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SUMMARY OF A SPEECH TITLED

AEROSPACE NUCLEAR SAFETY PROGRAM AT SANDIA CORPORATION

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The increasingly complex satellites and spacecraft developed by the U. S. in recent years have created demands for larger amounts of auxiliary electrical power than can be economically supplied by batteries, solar cells, or other means. Longer-lived orbital vehicles, especially the manned versions now being developed, have further increased these demands for power.

Nuclear power sources offer the obvious solution for some of these power requirements. Research work, initiated several years ago under contracts from the AEC and DOD, has resulted in the development of functional nuclear systems for the production of power for these applications. There are two general types of Systems for Nuclear Auxiliary Power (SNAP's): radio-isotopic systems and nuclear reactor systems.

Radioisotope-fueled generators rely on the decay process of special radio-isotopes to produce thermal energy. Through the thermoelectric process this thermal energy is converted directly into usable electric energy without the aid of rotating generating equipment. Systems of this type are currently limited to relatively low power outputs (several hundred watts).

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Reactor power supplies use nuclear reactors to produce thermal energy. This thermal energy is converted into electrical energy either by direct thermoelectric conversion or by rotating-type generators. Systems of this type are capable of producing hundreds or thousands of watts.

Sandia Corporation, under a prime contract with the Atomic Energy Commission, operates two laboratories and a test range, all of which are engaged in research and development work on the ordnance phases of nuclear weapons.

Sandia has been engaged in weapon work for the AEC for a number of years. During this time, capabilities have been developed at Sandia that are directly applicable and highly valuable to work in the Aerospace Nuclear Safety Program. Some of these are:

1. A research organization whose scientific fields of interest include physical electronics, plasma physics, high-temperature physics, solid-state physics, radiation effects, theoretical mechanics, molecular and crystal structure studies, high-rate chemical kinetics, and nuclear-burst phenomena.
2. An environmental testing organization equipped with complete facilities to perform drop-tower, radiant-heat, vibration, shock, chemical-interaction, acoustical, and rocket-sled impact tests, as well as many others.
3. A materials and processes organization that develops new materials, keeps abreast of research and development in its fields, evaluates commercially available materials, and operates its own analytical and material properties laboratories.

4. A field testing organization that performs and supports Sandia test programs at its own ranges and at other locations around the world.

In the latter half of 1961, Sandia Corporation was requested by the AEC Division of Reactor Development to serve as technical contractor in examining the safety of aerospace nuclear power sources and in performing the related basic research and development work. At the present time, these four distinct work areas have been delineated by AEC/DRD&T:

1. a Basic Aerospace Safety Research and Development Program,
2. an Aerospace Safety Ground Test Program,
3. an Aerospace Safety Flight Test Program, and
4. an Independent Assessment of the Safety of all Aerospace Nuclear Power Sources.

Brief summaries of the scope of work involved in the above-listed tasks are:

TASK I. Applied Research and Advanced Development Program

TASK I of the Aerospace Nuclear Safety Program encompasses the responsibility for conduct of a Research and Advanced Development Program. The task objective is to carry out laboratory and analytical investigations necessary to an understanding of phenomena affecting the safe application of aerospace nuclear systems. In particular, this task encompasses studies to understand the response of materials

when subjected to the environment of atmospheric re-entry, to understand and derive means for predicting the behavior of debris deposited in the atmosphere, and to derive means and understanding necessary for the final assessment of hazards in the biosphere.

The technical approach to satisfy these objectives consists of dividing the task into three broad areas of work and subdividing these areas into individual projects. The projects so defined are assigned to competent staff members and in some cases subcontractors are selected.

TASK I is described in terms of three general project areas:

1. Re-entry Studies
2. Debris Fate and Particle Studies
3. Support Studies

Results obtained from the TASK I studies will be useful in the systems analysis and safety assessment of operational systems and will help to provide safety guidelines for the specification and design of operational systems.

TASK II. Safety Ground Test Program

The Aerospace Safety Ground Test Program at Sandia is broadly defined as that effort to obtain engineering information from ground-based tests required for the assessment of the effects of mechanical actions, thermal and chemical interactions, and nuclear reactions upon the

safety of nuclear devices which are intended for aerospace applications. This program is responsible for performing ground tests to obtain information on all effects resulting from conceivable accident conditions from the time of factory shipment through terrestrial re-entry, with the exception of the actual re-entry covered under TASK III.

An outline of work presently under way or planned for the TASK II program follows:

Project Engineering

Mechanical Actions

1. Containment Capsule Impact Safety Studies
2. Earth Impact & Penetration Study
3. Reactor Impact Tests
4. Dynamic Analysis Studies
5. Aerodynamic Attitude Studies

Thermal & Chemical Interactions

1. Launch Abort Environment Studies
2. ROVER Explosive Destruct Instrumentation Study
3. Containment Material Integrity Study
4. Isotope Fuel Release & Dispersal Study
5. Chemical Interaction Tests
6. Thermal Interaction Tests
7. Beryllium Compound Formation & Dispersal Study

Nuclear Reactions

1. Nuclear Design Safety Reviews
2. Hazardous Conditions Analysis
3. Other Nuclear Test Analyses

TASK III. Safety Flight Test Program

In the course of safety assessment of nuclear power supplies, it eventually becomes necessary to evaluate the consequences of the re-entry of reactors and radioactive power supplies into the earth's atmosphere. One method of evaluating these consequences is by theoretical analysis; however, the theoretical analysis of re-entry burnup or re-entry survival requires knowledge of the re-entry trajectory and attitude of the SNAP unit/payload combination. Information is also required on the aerodynamic heat transfer to the combination and the structural modes of failure of the combination. Since the power-supply/payload combination is generally of a complex shape with a complex internal structure, many simplifying assumptions in the analysis of structural burnup and breakup are required. Even in the best theoretical analysis, additional experimental results are often needed for use in this theory.

At present full simulation of all aspects of the re-entry environment to which SNAP units are subject is impossible using ground-based test facilities. The ground-based test facilities can and are being used, however, to investigate many specific areas of interest in the re-entry problem.

Because of the present limitations in ground-test facilities and theoretical methods, re-entry flight tests of nuclear power supplies are required. The re-entry flight tests will (1) investigate nuclear-power-supply disassembly characteristics and burnup, (2) obtain data on basic re-entry burnup not obtainable in ground facilities, (3) obtain experimental re-entry heating data for correlation with the results of ground-test facilities and theoretical analyses, and (4) demonstrate the feasibility of other disposal techniques, such as intact re-entry.

The work necessary to accomplish this type of testing is covered by the TASK III assignment which is listed under the six main headings below:

- Project Engineering
- Payload
- Re-entry System Engineering
- Telemetry System Design
- Launch and Range Operations
- Flight Test Data Analysis

TASK IV. System Analysis and Safety Assessment Program

TASK IV of the aerospace nuclear safety work at Sandia Corporation includes Systems Analysis and Safety Assessment. These are very broad and general activities which can be called the beginning and end of the ANS work by Sandia. The systems analysis work helps

initiate research and engineering investigations, and the safety assessment utilizes the output of these investigations to assess specific missions for a SNAP systems.

The systems analysis activities encompass the entire spectrum of potential hazards which can occur with the use of a SNAP system. This includes the handling, transportation, assembly with a satellite, launch, powered flight, orbit, and eventual disposal of the SNAP fuel. This entire sequence must be analyzed, and the method of analysis should help determine the events and probabilities which produce the greatest hazard. The method of analysis should also produce results which may be compared to other systems or to other disposal methods for the same mission. The development of such quantitative hazard analyses will provide guidance to the designers in considering additional safety features or alternate disposal methods for a specific mission.

The safety assessment portion of this task utilizes the information developed by the above efforts and information resulting from TASKS I, II, and III. The applicable information developed in the entire ANS program must be utilized in the safety assessment of a specific mission. These studies need to be done in a realistic fashion and utilize the best technical data available.

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