Dynatube Seal Savers

Following repeated propellant feedline disconnections and connections to support thruster failures, it became evident that Dynatube connections were easily susceptible to sealing surface damage. Any rotational movement during the torque sequence can also cause galling and subsequent leak integrity failure. As early as 1979, Shop Aids (1) were developed to remove minor surface damage i.e. radial scratches extending across the sealing surface(s). Dynatube polishing became such a common practice that Standard Repair Procedures (SRP's)(2) were developed in 1994 as pre-approved documentation to address the repair. Polishing of the sealing surfaces of both the feedline and thruster side Dynatube to remove these defects proved to be an effective method of repair for the short term, but it was found that repeated polishing actually changed the design characteristic of the joint. Flattening of the female inner spring seal was observed when the feedline sides were polished, and in extremes cases failed to provide an acceptable leak tight joint. Dynatube fittings damaged past the point of repair must be cut out, and a replacement welded into place. The replacement process is labor intensive, time consuming and potentially hazardous based on the configuration with respect to propellant residuals. Based on the likelihood of Dynatube sealing surface damage during disconnections and that thruster removals were to become more prevalent for scheduled maintenance, Teflon coated seal inserts (Seal Savers) were designed by NASA - JSC to be installed between the highly polished sealing surfaces to alleviate damage during connections and subsequent disconnections.

The seal saver consists of an annealed stainless steel substrate (CRES 304L), coated with three layers of Teflon with a total buildup of 0.002" on each side. Previous versions specified a 0.005" Teflon buildup, but were found to be susceptible to delamination (see photo LIA Fu) and cold flow (3). The yield strength of the CRES seal is 25 KSI, while the yield strength of the Dynatube (CRES 17-4 PH) is 125 KSI (4). In December 1990, a Program Requirements Control Board Directive (PRCBD) approved the installation of the 1st primary thruster Seal Saver on STS37 RP01 Flt 14, followed by the specification ME276-0052 in November 1991.

Early installations proved to be difficult as the seal savers installed in the horizontal or downward facing fittings could fall out prior to making the connection. A tool was developed to aid in the installation of the seal savers which provided 2 crimps, 180 degrees apart, which helped keep them locked in place under the Dynatube spring. While installation with the tool is the preferred method, in cases where the tool can not be used due to envelope, access, etc. the seal may be pre-crimped and installed by hand as the situation dictates.

In May 1997 specification ML0306-0058 was released to establish the requirements for seal saver installations. It must be noted that seal savers must be properly aligned within the mating halves. Should a seal saver be sufficiently improperly aligned, it can exist with part of the lip crushed between the Dynatube mating halves. Should this occur, the independent action of the fitting's inner and outer seal surfaces will result in the outer seal attempting to form a leak tight seal regardless of the irregular surface in contact with the inner seal. With such a non uniform loading, yielding of the seal may allow 360 degrees contact at the outer seal, which may be sufficient to produce sealing at the joint. In critical applications, radiographic inspection is employed following connection to verify the internal lip of the seal saver is visible and exhibits no evidence of deformation, damage or of being crushed.

Low breakaway torques with fittings where seal savers had been previously installed was also noted during the program. While the practice of measuring breakaway torque is not a reliable method to determine initial installation torque, experience has indicated that breakaway measurements as low as 50% of the initial torque are not uncommon. Qualification testing using initial installation torques as low as 25% of the specified torque, demonstrated that the coupling nuts did not show any tendency to loosen also negating the need for safety wire (5)(6). Certification testing included leak testing, surge pressure, vibration, thermal cycling and propellant exposure and qualified the seal savers to successfully repair a fitting with a minor leak. There are currently no known occurrences of coupling nuts backing off and permitting leakage. Testing and analysis of the seal savers has indicated that the seals of the current design should be limited to normal operating pressures of 250 psia with the maximum operating pressure being 350 psig, as the Teflon tends to cold flow at higher pressure applications.

5/8" Fuel and ¾" Oxid Seal Savers (7) have since been installed in all thruster locations, on all pods and FRCS modules, and have been proven to be an effective interface seal, providing a soft seal material between the mating halves of the fitting that can deform to any potential sealing surface irregularities and aid in forming a leak free joint. Dynatube locations with no defects, or with scuffs and scratches, lacking evidence of raised metal, are used "as is" with no rework required prior to installation of the seal saver.

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References:

(1) Dwg's T7140624 5/8", T-7140287 3/4"

(2) SRP-V-PL-0013-0 Feedline Dynatube Repair, SRP-V-PL-0014-0 Thruster Dynatube Repair

(3) CAR KB2534-000 11-30-1992

(4) Boeing Letter 284-200-97-111 4-2-1997

(5) Boeing Letter N852-DCO-02-113 7-23-2002

(6) JSC Memo WTS-M597 3-31-1977

(7) JSC Dwg SDD33106416-001 5/8" and SDD33106416-003 ¾"