U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH
CINCINNATI, OHIO 45202

HEALTH HAZARD EVALUATION DETERMINATION
REPORT NO. 73-92-157

ALBUQUERQUE ALLERGY CLINIC
ALBUQUERQUE, NEW MEXICO
NOVEMBER 1974

I. TOXICITY DETERMINATION

It is the judgement of the National Institute for Occupational Safety and Health(NIOSH) that the employer and employees at the Albuquerque Allergy Clinic in Albuquerque, New Mexico, are not exposed to toxic concentrations of mercaptans and dimethyl sulfoxide. This determination is made because of the inability to develop a significant relationship between measured environmental levels and medical findings and is concluded for the following reasons:

(1) Environmental levels of mercaptans and dimethyl sulfoxide (DMSO) at the Juan Tabo office were not detectable at the lower limits of sensitivity of the analytical methods with such levels being well below concentrations believed to be toxic.

(2) The symptomatology, physical findings, and laboratory analyses give insufficient support to an etiology of excessive mercaptan and dimethyl sulfoxide exposure.

Additionally, although no measurements were made for other alleged substances such as dimethyl sulfide, dimethyl disulfide, and hydrogen sulfide, it is most unlikely that these agents are present in sufficient concentrations to be toxic. This is concluded because such substances are found in commercial natural gas in concentrations considerably less than the corresponding mercaptan fraction, which by NIOSH's measurements were not detectable.

II. DISTRIBUTION AND AVAILABILITY OF DETERMINATION REPORT

Copies of this report are available upon request from the Hazard Evaluation Services Branch, NIOSH, U.S. Post Office Building, Room 508, 5th and Walnut Streets, Cincinnati, Ohio 45202. Copies have been sent to:

a) Albuquerque Allergy Clinic, Albuquerque, New Mexico
b) U.S. Department of Labor - Region VI
c) NIOSH - Region VI

III. INTRODUCTION

Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6) authorizes the Secretary of Health, Education, and Welfare, following a written request by 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 National Institute for Occupational Safety and Health (NIOSH) received such a request from the employer and employees at the Albuquerque Allergy Clinic, Albuquerque, New Mexico, regarding exposure to natural gas and its reactive by-products from leaking gas lines.

IV. HEALTH HAZARD EVALUATION

A. Description of Process - Conditions of Use

The clinic facility located at 2133 Juan Tabo Road in Albuquerque is the site specified in the health hazard request. The clinic staff presently consists of the employer (an allergist) and five employees. The major activities of the clinic involve the care and management of allergy patients, although a small percent of the practice is general (family) medicine. The Juan Tabo office has been in operation for approximately six years. However, since June, 1973, a temporary facility has been set up in a mobile home outside Albuquerque and is now used as the principal office. This has taken place because of employer and employee illness which is allegedly due to leaking natural gas at the Juan Tabo office. At the time of the NIOSH investigation the Juan Tabo office was used only for x-ray procedures and some clerical work.

The Clinic on Juan Tabo Road lies on a large asphalt topped lot in the eastern part of Albuquerque, New Mexico. The building is a one story concrete-block stucco structure built by the Bob Hilton Construction Company approximately six years ago. The architect was Atrium-One of Albuquerque. The building consists of approximately 25 rooms (See Figure 1). The building is divided into three basic parts. Along the north wall are eight rooms most of which were used for examination. Room #1 was the employer's office. Room #7 was an examinating room but has been converted to storage. Storage materials included: Carpet cleaners, lab tubing, wheel chairs, light fixtures, air purifying equipment, purifil and odor oxidants used in the air purifying equipment, ethylene glycol, and various developing solutions used in developing x-ray films. These included acetic acid, sodium bicarbonate, sulfuric acid, denatured alcohol, alcohol-ether, hydrogen peroxide, potassium dichromate, starch and sodium hydroxide. Room #8 is the x-ray room. Room E on the diagram was the developing room. There was strong odor of acetic acid in the room and in the adjacent hallway. It was in this area that the employer and some employees experienced accentuated symptoms. Rooms #9 and #15 were also used for storage of various equipment and chemicals; examples of the chemicals found in Room #15 included: salt, sodium carbonate, phenol, benzoic acid, formaldehyde, glycerol,

and more air purifying chemicals. Rooms #10 through #14 were either examining rooms or rooms for storage of papers, etc. Room H is a utility room where the fresh air intake to the ventilation system is located. Room A was the waiting room and Room D was the nurses station. The clinical laboratory was located between Rooms #9 and #16 in the center of the building. The floors in most rooms are covered with a blue-green carpet glued to plywood subfloors. Some rooms have tile flooring while other rooms have polyethylene plastic layed down on top of the carpet. All interior walls are either (1) a formica covered sandwich partition material or (2) a beige latex paint covering sheet rock. The ceiling throughout the entire building is constructed of suspended, pressed, ceiling tile. The ventilation system in the building is somewhat unique. The heating and cooling unit is located on the roof of the building. Tempered air is blown into the plenum between the ceiling and the roof of the building. It is then distributed from the plenum to each individual room through vents in the ceiling tile. The air then flows downward into collecting registers laying adjacent to the exterior wall. An insulated air collection trench of approximately 1-1/2 by 2-1/2 feet in dimension lies around the entire perimeter of the building. Returning air is collected at a point near Room E and is ducted upward and back to the central heating-cooling unit on the roof. All structural components in the ceiling plenum have been covered with a 3-5 inch layer of polyurethane-type foam. The heating unit of the ventilation system is gas fired and there appears to be no chance of combustion by-products being introduced into the building. The outside of the building is surrounded with a 10-foot border of desert plants.

B. Evaluation Design and Methods

Both environmental and medical sampling techniques were utilized is accessing the alleged natural gas hazard.

Environmental Evaluation Methods

Air sampling of the clinic on December 6-7, 1974, for DMSO and mercaptans was performed using activated charcoal. Analysis was performed by the Western Area Occupational Health Laboratory in Salt Lake City using Gas Chromotography. Ten samples were taken inside and outside the clinic. Sampling was performed during all hours of the day and night. Neighbors of the clinic were interviewed to determine if similar complaints were to be found.

Medical Evaluation Methods

(1) Sampling Methods

Medical evaluation was carried out on all personnel working at the Albuquerque Allergy Clinic; this included the employer and five employees. The following evaluation took place:

(a) Complete medical history and physical examination
(b) General laboratory screening examination: Complete blood count (WBC, Hgb, Hct, Differential, Reticulocyte count), Eosinophil count, Urinalysis, Serum glucose, Creatinine, Glutamic oxaloacetic transaminase, Alkaline phosphatase.

(2) Analytical Methods

All blood and urine samples were analyzed by the clinical laboratory of the Albuquerque Indian Health Hospital.

C. Evaluation Criteria

The components of natural gas are alleged to have caused health problems in employees of the Clinic. A brief discussion of natural gas components as well as their respective toxicities is therefore appropriate.

Natural gas in its "natural" state is an odorless, colorless gas which is composed primarily of light-weight saturated hydrocarbons. Therefore, in order to be detectable, an odorant of some type is added to commercial natural gas. In the Albuquerque area, the supplier of commercial natural gas is the Southern Union Gas Company. Chromatographic analysis of their gas reveals it to contain about 90% methane, 5-7% ethane, 1% carbon dioxide, and trace amounts of nitrogen, propane and higher hydrocarbons.[1] The odorant used varies in composition but is composed primarily of different mercaptans (isopropyl mercaptan, t-butyl mercaptan, n-propyl mercaptan and other mercaptans) as well as some contaminants which may include dimethyl sulfide (DMS), hydrogen sulfide (H_2S), and others.[2] The approximate concentration of odorant is 17 ppm.

With regard to toxicity, methane and ethane (which comprise more than 95% of Albuquerque's commercial natural gas) may act adversely in high concentrations of exposure to suffocate the individual; in other words, the gas in very high concentrations exerts no physiologic effect other than to limit the amount of oxygen available in the inspired air, thus creating an hypoxic state in exposed individuals.[3] The other agents of potential toxicity in commercial natural gas include the various mercaptans as well as contaminants found in odorant additives. Furthermore, it is alleged that certain reactive products of natural gas components such as dimethyl sulfoxide (DMSO), dimethyl disulfide (DMDS), and others are present in toxic concentrations. Included below is a brief review of the toxicologic properties of these agents.

(1) Mercaptans - These thioalcohols (or thiols) have an unpleasant and very strong odor which is evident at extremely low concentrations. As the number of carbon atoms increase in the mercaptan, the odor strength diminishes hence, for odorant purposes, low carbon numbered mercaptans are used, eg. methyl, ethyl, propyl, and butyl. The threshold limit value (TLV) which has been established for mercaptans used as odorants is0.5 parts per million (ppm) or 1.0 mgm/m^3. Yet the ability to detect such substances by smell is at concentrations considerably less than the TLV, eg. butyl mercaptan (0.001 ppm), ethyl mercaptan (0.00026 ppm), methyl mercaptan (0.04100 ppm).[4] The toxic effects of mercaptans on humans are not widely reported in the medical literature;[5,6] presumably because the extremely low odor threshold and piercing odor

alerts the individual to his exposure. Exposure to the strong, offensive smell can cause headache and nausea. Further exposure to high concentrations of mercaptans can lead to unconsciousness, tachycardia, cyanosis, pulmonary edema, and seizures. One study of the toxicity of mercaptans in mice and rats through inhalation exposure demonstrated that concentrations of 64-78 ppm induced adverse central nervous system effects (restlessness, weakness, incoordinated movement, etc.) after 20-30 minutes of exposure. Higher concentrations of exposure in the animals produced central nervous system depression and respiratory paralysis.[7]

(2) Dimethyl sulfoxide (DMSO) - DMSO has found wide use in a variety of clinical trials evaluating its therapeutic potential. Consequently, a significant amount of research in man and animals is available regarding its toxicologic properties. Nearly all therapeutic trials of DMSO have utilized topical application. Animal toxicologic studies have noted a number of adverse effects on various body systems including the central nervous system, respiratory, cardiovascular, gastrointentinal, genitourinary, hematologic and musculoskeletal systems. However the concentrations of exposure have generally been quite high (i.e. in the mgm/kg range) and have often been by routes other than topical (eg. oral, intravenous, subcutaneous, intraperitoneal, etc.). In their review of DMSO side effects in man, Jacob and Wood[8] report "few troublesome side effects have been observed in man after administration of DMSO. Topical application of DMSO in over 4,000 patients for long periods of treatment produced the following effects: local dermatitis(3.5%), generalized dermatitis (0.1%), and headache and nausea(1.6%). No toxicity to the eye was attributable to DMSO and a battery of hematologic and body chemistry tests showed no significant abnormalities.[8]

(3) Dimethyl sulfide (DMS) and Dimethyl disulfide (DMDS) - Little information is available regarding these substances but they are generally felt to be toxic, probably similar to hydrogen sulfide in their manifestations.[9]

(4) Hydrogen sulfide (H_2S) - The acute effects from inhalation of high concentrations of H_2S (eg. 400 ppm and above) are most serious, resulting in central nervous system depression and increased respiratory rate with subsequent unconsciousness and respiratory paralysis. Subacute effects are attributed to exposures at lower levels of exposure and may bring about headache, dizziness, nausea, irritability, mucous membrane irritation, and pulmonary edema. Notable among the effects of low levels of exposure (50-300 ppm) over a prolonged time is eye irritation, described as itching, smarting, or a feeling of sand in the eyes. Destructive effects on the cornea may result in corneal clouding and blurred vision.[10] The effects of long term very low levels of exposure are unclear at present; some epidemiologic evidence is suggestive of increased risk to cardiorespiratory disease as well as suicide, but this needs much more substantiation. Whereas the TLV for H_2S is 10 ppm, the characteristic odor of the gas is detectable in concentrations as low as 0.025 ppm and is readily noted at 0.3 ppm.

D. Environmental Evaluation Results and Discussion

No mercaptans or DMSO were detected in any of the samples at the lower limit of sensitivity of the analytical method. The average lower limit of detectability for DMSO was 0.02 ug/M^3 (micrograms DMSO per cubic meter of air). The average lower limit of detectability for mercaptan was 0.03 ug/M^3. A note accompanying the lab report stated, "No sulfur compounds of any kind were detected on any of the charcoal tubes." It is thus concluded that on the days of sampling no perceivable amounts of mercaptan or DMSO were present in or around the clinic.

Results of the interviews were as follows:

1. A secretary in an office building across the street said she smelled natural gas "3-4 times a month." On the day of the interview she said she had smelled "gas" at her lunch break "coming from the (nearby) construction work" at which hot roofing tar was being poured.

2. Another man in the same office as (1) above stated that he had never smelled natural gas at this location.

3. A tenant in an apartment house directly west and directly adjacent to the clinic stated that she had never smelled natural gas in the two years she has lived in the apartment.

E. Medical Evaluation Results and Discussion

1. History and Physical Examination Results

Three of the six individuals interview noted only a few symptoms while the other three noted a wide diversity of symptomatology which they experienced when they were in the Juan Tabo office. Symptoms reported by the former group included detection of gas-like odor(1), headache(1), and burning of eyes(1). The latter group reported symptoms involving the following systems: central nervous system, respiratory, cardiovascular, gastrointestinal, genitourinary, musculosketetal, cutaneous and endocrine systems. Examples of the various symptomatology included detection of musty or gas-like odor, generalized headache, poor ability to concentrate, lapses in memory, hyperactivity and anxiousness, dizziness, tremors, emotional lability, shortness of breath, cough with sputum production, palpitations, belching, anorexia, weight loss, urinary frequency, muscle cramps, arthralgia, edema of hands and feet, skin rashes, and other symptoms as well. No particular chronologic pattern of symptomatology was elucidated in the symptomatology reported. Two of the individuals began noting the first onset of symptoms approximately two years ago.

All physical examination findings were considered normal with the following exception: dyshidrotic appearing rash on the volar surface of hands and feet of one individual and persistent falling backward in one individual when the Rhomberg position was held.

2. General Laboratory Examination

General laboratory screening examination revealed normal results with several exceptions (see Tables I, II, III). Blood and urine examination on employee L.C. showed the following abnormalities: Hemoglobin and hematocrit values which were above normal, an excessive number of red blood cells in the urine specimen, and an alkaline phosphatase value somewhat above normal. Although not outside of two standard deviations from the mean, two individuals (J.C. and M.D.) showed relatively high absolute eosinophil counts; however, both individuals gave a history of a long-term allergic diathesis.

The wide array of symptomatology in some of the personnel is puzzling in that it spans nearly all of the body systems and does not correspond entirely to the symptom complex associated with any single alleged agent of exposure. A mixed type of exposure (i.e. exposure to more than one agent) could possibly induce such wide symptomatology, but the non-detectable environmental levels of mercaptans and dimethyl sulfoxide (DMSO) do not support this possibility. It should be pointed out, however, that although there would appear to be negligible change in environmental mercaptan and DMSO concentrations from day to day, the NIOSH values represent only one day of sampling results. Furthermore, the medical history from some personnel suggests that there may have been much higher concentrations of natural gas constituents in the Juan Tabo office in the winter of 1972-1973.

The physical examination findings and laboratory results warrant some comment. The two physical examination abnormalities noted were felt to be unrelated to natural gas exposure. The laboratory abnormalities in L.C. were also felt to be unrelated to natural gas toxicity because this individual had worked only transiently in the Juan Tabo office whereas the other individuals had experienced consistent exposure without showing similar abnormalities. Also the significance of such abnormalities as they relate to natural gas exposure would, in itself, be questionable in nature.

At the request of the NIOSH medical officer, a number of references and other literature pertinent to the alleged hazards was sent to NIOSH by the employer of the Clinic; these were articles, etc. that he had researched from professional literature which he felt were pertinent to the allegation that natural gas and its reactive by-products were present in toxic concentrations at the Juan Tabo facility. A conference was held in which NIOSH specialists and outside consultants reviewed the medical and environmental findings as well as the pertinent reference material forwarded by the employer. It was the consensus of the conference participants that there appeared to be no significant relationship between measured environmental concentrations of mercaptans and DMSO and the medical findings.

V. REFERENCES

1. Communication from Southern Union Gas.
2. Communication from Southern Union Gas Company to Environmental Health Department of Albuquerque, November 30, 1972.
3. Patty, F.A., Industrial Hygiene and Toxicology, II, p. 1196, 1963.
4. "Mercaptans," I.L.O. Encyclopedia, p. 854-855.
5. Shults, W.T., et al. J.A.M.A., 211(13):2153, March 30, 1970.
6. Cristescu, V., Medical Bulletin Standard Oil Co., N.J., 5:78-84, 1941.
7. Fairchild, E.J., Stokinger, H.E., Ind. Hyg. J. p. 171-189, June, 1958.
8. Jacob, S.W., Wood, D.C., Am J. Surg. 114:414-426, Sept., 1967.
9. Sax, N.I., Dangerous Properties of Industrial Materials, p. 936, 1968.
10. Patty, F.A., Industrial Hygiene and Toxciology, II, p. 896-900, 1963.

VI. AUTHORSHIP

Evaluation Conducted and Report Prepared by:

David J. Burton
Industrial Hygienist
Western Area Occupational Health Laboratory
Salt Lake City, Utah

John W. Cromer, M.D.
Medical Officer
Medical Services Branch
Cincinnati, Ohio

Originating Office:

Jerome P. Flesch
Chief, Hazard Evaluation Services Branch
Cincinnati, Ohio

TABLE I

BLOOD ANALYSIS

NAME	SEX	Hgb	HCT(%)	WBC	Bd	Seg	Lym	Eos	Baso	Mono	Plts	Retic	Eos. Count
N.A.	F	15.2	47	6100		53	39	2		6	Adq.	1.9*	70
J.C.	M	16.2	48	5700	1	48	35	6	3	7	Adq.	2.0*	405**
L.C.	F	17.6**	53**	7600	6	68	19			7	Adq.	1.3	88
M.C.	F	15.1	47	6000	2	69	23			6	Adq.	2.1*	53
M.D.	F	15.4	46	6800		48	40	5		7	Adq.	1.2	493**
M.F.	F	14.4	43	5900	1	50	42	1	1	5	Adq.	2.2*	53

*Within two standard deviations from the mean ($Retic_{2\sigma}$ = 0.56 - 2.72%)

**Exceeds two standard deviations from the mean (Hgb_{Female} = 14 $\pm$ 2 gms; Hct = 44 $\pm$ 5%)

TABLE II

URINALYSIS

NAME	S.G.	pH	Glu	Pro	Ket	WBC	RBC	Bile
N.A.	1.024	6.0	neg	neg	neg	occ	0	neg
J.C.	1.009	6.0	neg	neg	neg	0	0	neg
L.C.	1.027	6.0	neg	neg	neg	0	100+*	neg
M.C.	1.013	6.0	neg	neg	neg	0	0-2	neg
M.D.	1.017	6.5	neg	neg	neg	occ	4-6	neg
M.F.	1.007	6.5	neg	neg	neg	occ	1-3	neg

*Exceeds normal range of 1-3 RBC/HPF

TABLE III

BLOOD CHEMISTRY

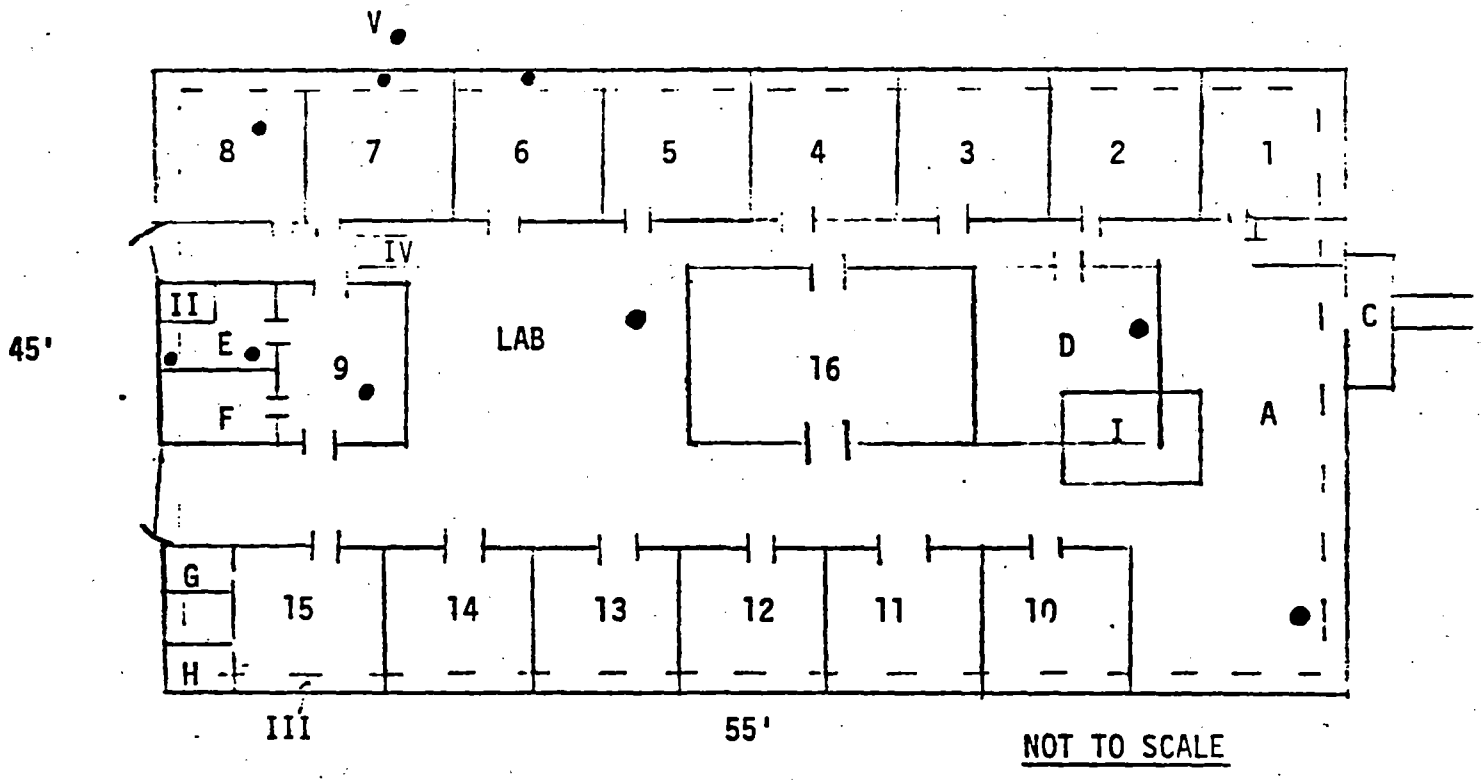
Name	Glucose (mgm %)	Creatinine (mgm %)	SGOT (F Units)	ALK Phos. (KA Units)
*N.A. #1	102	0.9	22	20
*N.A. #2	100	0.9	22	18
*J.C. #1	100	1.1	24	19
*J.C. #2	99	1.1	22	20
L.C.	87	0.8	22	29**
M.C.	105	0.8	20	13
*M.D. #1	76	1.1	18	14
*M.D. #2	73	1.1	22	14
M.F.	87	0.8	22	17

*Split samples were submitted for N.A., J.C., and M.D. under pseudonyms to determine laboratory reliability in the analyses. Additionally, these three individuals were the most symptomatic of the six office personnel.

**Exceeds normal range of 4-20 K.A. units.

APPENDIX I

FIGURE 1



JUAN TABO OFFICE

A. Waiting Room
B. Storage
C. Entry Way
D. Nurses Station
E. Film Developing & Utility, Return Air Duct
F,G. Bathroom
H. Utility Room, Fresh Air Inlet to Ventilation System

1. Employer's Office
2-6. Exam Rooms
7,9,15. Storage
8. X-ray Room
10-14. Office, Exam, Storage
16. Medical Records

I. Heating-Cooling Unit on Roof
II. Return-Air Riser, Duct Back to Unit
III. Return-Air Trench
IV. Entry to Ceiling Plenum
V. Disconnected Gas Line
● Sampling Locations