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Leak Testing of Pressurized-Bulkhead Mil Connectors

by Mark R. Probst

ARL-TN-0415 **November 2010**

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14. ABSTRACT
An objective of a program cost-reduction effort was to replace a high-priced pair of custom Mil-style hermetically sealed connectors with a suitable pair of commercial-off-the-shelf (COTS), Mil-style connectors that would satisfy a 66 ft water submersion requirement and fit within the system's size limits. An extensive search led to the Mil-C-26482, Series 1, Service Class C, Pressurized Receptacle connector as the most promising choice. A series of pressurized leak tests proved that this type of connector meets the submersion requirement with a large margin of safety.

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Leak testing, Mil connector, overtest

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1. Introduction

The removable-antenna connector interface of the Magneto-Inductive Remote Activation System (MI-RAMS) receiver must be able to perform at 33 psi submersed in up to 66 ft of water. Previously, the development contractor had been unsuccessful in finding a suitable pair of commercial-off-the-shelf (COTS), military (Mil)-style connectors that would satisfy this requirement and fit within the system's size limits (either as-is or with minor physical modifications). Instead, their final design used a very expensive, custom, hermetically sealed Mil-style connector pair. As part of recent efforts to reduce system costs, the U.S. Army Research Laboratory (ARL) targeted this connector pair. ARL's objective was to find a cheaper pair of connectors with performance specifications that satisfy the pressure requirement with a reasonable safety margin. Failing this, the fallback objective was to find a cheaper pair of connectors with marginal performance specifications and qualify them through testing beyond their stated limits.

2. Physical Design Description and Requirements

The handheld MI-RAMS receiver is a rectangular box-shaped device with a fixed bulkhead-style receptacle connector on top. The rear section of this connector's one-piece, non-leaking metal shell is threaded and it is screwed into the metal body of the receiver. This threaded joint is sealed with an O-ring. The internal portion of the connector, referred to as the insert, is made of nonconductive material. The insert holds the contacts in their fixed orientation. For a sealed connector, the insert must be sealed to the connector shell and the exterior surfaces of the contacts, and the contacts, in turn, must have no internal leakage paths.

The receiver's removable antenna has a quick-disconnect, bayonet-style plug connector at its base, which mates with the receiver's bulkhead connector. The rear section of the antenna connector's cylindrical, one-piece, non-leaking metal shell is threaded and it is screwed into the metal body of the antenna and sealed with thread sealant. It has an insert similar to that of the receptacle connector with the same sealing requirements but with opposite-sex contacts.

3. Mil Connector Specification Review

An extensive search of the various classes and styles of Mil connectors was conducted. While there were some hermetically sealed connectors that could be used with minor modifications to the exterior metal shell, their base cost was so much higher than non-hermetically sealed

connectors that they were not considered. The most promising non-hermetically sealed candidate was the Mil-C-26482, Series 1, Service Class C, Pressurized Receptacle connector. It has solder pot contacts and a leakage rate specified to be less than 1 cubic inch per hour at 30 psi over a temperature range from –65 to +257 °F. Since the operational and long-term storage temperature range for the MI-RAMS receiver is –35 to +160 °F, it was felt that a connector that was certified to such a miniscule leakage rate at 30 psi over a much larger temperature range might, in fact, have a large enough design margin to meet our 33-psi requirement over a less severe temperature range. It was determined that a minor modification to the mounting flange of this connector would allow it to replace the existing custom receptacle connector on top of the receiver, so it was chosen to undergo qualification testing.

Service Class C, Pressurized Receptacle connectors are only made as bulkhead-style connectors, which are typically installed in a stationary position on the outside of an enclosure as opposed to plug-style connectors, which are typically attached to the end of a cable or some other removable device. Thus, it was not surprising that the search for a sealed, quick-disconnect, bayonet-style plug connector for the antenna yielded no obvious candidates. Since the existing MI-RAMS antenna assembly included an epoxy potting fill that would seal around the wires and contacts as well as the insert-to-connector-shell interface at the rear of the connector, this was not considered a problem. Therefore, a Mil-C-26482, Series 1, Service Class A quick-disconnect, bayonet-style plug connector was chosen to undergo qualification testing.

4. Qualification Test Method and Hardware Description

The test hardware consisted of a regulated air pressure source with quick-disconnect attachments, and various connector adaptors with an air hose fitting at one end and a connector interface at the other such that the connector shell could be sealed to the adaptor. The adaptor with connector was then attached to the air supply via a flexible hose and then submersed in water. When the adaptor was pressurized from the air supply, any leakage would be indicated by the appearance of bubbles. The connectors were tested for leakage in both directions—the normal direction of pressurization when submerged as well as the opposite direction as a check for overall connector design robustness.

5. Test Item Configurations

To expedite testing, eight-contact connectors were used in lieu of the four-contact connectors, which were not available “off-the -shelf.” If more than four contacts are needed for a future antenna connector, then the eight-contact connector is the next size available in the shell size 12

series. The only difference between the two sizes is the contact gage—the 12-4 has #16 AWG contacts and the 12-8 has #20 AWG contacts.

Figure 1 shows configuration a, in which a Pressurized Receptacle PT00C-12-8S (unmodified) was screwed into test adaptor #1 and sealed with Loctite 380 Black Max adhesive on the threads and between the flange and the adaptor face. Testing in this configuration is in the opposite direction from that which the connector would see when submerged to the required 66 ft of water.

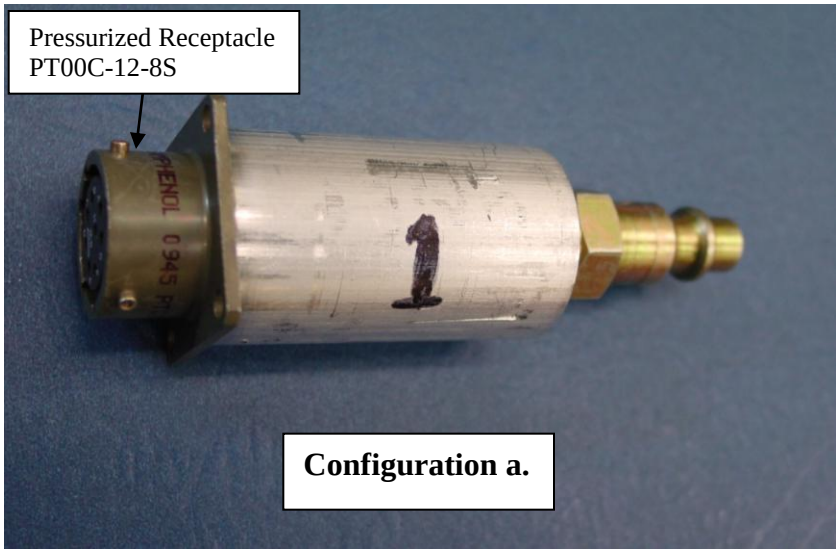

Figure 1. Configuration a.

Figure 2 shows Configuration b, in which the Pressurized Receptacle PT00C-12-8S (unmodified) was inserted face-first into test adaptor #2, attached with four screws, and sealed with an O-ring between its flange and the adaptor face. This configuration is correct for the submersion requirement.

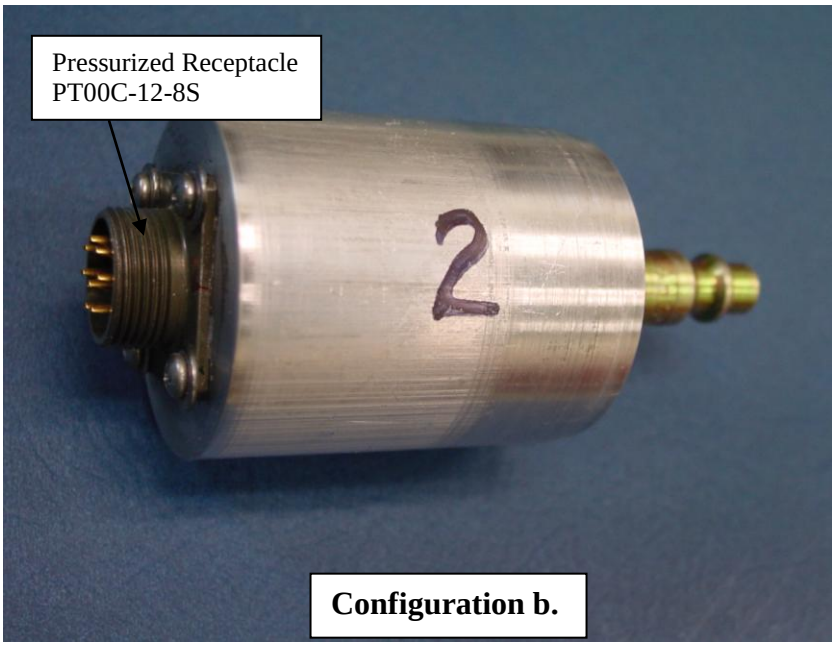

Figure 2. Configuration b.

Figure 3 shows configuration c, in which a crimp-contact MS3472W12-8S Receptacle was inserted face-out into test adaptor #3, attached with four screws, and sealed with an O-ring between its flange and the adaptor face. For the purpose of this testing, this unsealed connector was considered to be part of adaptor #3—its unsealed contacts allow the test air pressure to be applied directly against the face of the molded neoprene insert of the mating connector that is being tested (two of the crimp-contacts were removed to ensure the test item would be fully pressurized). This configuration is correct for the submersion requirement.

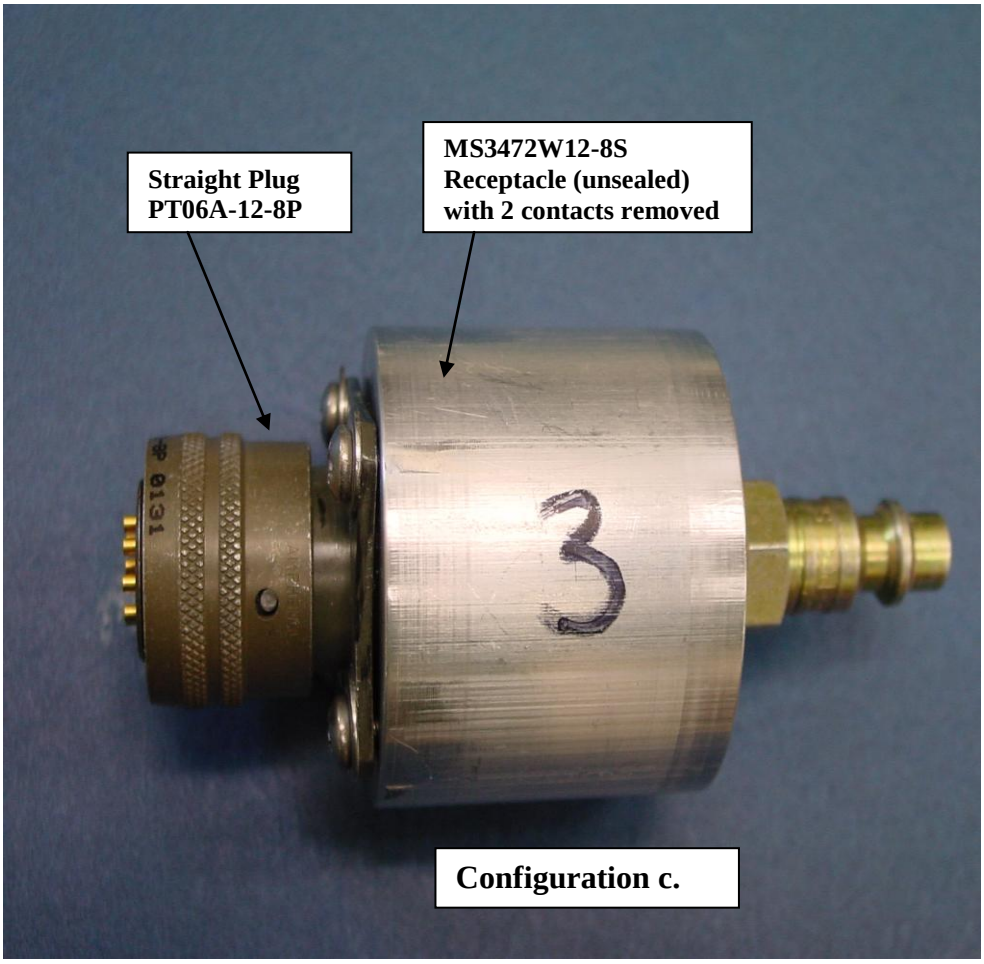

Figure 3. Configuration c.

Figure 4 shows configuration d, in which a straight plug connector (PT06A-12-8P), with its bayonet-style locking collar removed, was screwed into test adaptor #1 and sealed with an O-ring, thus exposing the solder-pot/wire side of the contact-bearing insert to the test air pressure. Testing in this configuration is in the opposite direction from that which the connector would see when submerged to the required 66 ft of water.

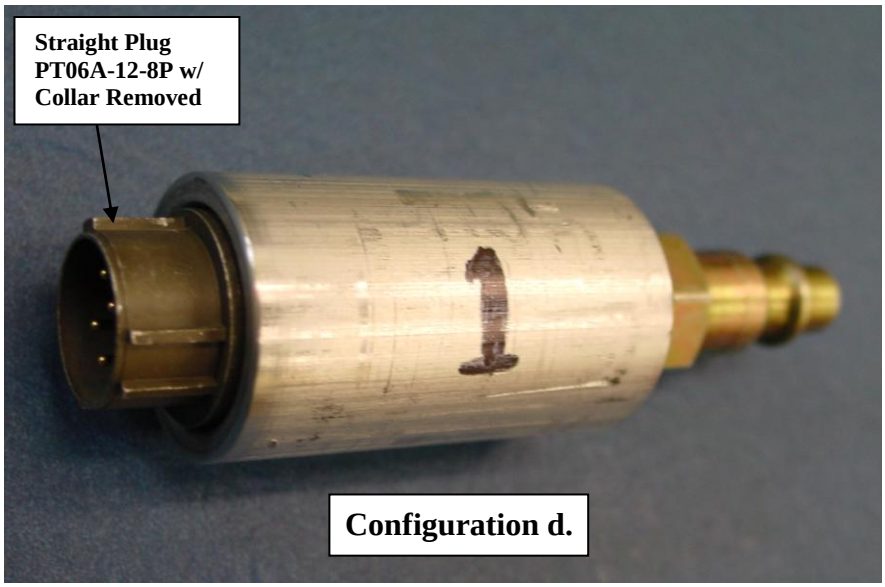

Figure 4. Configuration d.

Additional pictures are provided in appendix A. Appendix B shows the required modifications made to the Mil-C-26482, Series 1, Service Class C, Pressurized Receptacle Connector.

6. Test Results and Discussion

Table 1 shows a summary of the test results.

Table 1. Summary of the test results.

Test No.	Connector Serial No.	Configuration/ Adaptor	Max psi	Comments
1	PT00C-12-8S/1	a. / 1	80	No leaks: 0 to 80 to 0; repeated two more times.
2	PT00C-12-8S/2	b. / 2	80	No leaks: 0 to 80 to 0; repeated two more times then left overnight at 80 psi.
3	PT00C-12-8S/6	b. / 2	80	No leaks: 0 to 80 to 0; repeated four more times.
4	PT00C-12-8S/7	b. / 2	80	No leaks: 0 to 80 to 0; repeated four more times.
5	PT06A-12-8P/3	c. / 3	58	A leak started at the face-to-face seal; no insert/contact leakage. There was epoxy potting on solder-pot/wire side of the contact-bearing insert.
6	PT06A-12-8P/4	c. / 3	75	A leak started at the face-to-face seal; no insert/contact leakage. No epoxy potting.
7	PT06A-12-8P/5	c. / 3	83	A leak started at the face-to-face seal; no insert/contact leakage. No epoxy potting.
8	PT06A-12-8P/5	d. / 1	80	No leaks: 0 to 80 to 0; repeated two more times then left overnight at 80 psi. No epoxy potting.

Test #1: The results were much better than expected, and since the direction was opposite to the intended usage, no more connectors were tested in this configuration.

Test #2: The results were much better than expected, and since the pressure load direction was the same as the intended usage, two more connectors were tested in this configuration.

Tests #3 and #4: These tests were the same as #2 except the quick 0 to 80 to 0 cycle was run a total of five times and the overnight soak at 80 psi was left out.

Test #5: Since the rear of this connector was epoxy potted, there was no sign of leakage from the insert/contact region at the back of the connector. When bubbles started emerging at ~58 psi, they were clearly coming from under the collar, which indicates leakage at the face seal between the mated connectors rather than a breach of the seals between the contacts and the insert or the seal between the insert and the connector shell. Since the pressure load direction was the same as the intended usage, two more connectors were tested in this configuration.

Tests #6 and #7: In an attempt to determine the pressure limit of the seals between the contacts and the insert and/or the seal between the insert and the connector shell, epoxy potting was not used on these connectors. Surprisingly enough, both withstood higher pressures than the epoxy-potted connector, and both leaked only at the face seal—one at ~75 psi and the other at ~83 psi.

Test #8: Since there was no way to determine the pressure limit of the seals between the contacts and the insert and/or the seal between the insert and the connector shell without building a more complicated test adaptor, I substituted a test of the seals in the direction opposite to the intended usage of the connector. The results were much better than expected—80 psi and no leaks, and since the direction was opposite to the intended usage, no more connectors were tested in this configuration.

7. Conclusions

Both the Pressurized Receptacle and Straight Plug PT06A-12-4P appear to be more than capable of meeting our system requirements for sealed connectors. The contact-bearing inserts of both appear identical, and neither leaked at pressures up to 80 psi. When I discussed this with an Amphenol connector engineer, he said that the Class C, 30-psi-rated connectors employed a "double-bonded seal" versus the "standard" seal employed for their other connectors. Though test results indicate that we could use the non-rated Straight Plug PT06A-12-4P without potting, potting is likely to be part of the normal assembly process for building the antenna and should be used to ensure success. While potting should not be required for the Pressurized Receptacle PT00C-12-4S, it could be added without too much difficulty with an ultraviolet (UV)-cure sealant.

Though all of the testing was conducted at an ambient condition of ~70 °F, the connectors' performance so far exceeded our requirements, as well as their specified limits, that any further testing at high and low temperature limits was deemed unnecessary.

Appendix A. Additional Photos

Figures A-1 through A-7 are additional pictures of the connectors used in the tests.

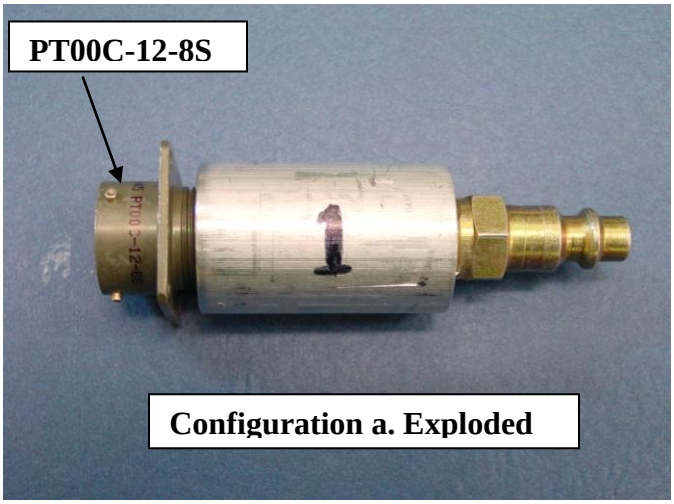

Figure A-1. Configuration a exploded.

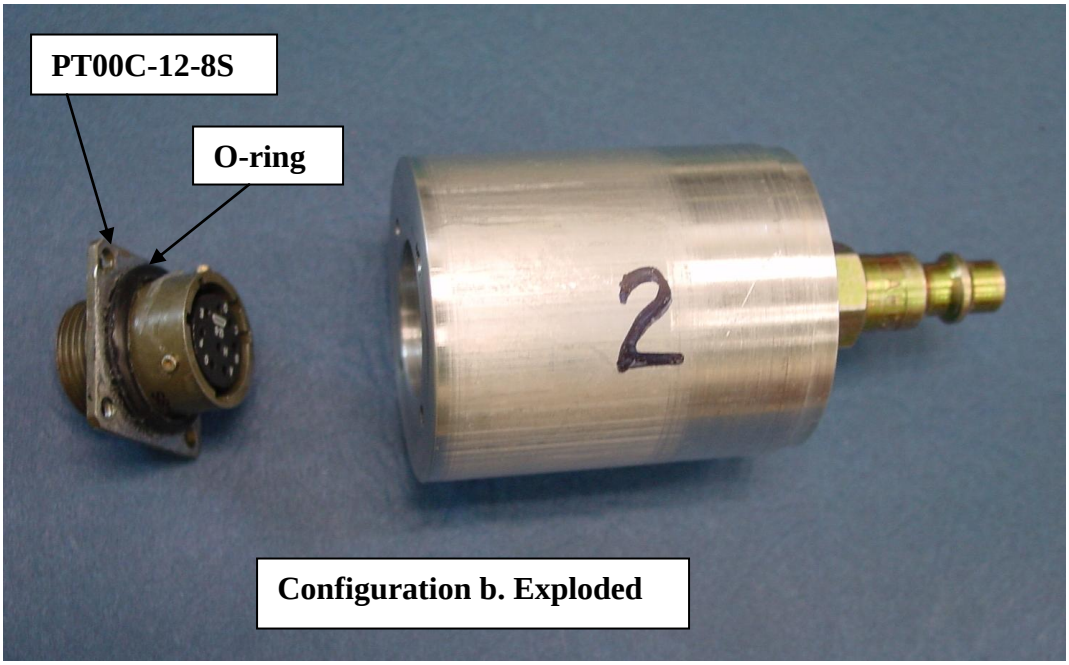

Figure A-2. Configuration b exploded.

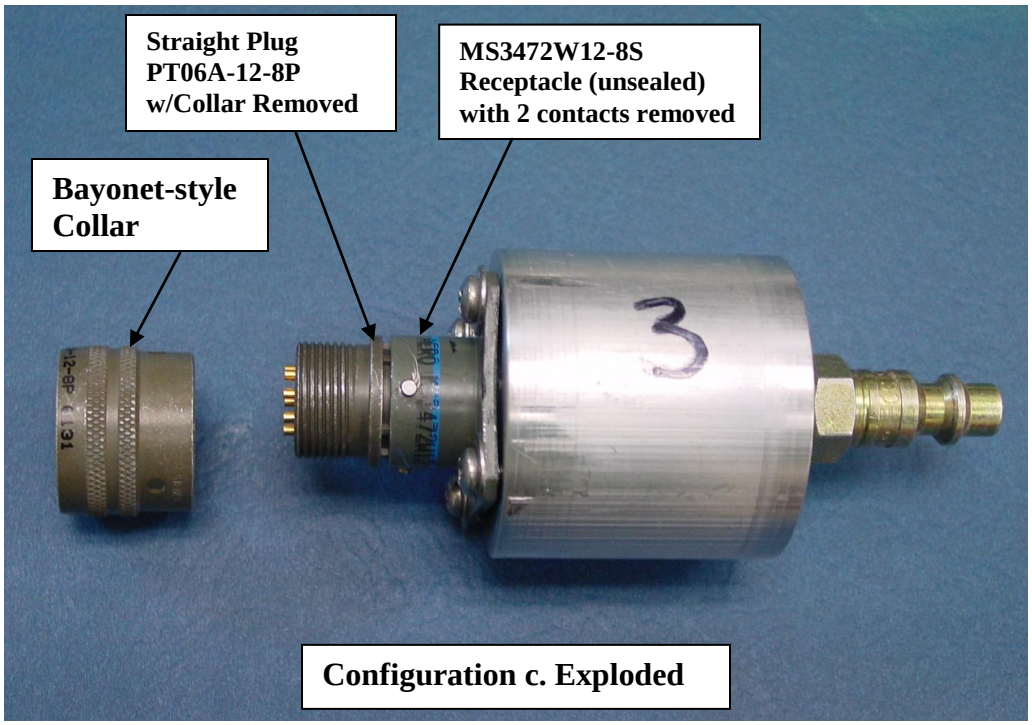

Figure A-3. Configuration c exploded.

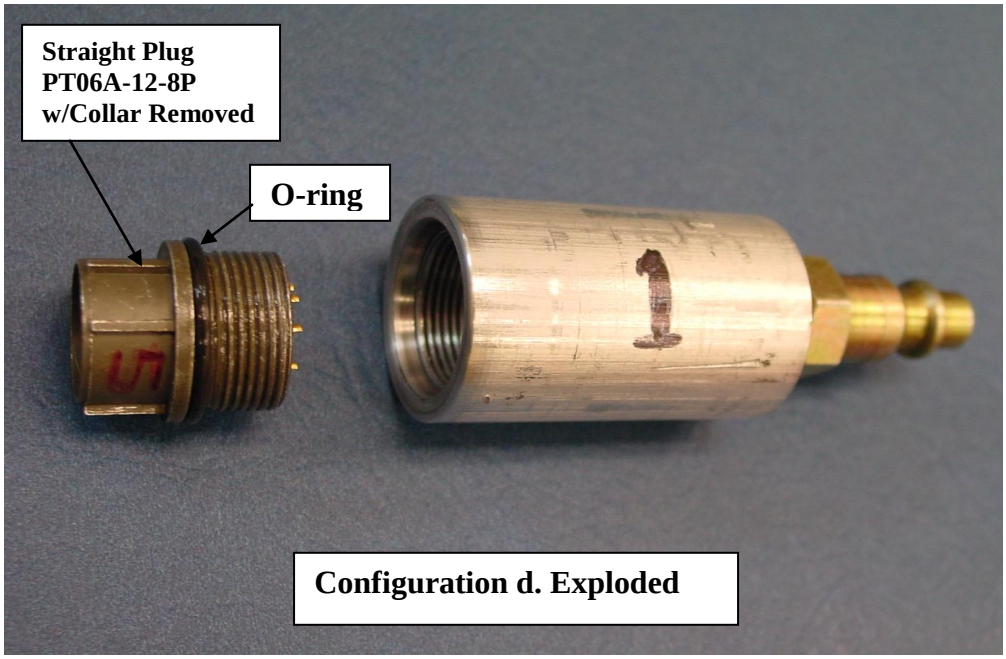

Figure A-4. Configuration d exploded.

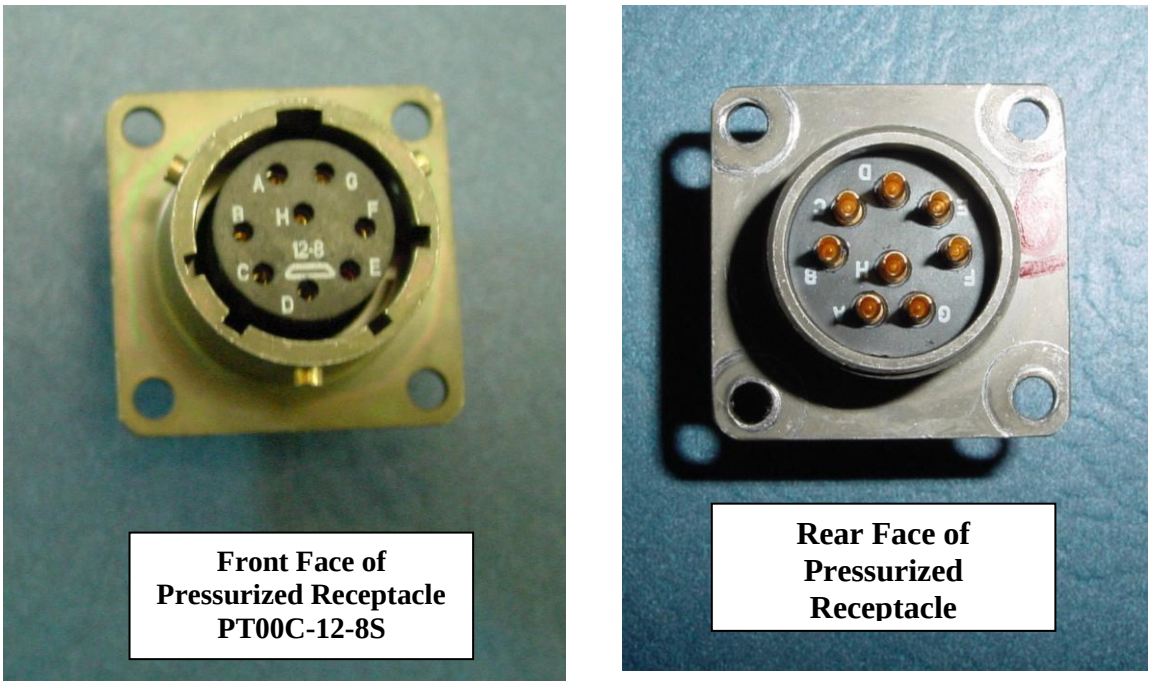

Figure A-5. (Left) Front face and (right) rear face of the Pressurized Receptacle PT00C-12-8S.

Figure A-6. (Left) Front face and (right) rear face of the Straight Plug PT06A-12-8P.

Figure A-7. Straight Plug PT06A-12-8P showing the epoxy-potted rear face of the contract-bearing insert.

Appendix B. Required Modifications to the Mil-C-26482, Series 1, Service Class C, Pressurized Receptacle Connector

Figure B-1 shows the required modifications made to the Mil-C-26482, Series 1, Service Class C, Pressurized Receptacle Connector.

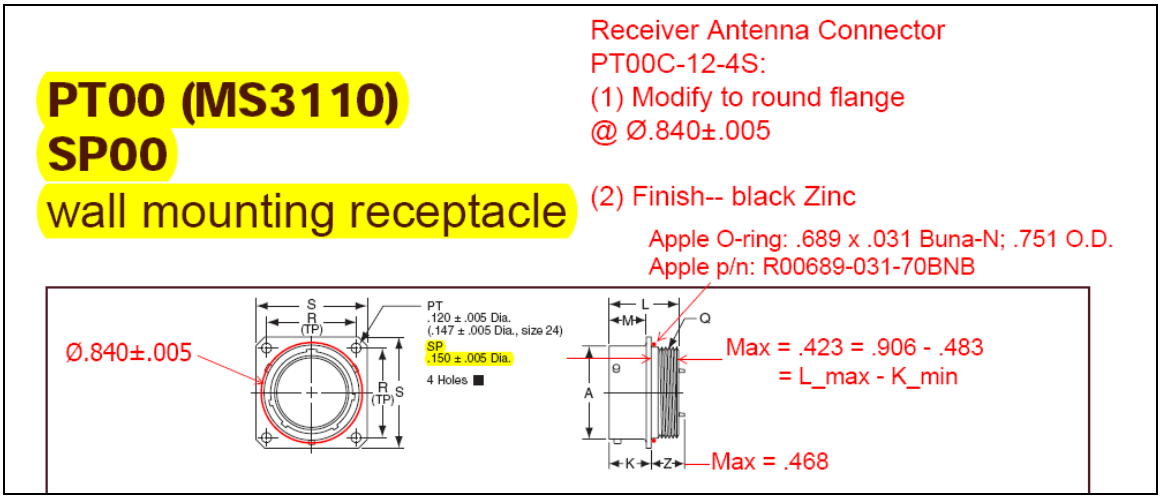

Figure B-1. The required modifications made to the Mil-C-26482, Series 1, Service Class C, pressurized receptacle connector.

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