by Vincent S. Haneman, Jr.

ELECTROSTATIC CHARGE HAZARDS IN HELICOPTERS IN THE ARCTIC

An Alaskan National Guard CH-54A Sky Crane lifts a bulldozer at Fort Wainwright for fire fighting in interior Alaska. Airlifting heavy equipment in Alaska requires special care to reduce buildup of electrostatic charge. (Photos courtesy of the U.S. Army.)

A helicopter flying in certain types of atmospheres accumulates an electrostatic charge that can be a fire hazard, cause radio interference, attract lightning, and shock people. Most of these charging hazards can be particularly severe in the Arctic because of the extraordinary dryness of the air, yet electrostatic charging is not generally recognized as the source of some serious problems in arctic transportation support.

BACKGROUND

Helicopters accumulate a charge by several processes. First, as they move through air, they agglomerate atmospheric ions by attraction and by direct impact. (The ions can be produced by cosmic rays, blowing wind, fracturing ice crystals, falling and fractionating rain, falling or blowing snow, bubbles bursting at the sea surface, and other mechanisms.) Then there is that portion of the charge induced by friction; it may help to envision a helicopter rubbing against dust particles, developing an electrostatic charge as a cat will when it rubs against a chair leg. Furthermore, internal combustion engines produce ions a flame is a plume of glowing ionized gases.

The National Aeronautics and Space Administration has been extensively studying the problem of charge buildup on flying vehicles, and for some time the Department of Defense has been studying the problems of helicopter electrostatic charge accumulation. The DOD studies have not provided design criteria for helicopters to reduce the charge accumulation, but the data indicate that the charge rate is proportional to the number of

Vincent S. Haneman, Jr., *is dean of the School of Engineering, University of Alaska-Fairbanks, and a retired Major General, U.S. Air Force. He believes his extensive experience as a military combat pilot stimulated his interest in the problems of helicopters.*

airborne particles which come into contact with the vehicle, particularly the rotor blades; the types of charges of the particles; the size and geometry of the helicopter; the relative dielectric constants of the aircraft and the particles impinging upon it; and the temperatures involved. Special dangers may be posed for helicopters in the hover and near-hover condition, where increased power is required, and therefore increased flow through the engine and rotor, to provide the lift. The resultant turbulence creates a doughnut-shaped flow, bringing exhaust mixture high in ions and particles from the ground up, around and back down through the rotor and the engine intake. This results in more particle impacts and therefore a higher charge rate.

The storage capability of the charge on the aircraft — the aircraft capacitance — is dependent upon this charge rate and the intrinsic capacity of the aircraft. Charging continues until the voltage exceeds the breakdown voltage of the air, when a corona discharge equal to the charging rate will occur. This can be between 30,000 and 200,000 volts, again depending upon the aircraft and ambient conditions. With drier conditions the capacity would be expected to be greater for all other parameters being the same, so in the Arctic where very low temperatures lead to much drier air, one may expect higher voltage and greater danger.

HAZARDS

Serious hazards exist when an individual or a combustible material becomes part of the short circuit path for discharging stored energies of this magnitude, i.e., 30,000 to 200,000 volts with capacity to provide moderate to high currents. Less obvious but also potentially dangerous are the hazards associated with electrostatically caused malfunctions in electrical equipment.

Human Hazards

The strength of a shock depends on both current and voltage — the smaller one is, the larger the other can be without causing harm — so the amount of energy released in a shock is measured in joules. At energy levels of five millijoules, the human body feels a shock; this is the threshold of sensitivity. At ten millijoules the shock is uncomfortable. That is about the level of the dry winter climate effects with which northerners are familiar - the charge a person develops walking on the carpet in a house, which is discharged when he reaches for the grounded light switch: it is about 30,000 volts discharged over a distance of approximately one centimeter. A 100-millijoule shock is severe and a one-joule shock kills. This one joule is a watt-second, a volt-ampere second; with a 30,000-volt charge it would require only 0.0000333 ampere-seconds to be lethal.

In dusty environments, the measured levels on the CH-54A helicopter have exceeded 30 microamperes, with rates of 200 microamperes sustained for considerable periods. The accumulation resulted in stored energy in the area upward of three joules — capable of lethal shock.

Ignition of Flammables

About seven or eight years ago, an airman refueling a plane in an old hangar at Eielson Air Force Base, near Fairbanks, drew a static spark from the fur collar of his jacket. The spark ignited the fuel vapors; the resulting fire destroyed the hanger and burned its contents to the ground in four hours. This arc was of the level of that generated in walking across a carpet, and is not near the intensity of that obtainable from a helicopter. "Hot refueling," i.e. fueling operations with the engines running and blades turning, is conducted by the armed services now. This means all the potential for ignition of a fuel fire exists — the presence of flammable vapors, continuous charging of the airframe, and coronal discharge.

Energy levels of less than one millijoule will ignite aviation fuels and other highly volatile materials under the most ideal conditions of temperature and mixture. The level of energy measured in airborne helicopters is considerably above this minimum and can be considered extremely hazardous to all flammable materials, under proper conditions.

Military work evidently has concentrated on this area of the problem. According to personnel of the U.S. Army Cold Regions Research and Engineering Laboratory, the major consideration of arctic electrostatic charging hazards has been for refueling and arming operations of army helicopters. A study done for the U.S. Army Arctic Test Center at Ft. Greely, Alaska, was primarily concerned with the phenomenon's effect on helicopter ammunition and fuels.[1]

Corona Discharge

The corona discharge will occur when the voltage level has exceeded the breakdown field of the air. This discharge has been observed many times on the pickup cable hooks of such aircraft as the CH-53. The resultant interference creates false control signals to servo-operated systems and has caused remote control systems to activate prematurely and release cargoes, and has also created radio interference with ground/air communications and control links. It also provides a mechanism to trigger electro-controlled explosives.

U.S. Army CH-47C Chinook helicopter about to hook up equipment for transportation into a remote area to help Bureau of Land Management fire fighters. Grounding of the aircraft at this stage of operation is needed to reduce hazard to the ground crew.

Lightning Strikes

Thunderstorms are extremely rare in the high Arctic, in part because thunderclouds are most likely to form over warm earth surfaces with irregular terrain in areas where there is considerable moisture in the middle atmosphere. Such conditions do occur every summer in interior Alaska, however.

While complete data are not available, still the indications are that lightning strikes caused by electrostatic discharges have occurred. The charge on a helicopter may be positive; elevating this charge closer to the negative charge at the base of a thunderstorm provides a shorter path for lightning to discharge, and a higher probability that it will strike the helicopter, with possibly disastrous results.

CONCLUSIONS

The electrostatic capacity of helicopters operating in the atmospheric conditions found in the Arctic and subarctic can cause serious hazards in at least four modes. Means to reduce this charge and the concommitant dangers must be found.

The aircraft should be grounded electrically before such operations as refueling, picking up sling loads, and using cable-controlled devices; a conductive material such as the steel hoist cable should first make contact with suitable ground. For areas where water exists, the quality of the electrical ground is not a problem since the cable can be trailed in the water, thus discharging the aircraft's potential. Extreme caution must be exercised over other areas; a frayed metallic end on the hook dragged on the ground may provide adequate discharge.

With proper foot gear, ground crew standing on dry snow may be isolated from real electrical ground. Therefore the magnitude of the shock any one of them might receive would be limited to that required to elevate the individual's body potential to that of the aircraft similar to the shock and current flow caused by walking on a carpet, as described above. However, the effect could be extremely dangerous in and around heavy operations: Recall that it is only an order of magnitude, a factor of ten, for severe shock, and this could certainly occur, even if the person was isolated from real ground.

Operating in thunderstorms obviously should be avoided.

RECOMMENDATIONS

1. Measurements of charge rates on a number of helicopter types with different loads under recorded conditions of snow, dust, and particulate matter are required to provide a synoptic picture of the electrostatic charge phenomenon.

2. An effective discharge technique for operations at hover is needed. It may not always be prudent to dunk the lift hook even if free water is available, given the possibility of snaring an underwater obstruction.

3. Individual shock protection should be tested under arctic conditions. The potential isolation of bunny boots and dry snow may be less than the breakdown voltage of air, and thus provide little or no protection.

4. All automated or remote control systems must be checked for sensitivity to voltage surges and spurious transmission signals. Release of a load a few feet or even a few inches above the desired point can have disastrous results.

5. All flammable materials in these systems must be protected by positive grounding features. (One of the problems to be solved is that of finding a true ground under arctic conditions.) Arcing must be suppressed.

6. Hover operations of helicopters during electrical storms are at best ill advised. There appears to be no solution to this problem other than to avoid operating in such storms.

REFERENCES

[1] Davey, Charles T. 1974. Static Electricity Study on Helicopter Related Safety with Ammunition and Fuels (U) U.S. Army Arctic Test Center, Report Contract DAFA03-73-C-0190, Final Report F-C 3706. Applied Physics Laboratory, January. ♦

MEETINGS

When your Outside friends grow tired of hearing about your difficulties with engineering to beat the ramifications of cold, you can always shake them up a bit by shifting to another topic vital to most sections of Alaska – especially if you attend this meeting. **Fundamentals of Earthquake Engineering,** a regional seminar of the Earthquake Engineering Research Institute, will be held at Alaska Pacific University in Anchorage on 19 21 October 1982. Co-sponsoring organizations with EERI are the U.S. Geological Survey Alaska Branch and the Alaska Division of Geological and Geophysical Surveys. The main sessions will be Overview of the Fundamentals of Earthquake Engineering in Alaska—a Multidisciplinary Team Activity; Overview of Empirical, Experimental, and Theoretical Data that Guide Design Criteria; and Structural Design Problems. Additionally, there will be two panel discussions on current Alaskan design problems: Siting Considerations for New Construction and Foundations in Arctic and Offshore Environments. The sessions are not concurrent, so it will be possible to attend all of them. Most of the 14 speakers are engineers; all are scheduled to allow time for questions.

The fee of $275 will cover all three days of the seminar, three lunches, one dinner and one cocktail party. Registration forms and information packets are available from *Martha Jokela, Harding-Lawson Associates, 624 West International Airport Road, Anchorage, AK 99502;* phone *(907)276-8102.*

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Arctic Drilling: Promise and Potential will be held October 13th and 14th at the Fairmont Hotel in San Francisco. The program is designed for executives involved in or seeking entry into arctic oil and gas exploration, drilling, production and service industries as well as financial, legal and consulting firms serving the arctic region, and all industries affected by the prospects and the outlook for arctic drilling. The emphasis will be on technology and economic assessment. Speakers are

LETTER

That sinking feeling . . .

Reference: "Symmes' Hole," Volume 3, No. 1

Dear Editor,

This is a follow-up to my letter to you dated June 22, 1971, (Volume 3, No. 3) regarding "Symmes' Hole," which appeared in Volume 3, No. 1.

I apologize for the delay in corresponding.

I can now state that Symmes' Hole does exist and I have found it. It is locally known as the Farmers Loop Sinkhole. This phenomenon is being investigated and will be reported to you in future correspondence.

Sincerely,
Larry Sweet
Fairbanks, Alaska

To spare you searching the old TNEs, *gentle readers, here's some background explanation for the letter above:*

John Cleves Symmes, as reported by historian Bill Hunt in Vol. 3, No. 1, was busy during the 1820s convincing people that the earth was a set of layers rather like an onion. Access to the lower skins, which he envisioned to be rich lands crowded with animals, would be via a hole that his theory said must exist at the North Pole (he was sure there was one at the South Pole as well, but north seemed the easier direction in those days). He convinced a fair number of people, including at least one Congressman, but was unable to raise enough money for an expedition in search of the hole.

Reader Sweet was much taken with the possibility of finding Symmes' Hole to use as a garbage repository, suggesting in his Vol. 3, No. 3 letter that "the heat from radioactive waste products would melt down old car bodies which could eventually be mined and reused."

Author Sweet was far less taken with the Farmers Loop Sinkhole, a local horror on the highway which he and Billy Connor discussed in Vol. 12, No. 4. By that time, Sweet was (and is) head of the Alaska Department of Transportation and Public Facilities Research Section, which is searching for an affordable fix for the hole. So far, the Sinkhole is winning.

Ironically, the Sinkhole is a splendid trap for cars – many of which were not old before they started across it.

The moral of this story may be: He who puts tongue in cheek may find unexpected hole.

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drawn from the Alaskan state government, oil and gas industry, consulting, and oil service communities. For further information contact *Paul N. Gilman, planning manager, The Energy Bureau, Inc., 41 East 42nd Street, New York, NY 10017;* phone *(212)687-3177.*

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The **District No. 2 convention of the Canadian Institute of Mining and Metallurgical Engineers** will be held at Sept-Iles, Quebec, on 13–16 September 1982. Theme for the meeting is, "The 80's – a challenge for the Quebec North Shore mining industry." Despite the apparent local emphasis, the organizers stress that the meeting's real perspective is global, and the listed speakers hail from all over North America. Technical presentations will address energy resources management, productivity improvement, developing new ore deposits, open pit and underground mining, handling and transportation of raw and beneficiated material, health and safety, and the outlook for the mining industry. The final session is devoted to the Carol project, based in Labrador City, Newfoundland – and one of the papers is on the development of Labrador City itself. Simultaneous translation will be available throughout the conference. Supplementing the substantial technical program will be an array of post-meeting tours; options include ore pelletizing facilities, loading docks and terminals, open pit and underground mines, and ore boats.

More information is available from *Ms. Linda Boudreault, Chairman Publicity, P.O. Box 999, Sept-Iles, Quebec G4R 4S3, Canada;* telex *051-8-4102.*

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In conjunction with the 33rd AAAS Alaska Science Conference mentioned last issue, there will also be the **29th Pacific Northwest Meeting of the American Geophysical Union,** 15–16 September 1982, at Alaskaland in Fairbanks. Presented papers will concentrate on the Pacific Northwest and Alaska; sessions are slated for glaciology, hydrology, geochemistry, meteorology, oceanography, seismology and volcanology. Two interdisciplinary sessions are also planned, one on the geophysics of Alaska's Pacific coast and the other on the oceanography of the Beaufort Sea. Incidentally, one form can register you for both the AAAS and PNAGU meetings. Forms or further information may be obtained from the *Institute of Marine Science, University of Alaska, Fairbanks, AK 99701.*

NOTED

Coming soon: Detailed information on the new **Alaska Academy of Engineering and Science.** Preliminary organizational meetings have been held in Fairbanks and Anchorage, and by-laws have been drafted, but it's not too late to contribute to the basic design of the organization. The people who need to hear from you are *W.M. Sackinger, Geophysical Institute, University of Alaska, Fairbanks, AK 99701* (phone *474-7864*); or *Lyle D. Perrigo, Battelle Alaska Operations, 101 W. Benson, Suite 305, Anchorage, AK 99503* (phone *274-8811*).

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Honors to authors past: **Christine Ehlig-Economides** (*TNE* Vol. 13, No. 1) and **Michael Economides** (Vol. 13, No. 2) have been named technical editors for the *Journal of Petroleum Technology* and the *Society of Petroleum Engineers Journal.* Dr. Ehlig-Economides was also named recipient of one of the six Society of Petroleum Engineers Distinguished Achievement Awards for Petroleum Engineering Faculty.

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The ARCTEC, Incorporated newsletter *Ice News* early this year announced both **a new compound of the firm's**