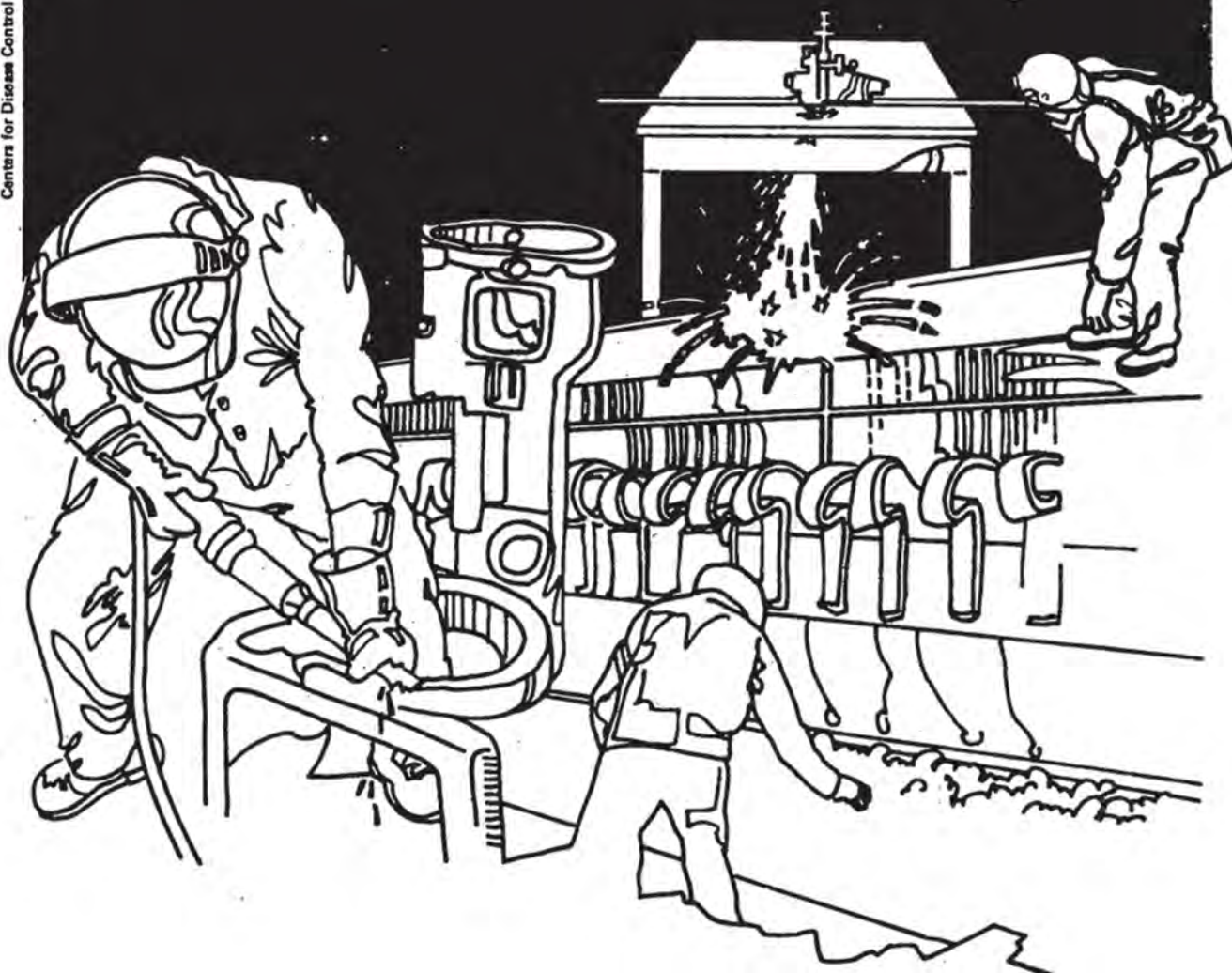


NIOSH



Health Hazard Evaluation Report

HETA 82-365-1282
MGM GRAND
HOTEL & CASINO
LAS VEGAS, NEVADA

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.

Mention of company names or products does not constitute endorsement by the National Institute for Occupational Safety and Health.

HETA 82-365-1282
MARCH 1983
MGM GRAND HOTEL & CASINO
LAS VEGAS, NEVADA

NIOSH INVESTIGATOR:
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I. SUMMARY

On August 23, 1982, the National Institute for Occupational Safety and Health (NIOSH) received a request from the local union to evaluate exposures to smoke produced by pyrotechnics used during the show, "Jubilee", in the Ziegfeld Showroom of the MGM Grand Hotel, Las Vegas, Nevada. Of concern were respiratory difficulties, sinus problems, eye irritation, and nausea occurring among the approximately 150 stagehands, wardrobe attendants, and entertainers (performers).

During a visit on September 16 and 17, 1982, a NIOSH physician met with MGM and union officials, and interviewed 17 concerned workers and ex-workers individually at the union hall. Sixteen (16) workers had had respiratory and/or eye irritation from the smoke. Nine (9) reported symptoms suggestive of bronchitis. Skin irritation was also mentioned. When appropriate, private physicians were contacted.

The results of air monitoring supplied by the Department of Occupational Safety and Health, State of Nevada (DOSH), showed time-weighted average concentrations of 1.34, 0.02, and 1.81 milligrams total particulate per cubic meter of air (mg/m^3) derived from approximately 4-hour samples. Short term concentrations existing during pyrotechnic use were considerably higher and probably approached or exceeded $10 \text{ mg}/\text{m}^3$. These levels were all below the Occupational Safety and Health Administration (OSHA) inert dust standard of $15 \text{ mg}/\text{m}^3$. However, the dust from the pyrotechnics is probably alkaline and NIOSH has found that alkaline dusts do cause irritative problems at levels acceptable for inert dust. A review of information supplied by the manufacturer of the pyrotechnics suggested the residue from the smoke would be an alkaline dust consisting of potassium carbonate and strontium hydroxide. Sulfate particulates are probably also present.

After receiving an interim report on the NIOSH visit, MGM made extensive modifications in the use of pyrotechnics during the show and have allowed the use of respirators by some of the stage hands. A telephone survey of the workers previously interviewed confirmed there had been improvements in air quality during the show with symptomatic improvement in most of the interviewed workers.

Based on employee interviews and review of past medical history, DOSH environmental sampling findings, and a product report from the company manufacturing the pyrotechnics, NIOSH determined that at the time of the interviews a health hazard existed due to the smoke from the pyrotechnic displays. Subsequent changes in the show have improved the situation. Recommendations for further improvement are included in this report.

KEYWORDS: SIC 7922 (Theatrical Producers), pyrotechnics, alkaline dust, potassium carbonate, strontium hydroxide, sulfate particulates, bronchitis.

II. INTRODUCTION

On August 23, 1982, the National Institute for Occupational Safety and Health (NIOSH) received a request from the President of Local 720 of the International Alliance of Theatrical Stage Employees and Moving Picture Machine Operators of United States and Canada (I.A.T.S.E.), to evaluate exposures to the smoke produced by the pyrotechnics used during the show, "Jubilee", in the Ziegfeld Showroom of the MGM Grand Hotel, Las Vegas, Nevada. Of concern were respiratory difficulties, sinus problems, eye irritation, and nausea among the approximately 150 stagehands, wardrobe attendants, and entertainers (performers).

On September 16, 1982, a meeting was held with the Personnel Director and Assistant Personnel Manager of MGM together with the Union President of Local 720, I.A.T.S.E. On September 15 and 16, 1982, the NIOSH physician interviewed concerned workers and ex-workers individually at the union hall. Based on the information obtained during these interviews and contacts with private physicians following the interviews, a review of information supplied by the manufacturer of the pyrotechnics, and the results of air monitoring supplied by The Department of Occupational Safety and Health, State of Nevada (DOSH), an Interim Report No. 1 was sent to all concerned parties in October 1982 suggesting that a health hazard did exist to workers and performers in the show.

Although MGM has remained reluctant for NIOSH to make a site visit and do further air sampling, on receipt of the Interim Report they made extensive modifications in the use of pyrotechnics during the show and have allowed the use of respirators by some of the stage hands. A telephone survey of the workers previously interviewed confirmed there had been changes for the better in air quality during the show. Because of the changed situation, this health hazard evaluation is being concluded with this report. If the changed conditions require further investigation either MGM, the union, or a group of workers and/or performers should submit a new request.

III. BACKGROUND

A. The Show

The current show has been running about 14 months with rehearsals having started before that. It is the first show to be put on in the Ziegfeld Showroom since the MGM fire in 1980. There are two shows of approximately two hours duration nightly Sunday through Friday and three shows on Saturdays. Individual workers and performers work six nights weekly and get about two weeks vacation during the year. The pyrotechnics were used four times during the show, once during the "buzz saw" or "Flickers" scene which occurs on stage right; once during the "Sampson and Delilah" scene; and twice during the sinking of the Titanic, which occurs upstage. In the "buzz saw" the set is pulled off stage. In the Titanic the set is lowered on the stage elevator into the basement area. There are specific individuals responsible for covering the spent pyrotechnics. Several exhaust fans are said to be located in the ceiling immediately behind the proscenium which separates the space above the stage from the space above the audience.

Stagehands work on the stage itself (the "deck") moving sets, on a partly enclosed elevated platform off stage right to control the stage elevators, on an even higher elevated platform (the "rail") off stage right to raise and lower the sets, or in the basement. Other duties include building and repairing sets. The wardrobe attendants work in the dressing and wardrobe rooms two floors down from stage level, backstage, in the wings, and in an elevated "loft" to the back of the stage. Besides helping the performers dress and make the quick costume changes required by the show, they are responsible for repairs to the costumes, washing the costumes, and sending out those that require dry cleaning.

B. Previous Investigation by Department of Occupational Safety and Health, State of Nevada (DOSH)

DOSH was called in to investigate the problems. After observing the show, the DOSH hygienist took three personal breathing zone samples of four hours duration on November 17, 1981. These involved the Buzz Saw sequence, the Bull Rider sequence, and the Titanic sequence. Samples were analyzed for total particulates (1.34, 0.02, and 1.81 mg/m³, respectively) and for barium content. No barium was found. The total particulates were compared to the OSHA nuisance dust standard of 15 mg/m³ as DOSH had no more appropriate standard to use. In responding to the DOSH investigation, MGM found that turning off the air conditioning backstage briefly while the exhaust fans were turned on improved the speed with which the smoke was removed from stage level. This is now said to be standard procedure.

IV. DESIGN AND METHODS

Because DOSH had previously sampled and found no citable problem, MGM was reluctant to allow another on-stage investigation. Considering this, and the impracticality of interviewing during a show, the NIOSH investigation was conducted at the union hall. Workers (stage hands, wardrobe attendants, or performers) and ex-workers who wished to be interviewed were individually interviewed in private. When appropriate, permission was obtained and private physicians contacted. One worker who was unable to attend was interviewed by telephone. As all interviewees were volunteers, this cannot be considered a random sample suitable for inferring incidence data for all exposed workers.

Because of the extensive modifications attempted following the Interim Report, an attempt was made to contact all interviewees by telephone to obtain their assessment of how effective the changes were in reducing the problem.

V. EVALUATION CRITERIA

A. Report from the Manufacturer

Review of the information supplied on the pyrotechnics by the manufacturer included a discussion of the general composition of the various types of mixtures used and the expected decomposition products. Exact formulas were not given as they are considered trade secrets.

Gaseous Products of Combustion: Approximately 54% of the decomposition products are gaseous. The bulk of gas produced is carbon dioxide and nitrogen, both normal constituents of air. Smaller amounts of carbon monoxide and hydrogen sulfide are also produced. The company referred to tests on black powder which did not show production of oxides of sulfur or of nitrogen.

Solids and "Smoke": The rest of the decomposition products are solid, the bulk remaining as a solid residue with the rest constituting the "smoke" (airborne particulates) which eventually settled out as a fine grayish dust. Solids and particulates consist of aluminum and titanium oxides, strontium carbonate, and carbon, all rather inert chemically and considered nontoxic; strontium and potassium chlorides and potassium sulfate, all neutral salts with no anticipated toxicity at anticipated exposure levels (however see later); and strontium hydroxide and potassium carbonate, both of which would be alkaline. The strontium hydroxide would slowly react with the carbon dioxide in the air to form strontium carbonate (similar chemically to limestone), but the potassium carbonate would remain and have effects similar to washing soda (sodium carbonate) dust. Thus the end result of the pyrotechnics are an alkaline smoke which eventually settles as an alkaline dust.

B. Environmental

The three sources of criteria often used to assess the workroom air concentrations of chemicals are (1) recommended Threshold Limit Values (TLVs) and their supporting documentation as set forth by the American Conference of Governmental Industrial Hygienists (ACGIH), 1981, (2) the NIOSH criteria for recommended standards, and (3) the Occupational Safety and Health Administration (OSHA) standards (29 CFR 1910.10000), July 1980. None have standards for alkaline dust as such. OSHA has a standard for Inert or Nuisance Dust. The ACGIH has a TLV for Nuisance Particulates. NIOSH does not have a comparable recommended standard.

| | Permissible Exposure Limits 8-Hour Time-Weighted Exposure Basis | |
|---------------------------------|---|----------------------|
| | <u>OSHA</u> | <u>ACGIH/TLV</u> |
| Total dust (particulate)..... | 15 mg/m ³ | 10 mg/m ³ |
| Respirable fraction (dust)..... | 5 mg/m ³ | 5 mg/m ³ |

mg/m³ = milligrams of substance per cubic meter of air

Occupational health standards are established at levels designed to protect individuals occupationally exposed to toxic substances during an 8 to 10-hour day, 40-hours per week for a normal working lifetime. In most cases brief exposures may exceed these levels somewhat without harm.

This standard is not quite appropriate for the "smoke" as nuisance dust assumes that the dust be chemically inert and contain no substances (such as silica) which will cause long term lung damage. Alkaline dusts, by definition, are alkaline (chemically active). Although no specific standards have been published, in a study in a soap factory (HHE 79-48-626) the NIOSH investigators found problems with irritation of skin and mucous membranes at air concentrations which would be acceptable under the nuisance dust standards. Soap dust is an example of an alkaline dust. As detailed in the discussion of the manufacturer's report, the dust from the pyrotechnics is expected to be alkaline.

C. Toxicology

Alkaline dust¹ -- Strongly alkaline solutions tend to gelatinize tissue and so can cause deep tissue destruction of any body surface with which they come in contact. They are also very drying, being able to draw moisture both from the tissue and from the air. Thus when alkaline dusts come in contact with moist body surfaces, as the eyes and respiratory passages, they form solutions which are at least irritating. Prolonged skin contact, particularly with moist skin, can also be irritating. The carbonates, being inherently less alkaline than many alkaline compounds, are much less likely to cause tissue destruction.

Sulfate particulates -- In the recent literature there is a suggestion that sulfate particulates can cause adverse effects on the bronchi and lung function.^{2,5} The exact mechanism of this action is unclear, but may relate to the ability of the particles to carry other pollutants more deeply into the respiratory system.

VI. RESULTS AND DISCUSSION

A. DOSH Findings

DOSH's three personal breathing zone samples of four hours duration showed 1.34, 0.02, and 1.81 mg/m³ total particulates for the Buzz Saw sequence, the Bull Rider sequence, and the Titanic sequence, respectively. No barium was found. The total particulates were compared to the OSHA Nuisance Dust standard of 15 mg/m³. As no standard exists for alkaline dust, DOSH had no more appropriate standard to use.

Also as exposures sometimes were of short duration, short term peak exposure samples would better characterize exposure problems than would long term samples. For example, the 1.81 mg/m³ sample (a time-weighted average concentration) was actually derived from two 20-minute exposures and 3 hours and 20 minutes of very low or negligible exposure. This back calculates to a concentration of 9 mg/m³ during the actual high exposure periods, which is only slightly lower than the 10 mg/m³ suggested by the latest ACGIH recommendation for nuisance particulates.

Because the dust being measured is being produced by explosive combustion there is a good possibility that a fair proportion of the particles will be of respirable size. Thus the criterion of 5 mg/m³ might be a more appropriate guide than the criterion for total dust.

B. NIOSH Findings -- Las Vegas Visit

In all, 16 stagehands, wardrobe attendants, and performers were interviewed individually. One ex-worker was also seen. The interviewing was done on a self-selected group of workers at the union hall during the workers' off time (approximately 10% sample). Of the 16, three were smokers, four were ex-smokers, and nine were nonsmokers.

A couple of the interviewees had had occasion to taste the dust which had collected on objects backstage. It was bitter, the taste associated with alkalis. (Acids give a sour taste, neutral salts a salty taste.)

Respiratory complaints -- Only one of those interviewed had no appreciable problem with the smoke from the show. Of the other 15, nine had symptoms suggestive of bronchitis (a persistent cough productive of phlegm) and the other six complained of various irritative symptoms, primarily eye, nose, and/or throat irritation, sinus congestion, metallic and/or bitter taste, increased problems with allergies, and/or feelings of fatigue. These were generally identified as clearing completely when away from the show for a week or two. The stage was identified as clearing relatively quickly, but the elevated areas (stage elevator controls, the loft, and the rail) continued to have problems throughout the show. Some of the stagehands had obtained cartridge respirators on their own and found them of considerable value in protecting them from the ill effects of the smoke. However, one stagehand mentioned that, although the respirator helped, he was unable to wear it during some of his exposed time because it interfered with the increased breathing necessitated by his strenuous activity.

Skin problems -- An additional problem mentioned was skin rashes among wardrobe attendants and performers from exposure to the dust and smoke or to costumes exposed to them. This improved after the individual washed up. Alkaline residues from the smoke could cause this type of problem. Along this same line, it was mentioned that the residue from the pyrotechnics was quite irritating if not washed off promptly.

Comparison with prior studies -- In comparing findings in this study with a prior NIOSH study in a soap factory (HE 79-48-626) most of the symptoms reported were similar except bronchitis was not a problem in the soap factory.

Other problems -- It was mentioned that the ventilation in the wardrobe and dressing rooms was poor. It was felt to be "close", sometimes hampered by noxious gases from a parking garage, from lowering the pyrotechnics for the sinking of the Titanic into the

basement, or from the basement toilets. The door from the garage was said to be left open at times to facilitate moving sets. On occasions the toilets overflow or allow the back-up of sewer gas. Also the toilet rooms are used for smoking. Reportedly little or no exhaust ventilation is provided.

C. Follow-up Telephone Survey

Twelve (12) of the 16 interviewees were contacted by telephone. They confirmed that extensive changes had been made in the amount of pyrotechnics used in the show and consequently the amount of smoke present. One did not feel in a position to have observed how effective these changes had been. Of the other 11, four noted considerable improvement in their prior health complaints, six noted at least some improvement in their prior health complaints, and one felt too busy to have really noticed. The opinion was expressed that at least part of the improvement may have been due to cold weather as the problems had usually improved some during cold weather in the past.

The opinion was also expressed that the more important problem at this time is the odor of sewer gas in the dressing and wardrobe rooms, at times being bad enough to permeate the stage and the casino. As the basement areas were not part of the original evaluation request and almost no data is available to NIOSH on the problem, no opinion can be given without study. This would require a separate request. However, one can conclude that the smoke problem has improved if it is now felt that sewer gas is the more important problem.

VII. CONCLUSIONS

There is a health hazard due to the alkaline dust produced by the pyrotechnics in the "Jubilee" show. There is also a possibility that the potassium sulfate which is probably present in the smoke is at least in part responsible for the bronchitis. A 10% incidence of respiratory problems, some being a bronchitis, is excessively high. This represents a minimum incidence although all of the more serious cases may be included in this sample. The rashes mentioned by wardrobe attendants and performers may also be due in part to the alkaline dust.

The health problems due to the smoke have improved since the considerable changes made in the amount of pyrotechnics used in the show.

There is probably a problem with the ventilation in the dressing and wardrobe rooms, but NIOSH would have to receive an additional request for evaluation and study the problem before any conclusions can be drawn.

VIII. RECOMMENDATIONS

1. Although not previously recommended, changing the show by eliminating much of the pyrotechnics has proved to be an effective means of greatly reducing the smoke problem.

2. A thorough review of the ventilation should be done by a qualified ventilation expert who has become thoroughly familiar with the unique problems presented by the theatrical setting. Trying to correct ventilation problems piecemeal is likely to cause one system to work at cross purposes with another. It would appear desirable to supply make-up air into the areas where workers are and allow the smoke to move into the unoccupied space above the stage and thence out the exhaust fans. As mentioned at the conference, exhaust fans affect airflow very little except very close to their inlets and at their outlets.
3. The proper use of respirators requires a well thought out respirator program to insure appropriate choice of respirators, proper respirator fit, and proper respirator maintenance (see OSHA regulations contained in 29 CFR Part 1910.134). Because negative pressure respirators increase the effort required to breathe, some persons, particularly those required to do hard physical labor, may find the increased resistance intolerable. Also a respirator program would not be feasible for the performers who are also exposed. There will probably be a few jobs which will require the use of respirators for short periods, but by and large changes in pyrotechnics use and ventilation are the preferable control measures.
4. If further study of the smoke by NIOSH is desired, the hotel management, an official of the union, or three or more workers in concert should submit a new Health Hazard Evaluation request being as specific as possible as to the area they feel needs further study.

IX. REFERENCES

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XI. DISTRIBUTION AND AVAILABILITY

Copies of this report are currently available upon request from NIOSH, Division of Standards Development and Technology Transfer, Information Resources and Dissemination Section, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days the report will be available through the National Technical Information Service (NTIS), Springfield, Virginia. Information regarding its availability through NTIS can be obtained from NIOSH, Publications Office, at the Cincinnati address.

Copies of this report have been sent to:

1. MGM Grand Hotel and Casino.
2. Local 720, International Alliance of Theatrical Stage Employees and Moving Picture Machine Operators of United States and Canada.
3. International Alliance of Theatrical Stage Employees and Moving Picture Machine Operators of United States and Canada.
4. U.S. Department of Labor/OSHA - Region IX.
5. NIOSH - Region IX.
6. Nevada Department of Health.
7. State Designated Agency.

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.