Statement of Work for Repair of a Miniature Liquid Helium-3 Refrigerator

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1 **General Description:**
A helium-3 ($^3$He) cooled 19-Channel Bolometer radiometer system is used by the Arizona Radio Observatory (ARO) at its 10-meter observatory. The system is routinely used during the winter months and is kept warm during the remainder of the year. A problem was detected with the $^3$He refrigerator early this season when it was cooled for the first time. A repair of the $^3$He refrigerator system is desired. A price and schedule for the successful repair shall be provided.

The refrigerator is a miniature self-contained closed-cycle system mounted on the helium-4 ($^4$He) stage of a commercial Dewar. A refrigeration cycle is initiated by heating a vessel containing an absorbing material to expel absorbed $^3$He gas. The gas condenses into a second vessel from which it begins to evaporate. A low boiling temperature is achieved by reducing the vapor pressure by the cryo-pumping action of the absorbing material.

The exact nature of the failure is unknown. Our analysis indicates that most of the $^3$He gas may have escaped. The cooling time for the evaporator to reach thermal equilibrium with its surroundings is about 2 days. This indicates a high degree of thermal isolation, whereas if $^3$He gas were present in the refrigerator, the isolation would be much less. The refrigerator does exhibit some amount of cooling, but the magnitude and duration are far from expectations. ARO test reports are available as well as the opportunity for visual inspections or performance evaluation tests.

A repair can be achieved by correcting the problem or by replacing the current refrigerator with an operational duplicate. The repaired unit shall meet all the requirements of applicable documents [1].

2 **Applicable Documents:**
The following document forms part of the requirements to the extent specified herein.

[1] “Requirements for Repair of a Miniature Liquid Helium-3 Refrigerator”,

3 **Device Performance:**
Requirements and performance are described by applicable document [1].
4 **Contract Performance:**

4.1 **Proposal Materials:**

All proposal materials shall clearly exhibit the bid number in a prominent location on the proposal package and shall be delivered on or before the closing time and date. The proposal shall be valid for 60 calendar days following the due date.

4.2 **Price:**

A firm fixed cost shall be provided for the repair, testing, reports, and acceptance testing. Descriptions of the required tests and reports are contained in Section 4 of applicable document [1]. The acceptance test is described in Section 6.3.7 below. The cost shall be expressed in US dollars. The proposed approach, repair or replacement, shall be identified in the proposal.

4.3 **Completion Date:**

The repaired and tested refrigerator shall be completed and returned to the ARO within 4 months after receipt of order.

4.4 **Alternate Date:**

Exceptions to the requested delivery schedule shall be clearly noted in the proposal. If an alternate delivery schedule is proposed, a price for the original requested delivery schedule shall be provided.

4.5 **Warranty Terms and Conditions:**

A warranty shall be provided and include in the price. The warranty period shall commence upon final acceptance of the repair. At a minimum, the warranty shall address leaks due to workmanship and material quality. Specific terms and conditions shall be included with the quotation.

4.6 **Late Delivery:**

If the acceptance tests have not been scheduled within 5 working days following the negotiated contract completion date, the University of Arizona may cancel the contract without penalty and demand the return of its property. The contractor will be contacted and a written notice will confirm the cancellation.

5 **Shipping:**

The transportation of the $^3$He refrigerator to and from the contractor’s site shall be the responsibility of the ARO. Following the operational acceptance test, the contractor shall arrange with the ARO in writing for the return of the refrigerator.
6 Contract Compliance:

6.1 Responses, Inquires and correspondences:
All responses, inquires and correspondence regarding this solicitation must reference the bid number.

6.2 Modifications and Changes:
No modifications or substitutions to the statement of work or requirements and specifications are permitted unless authorized by a written addendum.

6.3 Verification Tests:
Verification tests are described in Section 4 of applicable document [1] and are summarized below. This section describes the actions and deliverables for each test. An operational acceptance test is required and is described in Section 6.3.7 of this document.

6.3.1 Operating point:

6.3.1.1 Action:
The normal operating temperature of the $^3$He cold stage shall be measured as described in Section 4.1.1 of applicable document [1].

6.3.1.2 Deliverable:
A written report describing the test result and the measured temperature shall be provided. The temperature of the thermal sink shall be provided.

6.3.2 Load Map:

6.3.2.1 Action:
The temperature of the $^3$He cold stage shall be measured for 7 different applied heat loads as described in Section 4.1.2 of applicable document [1]. The applied loads are 1, 2, 5, 10, 20, 50, and 100 µwatts. The corresponding values for the two attached “relative” temperature sensors shall be logged.

6.3.2.2 Deliverable:
A written report describing the 7 measured temperatures and the corresponding 14 logged values shall be provided. The temperature of the thermal sink shall be provided.
6.3.3 Typical Operation Run Time:

6.3.3.1 Action:

The temperature of the $^3$He cold stage shall be measured on a periodic basis, at least once per hour, as described in Section 4.2.1 of the applicable document [1]. The corresponding values from the two attached “relative” temperature sensors shall be logged for the initial and final temperature.

6.3.3.2 Deliverable:

A written report describing the test result, the measured temperatures, and the corresponding logged values shall be provided. The temperature of the thermal sink shall be provided.

6.3.4 Run Time Capacity:

6.3.4.1 Action:

The temperature of the $^3$He cold stage and sorption pump shall be measured every 15 minutes as described in Section 4.2.2 of applicable document [1]. The corresponding values from the two attached “relative” temperature sensors shall be logged.

6.3.4.2 Deliverable:

A written report describing the test results, the measured temperatures, and the corresponding logged values shall be provided. The temperature of the thermal sink shall be provided.

6.3.5 “Hot” Recycle:

6.3.5.1 Action:

The temperature of the sorption pump shall be measured every 30 seconds as described in Section 4.3 of applicable document [1]. The corresponding values from the attached “relative” temperature sensor shall be logged.

6.3.5.2 Deliverable:

A written report describing the measured temperatures and the corresponding logged values shall be provided. The temperature of the thermal sink shall be provided.

6.3.6 Attached Sensor Calibration:

6.3.6.1 Action:

During the performance of the acceptance tests, the two attached “relative” temperature sensors will be subject to the temperatures described in Table 1 of applicable document [1].
The sensor values corresponding to these temperatures shall be logged as described in Section 3.2 of applicable document [1].

6.3.6.2 Deliverable:
A written report describing the values of the two attached “relative” temperature sensors corresponding to the measured values of Table 1 shall be provided.

6.3.7 Acceptance Test:

6.3.7.1 Action:
An ARO representative shall observe a portion of a full refrigeration cycle. The demonstrated portion shall start near the conclusion of one “cold” cycle and proceed into the beginning of the next “cold” cycle. The demonstration shall begin with an applied load of 10 µw and with the $^4$He to duplicate normal operation. During the heating of the sorption pump, the vapor pressure of the $^4$He bath shall be measured and logged at a 30 second rate. After heating, the $^3$He cold stage temperature shall be measured and logged at a 30 second rate until this temperature stabilizes. Thereafter, the $^3$He cold stage temperature shall be measured and logged for 2 additional temperatures of the $^4$He stage, 1.8K and unpumped $^4$He. For both test situations, the $^4$He vapor pressure and the temperature shall be measured. The corresponding values of the two attached “relative” sensors shall be logged.

6.3.7.2 Deliverable:
A written report describing the measured and logged values and operation differences shall be provided. Any expected differences between the “laboratory” and “production” operations shall be clearly explained and described in a written report.

7 Contact Information:

7.1 Inquiries and Correspondence:
All inquiries and correspondence regarding this solicitation must be in writing and addressed to the undersigned individuals. Inquiries will be accepted by mail, FAX or electronic transmission. Questions and their responses will be provided in writing and in a timely manner to all recipients of this solicitation. Following the distribution of this solicitation, any direct communication by a potential contractor with other ARO representatives may result in rejection of their proposal.

7.2 Administrative:

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7.3 Technical:

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8 Disclaimer:

At its sole discretion, The University of Arizona and Steward Observatory may reject any or all proposals if it is in the best interest of the Observatory or University to do so. The University of Arizona and Steward Observatory does not warrant that any order will be issued in response to this solicitation. The University of Arizona and Steward Observatory will have no liability for expenses incurred in connection with the preparation of this proposal.