

**INTRODUCTION TO LIFE-SUPPORT SYSTEMS FOR
EXTRATERRESTRIAL APPLICATION**

Issued 9-20-65
Revised

PREFACE - This report is an introductory treatment of life-support systems for extra-terrestrial application and serves to make an initial step in organizing currently available information on the subject. It is designed to illustrate the need for further more detailed treatment of many areas, including:

Requirements for life-support systems
Instrumentation and control in life-support systems
Reliability aspects of life-support systems
Testing of life-support systems

It is intended that SAE Committee SC-9 will continue to develop such areas to the extent required by the industry.

1. **PURPOSE** - This report was prepared in order to:

- a. Examine the disciplines of sciences and engineering which are involved in design, manufacturing and operation of life-support systems for use in spacecraft.
- b. Indicate the present extent of knowledge.
- c. Recommend areas where additional knowledge is most urgently needed for near future applications.

2. **CONCLUSIONS**

2.1 For mission durations which will be encountered in the immediate future, it is concluded that there is a definite need for continuous major effort to provide lightweight gravity insensitive (or reduced gravity) equipment systems for the following:

- a. Removal of carbon dioxide and other contaminants from local atmosphere.
- b. Recovery of oxygen from carbon dioxide and/or water.
- c. Potable water recovery from urine and hygienic water.
- d. Waste collection, handling, treatment and personal hygiene.

2.2 For extended mission durations and large multi-manned vehicles, more sophisticated systems will be required for the above areas, and additional problem areas will be encountered. Among these are:

- a. Minimized heat leakage and wall condensation.
- b. Atmosphere stratification in large compartments.
- c. Compartmentation, pressure lock operation, and decompression.
- d. Long-term atmosphere storage.
- e. Integration of multiple subsystems, including space radiators with structure.
- f. Extravehicular and intervehicular operations.

- g. Resupply, maintenance, emergency operation, and long-duration system monitoring.

These problem areas will be discussed in future revisions of this information report.

- 2.3 Additional development is required in all of the hardware areas to improve the ability to provide systems of minimum weight and maximum reliability.
- 2.4 Life-science requirements are sufficiently complete to guide development of equipment. Application of general engineering, physics, chemistry, etc., and ingenious designs are needed. Better knowledge of the external environment (meteoroids, composition of lunar soil, etc.) is needed for future designs.

Further work is required in the life-sciences area to more adequately define physiological limits and extremes. This is particularly true for multiple stress conditions, pressure-suit conditions, and other conditions unique to space flight.

3. DEFINITIONS

- 3.1 Life-Support System - A life-support system is commonly defined in the industry as a system which provides elements necessary for maintaining human life and health in a state required for performance of the prescribed mission. In its function, a life support system, depending upon specific design requirements, will provide suitable pressure, temperature and composition of local atmosphere, control carbon dioxide and water vapor, dispose of wastes, and supply food and water. Depending on the length of mission and number of crew members, it may or may not reprocess wastes such as carbon dioxide, water vapor, urine, feces, etc.

Life-support systems may differ widely depending on mission requirements, such as normal operation, escape, emergency, parking, moon landing, etc. In all cases, time of the operation is a very important design factor.

A life-support system is sometimes briefly defined as a system providing atmospheric control, water, food, thermal management, and waste management.

- 3.2 Life Sciences and Bioastronautics - Life sciences are, collectively, the discipline of sciences concerned with basic information on life, its processes, chemical reactions, requirements, by-products, response to different conditions, etc. Bioastronautics is a term which denotes the spectrum of scientific, technical and engineering research, development and applications related to the support of man and the preservation of his effectiveness in aerospace systems.

- 3.3 Human Factors - The science of human factors is devoted to determination of human (although it could include other living creatures) machine relations, establishing best shapes, arrangements, physical layouts of work and rest area, etc., in order to obtain best overall performance. Human factors is often considered to be a part of life sciences.
- 3.4 Application of Definitions - Both life sciences and human factors along with a multitude of other sciences, such as thermodynamics, chemistry, mechanics, etc., supply vital information for the design of the life-support systems as well as many other systems. This comment is made because in some cases confusion exists in using the above definitions.

To repeat: life sciences supply basic information on life, which defines the requirements that must be met by a life-support system.

4. GENERAL REMARKS - In order to evaluate the status of the life-support systems, two areas were surveyed:
- a. Availability of design information
 - b. Status of equipment and systems (hardware)

Required design information encompasses large numbers of different scientific disciplines and it would not be practical to list them all in detail. The list concentrates on areas where there is lack of information to the extent that it may impair satisfactory design of life-support system.

A small number of life-support equipment and systems have been built in the industry. An attempt is made to list most of them and point out their limitations and need for further work.

It can be visualized that there are cases in which equipment could be built except for lack of specific design requirements of data, or where design data is available but engineering knowledge is insufficient to design satisfactory equipment. It is also possible to have so little data that no intelligent guess as to a possible design or even need of equipment or a system can be made.

In some other cases the system could be improved somewhat but not to the point that existing systems should be considered inadequate. In the continuous effort to save weight, there is no definite line between completely satisfactory system and one which needs more development.

Length and type of the mission influence to a large extent the detail information needed and the approach to the equipment design. Proper design approaches for shorter missions, for example, may not be satisfactory for longer missions and new principles may have to be applied.