models. According to KW, this new truck model did not result in any appreciable product changes other than the adhesive holding the new one-piece windshields. This isocyanate adhesive was one of the products tested by the University of Washington and found not to offgas detectable amounts of isocyanate.

The results of the NIOSH sampling confirmed the presence in the air of large numbers of organic chemicals in small quantities. The total hydrocarbon levels were substantially higher in vehicles tested on the lot soon after manufacture, than those collected on the road. This may in part be due to 1) the fast outgassing of organics soon after manufacture, 2) open windows on the road, and 3) the high heat generated from stationary trucks in the DMFC lot running with the heater on full power. Two known skin irritants/sensitizers were found in measurable quantities, 2-ethyl-hexyl acrylate (EHA) and fiberglass, but, the levels were so low that it was unlikely that they were responsible for the widespread skin problems.

Many employees noted improvement in symptoms, particularly the skin symptoms, from October 1990 to October 1991 (Table 7). Whether this represented a true reduction in exposure, or merely an improved ability to avoid the situations which exacerbate the symptoms (running the heater, sleeping in the trucks, etc.), is unclear.

The questionnaire data collected by NIOSH investigators revealed no relationship between the "average number of trips per month over the past year," and symptoms. Conclusions based upon this finding must be tempered for the following reasons: 1) only 12 of the 35 drivers answered the question (low response rate), 2) only two asymptomatic drivers answered the question (low statistical power), and 3) a few symptomatic employees were put on work restrictions, thereby reducing their average number of trips per month (a type of confounding bias). Therefore our investigation cannot draw any definative conclusions regarding the association of the symptoms and number of trips taken by the drivers.

Four of the 22 DMFC employees filing workers compensation claims quit or were laid off prior to the administration of our symptom questionnaire in October 1991. Two of these four workers have since returned to work for DMFC. Given this low rate of turnover, it is unlikely that a strong survivor bias occurred.

VIII. CONCLUSIONS

No single contaminant or set of conditions was identified that would explain the DMFC employees' health complaints. Based on the NIOSH interviews, the symptoms experienced by DMFC employees appear related to the driving of new KW trucks. Conditions exacerbating these symptoms included operating the heater, sleeping in the cab of the truck, and keeping the truck closed-up; opening the windows alleviated symptoms. Some employees with skin symptoms had, during prior evaluations, objective evidence of some type of skin rash consistent with an irritant contact dermatitis. A number of specific chemicals, many of which are known skin irritants, were identified in the air of the truck cabs, but at levels not known to cause health effects.

IX. RECOMMENDATIONS

1. The total hydrocarbon levels found in the new KW trucks were quite high. Since there is a temporal relationship between the employees' symptoms and the trucks, it would seem prudent to reduce the levels of hydrocarbons before the trucks are delivered. Two possible approaches to reducing total hydrocarbon levels are to 1) "bake-out" the trucks for a specified time period, or 2) allow the trucks to sit on the lot long enough for natural chemical offgassing to occur.

2. Encourage employees to avoid conditions which exacerbate symptoms such as sleeping in the truck, and keeping the truck closed-up.

3. Encourage employees to immediately report onset of symptoms, and circumstances surrounding those symptoms, to a health care provider (HCP) appraised of the situation. Further diagnostic testing (skin biopsies, pulmonary function tests, etc.) should be at the discretion of the evaluating HCP.

4. Encourage employees with visible skin rashes to be examined by the selected HCP.

X. REFERENCES

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XI. AUTHORSHIP AND ACKNOWLEDGMENTS

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

TABLE 1
SUMMARY OF SPECIFIC HYDROCARBON ANALYSIS (PPM)

DALLAS AND MAVIS TRUCKING
SEATTLE, WASHINGTON

HETA 91-103

SAMPLE	VOLUME (L)	DESCRIPTION/ LOCATION	DATE	MEK	THF	TCE	MIBK	TOL	XYL	STY	MPD	EHA	TOTAL HYDRO CARBONS (MG/M^3)
CT-02	30	Dallas & Mavis lot, new T-800 truck, #9699, heater on	3-2-92	ND	0.02	1.3	0.06	0.2	1.8	0.13	0.23	0.13	8.5
CT-05	25	Dallas & Mavis lot, new T-600 truck, #9520, front & rear heaters on	3-2-92	0.08	0.2	1.8	0.09	0.6	2.0	0.16	0.17	0.06	6.0
CT-08	10	Dallas & Mavis lot, new T-600 truck, #9531, front & rear heaters on	3-3-92	ND	ND	0.2	ND	0.2	0.4	ND	ND	ND	1.3
CT-09	6	On Road, new T-600 truck, window open, T=70°F, afternoon	3-3-92	ND	ND	0.5	ND	0.2	0.6	ND	ND	ND	ND
CT-10	7	On Road, new T-600 truck (red) window open, T=72°F, early evening	3-3-92	ND	ND	0.5	ND	0.2	0.5	ND	ND	ND	ND
CT-11	68	On Road, new T-600 (blue) with plastic interior, T=60°F, night	3/3-4/92	0.02	0.02	0.5	<.01	0.05	0.3	0.03		ND	0.4
LOD (Mg/s)				1.0	1.0	2.0	1.0	1.0	1.0	2.0	3.0	2.0	11.0
LOQ (Mg/s)				3.0	3.0	7.0	3.0	3.0	3.0	7.0	11.0	7.0	36.0
REL -TWA STEL	(ppm) (ppm)			200 300	200 250	350	50 75	100 150	100 150	50 100	NA	NA	
PEL - TWA STEL	(ppm) (ppm)			200 300	200 250	350 450	50 75	100 150	100 150	50 100	NA	NA	
PEL - TWA STEL	(mg/M^3) (mg/M^3)			590 885	590 735	1900 2450	205 300	375 560	435 655	215 425			

*NOTE: MEK = methyl ethyl ketone
THF = tetrahydrofuran
TCE = 1,1,1-trichloroethylene
MIBK = methyl isobutyl ketone
TOL = toluene
XYL = xylene
STY = styrene
MPD = 1-methyl -2-pyrolidinone
EHA = 2-ethyl-hexyl-acrylate
REL = Recommended Exposure Limit set by NIOSH
PEL = Permissible Exposure Limit Set by OSHA
TWA = Time-weighted Average
STEL = Short-term Exposure Level
ppm = Parts per million
mg/M^3= Milligrams of contaminant per cubic meter of air
LOD = Limit of Detection for analytical method
LOQ = Limit of Quantitation for analytical method

Table 2
Symptoms Survey: VMMC[+] Apr 1990, NIOSH[ss] Oct, 1991
Dallas & Mavis, Seattle, Washington
HETA 91-103

Symptoms Of Workers	VMMC - 4/90 (n=39)[++]	NIOSH 10/91 Drivers (n=35)	NIOSH 10/91 Deckers (n=8)
Any Symptoms	**84%**	**80%**	**100%**
Skin Rash	**74%***	**66%**	**75%**
Itchy skin	**74%***	**77%**	**88%**
Dry skin	**	**69%**	**50%**
Headache	**46%**	**63%**	**63%**
Nausea	**15%**	**20%**	**25%**
Lightheadedness	**15%**	**37%**	**38%**
Grogginess	**13%**	**49%**	**13%**
Nose irritation	**31%**	**51%**	**50%**
Nasal congestion	**36%**	**57%**	**63%**
Throat irritation	**43%**	**60%**	**63%**
Shortness of breath	**26%**	**49%**	**63%**
Chest tightness	**23%**	**37%**	**38%**
Wheezing	**18%**	**26%**	**25%**
Fever	**	**11%**	**25%**
Depression	**26%*** **	**40%**	**13%**
Irritability	**26%*** **	**51%**	**25%**

[+] **Virginia Mason Medical Clinic symptom survey, April 1990**

[ss] **National Institute for Occupational Safety & Health, October 1991**

[++] **Did not separate drivers from deckers**

* **No separation of skin rash and itching symptoms; included in one category.**

** **Symptom not included as part of survey.**

*** **No separation of depression and irritability symptoms; included in one category.**

Table 3
Distribution of Skin Symptoms: VMMC[+] Apr 1990, NIOSH[ss] Oct 1991
Dallas & Mavis, Seattle, Washington
HETA 91-103

Location on Body	**VMMC 4/90 (n=39)[++]**	**NIOSH 10/91 Drivers (n=35)**			**NIOSH 10/91 Deckers (n=8)**		
	Rash/Itch	**Rash**	**Dry**	**Itch**	**Rash**	**Dry**	**Itch**
Face	31%	43%	43%	30%	63%	63%	38%
Eyes	NA*	37%	37%	14%	38%	38%	25%
Neck	NA*	30%	30%	14%	38%	50%	25%
Chest	28%	37%	30%	14%	25%	25%	0%
Arms	49%	20%	29%	29%	38%	38%	38%
Legs	38%	40%	43%	34%	13%	25%	25%
Other	NA*	37%	37%	26%	13%	25%	0%

* **Was not included as part of survey.**

[+] **Virginia Mason Medical Clinic symptom survey, April 1990**

[ss] **National Institute for Occupational Safety & Health, October 1991**

[++] **Did not separate drivers from deckers**

Table 4
Clinical Diagnosis & Biopsy Results
Dallas-Mavis, Seattle, WA
HETA 91-103

CASE	CLINICAL DIAGNOSIS	BIOPSY RESULTS
1	Keratosis pilaris with some folliculitis	VMMC*: Keratosis pilaris vs pityrosporum folliculitis OHSU+: Not reviewed
2	Transient acantholytic dermatosis (Grover's disease)	VMMC: Acantholytic dyskeratosis OHSU: Focal acantholytic dyskeratosis
3	Acute Rosacea and excoriations	VMMC: Chronic inflammation with associated cystic hyperkeratotic follicle OHSU: Rosacea - like dermatitis
4	Seborrheic blepharitis with non-specific dermatitis, or a plague of nummular eczema	VMMC: Superficial chronic dermatitis with folliculitis OHSU: Spongiotic dermatitis
5	Keratosis pilaris, or a non-specific dermatitis	VMMC: Mild paratceratosis OHSU: Sparce, superficial dermatitis with focal paratceratosis
6	Folliculitis on the face	VMMC: Transmural necrosis with exudate of undermined type OHSU: Suppurative folliculitis, traumatized
7	Allergic contact dermatitis	VMMC: Superficial dermatitis with spongiosis; changes consistent with eczematous (contact) dermatitis OHSU: Spongiotic dermatitis
8	Probable insect bites	VMMC: Chronic inflammation, severe, with associated epithelial excoriation OHSU: Superficial and deep mixed dermatitis, ulcerated

* **Virginia Mason Medical Clinic**
\+ **Oregon Health Sciences University**

Table 5
Clinical Diagnosis Only
Oregon Health Sciences University
Dallas-Mavis, Seattle, WA
HETA 91-103

CASE	CLINICAL DIAGNOSIS
9	Probable irritant hand eczema
10	Telangiectasias on the chest with low grade truncal folliculitis
11	Arm scar versus nonspecific dermatitis
12	Low grade truncal folliculitis or possible resolving herpes zoster
13	Atopic dermatitis and flare
14	Nonspecific excoriations
15	Annular seborrheic dermatitis versus discoid lupus erythematosus versus granuloma annulare

Table 6
Factors Affecting the Occurrence of Symptoms, NIOSH - Oct 1991
Dallas & Mavis, Seattle, Washington
HETA 91-103

Action or Material	**Drivers (n=30)**		**Deckers (n=8)**	
	Symptoms Better	**Symptoms Worse**	**Symptoms Better**	**Symptoms Worse**
Running the heater	0%	82%	0%	100%
Running the air conditioner	21%	32%	0%	71%
Sleeping in the sleeper	0%	46%	0%	0%
Truck closed-up overnight	0%	43%	0%	14%
When hot outside	11%	7%	14%	86%
Windows open	57%	0%	100%	0%
Rubber matting	7%	7%	0%	0%
Carpet matting	4%	14%	0%	0%
Driving T-600*	4%	32%	0%	0%
Driving T-602	4%	11%	0%	0%
Driving T-800	7%	29%	0%	0%
Driving T-900	18%	18%	0%	0%
Driving T-454	0%	0%	0%	0%

* **T-600, T-602, T-800, T-900, & T-454 are truck models**

Table 7
Symptoms Improvement in Past Year, NIOSH Oct 1991
Dallas & Mavis, Seattle, Washington
HETA 91-103

Symptoms Of Workers	Symptoms Improved Drivers (n=30)	Symptoms Improved Deckers (n=8)
Skin rash	37%	63%
Itchy skin	37%	50%
Dry skin	29%	25%
Headache	37%	50%
Nausea	20%	25%
Lightheadedness	26%	38%
Grogginess	23%	0%
Nose irritation	17%	25%
Nasal congestion	17%	25%
Throat irritation	37%	25%
Shortness of breath	26%	25%
Chest tightness	29%	25%
Wheezing	14%	25%
Fever	6%	25%
Depression	20%	0%
Irritability	20%	13%

ATTACHMENT 1

DEPARTMENT OF HEALTH & HUMAN SERVICES

RECEIVED
MAR 3 0 1992
INDUSTRIAL HYGIENE SECTION

Memorandum

Date: March 26, 1992

From: Chemist, MDS, MRSB

Subject: Sequence #7456A, B, C; HETA 91-103: Qualitative Analysis of Thermal Desorption Tubes and Filters for Organic Compounds.

To: D. Tharr, HETAB Lab Coordinator
Attn: C. McCammon, Denver Region
Through: Director, DPSE
Chief, MRSB, DPSE

INTRODUCTION:

Ten thermal desorption tubes and nine glass fiber filters (6 used as wipe samples) collected in new truck cabs were submitted for qualitative analysis of volatile organic compounds. Charcoal tubes collected at the same time were put on hold for later quantitation of specific compounds.

EXPERIMENAL:

Since concentrations of contaminants were expected to be low for this survey, thermal tubes were used for sampling. For this study, stainless steel tubes configured for the Perkin-Elmer ATD 400 thermal desorption system were prepared in-house. Each thermal tube contained three beds of sorbent materials--a front layer of Carbotrap C (≈350 mg), a middle layer of Carbotrap (≈175 mg), and a back section of Carboxen 569 (≈150 mg). Prior to field sampling, the thermal desorption tubes were conditioned for 30 minutes at 375°C followed by a second 30 minute conditioning at 375°C. Samples were analyzed using the ATD 400 automatic thermal desorber interfaced directly to a HP5890A gas chromatograph and HP5790 mass selective detector (TD-GC-MSD). The mass spectrometer was operated under EI conditions in full scan mode (20-300 amu). Samples were analyzed separately by directly inserting each into the thermal desorber unit with no other sample preparation. Each sample tube was desorbed at 310°C for 10 minutes. A 30 meter DB-1 capillary column was used for the analyses. Spikes containing known amounts of several common solvents were prepared and analyzed along with this sample set to estimate concentrations.

Filter samples and wipes were extracted with 3 mL methylene chloride in an ultrasonic bath for 30 minutes. The extracts were screened by gas chromatography (FID) using a 30 meter DB-1 capillary column (splitless mode). Extracts from the blank filter and one of the wipes (WM-4) were concentrated by evaporating most of the methylene chloride solvent with a stream of air. These concentrated solutions were analyzed by GC-FID and GC-MS.

RESULTS:

No compounds other than those associated with the blank filter were detected in any of the filter samples; a possible trace of bis(2-ethylhexyl)phthalate was detected in the concentrated extract from WM-4 by GC-MS, but no significant components could be detected even in this concentrated sample.

A significant number of contaminats was observed on all the thermal tubes, however. Over a hundred different compounds were detected on these samples. Seventy of these individual components have been identified and reported on the enclosed chromatograms. Copies of the reconstructed total ion chromatograms (TIC) from the TD-GC-MSD analyses of all samples (except sample CX-12 whose data was lost due to a mass spectrometer software problem) and standard spikes are enclosed. The TIC for sample CX-1 has been expanded to two pages so all the peaks could be numbered for identification. The remaining chromatograms are all scaled the same for comparison (same time and abundance axes). Since the compounds identified were similar for all samples, only the larger or more unusual components are numbered on all chromatograms. A separate table is enclosed listing each peak number with its corresponding identification. Figure 1 shows the chromatograms of samples CX-1 and CX-10 (taken on the road) plotted back-to-back to illustrate the similarities among all the samples. Most major components appear to be in the 10-20 µg per sample range; MEK on sample CX-9 was greater than 10 µg based on the standard spike.

A copy of the chromatogram from CX-1 was faxed to you last week. As soon as you decide which components are of interest to you, the remaining charcoal tubes on hold will be quantified for those specific compounds and reported separately.

Ardith A. Grote

John L. Holtz
Chief, MRSB, DPSE

Attachments

SEQ 7456
PEAK IDENTIFICATION

1. Air/CO_2/water*
2. SO_2*
3. Acetaldehyde*
4. Butanes/C_4H_{10} isomers
5. Ethanol*
6. Acetone*
7. Trichlorofluoromethane (Freon 11)
8. Furan
9. Pentane
10. Dichloroethylene*
11. Methylene chloride*
12. Trichlorotrifluoroethane (Freon 113)
13. Carbon disulfide
14. Nitromethane
15. Methyl vinyl ketone?
15A. Butanal/C_6 alkane
16. Methyl ethyl ketone (MEK)
17. Isobutanol
18. 1,3-Dioxolane
19. n-hexane
20. Tetrahydrofuran (THF)
21. 1,1,1-Trichloroethane
22. Benzene
23. Methoxypropanol?
24. Heptanes/C_7H_{16} isomers
25. p-Dioxane
26. n-Heptane
27. Methyl isobutyl ketone (MIBK)
27A. Pyridine
28. Dimethylformamide (DMF)
29. 2-Hexanol?
30. Toluene
31. C_8H_{16}/C_8H_{18} alkanes
32. n-Butyl acetate
33. Perchloroethylene
34. n-Octane
35. C_9H_{18}/C_9H_{20} alkanes
36. Methoxyethyl acetate?
37. Xylene isomers
38. Cyclohexanone
39. Methyl amyl ketone (MAK)
40. Styrene
41. n-Nonane
42. C_9H_{12}, M.W.120 alkyl benzenes
43. Benzaldehyde
44. Phenol
45. α-Methyl styrene
46. 1-Methyl-2-pyrrolidinone
47. $C_{11}H_{24}$ alkane
48. Limonene
49. C_{11}-C_{12} alkanes/ $C_{10}H_{14}$, M.W.134 alkyl benzenes
50. Acetophenone
51. α,α-Dimethylbenzene methanol
52. n-Undecane
53. Ethylhexanoic acid?
54. Ethyl benzoate
55. Naphthalene
56. n-Dodecane
57. 2-Ethylhexyl acrylate
58. Caprolactam
59. n-Tridecane
60. Methyl naphthalenes
61. n-Tetradecane
62. Diacetyl benzenes
63. n-Pentadecane
64. BHT (2,6-di-t-butyl-4-methyl phenol)
65. Di-t-butyl-ethyl phenol
66. n-Hexadecane
67. Unknown, nitrogen compound?
68. Di-t-butyl-methylethyl phenol?
69. n-Heptadecane
70. Trimethyl phenyl indan
71. Butylbenzenesulfonamide

* Compounds sometimes found on blanks at low levels.

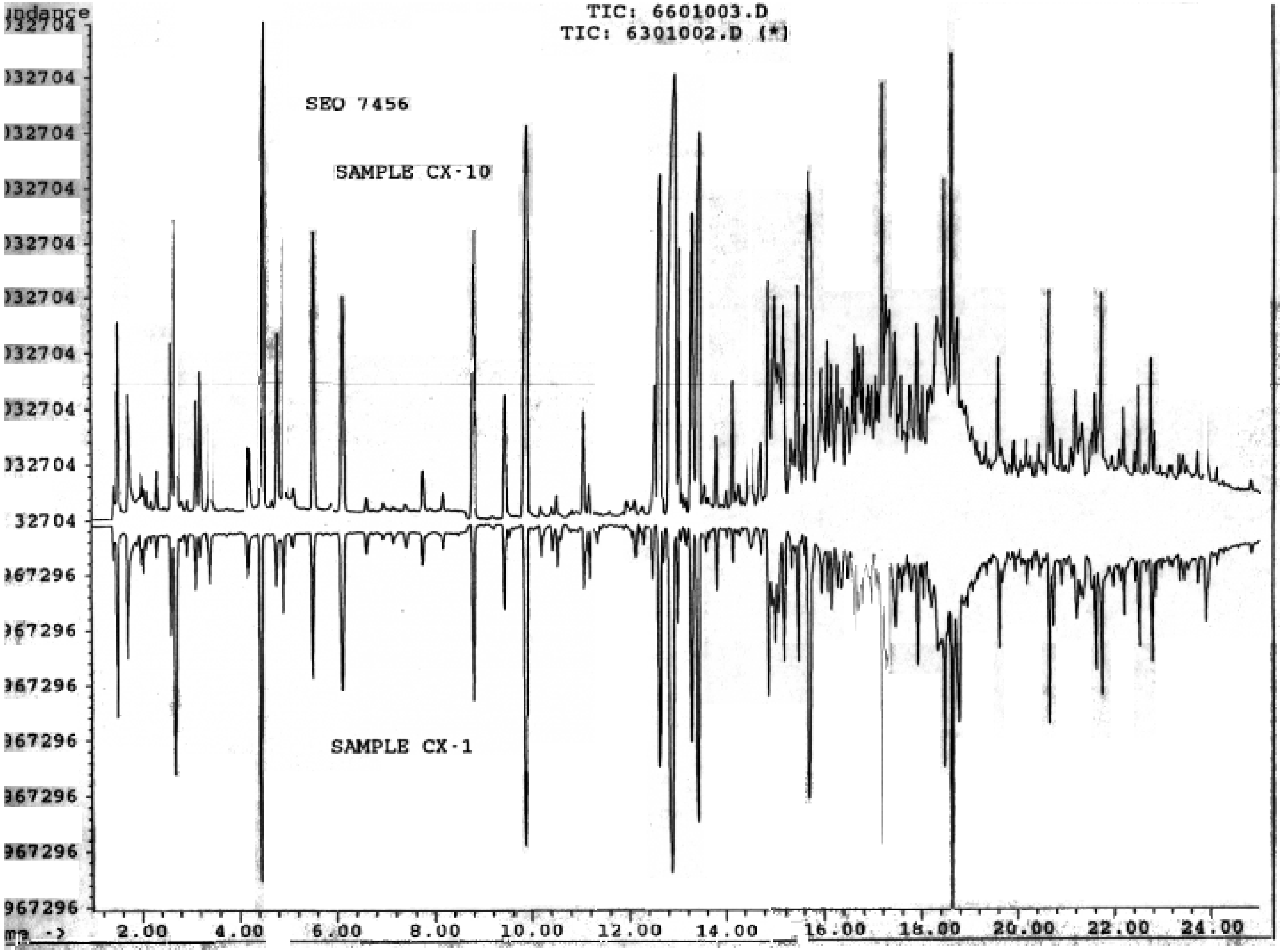
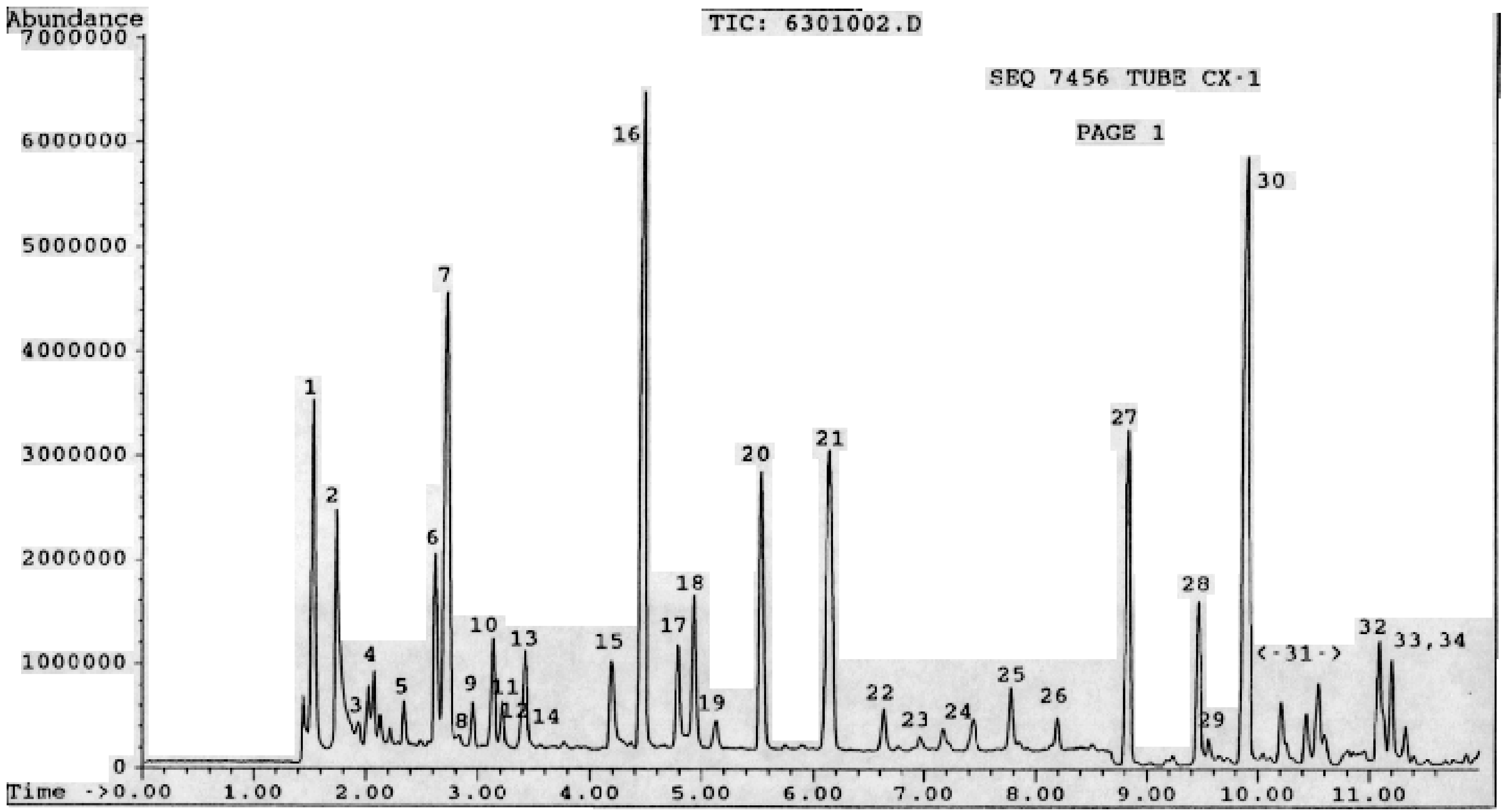


Fig.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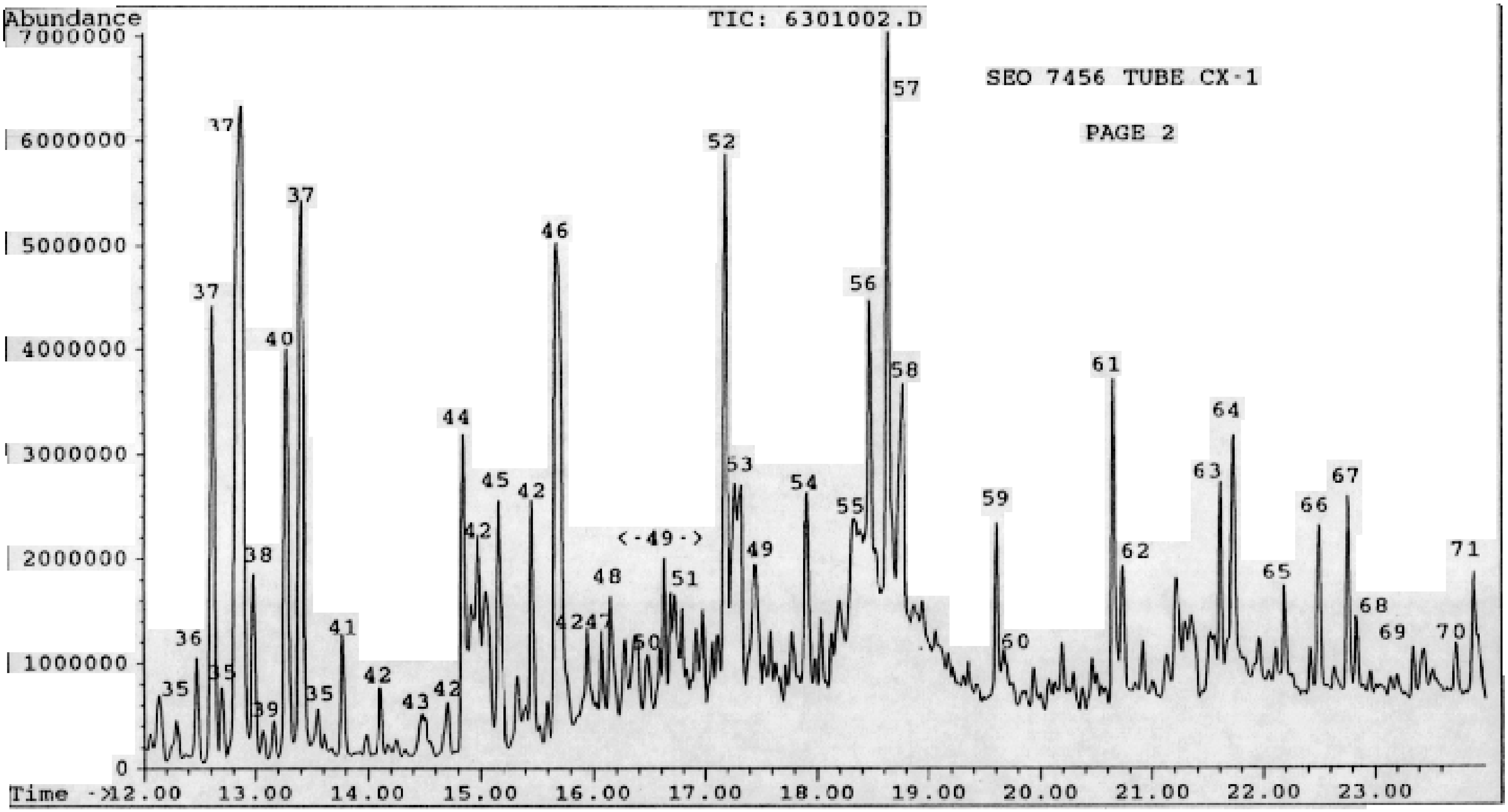

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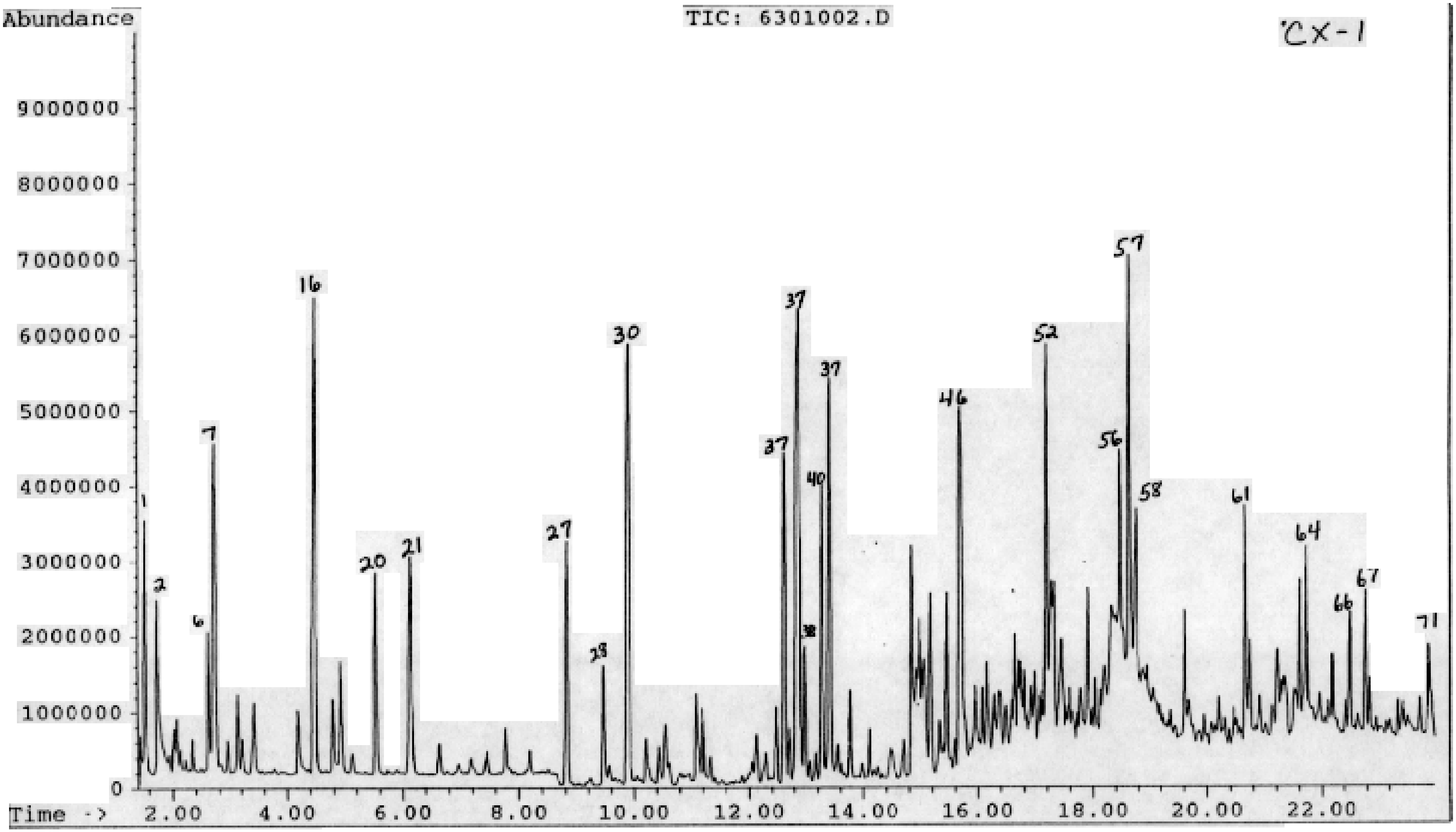
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67
71

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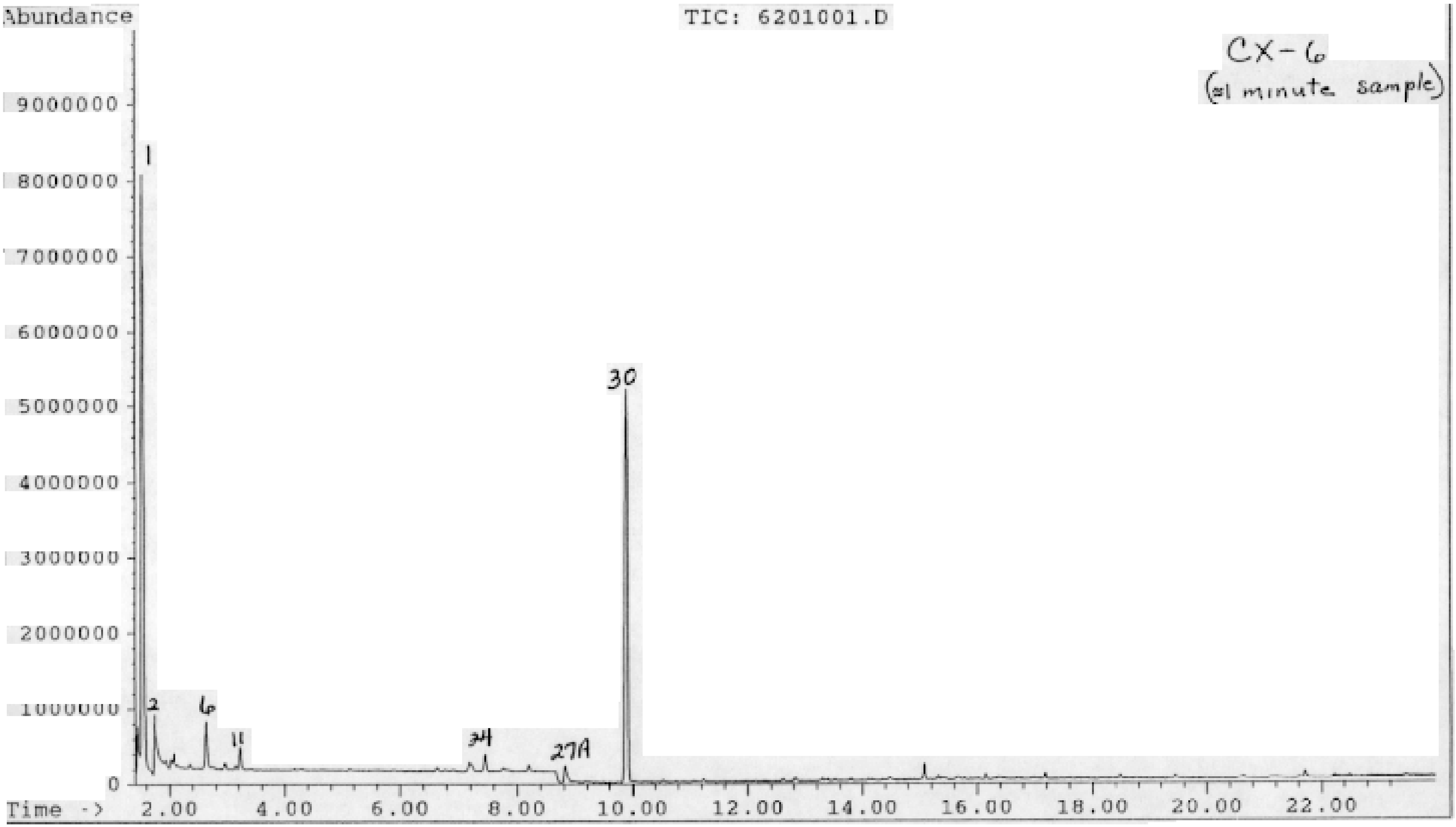
Vial Number 62



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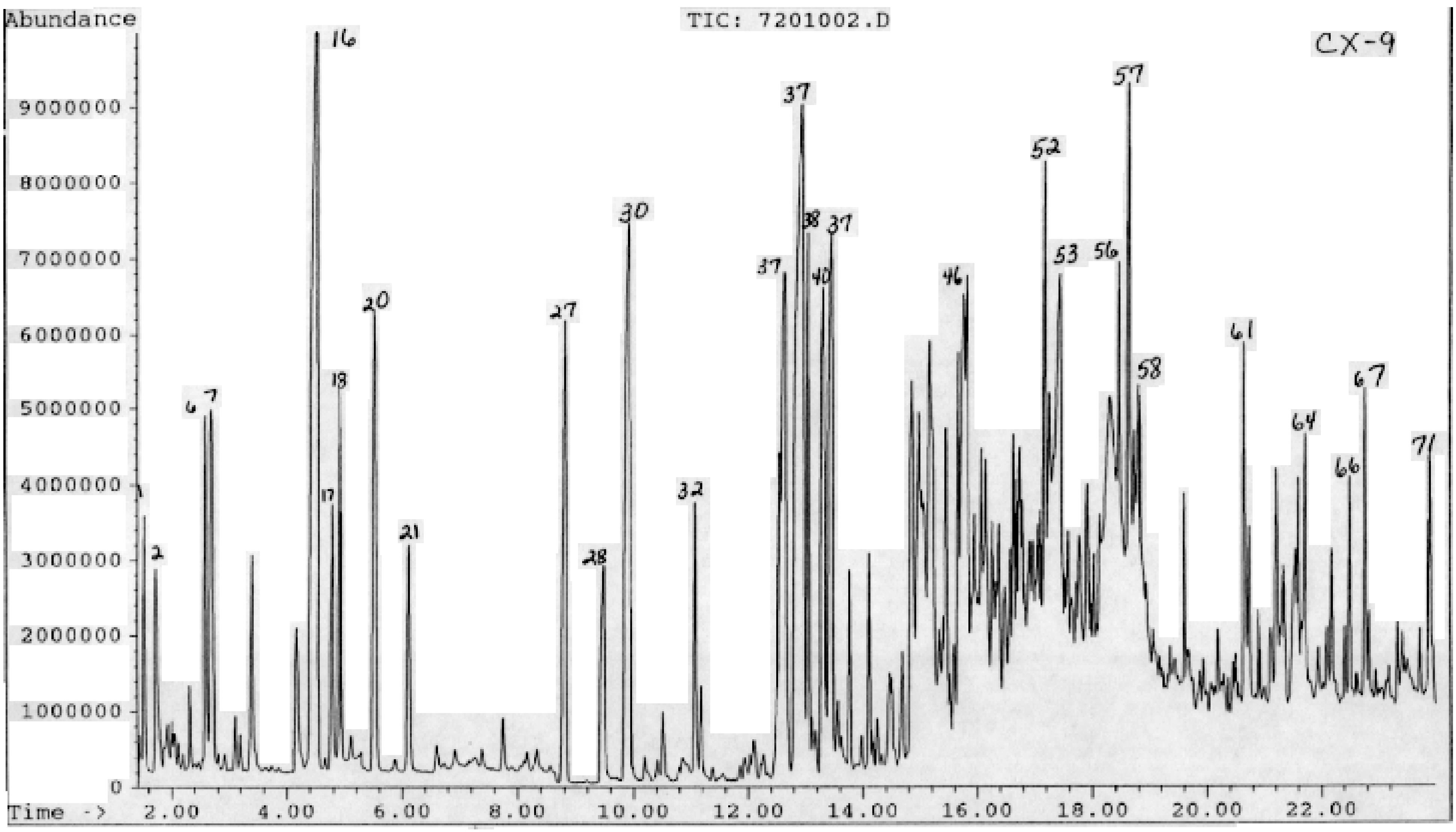

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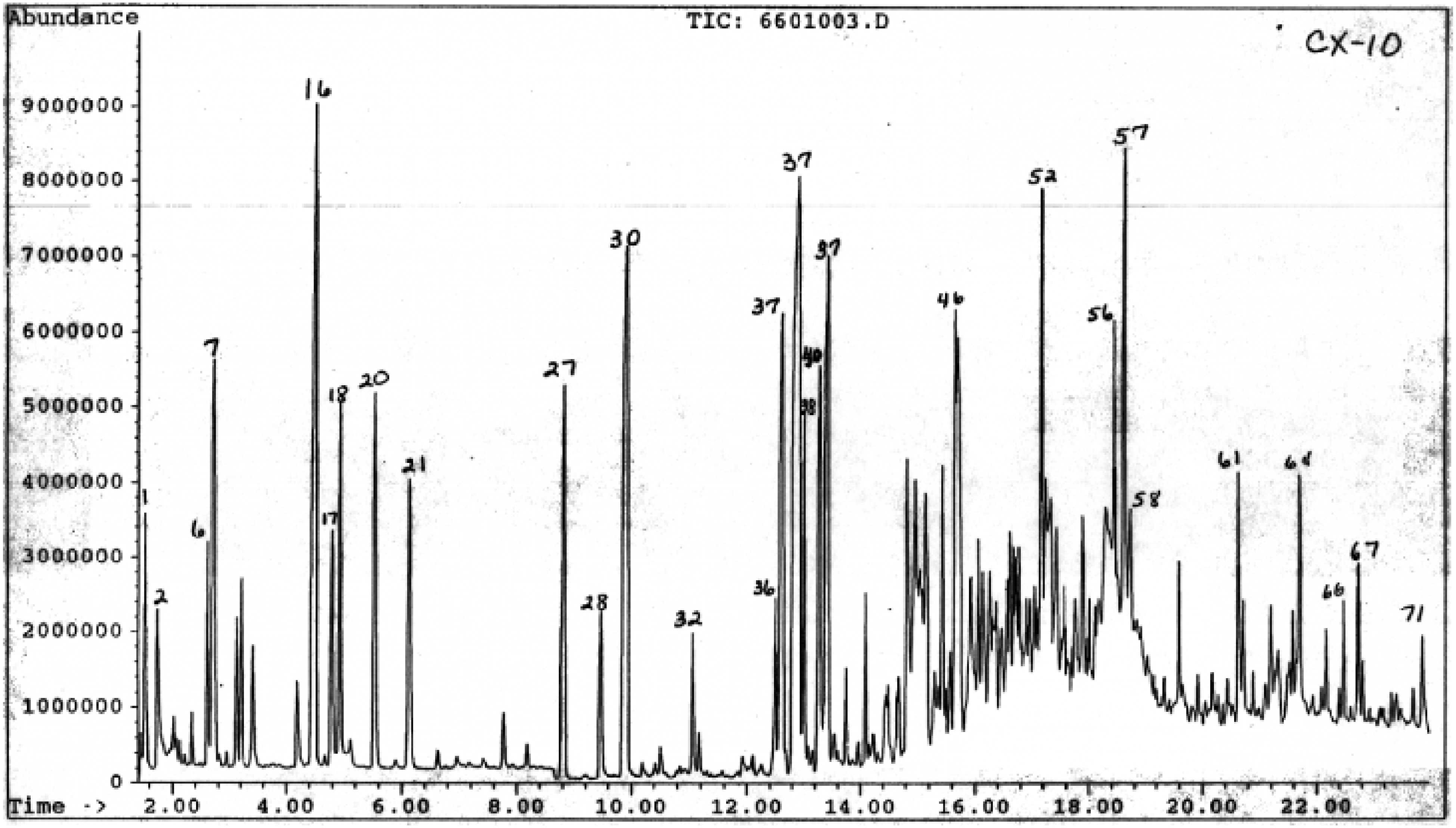

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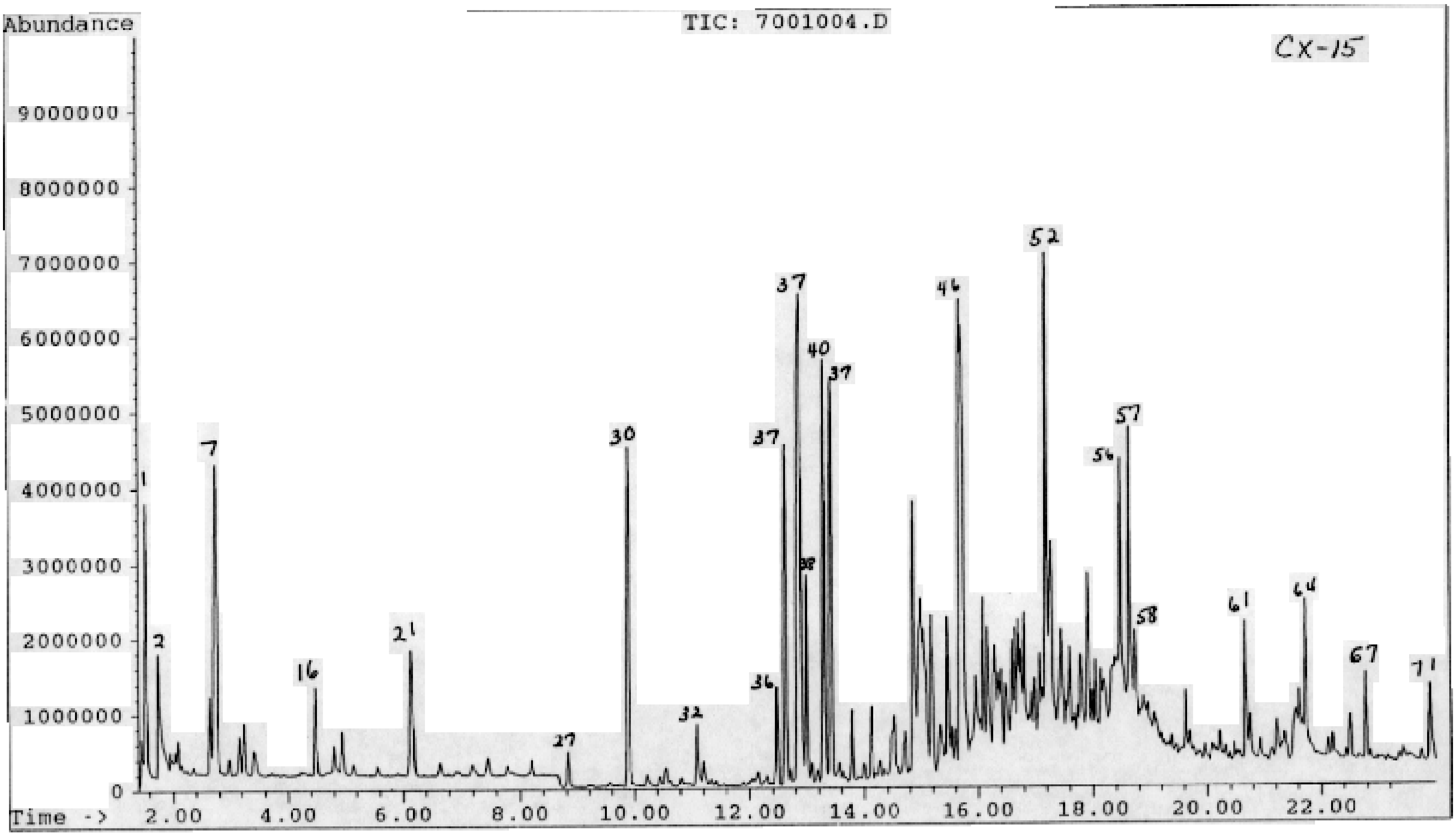

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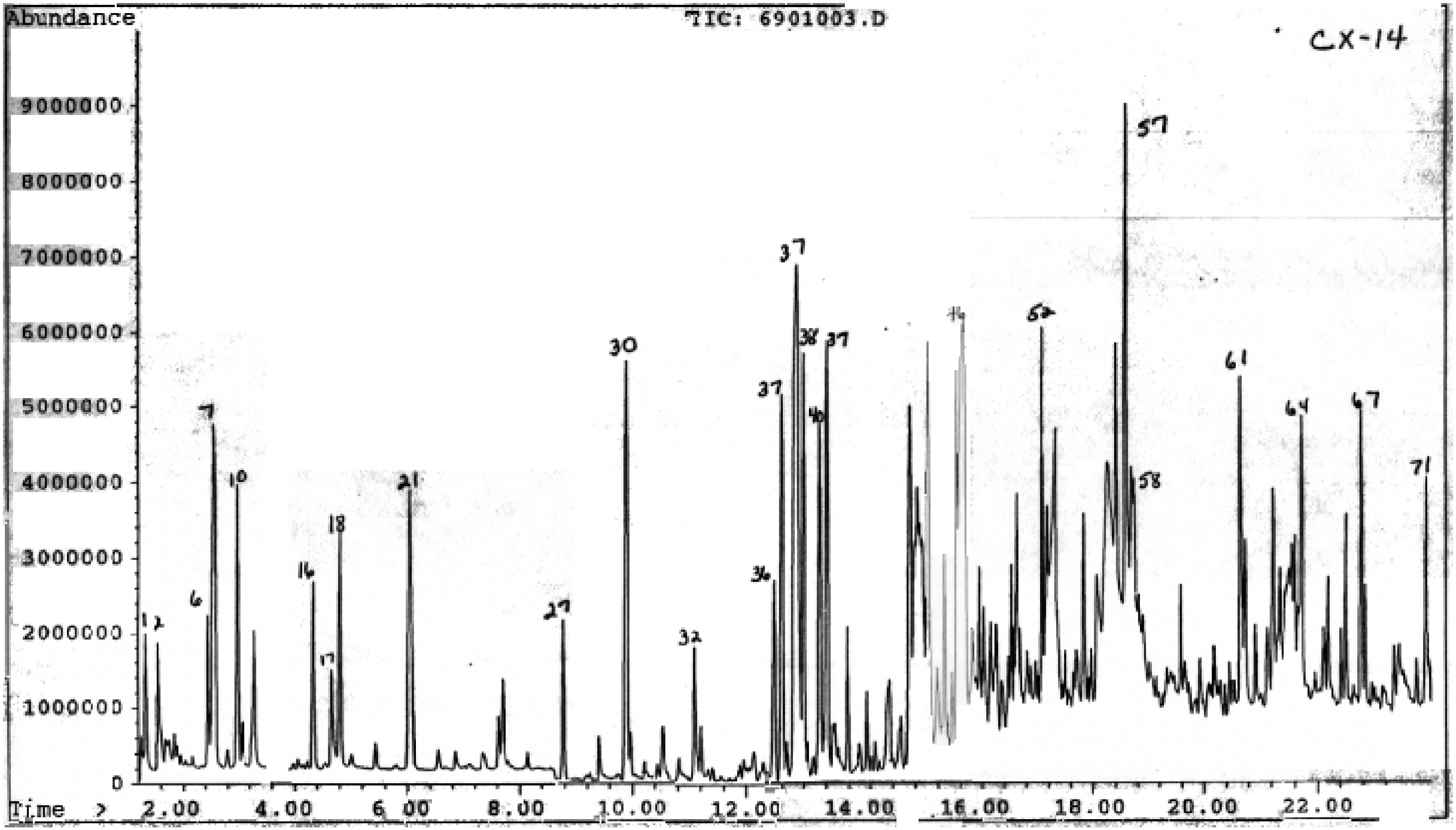

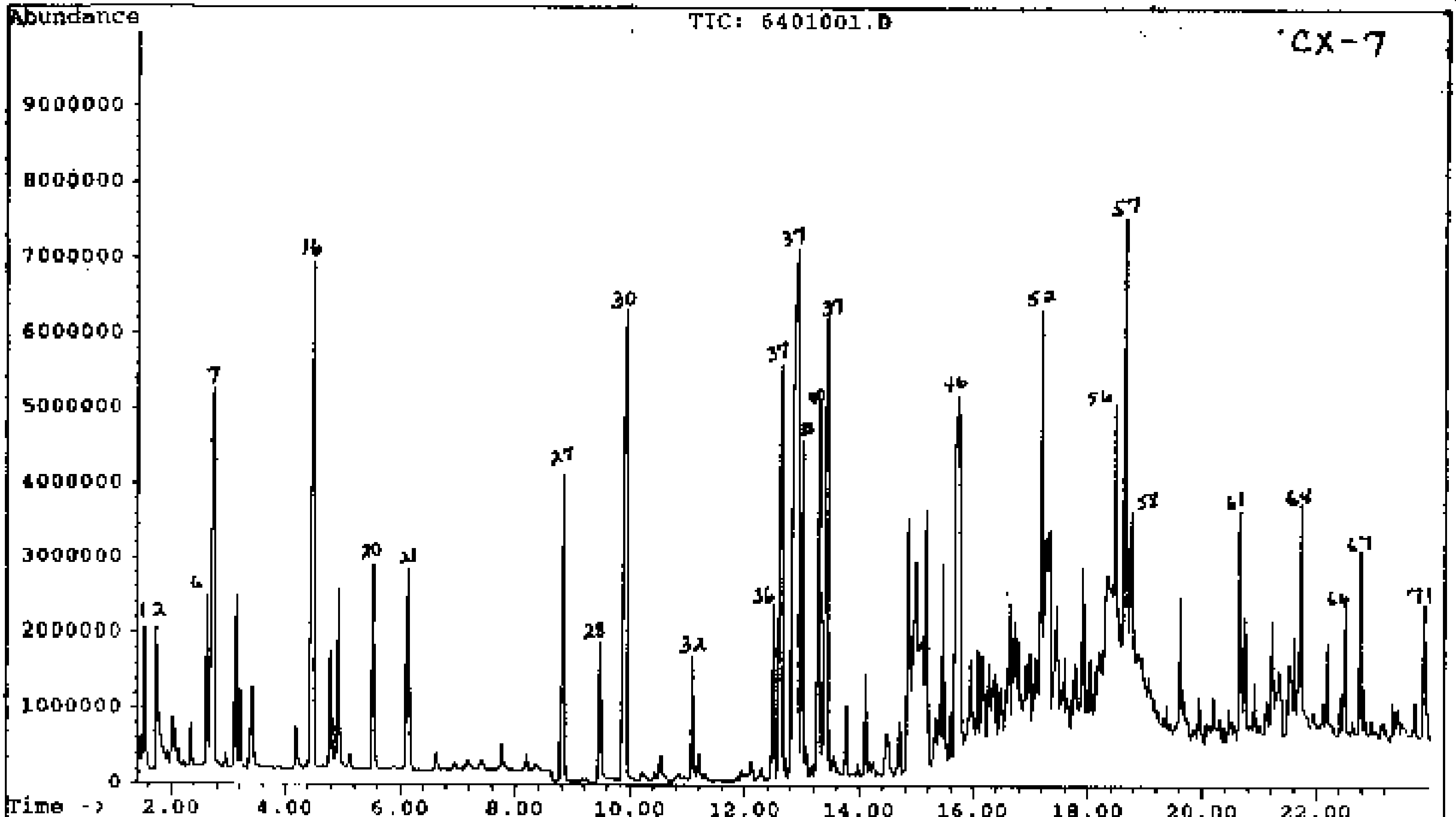

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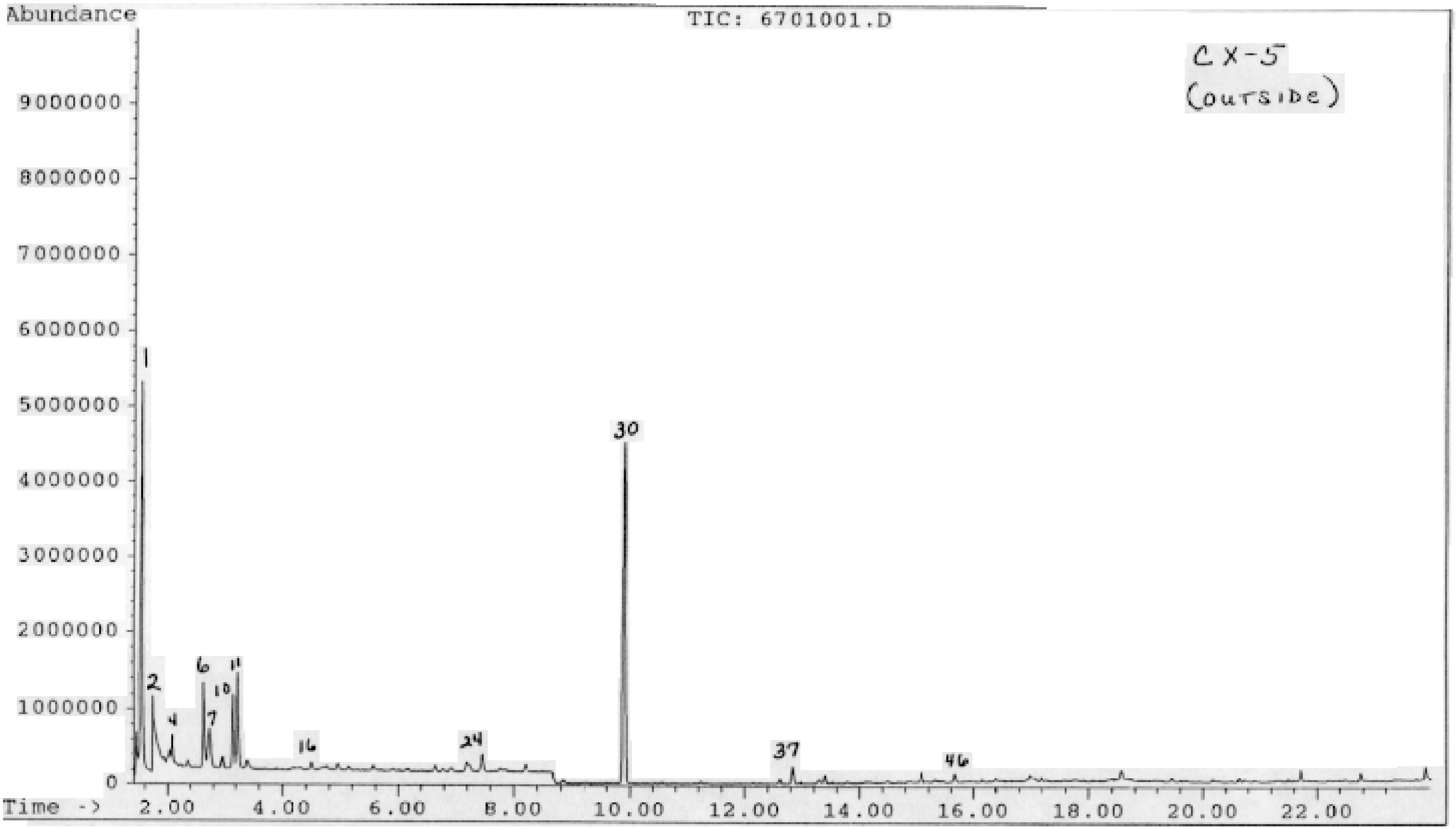

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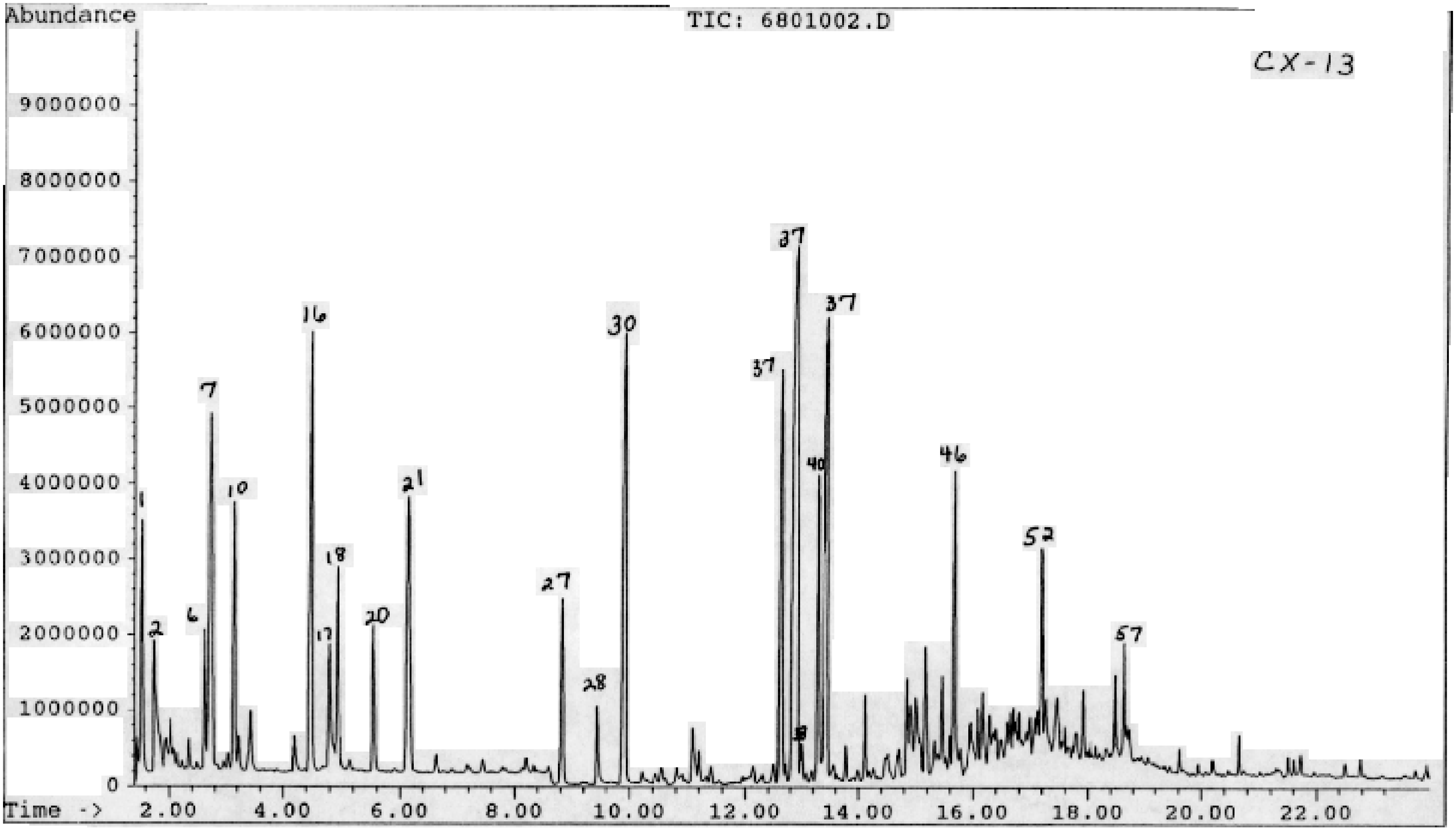
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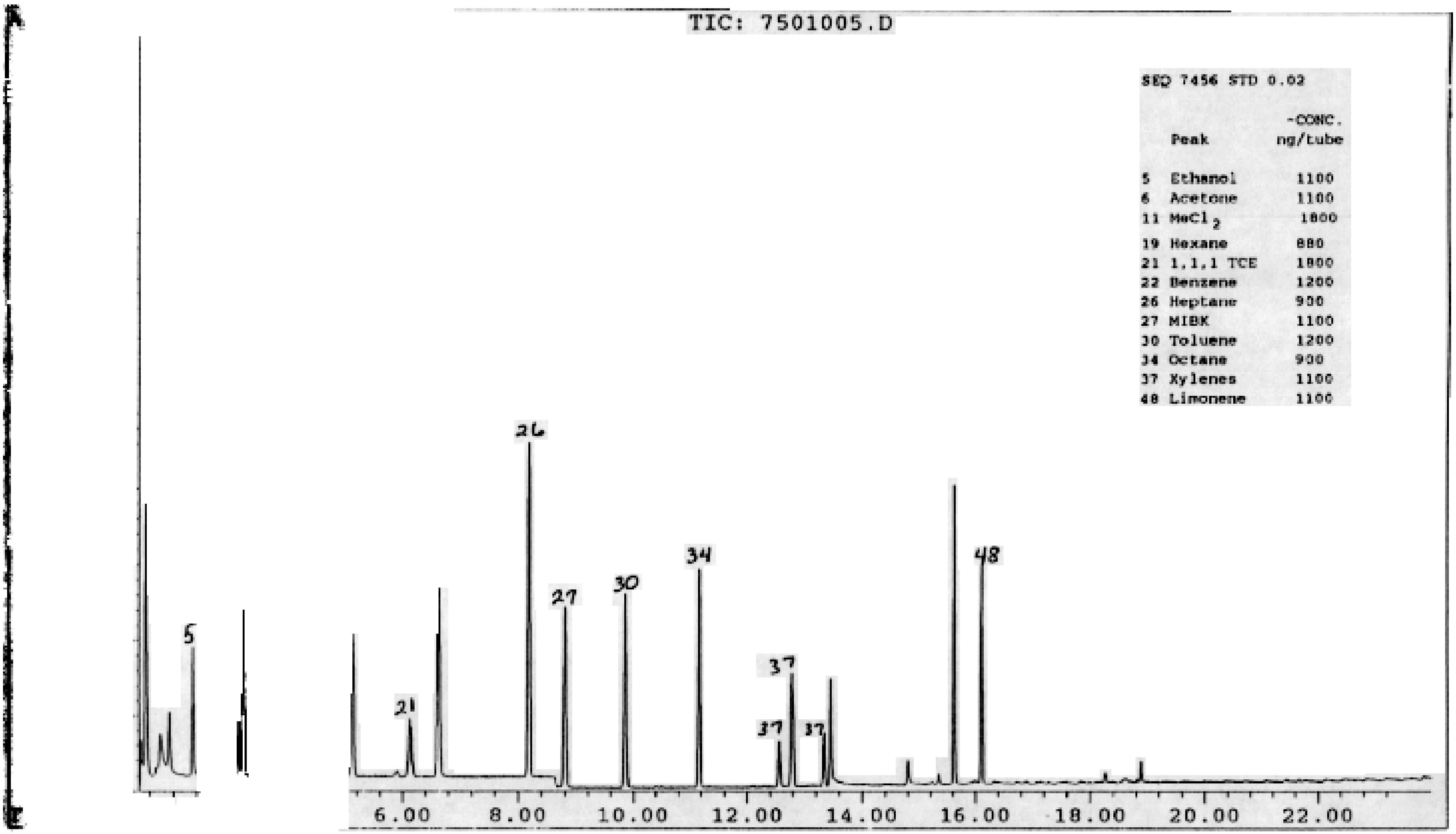
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SEQ 7456 STD 0.02
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6 Acetone 1100
11 MeCl2 1800
19 Hexane 880
21 1,1,1 TCE 1800
22 Benzene 1200
26 Heptane 900
27 MIBK 1100
30 Toluene 1200
34 Octane 900
37 Xylenes 1100
48 Limonene 1100
5
21
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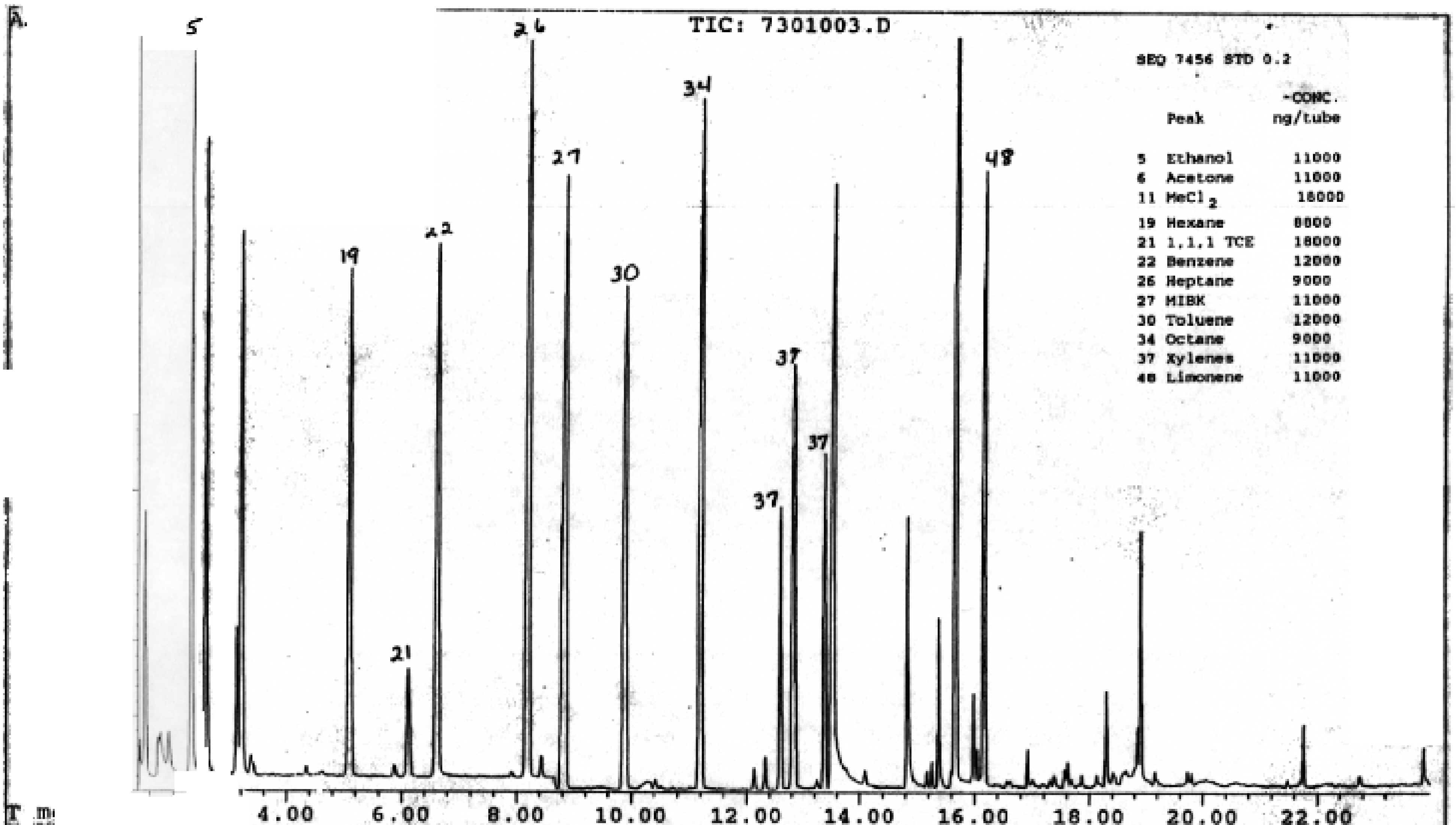
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SEQ 7456 STD 0.2
Peak
-CONC.
ng/tube
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21 1,1,1 TCE 18000
22 Benzene 12000
26 Heptane 9000
27 MIBK 11000
30 Toluene 12000
34 Octane 9000
37 Xylenes 11000
48 Limonene 11000
5
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