PRAIRIE ISLAND GENERATING STATION

TOXIC CHEMICAL STUDY

-Incapacitation Levels-

Prepared for the Northern States Power Company

By the Bechtel Power Corporation

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1. INTRODUCTION

In May of 1981 a Main Control Room Habitability study was performed for the Prairie Island power plant (Reference 1). That study concluded that four toxic chemicals would exceed the Threshold Limit Value (TLV) levels in the control room if an accidental spill occurred. Consequently it was recommended that monitors be installed to detect these chemicals. The possible sources of these chemicals are: on-site storage, the Burlington Northern Railroad, the Chicago, Milwaukee and Saint Paul Railroad, and barge traffic on the Mississippi river.

The Main Control Room Habitability Study also determined setpoints for the monitors and required response times to comply with Regulatory Guide 1.78. To insure compliance with Regulatory Guide 1.78 which specifies that operators have at least two minutes to put on self contained breathing apparatus, monitors were set either equal to or below TLV levels. With the TLV used as a monitor setpoint, operators will have adequate time before the Short-Term Exposure Limit (STEL) is reached. Both the TLV and the STEL are set for long-term occupational exposure, not a one-time exposure situation.

In early 1981, NUREG/CR-1741 entitled "Models for the Estimation of Incapacitation Times Following Exposures to Toxic Gases or Vapors" was published. The report presents another methodology to predict operator incapacitation for one-time exposure to toxic chemicals. It consisted of using 5 models (A-E) covering significant physiological and toxicological effects to humans.

This Toxic Chemical-Incapacitation Level Study has been undertaken to determine the possibility of eliminating some of the 4 chemicals currently being monitored by applying the techniques of NUREG/CR-1741 to Prairie Island.

2. NUREG/CR-1741 MODELS

Human exposure to airborne toxic materials produces a wide range of physiological and toxicological effects. For incapacitation effects there is a threshold concentration below which the body can eliminate, transform or otherwise act on the chemical to negate its effects. Above this threshold, there are two principal physiological modes which dominate: concentration dependence and dose dependence. For concentration dependent chemicals, the total dose received is not as important as the concentration of the chemical during exposure. Dose dependent chemicals produce an effect that is directly related to the total exposure regardless of the concentration at any given time.

NUREG/CR-1741 presents 5 models to describe incapacitation. However all the chemicals at Prairie Island fall into the range of the first or "A" model which is described below:

> Model A. Concentration Dependent - Immediate Sensory Irritants: This model describes a procedure for predicting the time to incapacitation for immediate sensory irritants (e.g. Ammonia, Chlorine, Hydrogen Chloride, and Formaldehyde). The effects are concentration and not dose dependent.
>
> Chemicals classified as immediate sensory irritants are corrosive or desiccant in their action. They inflame skin or mucous membrane especially when moist. They stimulate nerve endings in the eyes, nose, and oral cavity and inhibit respiration. They have essentially the same effect on animals as on humans and the exposure concentration is of greater significance than the duration of the exposure.

3. CHEMICAL DESCRIPTION

Presented below is a summary of each of the four toxic chemicals that are in question at Prairie Island. The information is taken from literature on the subject. The summaries focus on the effects these chemicals have on human beings. When such data was not available results on animals were presented.

Ammonia, NH_3

Ammonia is a colorless gas with a sharp, intensely irritating odor. It has an odor threshold of 46.8 ppm for humans (Reference 4). Complaint levels of 20-25 ppm were first observed. Human effects such as eye irritation sometimes with lacrimation, nose, throat, and chest irritation (coughing, edema of lungs) were found at concentrations up to 700 ppm, depending on exposure time (Reference 2,3,5). The chemical then becomes lethal starting at 2000 ppm concentration even for exposures of a very short duration (Reference 2).

Chlorine, CL_2

Chlorine in its gaseous form is greenish-yellow in color. It has a disagreeable, suffocating and irritating odor which is readily detectable at 3-5 ppm. Irritant effects to eyes, nose, throat and/or face were noted at low concentrations. Effects on the upper and lower respiratory tracts and pulmonary edema were reported at high concentrations. Chlorine becomes highly dangerous for exposures of 30 minutes at 40-60 ppm; it becomes fatal for exposures of 30-60 minutes at 833 ppm and fatal in a few breaths at 1000 ppm (Reference 2). There were reports on effects of concentrations around 5 ppm covering respiratory complaints, corrosion of teeth, inflammation of mucous membranes of nose and increased tuberculosis susceptibility (Reference 5).

Hydrogen Chloride, HCL

Hydrogen Chloride or hydrochloric acid in gaseous form is colorless with a suffocating odor (Reference 5). It causes irritating effects to the human nose and throat if inhaled at concentrations as low as 5 ppm and becomes barely tolerable at 50-100 ppm for a 1 hour exposure (Reference 3,5). Breathing HCL gas was found to be dangerous from concentrations of 1000 ppm and is fatal to humans for even a few minute exposure at 1300 ppm (Reference 2).

Formaldehyde, HCHO

Formaldehyde, a suspected carcinogen, is detectable by most people at levels below 1 ppm (Reference 3,4,5). Humans have experienced irritant effects on the eyes, noses, throat and upper respiratory tract at concentrations of 1 to 12 ppm. At high concentrations, severe respiratory tract irritations which lead to death were reported in humans. Inhalation studies on rats and mice indicated that formaldehyde has a carcinogenic effect on rats. Rats developed nasal cavity squamous cell carcinomas after 12-24 months's exposure to 15 ppm with deaths during this period. Fatalities were also observed for rats exposed up to 81 ppm (Reference 5).

4. ANALYSIS PREFORMED

The Bechtel standard computer code TOXGAS (NE314) described in appendix A of the Main Control Room Habitability Study and modified to include the models of NUREG/CR-1741 was used to perform the analysis. Using the results of the analysis a determination was made as to which toxic chemicals still required monitoring. The assumptions made in the analysis were essentially the same as the those used in the Main Control Room Habitability Study except that the evaporation rate for formaldehyde was modeled using a turbulent rather than a laminar flow across the spill*. This results in conservative concentrations at the control room air intake. As in the Main Control Room Habitability Study it is assumed that the control room HVAC system is in normal operation during the postulated accident (i.e. that there is no control room isolation), and that chemical monitoring is achieved just by the operators ability to detect the chemical. Using these assumptions the times to first detection of the chemical and the times to incapacitation were calculated. Chemicals that have at least 2 minutes between detection and incapacitation will not need to be monitored for operator protection.

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*The mass transfer coefficient for turbulent flow that should be added to Appendix A of the Main Control Room Habitability Study (Reference 1) is:

$$h_d = 0.037(D/L)(Re)^{0.8}(Sc)^{1/3}$$

See References 1 and 6 for more information.

5. RESULTS AND CONCLUSIONS

Of the four chemicals analyzed, two chemicals, Ammonia and Hydrogen Chloride allowed ample time from detection levels to incapacitation levels; Formaldehyde resulted in marginal time, and Chlorine did not provide adequate time to take protective measures. The results for each chemical are described below:

Ammonia

Detection levels for Ammonia released from a barge accident are reached 2 minutes and 19 seconds before incapacitation levels are reached. Thus, operators will have enough time to put on breathing apparatus once the odor is detected. Ammonia released from an accident involving the Burlington Northern Railroad will be detected 8 minutes and 7 seconds before incapacitation levels are reached. Since these times are greater than 2 minutes, no monitor is required for ammonia.

Hydrogen Chloride

Detection levels for Hydrogen Chloride are reached 7 minutes and 11 seconds before incapacitation levels are reached. Thus, operators will have ample time to take corrective measures, and therefore, no monitoring is required.

Formaldehyde

Detection levels for Formaldehyde are reached 1 minute and 59 seconds before incapacitation levels are reached. This time is just short of the 2 minutes quideline of Regulatory Guide 1.78 to give the operators time to put on breathing apparatus.

Since the calculation of Formaldehyde has several convervatisms built in, it is recommended that the detector be deleted. Modeling more realistically any one of the following conservatisms would result in times from detection to incapacitation greater than 2 minutes, thus allowing the operators time to take protective measures.

Formaldehyde concentration conservative assumptions:

1. The accident is assumed to occur at the closest approach to the control room.

2. The entire content of the tank car is assumed to spill.

3. No credit is taken for ground absorption.

4. Is is assumed that the wind is blowing directly from the spill to the control room air intake.

5. No credit is taken for dispersion by intervening structures or topography.

Chlorine: Detection levels for Chlorine gas spilled on the site occur only 33 seconds before incapacitation levels are reached; thus monitors will continue to be needed for chlorine. Chlorine spilled from the Chicago, Milwaukee and Saint Paul Railroad will be detected 1 minute and 8 seconds before incapacitation, which is also too short a time to take protective action.

Conclusion: As discussed above, of the four chemicals identified by the Main Control Room Habitability Study as being potentially hazardous to control room operators, Chlorine will reach incapacitation levels before operators can take protective actions. Therefore, to insure that the operators are protected, it is recommended that the monitor for this chemical be retained, and automatic isolation of the control room be required to insure that control room operators have sufficient time to take protective measures. For the other chemicals: Ammonia, Hydrogen Chloride and Formaldehyde, no monitoring will be required. For these chemicals a training program should be instituted for operators to recognize the characteristic odors and to take appropriate protective measures.

6. REFERENCES

1. "Prairie Island Main Control Room Habitability Study" Prepared by the Bechtel Power Corporation on May 1981

2. Effects of Exposure to Toxic Gases - First Aid and Medical Treatment by Braker, Mossman and Siegel, Second Edition

3. Patty's Industrial Hygiene and Toxicology by George D. and Florence E. Clayton, Volumes 2A & 2B, Third Edition.

4. Dept. of Transportation, "Coast Guard CHRIS Hazardous Chemical Data", Oct. 1978.

5. "Documentation of the Threshold Limit Value", Fourth Edition, 1980, American Conference of Government Industrial Hygienists Inc.

6. "User Manual for Bechtel S.C.P. TOXGAS NE314 Release 2", Bechtel Power Corporation, May 1982. (Bechtel Proprietary)

7. NUREG/CR-1741 - "Models for the Estimation of Incapacitation Times Following Exposure to Toxic Gases and Vapors", Gordon J. Smith, David E. Bennet, Sandia National Laboratories, Dec - 1980.