National Academy of Sciences
SPACE SCIENCE BOARD
2101 Constitution Avenue, N. W.
Washington 25, D. C.

MINUTES
Ad Hoc Group on Space Probe Sterilization
July 8, 1959
Stanford University
Palo Alto, California

Call to Order

The meeting of the Ad Hoc Group on Space Probe Sterilization convened at 10:30 A.M., with Dr. Joshua Lederberg presiding.

Present: Dr. Joshua Lederberg (Chairman) - Stanford University
Mr. R. C. Baumann - National Aeronautics and Space Administration
Washington, D. C.
Dr. Richard Davies - Jet Propulsion Laboratory
Pasadena, California
Dr. G. Wesley Dunlap - General Electric Company
Schenectady, New York
Dr. Charles R. Phillips - Fort Detrick, Frederick, Maryland
Mr. G. A. Derbyshire - Space Science Board Secretariat

Purpose of Meeting

In order to develop a Space Science Board position on space probe sterilization, considerable information is required. The broad considerations relating to this matter have been developed by discussions of WESTEX and EASTEX, and will be

contained in reports now being prepared. However, any position must necessarily be governed by practical and operational considerations. In order that these points might be developed, the Board requested Dr. Lederberg to convene this small group. The meeting will recommend to the Board: (1) those practical aspects of sterilization to be considered and (2) propose a program for the solution of the problems.

Discussion

Dr. Lederberg described the history of the EASTEX and WESTEX meetings. In order to establish uniform terminology, he defined biological contamination as: (1) infection -- that which can grow out of a deposit and spread, (2) pollution -- a deposit of enough micro-organisms to be significant in itself. Pollution may be of two kinds: (a) viable -- that which remains viable whenever observed and (b) non-viable material which might obscure later observations.

The group agreed that the best protection against pollution is cleanliness, and this is also the most important measure in forestalling infection. Careful procedures can cut down on the contamination load by a millionfold. For example, a thorough washing (scrubbing) will get about 99% of the bacteria as well as other dirt. It would, therefore, seem that those things which can be scrubbed should be so treated as fabrication proceeds.

The chemical composition of all materials and components used in probe construction should be available and to this end a complete inventory of everything sent out on every probe should be made. This inventory should include exact specifications on the identity and amount of all substances which might be deposited on a planet. This is important in order to design the most effective methods of sterilization. (WESTEX has already referred to its importance in the identification of objects found on planetary surfaces by later explorations.)

Bacteria are well preserved in vacuo in the laboratory -- in fact, this is the most generally used standard method for the preservation of important type strains. However, the much lower pressures of interplanetary space might prove to be lethal to micro-organisms, simply by virtue of the distillation of lipids and other slightly volatile constituents. This point is quite obscure, and it would be a weighty factor in the design of space missions for biological investigation, (as well as for the evaluation of possibilities of extraterrestrial life).

Three methods of sterilization are potentially applicable to the present problem: (1) heat, (2) chemical means, or (3) radiation. Thermal sterilization is more effective if performed with steam than if performed dry. In the former case, temperatures in the order of 120°C are adequate whereas for dry treatment 160°-170°C is required. There is a time temperature relation and flash temperatures even greatly exceeding these limits will not be effective. Chemical sterilization, particularly using ethylene oxide as described later, appears very effective wherever the gas can reach possibly contaminated surfaces. Radiation may be the last resort for components which are hermetically sealed and which will not stand thermal sterilization.

Dr. Davies' list of components used in Explorer IV showed a number which could not stand sterilization by thermal means and, while many of these could no doubt be sterilized chemically, such items as transistors, sealed capacitors, etc. may require radiation treatment unless they could be assembled originally in a sterile condition. It appeared evident from these discussions that none of the methods should be excluded from consideration.

Work at Fort Detrick

Phillips described the studies of ethylene oxide as a sterilization agent which had been carried out at Ft. Detrick. From these studies (bibliography of publications attached) he concluded that this chemical in the gaseous phase is a most effective, safe, relatively non-toxic sterilization agent. Concentrations required to reduce 10^6 spores to less than one per ml with a significant safety factor are 2000 mg per liter hours. This has the same kill factor as 4×10^6 r The chemical is non-flammable in concentrations of 10-12% in either CO_2 or freon and in combination with freon can be cheaply packaged in standard aerosol bombs. It will penetrate through any porous material and into liquids and such organic solids as rubber and most plastics. It will not penetrate, of course, into hermetically sealed locations. In solids such as rubber or plastics the gas evolves slowly over a period of time so that some residual sterilization effects result. Ethylene oxide in the gaseous phase is non-corrosive and non-damaging to almost all types of materials, although the liquid is an excellent solvent for many types of organic materials. Phillips proposed, and the group agreed, that it should be reasonably simple to provide space probe sterilization with the use of ethylene oxide. This agent has already been used to decontaminate large assemblies, e.g., an aircraft cabin.

Conclusions

(1) There is insufficient information available on the chemical composition of the components used in space probes (this includes knowledge as to whether the materials themselves are bactericidal).

(2) There is no information on the contamination level of parts or subassemblies or a complete payload as it exists under present procedures.

(3) Ethylene oxide is simple to use, safe, effective and practical as a primary sterilization agent.

(4) Sterilization of space probes should be feasible and--with proper attention to production, shipping, and assembly, plus a final ethylene oxide "fumigation"--relatively simple.

(5) In view of the potential scientific importance, and in view of the opinion expressed under 3. above, efforts should be made to sterilize all space probes including those intended for moon shots.

(6) Whatever sterilizing means are used must be compatible with the operation requirements of the device.

(7) In view of the competence available at Ft. Detrick, this organization is eminently qualified to assume technical leadership in determining sterilization requirements and developing the necessary procedures.

(8) The organization responsible for producing a space probe must, of course, retain responsibility for assuring itself that sterilization procedures are compatible with engineering and operational requirements.

Recommendations

The group recommends:

(1) the immediate establishment of a program to determine:

(a) the micro-biology of all parts used in space probes;

(b) the specific requirements for sterilization of these parts;

(c) the development of effective procedures to satisfy these requirements;

(d) the compatibility of sterilization procedures with design, procurement, and assembly procedures, as well as possible effects on reliability of performance.

Ft. Detrick (Dr. Phillips) would agree to accept this assignment, serving as the focal point, and enlisting such additional help as might be required. His organization is very well equipped and staffed to guide this program. (Dr. Phillips indicated that he would be agreeable to spending "transferred funds" on this project. We, therefore, recommend that NASA, or the appropriate agency, undertake to support Ft. Detrick in carrying out the program. This group would be pleased to act in a technical advisory capacity to the funding agency and to Ft. Detrick.)

(2) The chemical specifications of all materials used in all space probes should be carefully compiled.

(3) It is essential that there be complete inventories kept of everything on every space probes (exact duplicates of all components and materials should probably be kept).

(4) A simple satellite experiment to determine the effects of very high vacuum on bacteria should be programmed.