This ATM has been prepared (per Qual C QTRR RFC 1-2) to correlate the overall qualification testing of the Active Seismic Experiment (ASE) and the Final Test Reports which will collectively document the qualification results. This was deemed necessary at the Qual C QTRR recognizing that the Qual C Program did not provide a total qualification of the ASE. Specifically, the GLA, and Bendix supplied components for the GLA, have been qualified by subcontractor qualification testing. Additional copies of the following qualification reports have also been obtained from the subcontractors per the RFC 1-2 requirement:

- Design Verification Test Report of GLA, SOS DVTR 6542
- Single Axis Level Sensor, P/N C709589001, Qualification Test, Kearfott Report K-472
- Final Report, Qualification of Wurlitzer Model WC-343A Thermal Battery, Wurlitzer Report #68358
- Qualification Tests on the AS/T Transmitter, Type YTX4-2, S/N 2, CDC Report 8709/R1

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Test results of qualification testing of the Active Seismic Experiment (ASE) are to be documented by Bendix in Final Test Reports of major test phases of the Qual C Program. Test reports are to be issued for:

Baseline Functional Tests (ATR 171)

Design Limit Thermal Vacuum (ATR 172)

ASE EMI (ATR 173)

ASE Mass Properties (ATR 174)

Pre-Induced Environments Functional Tests (ATR 174)

Induced Environments Tests (ATR 176)

Post Induced Environments Tests (ATR 177)

The ASE qualification testing encompassed by the Qual C Program was designed, primarily, to qualify the ASE less the Grenade Launch Assembly (GLA). An inert (initiators, propellants, detonators and explosives) GLA is, however, used in the ASE Qual C Program during thermal vacuum, mass properties, EMI, vibration, shock and acceleration testing. The inert GLA which is identical to the flight model GLA, with the exception of the inert components, provides the required mechanical and thermal mass for a complete Mortar Package Assembly. In addition, the GLA permits monitoring of the GLA temperature, roll angle and pitch angle and correct grenade firing circuitry through the rocket motor initiator (SBASI). These circuits have been functionally verified in each Qual C thermal vacuum IST and all four grenade rocket motor initiators have been fired successfully (two at the lunar noon temperature and two at the lower survival temperature (-4°F) of the Mortar Package Assy.). In addition to the above functional testing the mechanical and electrical integrity of the inert GLA is verified prior to and after thermal vacuum and induced environmental tests by visual inspection and the performance of the Inert GLA Resistance Check (TP 2333023). This test measures the continuity and resistance of all GLA circuitry, verifies the operation of the SCR's (triggered by a test voltage), and verifies the operation of the transmitters. Specifically, the continuity and resistance measurements on each grenade are as follows:

1. Diode in transmitter power line (CR2) reverse impedance.
2. Zener diode forward impedance.
3. S.C.R. impedance (off condition).
4. Zener diode reverse impedance.
5. Transmitter feed.
6. Impact switch impedance.
7. CR 2 forward impedance.
8. The GLA temperature sensor impedance.
9. Both heater control sensor circuits.
10. Safety plate insertion check.
11. Thermal battery continuity check.
12. Capacitor charging diode (CR1) reverse impedance.
13. Rocket motor capacitors.
14. SCR gate circuit impedance.
15. Angle sensor power lines (+15 and +5V).
16. Roll and pitch telemetry output lines.
17. Both heater control senser thermistor impedances.
18. Range line impedances.
19. Propellant SBASI bridge wire impedance.
20. H.E. Detonator SBASI bridgewire impedance.

The qualification of the GLA, because of safety considerations associated with ordnance qualification testing, has been accomplished by testing at Space Ordnance Systems, Inc., the subcontractor responsible for the GLA design. In addition, components (thermal battery, transmitter, angle sensor) supplied by Bendix for incorporation into the GLA have been qualified by qualification testing at the respective subcontractor. The SBASI's, detonators and HNS high explosive charges used in the GLA are considered qualified by previous use on the Apollo program.

GLA Qualification

Space Ordnance Systems (SOS) was required per Bendix Specification AL 415240, Exhibit B, Paragraph 4.1.7 to conduct a combined Design Verification Test (DVT) and Qualification Test program. This DVT program, performed in accordance with SOS TP 6173, was conducted on the complete GLA and major subassemblies (grenade, rocket motor, safe/arm mechanism). The testing included both environmental testing and functional firing tests at ambient, hot and cold temperatures. A summary of the hardware tested is as follows:

Environmental Testing

Vibration - (1) GLA, (3) grenades, (8) Rocket Motors

Temperature Cycling - (1) GLA, (2) grenades, (6) Rocket Motors

High Temperature - (3) GLA's, (5) grenades

Low Temperature - (3) GLA's, (5) grenades

Acceleration - (1) GLA

Shock - (1) GLA

Functional Firing Testing

Safe/Arm Mechanism Firings -

(5) Mechanisms at Ambient Temperature
(5) Mechanisms at Low Temperature
(5) Mechanisms at High Temperature

High Explosive Detonation Tests

(5) Modified Grenades

Rocket Motor Firings

(26) Motors Ambient
(12) Low Temperature
(12) High Temperature

Full Earth Range Firings

(4) GLA's Ambient (1 GLA previously vibrated)
(1) GLA Low Temperature (previously shock & acceleration)
(1) GLA High Temperature (previously temperature cycled)

The full earth range firings were verification of the GLA end item configuration and were accomplished by firing each GLA from a Mortar Box supplied by Bendix. The initial firings at El Mirage Dry Lake involved GLAs of two configurations. Both configurations differed from the flight configuration, for safety and program economy reasons, as follows:

a.) Dummy transmitters were used in place of live transmitters.

b.) The charge limiting resistor in the grenade detonator firing circuit was 37 ohms instead of 2K ohms to allow full charging for short range firings due to grenade flight time differences between short earth ranges and long lunar ranges.

c.) Five gram token charge instead of full high explosive configuration.

d.) 3 of the 6 GLA's tested did not have thermal batteries. Each grenade in those GLA's incorporated capacitors (charged to 29V dc prior to launch to supply the energy normally supplied by the thermal battery, necessary to charge the detonator firing capacitors prior to impact. The other three GLA's did have thermal batteries.

Test results from the El Mirage firings included non-detonation failures attributable to the last two of these flight versus test configuration differences. In addition, grenade velocities measured exceeded the specification requirement for the rocket motors. Therefore, SOS was directed to reconfigure two GLA's to eliminate these test unique factors by incorporating flight thermal batteries and flight high explosive blocks. Additionally, SOS conducted a rocket motor down load, verified by tests (3 firings per motor size), to adjust the grenade velocities within specification. The two reconfigured GLA's, including the new rocket motor loads, were, therefore, flight configuration except for dummy transmitters and the detonator firing circuit charge limiting resistor (necessary under any circumstance for earth launches). These two GLA's were fired successfully at ambient, hot and cold temperatures at Camp Pendleton Marine Base.

With the completion of the firings at Camp Pendleton, the DVT program was concluded. These full earth range firings verified the full performance of the GLA, launch through impact detonation. The firings also verified that no deleterious effects occurred as a result of previous environmental testing and conclusively demonstrated the ASE Mortar Package Assy. (Mortar Box/GLA) firing stability and integrity under both hot and cold temperature launch conditions.

It should be noted that the DVT full earth range firings while verifying the grenade range line attachment and deployment design and associated velocity measurement technique, did not provide verification of the transmitter RF link. However, the RF link, with the transmitter powered from the thermal battery and radiating from the trailing range line, was verified during the ASE WSTF testing, Reference Bendix BSR 2319. Those tests additionally demonstrated the cessation of the transmitter signal coinciding with the instant of grenade impact and explosion.

The results of the GLA DVT program are documented in a DVT Report prepared by SOS (Test Report DVTR 6542). The test results were reviewed during the GLA Flight Article Configuration Inspection (FACI) conducted during November and December, 1968 in which the measured performance of the GLA (DVT test results) was compared with required performance specified by the GLA specification, AL 415240. It was concluded during the FACI that the GLA had, by DVT testing, been shown to have met or exceeded specification requirements and was qualified for use on the ALSEP program.

GLA Component Qualification

The development of the GLA design was subcontracted to SOS based on the requirement that the grenade thermal battery and transmitter and the angle sensors mounted on each GLA would be supplied by Bendix as qualified hardware. The development subcontract for each of these components included, therefore, a qualification test program. The qualification testing conducted included environmental testing (thermal, vacuum, vibration) compatible with the ASE and GLA testing. In addition, each of the grenade mounted components (transmitter, thermal battery) were qualified for the induced shock of a grenade launch and the angle sensors to a shock level induced into its mounting position on the GLA as a result of a grenade launch. It should also be noted that all of these components have been subjected to actual shock environments through GLA firings (SOS DVT and ASE WSTF tests) and subsequently performed satisfactorily. A summary of the component qualification testing is as follows:

a.) Thermal Battery

Twenty four flight configuration batteries were subjected to the battery qualification tests at The Wurlitzer Co., North Tonawanda, N. Y. Each battery was subjected to the following tests:

(1) Non-desctructive tests - including hermetic seal, insulation resistance, match resistance and monitor circuit resistance.

(2) Temperature cycling

(3) Vibration

(4) Handling Shock

(5) Apollo Launch Shock (20 gs)

(6) Impressed shock (300 g's simulating worst case shock from an adjacent grenade launch).

(7) Grenade launch shock - (3323 to 3608 gs with acceleration time integrals of 281 to 356 ft/sec.).

(8) Non-destructive tests.

After the completion of the above testing sequence twelve (12) batteries were successfully fired (4 each at ambient, +185°F and -4°F). The remaining twelve (12) batteries were opened for a visual examination verifying that no deleterious effects were evident after exposure to the environmental stresses. Then all twelve (12) matches were fired successfully.

The above testing, documented in Wurlitzer Final Qualification Report No. 68358, qualified the Model WC-343A battery, a revised design of the WC-343 initially used in the grenades tested at WSTF. The revised design incorporates a mechanically stronger thermal match, Atlas Part No. IGN 146, which packages the high temperature pyrotechnic mix in a metal sleeve. Since neither the Atlas certification or the battery qualification testing demonstrated long term storagability Wurlitzer has conducted a one year surveillance test under simulated lunar temperature cycling. Three groups of twenty matches have been subjected to alternating temperature cycles consisting of 14 days at +185°F followed by 14 days at -4°F. After three months of temperature cycling the first batch of twenty matches was fired after bridgewire resistance checks. After six months the second batch of twenty was also fired successfully. The final batch is scheduled to complete the temperature cycling and to be fired in June 1969.

b.) Transmitter

A flight configuration transmitter was qualified at Computing Devices of Canada, Ltd., Ottawa, Canada. CDC Report 8709/R1 documents the qualification test results. The transmitter was subjected to the following tests:

(1) Low temperature - soak at -72°C for 48 hours followed by operate test at -24°C.

(2) High temperature - soak at +102°C for 48 hours followed by operate test at +85°C.

(3) Humidity - soak at 60% relative humidity for 72 hours followed by operate test in chamber.

(4) Vibration - sine and random.

(5) Vacuum - operate test under 10^{-6} mm Hg vacuum.

(6) Shock - 3240 g's, acceleration time integral of 310 ft/sec.

The results of the qualification testing verified that the environment testing caused no significant changes in the transmitter operating parameters. Of particular interest is that the shock test had no effect on the transmitter performance. This was also the case during the WSTF grenade firings.

During the final phases of the transmitter design effort, preceding qualification and delivery of the flight hardware, CDC incorporated a design change to reduce long term frequency drift. At that time it was demonstrated by analysis and short term frequency tests that the frequency at the end of 1000 days could be predicted accurately from the results of 14 days of frequency monitoring. To provide positive verification of the analysis and short term testing, and to supplement the qualification status of the transmitter, a 6 month frequency monitoring test on 7 flight configuration transmitters was conducted. The data from those 6 months of testing verify that 14 days of initial testing is sufficient to predict the actual frequency after 1000 days (within 15 KHz to 99.73% confidence limits).

c.) Angle Sensor

A flight configuration Single Ax is Level Sensor was qualified at Kearfott Systems Division, General Precision, Inc., Little Falls, N. J. Kearfott Report No. K-472 documents the qualification testing. The sensor procured from Kearfott utilizes the C 70-1814-001 tilt angle sensors which had been previously developed and qualified for Philco. Repackaging of the sensor and the more stringent shock requirements dictated by mounting on the GLA (between the #3 and #4 launch tubes necessitated the following qualification testing:

(1) Vacuum

(2) Temperature (-30°C to +85°C)

(3) Vibration - sine and random

(4) Shock (100 gs, triangular pulse with 3 m sec rise time and 2 m sec decay)

In addition to the satisfactory completion of the qualification testing at Kearfott, a flight configuration Vertical Sensor and PC Board Assembly (Bendix Part 2338506), including two vertical sensors, was installed in the S/N 9 GLA during the SOS DVT firings at El Mirage. Thus, the flight version of the vertical sensor installation was successfully evaluated through the firing of four grenades from that GLA. These firings were conducted at a -4°F launch condition. Performance curves were obtained on the sensor assembly prior to being installed in the GLA and comparison of these curves with similar data taken subsequent to the tests verified no detrimental effects from the grenade launch environment.