Arh. hig. rada toksikol., **30** *(1979) suppl. pp. 1735–1740.*

THE ALASKA PIPELINE GEOGRAPHICAL IMPACT UPON OCCUPATIONAL HAZARDS

D. K. FREEDMAN
Westinghouse Health Systems, Columbia, Maryland, U.S.A.

ABSTRACT

This paper emphasizes the impact of geography upon some known dangers in oil pipeline construction as well as some less well-known. In the Alaska setting, a description of the major types of stress is presented, i.e. chemical, physical, radiation and noise. Traumatic injury, compensable injury, death and disease are reported in some detail. Cold injury and alcohol effects are touched upon lightly. The use of products such as polyurethane, isocyanate, and their breakdown, is described. Exposure to chlorinated hydrocarbons, free silica in respirable dusts, styrene-butadiene and welding fumes represents another significant aspect.

Background description of Alaska is provided covering varying conditions over the 800 miles of pipeline. This extends from the Arctic Ocean in the north, through valleys and over mountains, above the earth and in permafrost, to Valdez in the south, a year-round port. Temperatures rise to 34 °C and drop to minus 62 °C in winter. The line crosses the Yukon River and 70 other major rivers and streams, a major earthquake zone and three mountain ranges. It extends from a latitude above 70 degrees to 61 degrees in the south.

Methods utilized for combatting and/or preventing occupational hazards are explained. The paper concludes with suggestions to be taken into account in similar projects in the future.

In April 1974 construction started on the 1 200 km pipeline in Alaska, U.S.A. It continued until June 1977, when oil started flowing from Prodhoe Bay on the Arctic Ocean. Search of the literature including the largest automated reference library in the United States revealed no published, health-related scientific articles on this pipeline.

This presentation describes some of the occupational hazards involved in arctic and subarctic construction as well as the impact of geography. A basis will be suggested to lessen some of the hazards and their impact in future undertakings of a similar nature.

The setting for the pipeline is Alaska, the largest of the 50 states. It contains 3 million lakes, 10 000 rivers and streams, and the highest mountain peak in North America.

Over 5 years of advance planning was necessitated to meet government standards for occupational safety and health, as well as for environmental concerns. Geographical factors demanded unusual precautions and design because of the nature of the terrain and the environment along the 1 200 km of pipeline. Some of these factors[3] were as follows:

- a spread of 9 degrees from 70 to 61 degrees latitude,
- 24 hours of darkness per day in winter,
- temperature variation from 34 °C to minus 62 °C,
- wind velocity up to 90 km per hour,
- snow fall up to 75 cm per year,
- permafrost down to 390 meters in the earth*,
- construction across 800 rivers and streams,
- crossing a major earthquake zone,
- laying pipe over 3 mountain ranges rising to 1 450 meters,
- construction in sponge-like tundra,
- presence of wild animals and areas of caribou migration.

METHOD

Information was secured from several sources between 1974 and 1978. These included the State of Alaska Department of Labor, Alyeska Pipeline Service Company, on-site visits and personal communications.

Raw data obtained from the Alaska Department of Labor pertain only to those cases of injury, disease and death occurring in 1975 as reported by private physicians. Other data held by the Alyeska Company have not been made available.

RESULTS

Occupational hazards encountered were the customary ones found in pipeline construction, plus several that were highly unusual. We are concerned here primarily with chemical and physical stresses.

Chemical stress resulted generally from insulating activities. Isocyanate and polyurethane products were used extensively in the construction and maintenance of life-support facilities. Large quantities of polyurethane foaming were used for such objects as water lines, rooves of buses and water tank trucks. Above-ground portions of the pipeline, cement mix trucks and fuel storage tanks were also heavily insulated. Resulting from these processes were eight hazards, with their causes, as follows:

1. skin exposure – from liquid isocyanate-polyurethane;
2. respirable dust – from modification of the insulation, drilling bedrock and from rock crushing;
3. isocyanate (aerosols and mist concentrations) – from spraying or foaming of polyurethane;

*Permafrost is defined as any rock or soil material with or without included moisture or organic matter, that has remained below 0 °C for 2 years or longer. While some permafrost is stable, permanently frozen rock and gravel, other areas are simply ice rich soils which become unstable when thawed[1].

4. vaporized gases – from the curing process of insulation;
5. HCN, phosgene and CO – from inadvertent pyrolysis of urethane;
6. chlorinated hydrocarbon vapors – released during degreasing/solvent operations;
7. styrene – butadiene – released into workers breathing zones during fiberglassing operations;
8. fumes containing oxides of iron, cadmium, manganese, molybdenum, nickel, titanium or vanadium – from welding.

Physical stress related generally to ionizing radiations, noise and heavy work. Radiation hazards involved the use of X-ray, iridium 192 (up to 100 curies), cobalt 60 (up to 10 curies) and sealed isotopes.

Noise emanated from machines such as heavy construction equipment, bulldozers, scrapers and large dump trucks. Air compressors and diesel-powered generators were also implicated. Additional stress resulted from lifting and pushing heavy objects.

Protective measures

The use of adequate ventilation and of organic vapor respirators were two of the major methods used for protection against chemical stress. Ventilation helped to minimize the concentration of oxides in enclosed spaces where welding took place. It also protected workers from vaporized gases formed in the curing process of insulating. In the pipeline itself over 100 000 welds occurred[1]. Since these were done outdoors, work areas were enclosed in winter to protect against wind and cold.

Protection against liquid isocyanate-polyurethane involved using protective gloves and washing facilities. For respirable dust, a hood with a "back-pack" cyclone purifier was used to remove particles suspended in air. Respirable dusts with free silica were controlled by wet drilling.

A combination of ventilation and use of the organic vapor respirator were required for degreasing operation hazards such as released chlorinated hydrocarbons and for fiberglassing operations releasing styrene-butadiene.

The hazard from high concentrations of mists, gases and vapors was controlled with organic vapor, or supplied air, respirators. This method applied also to accidental fires involving polyurethane.

All radiographers and their assistants were required to wear film badges, pocket dosimeters and a Rad-Tad. The latter device sounds an audible alarm when the absorbed dose rises above a 2 mrem level.

Anticipating unconventional problems, such as fox bite, severe cold, isolation and long work hours, an orientation program was provided for all workers. Comfortable living quarters, meals and seven days leave every 8 weeks were given to employees, including free air transportation to Alaska's major cities, Fairbanks and Anchorage.

Medical data

Of the 1694 cases reported in 1975, nearly 60% were analysed. Table 1 indicates that "sprains and strains" accounted for over 40% of cases. The second most numerous group was "fractures", numbering 174. If one adds "contusions and lacerations" to the above, 76% fall into these 3 categories.

Frostbite accounted for only 10 cases, 1%, despite the frigid working conditions existing between October and April. The number of cases clearly related to noxious industrial substances is also 10.

Table 1 also shows that about 35% of the cases resulted from falls. Straining, or overexerting, such as by pulling and lifting accounted for over 20%. If we add the third largest category, "hit by moving object", 217 cases, the total approximates 80%.

TABLE 1
Number of compensable injuries, by diagnosis and by cause. Alaska Pipeline, 1975.

Disease/injury	N	Cause	N
Sprain/strain	423	Fall (slipping, tripping, jumping)	343
Fracture	174	Slipped on ice	219
Contusion and laceration	163	Hit by moving object (crushed, caught between 2 objects)	217
Hernia	36	Straining (pulling, lifting, cranking)	70
Eye injury	27	Heavy vehicle accident (tractors, machinery, loaders, trucks, etc.)	51
Torn ligament muscle	27	Self-inflicted injury, accidental	32
Burn	23	Industrial exposure (chemicals, gases, dusts, slag, flame, exposion)	30
Head injury	17	Exposure to cold	14
Crushing of extremity	14	Miscellaneous and unknown**	24
Amputation	10		
Frostbite	10		
Dislocation	10		
Miscellaneous*	66		
Total	1 000		1 000

*includes, for example, wolf bite, dermatitis, bursitis, infections, ruptured disc, bronchitis and allergy
**includes assaults by assailants

Industrial chemicals and related hazards were responsible for 30 cases, 3%. Cold, as an element of danger, effected only 14 persons.

Deaths during 1975 totaled 34. This represents slightly over 3% of injuries and deaths combined. The three major causes show quite similar proportions, divided among crushing injuries (26%), heart attacks (23.5%) and truck accidents (23.5%). The causes of death contributing to the diagnosis labeled "Miscellaneous" (20%) are noteworthy for their variety (drowning, gunshot, freezing, suffocation, head injury, plane crash, broncho-pneumonia, 1 each).

DISCUSSION

In analysing these data, it is helpful to realize that much of the terrain was steep, rocky, at times muddy and slippery and contained countless holes and soft pockets.

The large number of accidents is indicative of the stressful conditions of work and of carelessness. The effects of cold, of rough terrain, ice and snow, strong winds and darkness undoubtedly played a part. The use of heavy equipment, not always under full control, resulted in many injuries. Such vehicles at times rolled over embankments or slid down steep inclines. Workers often had to jump off equipment, regardless of the danger, from heights up to 9 meters. Poor visibility, ice-fog, deep snow, fatigue and the pressure to speed-up construction were contributing factors.

Wild foxes posed a continuing hazard since animal rabies is endemic. Attracted to kitchens and garbage areas at the many construction camps, foxes were unwisely treated as pets. Many workers were bitten.

Another winter danger was cold-related injury. Exposed skin adheres to metal, such as on emergency stretchers, at sub-zero temperatures. At -35 °C, skin cannot be separated from metal without adequate heat[2]. Frostbite and frozen extremities, including the ear and nose, were constant threats.

Work shifts extended 12 hours, 7 days a week. Alcohol was a serious problem with excessive drinking after work[4].

Perhaps the most significant findings are the small number of cases resulting from cold such as frostbite or freezing and from industrial hazards.

CONCLUSION

Gigantic construction projects provide the opportunity for accumulating essential health data. Careful analysis of such data should be encouraged by responsible agencies for their value in advance planning of needed safety features.

Tentatively this study suggests that the direct effects of cold can be minimized even at sub-zero levels, i.e., frozen limbs and pneumonia. Many potentially adverse effects from geographical and climatic factors have been partially controlled. Additional safeguards are required, i.e., cleated boots, frequent heavy equipment maintenance inspection and intensive safety training. Specifically, hazards exist from steepness of mountains, work above rivers, snow, ice, ice-fog, isolation, prolonged darkness and perhaps overeating. These conditions require early planning on engineering and design to eliminate or minimize anticipated problems from the beginning. An intensive and continuing campaign of information and education must be in operation as well as enforcement of safety practices.

The dangers from haste, carelessness and inadequate training may be largely overcome. The impact of fatigue, alcohol and unreported illness in the causation of these accidents remains unknown and unstudied. Clearly, medical records should be automated.

Additional data exist in the non-automated medical records covering the 3-year construction period. These must be analysed to evolve further guidelines directed toward job-specific, preventive programs in occupational health.

ACKNOWLEDGEMENTS

I acknowledge with thanks for personal correspondence to Mr Dick Boley, Paul Frith, D.V.M., Philip W. Hardie, Jr. M.D., Medical Director, Alyeska Pipeline Service Co., William F. Kinn, M.D., and John C. Morris, M.D. I also acknowledge to the State of Alaska, Department of Labor, for the list of employee injuries, 1975.

REFERENCES

1. *Alyeska Reports.* Alyeska Pipeline Service Co., July 1975 – Oct. 1977, 2, (Sept. 1976), 10, (Jan. 1977).
2. *Crippen, E.F.* Industrial Health Problems in a Frigid Environment. Am. J. Occup. Med., **13** (1971) 492–495.
3. *Wolfe, H.* TAPS: The Six-Billion Dollar Pipeline. Alaska Regional Profiles, Vol. 1, Office of the Governor, Division of Planning and Research, 1974.
4. *Zoller, S.* Pipeline Health Care. Am. Med. News, (1976) 7–10.