Papers on the Lunar Settlement

Engineering 5 : Dust

0. Introduction The presence of dust in the surface environment of Luna presents special challenges for life and work there. The nature of the problem, as well as solutions and adaptations, are examined.

1. The Dust Due principally to impacts of bodies falling in from outer space, and to the action of repeated cycles of heat and cold over thousands of millions of years, immense quantities of dust are present in the lunar surface environment. In the absence of a sensible atmosphere, the dust particles are largely cemented together, forming with larger rock fragments the partially-dense overburden known as the regolith.

The problem presented by the dust is that it does not all remain in one place. Grains are broken away from the surface by impacts, and the same effect can be produced by human activity. These grains travel in ballistic trajectories, unhindered by atmospheric drag, and may be expected to embed themselves in the surface where they land. Unfortunately, due to piezoelectricity, cosmic rays, and other effects, the grains can become electrically charged, which can result in their being suspended above the surface in clouds or plumes, and attracted to equipment. The dust grains are both adhesive and abrasive, and can rapidly damage moving parts, wear holes in fabrics, and scour all kinds of surfaces. These effects have recently been supposed to be a major obstacle to work on Luna. Concerns have even been raised that the dust, brought into habitat areas, could represent a health hazard.

2. Area Suppression Since all types of lunar surface activity can be expected to raise dust, some method of reducing the problem in a large zone is required. Dealing with the effects of dust on individual activities becomes a simpler problem if the quantity of dust involved is reduced. Some prevention methods, clearly, are possible, such as the use of heat to fuse the regolith material into a glassy surface in high-traffic areas, or laying down beds of chips or pellets of stone or slag, but in general the need is to suppress dust already raised.

The typical terrestrial solution to this problem, spraying water (or, in some cases, oil) on the ground, is certainly inapplicable. The substances in question cannot be spared, and water would rapidly evaporate, while the effectiveness of any wetting agent under lunar conditions is questionable at best. On the other hand, since the principal problem of dealing with lunar dust is its electrical charge, electrical methods can be applied. In a vacuum, while the “air ionizer” sometimes applied to the terrestrial problem of house dust cannot be used, the general principle of electrostatic precipitation is still valid. It is not difficult to imagine erecting large poles at intervals, some charged positively and others negatively, which would attract the charged grains and then neutralize them, causing them to fall to the ground. Such simple methods might not work as desired, but refinements are possible. Dust could be collected on charged curtains which would move in the manner of endless belts and be cleaned continuously ; the problem of grains acquiring an opposite rather than a neutral charge might be handled by constructing a wire mesh electrode of one polarity surrounding a solid electrode of the other polarity, so that

such grains would simply be attracted to the second electrode, rather than escaping to do further damage. Alternating currents have even been employed to impel dust from place to place.

3. Local Suppression Once large-area dust suppression measures are in place, it remains to exclude them from small areas where delicate work is occurring, and otherwise deal with the effects of the remaining material. It is worth observing that the dust particles do not behave as a gas, and their collisions with surfaces are apt to be inelastic. Accordingly, it is possible to use baffles and "labyrinth" seals to exclude dust from an area, particularly if they have roughened surfaces to trap the grains. Placing a metal cover or housing over something would exclude dust from without, while the loss of momentum in collisions, combined with electrical neutralization at the metal surface, would rapidly cause the dust remaining inside to die down. The problem then becomes not stirring up additional dust under the housing, and if the floor surface is not naked regolith the matter is not likely to be especially troublesome.

To control dust entering sensitive areas, it may be useful to employ curtains made of metal wire or foil. These may resemble the curtains of plastic strips used to pass materials between air-conditioned work areas and outdoors on Terra, or perhaps the familiar bead curtain. In any case, the purpose is to conduct away charges on surfaces, causing the dust grains to drop off, and to exert a certain wiping action. Wire brushes may also be employed. It may prove advantageous to impress charges on the curtains or brushes, to actively attract the dust ; in this case, one would expect to use bead curtains with insulating glass beads, and a fine gage of wire to maximize the electric field intensity.

When dealing with moving parts and exposed surfaces, other techniques are required. Certainly labyrinth seals can protect joints from dust infiltration, but they will contribute to friction and become dust-bound and wear out over time. Reciprocating joints, and such rotating joints as do not make complete revolutions, can be protected by sheet-metal bellows, which would have relatively low adhesion for charged dust as well as good resistance to abrasion ; the crowns of the bellows, however, would require special care in manufacture, and would be subject to failure through metal fatigue. In the same situation, protective covers made of glass cloth would also serve. These covers would trap dust grains in the mesh, and would require periodic replacement, but could simply be remelted. The trapped material would cause few problems, as the glass would have been made from regolith originally. This type of cloth shield is probably the most suitable protection for those cables and wires which would not be run in conduits.

Transparent windows might well be coated with a thin metallic layer, to serve the purpose of reducing erosion of the glass and neutralizing static charges, which could be renewed as abrasion and evaporation required. Such a layer could well be desirable simply to filter the incoming light. If required, the metallic layer could be divided into strip electrodes to move the dust away in an active manner.

4. Habitat Concerns It is well-known that the inhalation of fine mineral grains is damaging to human lungs. In addition, the regolith dust is different in composition from mineral dusts in the terrestrial environment, and may have unexpected effects. One of the Apollo astronauts reported an adverse reaction to lunar dust which he had brought into the capsule on his space suit and breathed after the area was repressurized. A health hazard is thus added to the other problems associated with lunar dust, making it all the more urgent that this dust be excluded from habitat spaces.

Fortunately, within the habitat area, there is an atmosphere. Before the area is first occupied, air can be circulated in it and subjected to electrostatic precipitation or similar measures to remove residual dust. Such dust-control methods will be incorporated into the air system in order to deal with the organic and inorganic dust always associated with human life. With suitable dust control in the habitable spaces proper, the issue becomes prevention of dust entry from outdoors.

Proper airlocks will certainly be used, as was not the case with the Apollo capsules. These airlocks will serve as a buffer zone, and a decontamination area, for anything coming in from the surface environment. Space-suits of the inflatable type could be cleaned of dust by subjecting them to strong blasts of air ; the skintight counterpressure type, which will likely be more common, would tend to accumulate dust in the weave and would require laundering. Both types would eventually wear out, in the manner of carpet with sand trapped in the pile, and inspections and replacement would be necessary to ensure their continued safety. Cloth over-smocks would be of considerable benefit in stopping the dust from reaching the pressure suit itself. Helmet bowls, of course, could be metallized as described above for windows.

5. Conclusion While the dusty environment of Luna does not present the danger once supposed, of sinking into the surface, it is by no means benign. On the other hand, the dust itself and the practical problems it represents are manageable. While not all of the techniques used for dealing with terrestrial dust problems can be applied, some of them can, especially in habitat areas, and new techniques adapted to the lunar environment can be developed. Experience on site in using the types of measures outlined will certainly lead to alterations and improvements which cannot clearly be seen from the present.

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