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NAA-SR-MEMO 7550

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SNAP 10A SNAPSHOT PROGRAM DEVELOPMENT

I. SNAP 10A PROGRAM REQUIREMENTS

The purpose of this document is to outline the ground rules for the component and system development program which will result in a flight SNAP 10A to meet the goals which have been set up for the SNAPSHOT program. From this development plan, a set of detailed component and system testing plans can be formulated. These detailed plans must then reflect all of the ground rules set forth in this section. It is recognized that many of the component development programs are well advanced and some have been planned in detail. It is expected, where necessary, that all of these test plans will be reviewed and revised as necessary so as to reflect the guidance contained herein.

A. General Requirements

The general requirements for the SNAP 10A program arise from many different sources. The AEC has imposed a set of objectives for the program which the final flight unit must meet. In addition, AI has taken these objectives and added additional self-imposed requirements on top of them. Inputs also come from LMSC and the Air Force in terms of mission and vehicle requirements. This section will discuss all of these requirements and attempt to outline which are to be used as SNAP 10A design and development goals.

The SNAPSHOT-SNAP 10A program is developmental and the several SNAP units to be flight tested are research type prototypes. Therefore, some of the requirements in terms of weight, environmental qualification, etc., are considerably relaxed over what an eventual SNAP 10A APU must meet. All of the goals set forth by the AEC as SNAPSHOT objectives are definite design and development goals for the program. These are:

1. A minimum electrical power output of at least 500 watts at 28.5 volts dc should be provided over a period of one year.
2. The maximum system weight for the SNAPSHOT vehicle should be 875 pounds. This includes extra components such as diagnostic instrumentation that are required to meet the SNAPSHOT objectives.
3. A radiation shield will be provided to limit the dose at the dose plane over a one-year period to below 10^{12} nvt and 10^7 r. The dose plane is defined at a level 17-1/2 ft. below the bottom of the reactor, 60 inches in diameter.
4. The SNAP 10A system shall utilize the SNAP 2 reactor design with minimum design modifications.
5. The system will be designed for orbital startup.

6. The system will be essentially static in operation and contain no moving parts, with the exception of the NaK coolant.
7. The system must be designed and qualified to meet the environment encountered during launch and in space.
8. The system shall be designed to eliminate the need for active reactor control following the startup period.
9. The unit must be designed to facilitate safe ground handling and launching and must be developed to contribute a minimal radiological hazard to the launch facilities personnel and surrounding inhabitants.
10. The power conversion subsystem shall be designed to accommodate future growth potential to systems of higher power and power/weight ratios.

In addition to the above AEC contractual objectives of SNAPSHOT, other basic objectives have been formulated both by AI and by LMSC so as to assure a unit compatible with the Agena vehicle and SNAPSHOT mission requirements. Some of the more important requirements are as follows:

1. The system configuration is limited in size and must not fall outside of an envelope defined by the LMSC nose fairing.
2. The life demonstration objectives for the SNAPSHOT program are 90 days. Ninety days of flight operation will constitute satisfactory demonstration of SNAPSHOT goals; however, all system and component designs should be capable of a one-year operating duration. Therefore, items such as reactor degradation, converter degradation, pump degradation, etc., should be factored into the design and development program based on a one-year objective.
3. No SNAPSHOT reliability goals have been set by the AEC for the APU. However, AI has established suitable goals for the SNAPSHOT program based on minimizing the risk that at least one of the two SNAP 10A units will function properly. These goals are as follows:

a. Probability of APU surviving ascent and pre-startup period	.98
b. Probability of APU reaching minimum design power	.95
c. Probability of APU running at least 90 days with at least minimum design power	.90
d. Probability of APU operating for a full one-year period with minimum design power	.76

These goals are to be considered only as objectives and are not required to be demonstrated by the SNAPSHOT developmental program. It appears to be impossible within the present test program funding and scheduling, to demonstrate, with any confidence, that these goals have been met.

Therefore, they should be used only in comparing analytical estimates of reliability (where data is available, e.g. startup controller and instrumentation equipment) with goals. Certain design decisions are influenced by these comparisons. For example, a decision could be made whether or not to use redundant components based on such a reliability calculation.

4. The APU unit shall be self-contained as nearly as possible in that a minimum of components vital to APU operation will be located in the Agena vehicle. All components necessary to start up and control the APU system will be contained within the APU itself. Only the telemetry links, pump battery, and power busses will be located in the Agena vehicle.
5. Provisions will be made in the design to include active reactor control following the initial stabilization period. This is because of the many uncertainties associated with reactor degradation in a space environment, and seems advisable since the controller is essentially the same as the SNAP 2 unit (which has a one-year life objective).
6. The APU must be designed so as not to interfere with the Agena vehicle operation. This imposes requirements on the APU in several areas, in addition to the ones already discussed.
 - a. The torques generated by the SNAP 10A unit shall not exceed those which can be handled by the Agena attitude control system. Otherwise, attitude stabilization of the Agena will be impossible, and eventual operational objectives of the APU cannot be met.
 - b. Electro interference from the APU shall not have any harmful effect on Agena vehicle equipment. This objective means that the APU must meet the requirements as set forth in military specifications involving radio interference (MIL-I-26600). In addition to radiated and conducted interference, the APU should not be susceptible to any interference generated by the Agena gear. This is particularly true of startup and control equipment located in the APU.
 - c. The center of gravity of the APU shall be within the limits prescribed for adequate vehicle stability of the Atlas-Agena.

In addition to the previously tabulated performance requirements, there is an equally severe set of environmental requirements imposed upon the APU which controls much of the testing for the 10A program. The APU must meet the environmental requirements associated with launch and space operation. In addition, however, the APU goes through many operations at Santa Susana and Vandenberg during the assembly, testing, and prelaunch operational phases. Additional environments are encountered during many of these operations. Some of the environmental problems which may arise from other than launch and space operation are:

1. Long storage periods (up to one year).
2. Shock and vibration encountered during shipment and handling.
3. Exposure to high humidity (with resulting condensation), sand, dust, rain, fungus growth, salt spray, and other corrosive environments.

Because of the developmental nature of the APU to be orbital tested for SNAPSHOT, it is not desirable or required to completely design, and qualify this unit for all of the environments associated with these ground operations. Future SNAP LOA programs (operational development and follow-on) are for the purpose of developing such an APU to meet all of these environments. The ground rules to be used for environmental development and testing for SNAPSHOT are as follows:

1. The APU will be designed and completely qualified to meet both the space and launch environments.
2. The APU will be protected during the ground operations which might involve exposure to severe launch site environments. This protection will consist of shipping containers, humidity and moisture control during storage and handling, and complete protection on the launch pad by means of an air-conditioned environment within the nose cone fairing. This philosophy shall be used during all operations which might involve any exposure to a harmful environment. It is recognized, however, that for very brief periods, such exposure will be encountered such as when the APU is raised into position by the gantry crane.
3. Where no design penalties are incurred, all APU components should be designed to meet the environments which may be encountered during the ground operational phases. For example, if it is possible to design or procure a component which will be moisture-resistant without any design penalties from a standpoint of performance, that component should be included in the SNAP LOA design. This philosophy will maximize the probability of the APU resisting the possible short periods of exposure to some of these harmful environments. In addition to designing the component to meet these environments, it is also desirable to perform the necessary qualification testing, where it is within the scope of the present funding and scheduling, to assure that it will, in fact, meet the required specifications. In some cases, components can be procured which have already been qualified to meet stringent military specifications. These qualified components should be used where possible.

All components must be completely qualified by testing to meet the space and launch environments. This will include complete testing (as applicable) in the following areas:

1. Radiation effects
2. Shock and vibration

3. Acceleration and static loading
4. Acoustic inputs
5. Endurance testing under simulated operating environment
6. Performance and functional testing
7. Thermal shock and cycling tests
8. Electro interference testing
9. Vacuum testing

All of the above listed tests may not apply to every component, and the component test plans should consider the qualification required on each component in light of the above. For example, it is obvious that non-electrical components need not have electro interference tests performed. Also, components of known radiation resistance need not have long-term radiation tests performed on them.

The component development programs must include combined tests where it is essential to properly simulate the space environment. For example, high-temperature endurance tests under high-vacuum conditions or combination radiation-thermal-vacuum tests may be necessary. The required testing on each of the components must be carefully reviewed in terms of its use in the system and its sensitivity to the various environments, and the test program include all required tests to assure that the component will, in fact, meet the launch and space environment conditions.

In many cases, it is impossible to define precisely the actual space environment. For example, in the area of shock and vibration, much data is missing in terms of the actual combination of acoustic and structural vibration inputs to the APU. LMSC has attempted to define equivalent test environments which, if the component can survive, will assure with reasonable confidence that it will also survive the actual launch environment. The components must be completely designed and tested to the equivalent environment, as this is the only information available. As more detailed information on the actual environment becomes available, component design and qualification specifications will be modified accordingly.

Testing levels in all cases must have margins of safety over the actual environmental levels, so as to assure high confidence that the component will meet the actual environmental conditions. These margins of safety shall be called out in the detailed component developmental programs and will be based on the following considerations:

1. Accuracy with which the environmental stress levels are known in actual operation.
2. Accuracy with which the ultimate strength of the material to this stress is known (failure criteria).
3. Accuracy with which the test conditions can be measured.

B. Schedule

The schedule of SNAP LOA development program will be released by a separate IOL (secret restricted data) and will be reflected in other documents giving specific program milestone dates.

C. Scope of Development

The overall SNAP LOA/SNAPSHOT development program consists of both component tests and system tests. Both types of tests are equally important in terms of assuring that SNAP LOA will meet its objectives. The purposes of the component tests are the following:

1. To demonstrate that the component will meet its performance objectives and to modify it accordingly until it will. This developmental type of testing can only be done on a component level since it would be extremely difficult, if not impossible, to perform the required developmental and test work as part of a system test.
2. To completely qualify the component to meet all of the environmental requirements. This also can only be done on the component level because of the large number of different types of tests and the facilities and time required. Because of the larger cost associated with system testing, it would be impractical to attempt to qualify components to all of the required environments as a part of the complete system tests.
3. To assure that the components have met their performance and environmental objectives before they are installed in a system test. This is an important objective of the component development program, since it can save time and money involved in the system tests if it can be assured that each component has a high probability of functioning properly when installed as part of a system. It is essential that at least one of each type component operated in the FSM-1 system tests has successfully passed the following tests, as applicable:
 - a. A performance test indicating the component will meet its design point operation.
 - b. An endurance test at operating conditions (temperature and vacuum) which demonstrates at least 1000 hours of operation (or 10 times normal design life) as applicable.
 - c. Shock, vibration, and acceleration tests to full qualification levels.
 - d. Resistance to thermal shocks up to at least 10 heating and cooling cycles over its full operating temperature range.

In addition, components which are operated in the FS-1 test should have met all of the previously mentioned tests, and shall have been demonstrated to meet the radiation level specifications and have at least 3000 hours endurance at design point conditions.

All components for flight test units (FS-2, 3, 4) shall have passed all qualification tests, including a 6000-hour or more test at design point conditions.

None of the components used on the qualification test program shall be installed into a system test. Instead, newly fabricated components of like design shall be used. Before being installed into the system test, the component will be acceptance tested to indicate that it is, in fact, similar to the previously qualified component.

In the process of testing each of the components to the various environmental conditions, a number of components will be required for these developmental qualification tests. It is recognized that even though it is not practical to demonstrate the required reliability goals for SNAPSHOT as a part of the component qualification testing, it is desirable that a statistically significant number of components be endurance tested so as to establish some confidence that the component will function properly in the orbital test.

APU system tests are planned as part of the overall SNAP 10A program. The system tests fall into several types:

1. Developmental system tests
2. Qualification system tests (nuclear, non-nuclear, and interface compatibility)

The developmental system tests are for the purpose of exploring one particular phase of system problems (e.g., hydraulic, thermal, or structural). The developmental systems are full-sized experimental prototype units and do not necessarily resemble flight system designs in great detail. They are run early in the program so as to learn as much as possible about system problems prior to establishing a firm flight design. The development units are highly flexible and well instrumented so that the various phases of system problems can be easily explored. The cost of a developmental system test is held down by simulating most of the components which are not vital for the function of the test. For example, many of the heavier components can be simulated by mass mockups in a structural developmental system. The developmental system, therefore, becomes a rapid way of resolving certain specific problems involving interaction of components. The testing program for the developmental systems is planned in such a manner that many of the analytical and design techniques used in predicting behavior of the flight design can be verified. Additional instrumentation (over and above what would normally be part of a flight design) will be provided to explore the more detailed aspects of system behavior. No tests will be included which could be done more easily

on the component level. Several types of developmental systems are planned for SNAP 10A, structural and thermal-hydraulic.

The qualification system tests will, in general, be of complete flight design with a very minimum of simulated functions. The qualification system tests fall into several types:

1. Nuclear
2. Non-nuclear
3. Interface compatibility tests, consisting primarily of electrical, control and instrumentation systems.

The fundamental purpose of the qualification system test is to gain confidence that the flight system design will meet its performance objectives.

The objective of the qualification system test program is to demonstrate, including acceptance testing, ground handling, prelaunch checkout, launch phase and orbital operation, that the flight system will meet its performance and environmental objectives. The use of several such tests further increases the confidence that the eventual flight system will be successful.

The non-nuclear qualification tests are complete with the exception of the nuclear reactor, which is simulated by suitable electrical heater elements. The advantage of the non-nuclear system test is that many of the problems involving the relationships and compatibility between components can be checked out and developed without the complication of radioactivity and remote maintenance. Thus, as problems are encountered with the operation of the system, they can be corrected.

The nuclear qualification system test is planned to supplement the non-nuclear unit and answer the remaining questions involving the operation of the reactor as part of the APU system and the operation of all components in a radiation environment. The nuclear system will go through all simulated operations, including startup and endurance running. The nuclear unit is scheduled to run 90 days at full power prior to flight tests in order to demonstrate adequate qualification of the flight design.

Complete system interface compatibility tests are also planned. These tests are essentially electrical simulations of the flight system design, and will be used to check compatibility between the Agena vehicle and APU electrical and instrumentation systems. They will be similar to the flight design with respect to mechanical configuration, weight, and center of gravity, and, as such, will be used to check out mechanical compatibility with the Agena vehicle and GSE gear. This compatibility test system will be connected electrically to the Agena metal mockup vehicle and the combined system will be checked out completely.

1. Reference Technical Documents

Internal documents have been prepared or are in preparation to further define the SNAP LOA program and are outlined in Section VI. These documents will form the basic guidelines for all of the technical work. They contain the basic technical performance requirements, qualification requirements, acceptance test requirements, system test requirements, necessary support activities, and other functions essential to the overall SNAP LOA SNAPSHOT program. These documents, together with the equipment and purchase specifications, and component and system development plans, should clearly define all aspects of the SNAP LOA program. These documents will be maintained current based on the most recent AEC technical guidance and requirements.

In addition to the internal generated documents, there are specifications from LMSC and Mil Specs. These specifications are not contractually binding on AI. They are, however, important and do contain necessary information of assistance in completing the SNAP LOA design and the overall program. These documents then are in many cases design objectives and we are in many cases, for example structurally, utilizing the LMSC-supplied specifications. Mil specifications should be used as a reference only. We are not contractually obligated to procure or supply components based on Mil Specs. If components can be obtained already qualified to Mil Specs, or if Mil Specs can be advantageously used, then we should do so. The one exception to this is Mil I-26600 which is being used as a definite design objective for electro interference. Testing should be done to demonstrate compliance with this specification. The other exception is Navy specification COMPMR instruction 5100.2B which defines the range safety requirements for flight destruct systems. The reactor destruct package must be designed consistent with this specification.

Detail specification requirements are also outlined in the Interface Agreements document prepared by the LMSC Coordination Project Engineer.

II. COMPONENT AND SUBSYSTEM DEVELOPMENT

As part of the overall SNAP LOA Development Program it is necessary to develop or otherwise procure the individual parts or components which are assembled into the final flight units and test systems. To ensure that these components fulfill their specified function in the system it is necessary to undertake a developmental-qualification and acceptance testing effort.

The specific objective of performing these tests is to assure with reasonable confidence that the component will perform the specified function without failure under given (environmental) conditions for a specified period of time. In the preparation of test plans for both component and system testing it is important to consider that for many of the components the definition of the wording "perform the specified function" includes the survival of the component through the ground testing and severe launch environments so that it can in fact perform its intended function in the orbital test of the SNAP LOA concept. The "specified period of time" is relatively short for survival in the ground testing and launch environment and relatively long (1 year) for orbital operation. It is essential that the component and system test plans include the proper relationship between function, environmental conditions and testing time.

All components for the flight systems must pass the applicable qualification test before an identical type component is installed in the flight systems.

The acceptance test is to ensure that the component that is to be installed in the flight system is in fact identical to the component that has previously passed the qualification test. The acceptance test must in no way damage the component, i.e., reduce the probability that the acceptance tested component will perform without failure the specified function for a specified period of time. To ensure that the acceptance test procedures are non-destructive, all components must pass the acceptance test before undergoing final qualification test.

A. Instrumentation

1. Development

The following major SNAP LOA Instrumentation, Control or Electrical components are considered as developmental items and are the responsibility of the Reactor Development Department.

a. Startup Controller

b. Control Drum Stepper Motor

- c. Control Drum Position Transducer
- d. Control Drum Limit Switches
- e. Temperature Sensor Switch for Control

A developmental testing program is included as part of the development of these components. The following comments relative to component qualification and acceptance testing also apply to these developmental components.

The majority of the Instrumentation, Control and Electrical components for SNAP 10A are being procured from outside sources with maximum emphasis on the use of off-the-shelf items that have been previously developed for missile and satellite applications. In many cases these components have been tested to some of the environmental levels required by the SNAP 10A component qualification test program. However, the qualification and acceptance test programs must ensure that all components will perform as required. In general, this means that every component must undergo certain phases of the qualification testing at AI or under AI direction, and that all components shall be acceptance tested at AI.

Previously outlined in Section I, was a discussion of the environment to which the components shall be qualified. This includes the space environment, launch environment, and ground handling environment. It is absolutely essential that all components be qualified to space and launch environments and it is desirable, but of secondary importance, that they also be qualified to the ground handling environment (i.e., humidity, sand, dust, etc.).

Most of the flight components should go through the following testing program. (Components with prior radiation experience need not be radiation tested if it is known they will suffer no deleterious effects therefrom.)

- a. Complete radiation tests to indicate that the component has no harmful rate effects and that it will survive the integrated dose corresponding to one year operation (or 90 days in FS-1, whichever is more severe). Radiation testing should, in general, be done at the proper component operating temperature and in a vacuum, if it is expected that these combination environments are important from the standpoint of component life. It appears that some components, particularly those which are hermetically sealed will not need to be irradiated in a vacuum, since the internal atmosphere within the enclosure is maintained even under radiation.

At least two components of each type should be irradiated to demonstrate that the component will, indeed meet these objectives. All instrumentation components being installed in the FS-1 should have had at least the equivalent of 3,000 hours integrated radiation damage prior to the operation of FS-1.

Complete performance of all components must be demonstrated while operating under a radiation field, if it is expected that rate effects may be important on the operation of the component. Operational testing of instrumentation while in a radiation environment will only be required on components mounted outside the radiation shield shadow.

- b. Two components of each type must be demonstrated to survive full qualification level shock, vibration, and acceleration loadings. Individual component tests should be performed on every component, including its support to assure that it will meet these requirements. Most instrumentation need not operate during these tests; however, those electrical components which must operate during the ascent phase (e.g., accelerometers) must be operated satisfactorily during test.

In addition to the individual component shock and vibration tests, the entire instrument compartment with all components assembled must pass shock and vibration tests at qualification levels in a separate instrument compartment test.

- c. The performance of every component should be demonstrated over the full operating temperature range of the components, including the low temperature range obtained before APU startup.
- d. The performance of each component must be demonstrated at its design operating temperature (in a non-radiation environment). This entire endurance program should demonstrate at least a 1,000 hour capability prior to the FSM-1 test operation and a 3,000 hour capability prior to the FS-1 test operation. At least two such units must pass this endurance test. Prior to the flight test, two units shall have demonstrated at least a 6,000 hour endurance.

High temperature endurance tests must be performed in a **high** vacuum if it is expected that the high vacuum environment will seriously affect the specified life of the component.

For components with limited life requirement (startup components) the extended endurance tests need not be run. Instead, it must be demonstrated that the component will survive at least ten startup cycles and/or ten times its operating life, whichever is applicable, prior to FSM-1 testing.

- e. The effects of thermal shock and temperature cycling must be demonstrated on each component. At least one component of each type shall undergo thermal cycling tests and demonstrate that it is capable of withstanding ten cycles over the full environment operating range of the component.
- f. A vacuum and/or pressure test shall be performed on every sealed component to assure that it will withstand the necessary differential pressure.
- g. An acoustic test will be performed on a complete instrument compartment assembly.
- h. Electro interference tests shall be performed on major subsystems to demonstrate whether or not they comply with the interference specifications as set forth in MIL-I-26600. Specifically, the following subsystems shall be given an electro interference test:
 - 1) Startup controller and actuators with mock-up wiring.
 - 2) RTD sensor and signal conditioning.
 - 3) Reflector ejection subsystem including initiator, simulated squibs and mock-up wiring.
 - 4) Electrical destruct subsystem, including initiator, simulated squibs, and mock-up wiring.
 - 5) Radiation detection subsystem including detector, signal conditioning and mock-up wiring.
 - 6) Flowmeter channel, including wiring and amplifier.
 - 7) Expansion compensator, position indicators, including transducers, signal conditioners and mock-up wiring.
 - 8) Drum position indicators, including transducers, signal conditioners and mock-up wiring.
 - 9) A complete instrument compartment assembly with all simulated functions, as required.

In addition to the tests required to qualify the unit to the launch and space environments, it is desirable that components be tested to withstand the environment of ground handling without the need for protection - even though this is not a definite SNAPSHOT requirement. Therefore, where it is possible to test a component to meet these environmental conditions without excessive cost or schedule delay, it should be done.

Considering all of the previously mentioned qualification tests, the overall qualification program should demonstrate that each component is capable of meeting its performance and environmental

objectives (based on a 90-day endurance) with a reliability of 97 percent and a minimum confidence level of 10 percent.

All components which are installed into system tests (starting with FSM-1) shall receive a complete acceptance test. The acceptance test is for the purpose of determining whether or not the component contains any manufacturing weaknesses, and to determine that it is similar in behavior to like components, which have been qualified. None of the components used for qualification testing shall be installed in system tests.

B. NaK Components

The principal NaK components requiring developmental and/or qualification testing are the NaK circulating pump, the volume expansion compensator, and (ground test auxiliary heaters). These components are to be tested to assure satisfactory operation through all phases of system ground tests, launch, and orbital operations. These tests are to include significant environmental effects encountered in all of these operations: system test vacuum, vacuum down to 10^{-6} , humidity, radiation, and shock and vibration.

1. Pump

The pump being developed for SNAP 10A is an integrally powered dc-type Faraday induction pump. The pump includes the electric power source, permanent magnet, and heat rejection system. The reference pump design will employ silicon-germanium as the thermoelectric power source. A backup pump design employing lead telluride or lead-tin telluride will be maintained under development until such time as qualification tests demonstrate the suitability of the silicon-germanium pump.

Development work on the pump will be based on sub-units testing operations conducted on a full-scale pump. This testing and operation will consider at all times the system operating environment. As a minimum, the pump development effort will include testing under the following conditions:

- a. The pump meets qualification level shock and vibration loadings.
- b. The ultimate shock and vibration capability of the pump will be established by testing to destruction.
- c. The performance of the pump will be established for both the startup and full operating range; i.e., initial to end-of-life.
- d. The pump performance, including up to 1000 hours degradation data, will be obtained at temperatures up to 100°F above the nominal operating point.
- e. The effects of thermal shock and cycling will be determined. The thermal cycle failure mode will be established.

- f. The effect on the pump of operating in environments typical of a system test will be established.
- g. The pump performance will be established following the same environmental conditions that the actual flight units will see:
 - 1) Acceptance testing including shock and vibration.
 - 2) Thermal cycling and short-term operation.
 - 3) Qualification testing including shock and vibration.
 - 4) Extended lifetime testing.

The pump development and qualification testing program will be of sufficient scope that design performance, following the sequence of events outlined in 'g' above, will be demonstrated with a reliability of 98 percent at a minimum confidence level of 10 percent, based on ninety-day performance. Furthermore, the development testing program must demonstrate 1000 hours capability prior to the FSM-1 test objective, and 3000 hours operating capability prior to the nuclear qualification test operation. This endurance and capability must be demonstrated on not less than three units. Prior to flight test, 6000 hours test operation will be obtained on one unit, and a total of 12,000 integrated test hours or more.

As an integral part of the pump development program, the full range of instrumentation, emissivity coatings, etc., required of the final flight pump must be demonstrated. However, actual qualification of the individual instrumentation will be accomplished under the instrumentation qualification program.

2. Expansion Compensator

The expansion compensator, in terms of its present status, is not considered to be a developmental item, but rather one which can be engineered, fabricated, and produced on known technology. As such, then, there is no further developmental program associated with the expansion compensator, but rather only a qualification test program. In general, the qualification test program will follow in scope that of the pump. Specifically, the following will be demonstrated:

- a. The expansion compensator will meet qualification level shock and vibration loadings.
- b. The ultimate shock and vibration capability of the expansion compensator will be established by testing to failure.

- c. The performance of the expansion compensator will be demonstrated for the full range of ground test, startup, and operating conditions.
- d. Satisfactory expansion compensator operation up to 100°F above the normal operating point will be demonstrated.
- e. The effects of thermal shock and cycling will be established. At least one unit will be thermal cycled to failure.
- f. The operation of the expansion compensator with its full complement of instrumentation will be demonstrated.
- g. Hydraulic testing will be accomplished on one specimen to failure.

As a minimum, the qualification test program will be such that a reliability of 98 percent with a confidence level of 10 percent will be demonstrated prior to the flight units, based on 90-day performance. Expansion compensators will have been demonstrated to survive qualification level shock and vibration, and to operate 1000 hours prior to the FSM-1 test operation and 3000 hours prior to the FS-1 test operation. A minimum of three expansion compensators will be placed on lifetime tests.

3. Auxiliary Heaters

Auxiliary NaK heaters are required to furnish power during some of the system ground tests, and during the acceptance tests of the flight units. It is not a requirement, but rather an objective that these various heaters be identical for the ground system tests and flight system acceptance tests. In any event, the heater should be capable of being installed, operated, and if possible, removed from the flight units prior to the flight operations. If the auxiliary heaters can be of sufficiently low weight (3 lb), and have other advantages of ease of operation, reliability, etc., they may be left on the actual flight units.

C. Structure and Secondary Components

Of principal importance, structurally, is the main APU support structure, including legs, the instrument compartment, and the ejectable heat shield. Of secondary importance is the reactor destruct device. These components, then, should be subjected to a test program which primarily determines their structural adequacy during all phases of the ground handling, tests, and launch phases.

The basic APU structure is to be developed to react dynamic and static loads imposed on the APU. As such, the test plan for the structure is almost wholly one of structural testing. Unlike some other components for the flight system which can be acceptance tested functionally prior to their use, the APU structure cannot. The development program, then, would include as a minimum (with proper account taken of the systems tests):

- a. The static and dynamic response characteristics at full input loads, including the determination of the most likely failure mode.
- b. The response of the structure up to 25 percent dynamic overloads or to failure, whichever occurs sooner.
- c. Establish, at least in a preliminary way, confidence level of subsequent structures to pass qualification tests based on expected material properties and statistical treatment of data spreads.
- d. Establish the confidence in the riveted joints, including their ultimate strength.
- e. Establish that the pre-launch thermal cycling and residual thermal stresses will not produce structural distortions.

As part of the structural development program, the characteristics of the material following the processes should be determined metallurgically, including the weld area, effect of chem-milling, etc.

1. Ejectable Heat Shield

Proper operation of the ejectable heat shield is essential for the successful flight test; therefore, sufficient ground testing of the device must be conducted to insure that the heat shield retainers will release, the shield will eject, and upon ejection will clear the APU and the vehicle. As a minimum then, the shield development program should prove:

- a. The ejection capability of the shield must be demonstrated under operating conditions, except for the zero-gravity field. Analytical extrapolation to zero gravity is required.
- b. The thermal stability of the shield will be demonstrated at conditions up to design.
- c. The stability of the shield release hardware with time shall be established.
- d. The operation of the electrical wire contact disconnect mechanism will be established.
- e. The shield ejection trajectory following initial release will be established in a 1-g environment, and extrapolated analytically to zero g's.
- f. The structural stability of the shield during vibration and shock conditions shall demonstrate adequacy, including not impacting or otherwise touching the thermoelectric converter radiators.

2. Instrument Compartment

Structural tests are required to be conducted on the instrument compartment, with mockups of the instruments, to establish the dynamic characteristics and confirm that the acceleration loadings to the instruments themselves are within specification values. It is a design objective that shock mounting of instrumentation be avoided. As such, then, the development program for the instrument compartment must:

- a. Establish the natural frequency and damping characteristics.
- b. Determine the maximum acceleration loadings imparted to the instruments.

As secondary objectives, the temperature distributions within the compartment should be established. This can be done on system tests if the thermal environment as determined analytically appears non-critical. As part of the fabrication development program, the application of emissivity coatings to the inside and outside of a full instrument compartment shall be demonstrated and these shall further be demonstrated to be shock and vibration resistant.

D. Coatings and Surface Control

Emissivity surface control is required on a multitude of different components associated with the APU. These coatings include those of high emissivity, low emissivity, and various combinations of thermal emissivity and solar absorptivity. The basic emissivity coatings program will demonstrate the properties of the coating, their general application technique, and the suitability of the coatings through all the environmental conditions which the APU sees including operation. The various component programs will be responsible for integrating the application of these coatings onto that component.

The emissivity program will demonstrate, as a minimum, the following:

1. The application of all coatings on their respective substrata material.
2. The vibration and shock resistance of all coatings.
3. The stability of the thermal emissivity and absorptivity properties for periods of not less than 3000 hours.
4. The degradation rates of the coatings at temperatures up to 100°F above nominal operating point shall be established.
5. The performance of the coating at vacuums down to the 10^{-6} will be established, as well as at vacuums and environments typical of the systems tests.

6. Resistance of the coating to ultraviolet shall be demonstrated.
7. The stability of the coating as exposed to a normal atmosphere will be established.
8. The behavior of the coating in atmospheres typical of the seashore will be established for periods up to 30 days.

In all of the above tests, sufficient test samples will be run in every test in order to be statistically meaningful; as a general rule of thumb, this should be considered to be a minimum of 10 tests for each process or environmental change.

E. Power Conversion System

The program for the power conversion system has the objective of producing flight qualified modules. This development work is split between AI and the RCA subcontract; however, overall design and specification responsibility lies with AI. The program encompasses materials development, engineering, process development, module testing, and acceptance testing and assembly. It is designed to ensure the highest probability of achieving the required reliability. The scope of the work is designed to provide an understanding of fundamentals in order that problems can be approached with a full understanding of the principles.

1. Materials

The basic responsibility for the development and optimization of the Si-Ge thermoelectric material lies with RCA. They will determine the optimum Si-Ge ratio. This optimum ratio is presently thought to be at 60 atom % Si, rather than the presently used 70 atom % Si. Composition will be optimized for SNAP 10A operating conditions. In performing these optimizations, Seebeck coefficient, resistivity, and thermal conductivity measurements as a function of temperature will be required. Material stability for long times at SNAP 10A operating conditions will need to be proven. RCA will also determine the effect of neutron radiation on the thermoelectric material. These experiments need to be carried out at flux levels up to 10^{19} nvt in order to cover the maximum pump exposure. Physical and mechanical properties, such as specific heat, strength, and coefficient of expansion will be determined to provide the data required for design and analysis.

Confirmatory measurements of thermoelectric properties will be made at AI. Although the bulk of the thermoelectric material development work will be done at RCA, it is necessary for AI to develop a familiarity with and understanding of the material in order to confirm RCA's results, interpret the results of module tests, and direct the course of future development. In addition to the measurement of thermoelectric properties, AI will conduct heat treatment investigations, metallographic studies, and evaluations of materials from long-term tests.

Any additional development of the materials in the thermoelectric-insulator stack is the responsibility of RCA. This development will be done as required to achieve design and reliability objectives. AI will determine the suitability of the current stack during qualification testing, post-mortem examinations, and long-term loop tests of NaK tube assemblies.

- a. A full converter (not presently funded) of acceptance-tested modules may be assembled in the PSM-3 facility. This converter will be operated as a converter test, with instrumentation as required to confirm design points, performance of individual components, and thermal performance of the converter. After detailing the operating characteristics of the converter as a function of temperature and thermal cycling, an extended run for a minimum of 3000 hours to determine long-time converter characteristics would be performed.
- b. In support of the module tests, NaK loops for laboratory testing modules will be assembled and operated to determine design point and long-time stability data.
- c. RCA will perform qualification tests on production modules representing approximately 5 percent of the total modules produced. In addition, evaluation and development tests including the extension of current tests toward a goal of 10,000 hours will be conducted.

The data from the above tests will be analyzed in terms of converter performance and thermoelectric and material properties. Information will be fed into reliability analysis which will assist in guiding the amount of additional testing required to achieve reliability goals. Continuous evaluation of this data will be required to determine the adequacy of the present design point.

2. Converter Assembly

Development work will be conducted to cover all areas necessary in assuring that the incoming modules are satisfactory. An important step in this operation will be the determination of the most suitable acceptance test procedure. The anticipated procedure for acceptance testing is; a) physical, dimensional, and electrical inspection; b) shock and vibration to two-thirds of qualification specification; c) repeat item (a); d) warm electrical and thermal test; e) repeat item (a).

Converter engineering, including optimization and the detailed module specification, is a responsibility of AI.

In performing the required analysis of the converter, the following tasks will be involved: a) thermoelectric optimization, b) thermal analysis, c) stress analysis, d) reliability analysis, and e) data analysis. It will be the responsibility of this analytical effort

to provide the information required to produce the flight specification, interpret test results, and plan testing required to achieve the desired reliability. Special mechanical tests will be analyzed to insure achievement of reliability objectives; acoustic testing will be included.

3. Process Development

The responsibility for the process development for both thermoelectric materials and converter modules belongs to RCA.

RCA will develop techniques, and will provide thermoelectric materials with a uniformity consistent with achieving the design specification criteria. This uniformity of thermoelectric material is required to ascertain the material we test is representative of all the material in the final converters. In addition, RCA will strive to achieve higher yields and lower costs.

RCA will develop bonding and module assembly techniques as required when the material composition is changed to achieve optimization. Bonding and assembly procedures will be refined toward the goal of achieving greater uniformity and reliability in the end products. When consistent with reliability, lower costs and weight reduction will be included in the development.

RCA will be responsible for developing the working process or applying emissivity coatings recommended by AI. They will supply samples of the coatings they process for AI measurements, and conduct long-term stability studies on their product.

4. Module Testing

Module tests will be conducted both at AI and RCA; however, the greatest bulk of the work will be performed at AI. The testing at AI will be broken down as follows:

- a. The qualification tests will consist of the maximum duty cycle, including acceptance tests. The cycle will consist of acceptance testing, steady-state power operation, thermal cycling, thermal shock, shock and vibration, and extended steady-state life testing. A minimum of 24 modules will be taken through this cycle, with the total module hours of testing to be approximately 70,000.
- b. Special tests will be conducted to verify the design assumptions and to investigate effects not included in the qualification testing. Included in these special tests will be thermal cycling tests, ultrahigh vacuum tests, radiation tests, and higher temperature testing (1100 to 1200°F). Special vibration and acoustical tests will also be conducted to determine the strength safety margin of the modules.

- c. Acceptance testing will be followed by welding and assembly into legs with suitable inspections.

Development work in critical areas, such as welding, will be conducted and handling procedures will be established based on the experience gained during handling development modules.

5. Emissivity Coatings

AI has the responsibility for selecting all the emissivity coatings. Improved coatings over the presently used high-emissivity Cr_2O_3 will be investigated for applicability to the SNAP 10A design. These investigations will include long-term life testing, mechanical and acoustical testing, and thermal cycle stability. Promising coatings will be turned over to RCA for process development in applying the new coatings to modules. Samples of the coatings as processed by RCA will be evaluated by AI. Alternates to the present low-emissivity coating, Au on Mo, will be investigated and alternate systems selected for detailed investigation as backups. Long-term tests will be conducted on the Ai-Mo system to determine if the present system will meet the design life requirements. RCA will conduct process development on backup coatings and supply samples for AI evaluation.

III. DEVELOPMENTAL SYSTEM TESTS

Developmental systems tests are programmed to yield engineering information on the overall system configuration, its performance, and operating characteristics. In general, the information must be obtained on a time schedule which is compatible with permitting the use of such data in design, engineering, or modifying the SNAPSHOT flight APUs. Developmental systems will not have any arbitrary limit on test instrumentation, environment, etc. These will in all cases be tailored to yield the specified information.

At the present time, five developmental type systems are programmed for SNAP 10A, each of which has one primary and several secondary purposes.

A. PSM-1

PSM-1 has been designed to yield basic APU structural data as well as data indicating the structural interaction between the various components. The design of PSM-1 reflects the status of engineering as of about July 1961. This system has been put on structural qualification testing and has yielded significant information pertaining to the flight system design. The utility of this system in terms of supplying information on the basic structure has been clearly diminished because of the subsequent design changes and the test failure of PSM-1. The system will, however, continue to play a useful role in establishing test techniques, determining the interaction between various components, and for other specialized test purposes. The detail test requirements on PSM-1 are outlined in the test specification.

B. PSM-1a

PSM-1a is scheduled to be a developmental and preliminary qualification test of the basic APU structure. As such, the system will be put through vibration and shock testing, static loading, and steady state acceleration testing. The steady state acceleration tests will only be run if the rocket sled induced vibrations are well below the expected failure norm. The PSM-1a system consists of a flight type structure complete with mass mockups of the reactor, converter, shield, NaK piping, etc. Up to five dummy mockup converter legs may be installed on the structure to establish their dynamic interaction. The test program for PSM-1a will be complete to the 100 percent vibration and shock loading condition, and completed prior to PSM-1 qualification. In support of PSM-1a, a complete fabrication and metallurgical program will be undertaken to ascertain the condition of the material as influenced by the fabrication steps; i.e. localized cracking, stress concentration, metallurgical appearance of the welds, effect of chem mill and surface cleaning, etc.

C. PSM-3

PSM-3 is a developmental system designed to yield information on the thermal and hydraulic characteristics of the flight configuration. Information of interest includes techniques of NaK loading and clean up, steady state performance of the NaK system as a function of temperature, system transient behavior, component thermal interactions, and information of a closely allied nature. The system reflects the same status of engineering design as PSM-1, i.e., July 1961, and as such is not of the latest flight configuration. It is, however, thermally similar to the qualification flight systems. Test specification for PSM-3 outlining the requirements has been issued.

D. FSM-2

FSM-2 is, in fact, a developmental system designed to yield information on the combined APU Agena instrumentation system and on the ability of the two systems to physically mate. The system will also be capable of being handled with and can functionally check out the APU AGE equipment. The FSM-2 unit will consist of the following APU components: A structure of the flight type configuration; mass mockups of the reactor and shield; an instrumentation compartment; an electrical mockup of the power converter; mass mockups of the NaK system components; and the complete APU instrumentation system, with the exception of pyrotechnics, which will be packaged, handled, and placed identical to the flight APU.

The FSM-2 testing program will be a joint endeavor by AI and LMSC to be conducted at the LMSC Sunnyvale plant. AI personnel will be assigned to the test operations at LMSC, as necessary.

The FSM-2 system, when first shipped to LMSC, must have a complete electrical control system, but need not have a complete diagnostic instrumentation complement. It is expected, however, that as components become available, they will be shipped to LMSC for installation on the system, thereby insuring constant updating.

The principal test objectives of the FSM-2/Agena integrated tests are:

1. Verify the SNAP 10A/Agena electrical interface compatibility.
2. Verify SNAP 10A instrument transducer (senior) signal compatibility with the Agena telemetry system.
3. Verify the absence of electro-interference signals which could cause false control or command signals.

4. Eliminate electro-interference which could introduce noise into telemetered data thus reducing measurement accuracy.
5. Eliminate electro-interference problems between the SNAP 10A system, the secondary payloads, and the Agena command, control and telemetry systems.

E. FSM-3

FSM-3 is essentially a duplicate of FSM-2 except that it must have a full compliment of flight qualified instrumentation. FSM-3 will be used at LMSC Sunnyvale to check out the actual flight Agena vehicle instrumentation prior to shipment of the Agena to VAFB.

IV. SYSTEM QUALIFICATION TESTS

A. FSM-1 Non-Nuclear Qualification Test System

The test objectives of the FSM-1 non-nuclear qualification system test is to determine the overall system performance in an integrated test which simulates the launch and space environment and orbital operating conditions as closely as possible. The specific test objectives are:

1. To verify the flight system NaK filling and cleanup procedure.
2. To verify the flight system prelaunch checkout tests and procedures.
3. To verify that the flight design will survive the launch environment by subjecting the fully assembled test system to the qualification level shock and vibration tests.
4. To evaluate the system performance during the automatic reactor startup period via means of an analog computer (simulator) which will program the heat transfer system heat-up rates to simulate as accurately as possible the actual nuclear heat startup.
5. To evaluate the flight system design performance under power operating conditions, verifying that the design is capable of meeting the SNAF 10A program objectives.

As an integrated system test of the flight system design, the test shall include the determination and evaluation of the performance of all system components, subassemblies, structures, etc. (with the exception of the nuclear fuel elements and upper grid plate) under launch, thermal and space environments. It is recognized that zero gravity cannot be simulated in this test. Specifically, this test shall include the performance evaluation of:

1. The entire structural complex
2. The thermoelectric power converters
3. The NaK pump
4. Structure under launch and thermal environments
5. Thermoelectric converter performance under launch
6. Control instrumentation
7. Diagnostic instrumentation

8. The instrument compartment
9. The heat transfer system
10. Pyrotechnique devices
11. Heat shield
12. Heat barrier

A test specification has been issued for this system.

B. FS-1 Nuclear Qualification Test

The SNAP 10A FS-1 system will be the first SNAP APU flight design to undergo full-scale ground testing for extended periods using nuclear heating. The principal objective of the S10A-FS-1 nuclear qualification test is to demonstrate startup and satisfactory operation of a flight system model for an integrated period of 90 days under flight operating conditions prior to orbital test of SNAP 10A FS-2. The FS-1 test program shall duplicate to the fullest extent possible the actual operating environment during system startup and operation.

Power Test Vault No.2 at the SNAP Experimental Test Facility (SETF), Building O24, will be used for the power operational test. Space environmental conditions will be simulated by a vacuum chamber with cold walls to provide a heat sink for radiation cooling of the various radiators on the APU.

In addition to the qualification requirements of this test, there are certain other specific test objectives that make up the overall nuclear qualification test program. These objectives include:

1. To test the automatic startup sequence and startup equipment on an operating system, and verify that the sequence of events and the rates of reactivity insertion programmed are correct.
2. To test the automatic reactor outlet temperature controller to verify that the controller will maintain the reactor outlet temperature within specified limits.
3. To determine experimentally the change of reactivity with time when operating in a flight system under simulated space conditions. This information will be used to improve methods used to predict reactivity changes and to determine the period after startup that automatic outlet temperature control is required.

4. Measurement of temperature profiles and rates of change of temperature during startup operation with nuclear heating.
5. Determination of the thermal and operational characteristics of the instrumentation in a nuclear radiation and vacuum environment.

The secondary test objectives are:

1. To provide training in diagnostic data reduction and data evaluation in order to acquire competence in rapid and accurate evaluation of data obtained during orbital operation.
2. To determine operational characteristics of flight system instrumentation when connected to flight prototypes of the Agena B command and telemetry systems.
3. To determine operational characteristics of the thermo-electric converter power system during startup with nuclear heat and connected to the Agena voltage regulating equipment.
4. To provide operational experience with prototype models of the checkout and monitoring instrumentation that will be used with the flight system during prelaunch operations at VAFB.
5. Operation of the flight system design with the Agena electrical system voltage regulator and simulated load to determine interaction between electrical load variations and reactor behavior.

V. FLIGHT TEST

As presently scheduled, SNAP 10A will be the first nuclear reactor powered electrical generator to be tested in a space application. Two test flights of the Atlas-Agena SNAP 10A satellites are planned. The U.S. Air Force program to provide for the proof test of the SNAP 10A system under actual operational launch and orbit conditions is termed the SNAPSHOT program for which the Lockheed Missiles and Space Company (LMSC) has been designated as the Air Force prime contractor. LMSC is responsible for the launch vehicles (Atlas and Agena), and for integrating the launch operations at Vandenberg Air Force Base (VAFB) and Navy Missile Facility at Point Arguello (NMFA). All LMSC funding for the SNAPSHOT program is from the Air Force Space Systems Division (SSD). The SNAP auxiliary power units (APU) are funded by the Atomic Energy Commission (AEC) as part of the SNAP Development Program. Atomics International is a prime contractor to the AEC to develop the SNAP 10A system. The relationship of Atomics International to LMSC is that of Associate Contractor, although no actual contract exists between AI and LMSC. All official AI contact with SSD is via the AEC and the AEC/AF/LMSC/AI Joint Working Group, and the SNAPSHOT Flight Test Working Group. The Atlas D boost vehicle is built by General Dynamic Astronautics (DGA) who are Associate Contractor's to LMSC for the SNAPSHOT Atlas vehicles.

A. SNAPSHOT Vehicle Description

The SNAPSHOT Atlas-Agena is a 2-1/2 stage liquid fueled satellite launch rocket in which the satellite stage uses a SNAP auxiliary power supply. In operation, the entire Agena upper stage becomes the orbiting satellite. Payload equipment (and in this case the nuclear power supply) is attached to the Agena structure.

The Atlas model SM-65 Series D vehicle will be used as the boost portion (1-1/2 stages) of the vehicle. The Atlas D built by General Dynamic Astronautics, 67 ft. 7 in. in length and 10 ft. in diameter, consists of a half-stage booster and a full-stage sustainer.

For the Atlas-Agena combination, a 13 ft. long tapered adapter section is attached to the Atlas. This sleeve contains stage separation "pin-pullers", Atlas retrorockets, Agena destruct charges, and the ascent radar beacon antenna.

The Agena upper stage vehicle is based on a design used on other Air Force programs. With the auxiliary power unit (APU) in place, the vehicle is about 40 ft. long and 5 ft. in diameter and uses a Bell Aerosystems Model 8096, 16,000 lb. thrust, liquid propellant rocket engine. This engine model provides 240 seconds of burning time and has restart capability. The existing Agena vehicle design will be adapted for SNAPSHOT with forward installation of the SNAP flight test APU and secondary payload devices.

The magnesium airframe, propulsion, electrical, guidance control, and satellite control subsystems are the Agena's major components.

The nose cone consists of a stainless steel nose cap for aerodynamic heat shielding supported by a truncated magnesium cone. The forward midbody is cylindrical in shape, about 4 ft. long, and contains the secondary payload and thermal insulation. Aluminum tanks hold the hypergolic propellants-3750 lbs. of unsymmetrical dimethyl hydrazine (UDMH) fuel and 4550 lb. of inhibited red fuming nitric acid (IRFNA) oxidizer. The main rocket engine, solid-fueled ullage rocket system, compressed gas attitude control system, orbital radar beacon radar antenna, and other equipment including possible secondary payload apparatus, is enclosed in the aft midbody and is exposed for use when the Agena emerges from the Atlas adapter section during stage separation. The restart capability of the Agena engine provides the opportunity to obtain a near circular high-perigee orbit without additional stages.

The launch site for SNAPSHOT is the U.S. Naval Missile Facility, Point Arguello, California. It is located on the Pacific coast about 55 miles west-northwest of Santa Barbara. On its 20,000 acres and the adjacent Vandenberg Air Force Base will be located facilities and instrumentation necessary for the support of SNAPSHOT launches.

The facilities at VAFB where various non-nuclear ground tests and prelaunch checkouts will be made are the SNAP Prelaunch Test Facility (SPTF) at the launch complex.

The launch site is Point Arguello Launch Complex 2 (PALC 2) which is now under construction. The complex will eventually consist of three launch pads, each with its own launch and service building and gantry, a launch operations building (LOB), and a technical support building.

The ultimate application of SNAP 10A in advanced satellite missions requires that the flight tests be as meaningful as possible in demonstrating the suitability of SNAP 10A. To demonstrate this capability the flight systems must:

- a. Survive the launch environment.
- b. Startup automatically upon receipt of a telemetered ground command.
- c. Operate satisfactorily in orbit for an extended period of time.

These program objectives are explicit in the SNAP 10A program requirements.

Three SNAP 10A systems will be built for operational tests in earth orbit. Two flights are planned with the third system being retained as a spare flight system. The first flight system, FS-2,

is schedule for launch in 1963. The second flight system, FS-3, will be launched approximately 3 months later. The third flight system, FS-4, is a spare which may be used to replace FS-2 or FS-3 in event of a major failure in either of these systems during any phase of operation prior to launch.

Final assembly of the flight systems FS-2, FS-3, and FS-4, will take place in Bldg. 013 at Santa Susana (SS). Following assembly the structural alignment will be checked, and continuity checks will be made on all instrumentation. It is intended that the checkout operations in Bldg. 013 be as complete as possible short of actual thermal operation of the system.

The acceptance test will be divided into two major parts. The first part consists of vibration tests at acceptance levels in Bldg. 027 at SS. The second part consists of thermal and nuclear criticality test in Bldg. 019. The vibration testing will be performed without nuclear fuel or NaK in the system. The acceptance test operations will be performed in Bldg. 019 and consist of the following.

- a. Visual inspection of all components to verify proper location and installation and to insure that all components required for the acceptance test are on hand.
- b. Continuity and impedance checks on all instruments.
- c. Functional checkout of instrumentation.
- d. Fuel loading.
- e. Nuclear calibration and checkout.
- f. Thermal operation on electrical heat and instrument calibration.
- g. Made ready for shipping.

Shipment of the SNAP 10A system will be made after satisfactory completion of the acceptance test. A partial disassembly of the APU will be made prior to shipment. The beryllium reflector control assembly will be removed and a shipping sleeve of minimum reflectivity substituted. The APU system will then be packaged separately in a specially designed shipping container. The shield will likewise be shipped separately.

The SNAP 10A systems will be delivered to the SNAP Prelaunch Test Facility Bldg. 060 at VAFB. The facility is being constructed by the Air Force for the SNAPSHOT operation, and will be staffed and operated by AI personnel and used exclusively for the reassembly and testing operations on the SNAP 10A systems. The operations to be performed at SPTF will consist of the following:

- a. Receiving visual inspection, as a check for any damage that may have occurred in the transportation operation and to determine that all components required for reassembly are on hand.
- b. Bench tests of the reflector control drum assembly.

- c. Functional checkout of all instrumentation and control equipments including simulated flight operation of control drums mounted separately on a test stand.
- d. Final assembly of all components except those pyrotechnic devices that must be installed at the launch pad.
- e. Mating of the SNAP 10A APU to the Agena flight adaptor.
- f. Weight and center of gravity check and the performance of the necessary shimming operations for proper alignment.

Provisions have been made for thermal testing of the APU within a vacuum chamber, although such tests are not presently planned as part of routine testing operations at VAFB.

At the present time the Air Force and LMSC are attempting to minimize the operations that will be performed on the Agena vehicle at VAFB. It is expected that the Agena vehicle will be delivered to LMSC (MAB) facility completely checked out, and that only a simplified checkout operation will be performed prior to moving the Agena to the launch pad.