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FM NASA JFKSC KENNEDY SPACE CENTER FLA  
TO MSC APOLLO SPACECRAFT PROGRAM OFFICE HOUSTON TEX

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UNCLAS ATTN: BGEN CARROLL H BOLENDER, MANAGER FOR THE LUNAR MODULE

SUBJECT: LEAKS IN LM-1 AT KSC

REFERENCE (A) HDQRS TWX NBR 183 DATED JULY 1967

AS REQUESTED, A REVIEW WAS MADE TO DETERMINE WHY THE  
LEAKS ON LM-1 WERE NOT FOUND PRIOR TO DELIVERY TO KSC.  
THE CONCLUSIONS DRAWN BY KSC WERE BASED ON ANALYSIS OF  
THE FOLLOWING HYPOTHESES:

1. RESIDUAL LIQUID (FREON OR WATER) REMAINED IN  
AREA OF FLANGES (THOSE AREAS FOUND LEAKING) AT GRUMMAN  
FROM TIME OF COLDFLOW I TESTING UNTIL THE TIME THAT  
LEAK CHECKS WERE PERFORMED DURING COLDFLOW II AND  
IMPEDED THE LEAKAGE OF HELIUM THROUGH THE FLANGES.  
PRELIMINARY TESTS PERFORMED AT GRUMMAN ON A TANK  
RECENTLY RECEIVED FROM THE VENDOR HAVE INDICATED THAT  
THE HELIUM LEAKAGE RATE THROUGH THE FLANGES OF THE  
AFOREMENTIONED TANK WAS REDUCED 50-75 PER CENT AFTER THE TANKS

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WERE FILLED WITH FREON AND THEN EMPTIED AND PURGED.

2. VIBRATION, DUE TO TUMBLING OF THE VEHICLE AT GRUMMAN AFTER COLDFLOW II AND DUE TO TRANSPORTING THE VEHICLE TO KSC, CAUSED MINOR DISTORTION OR DEGRADATION OF THE SEALS OR SEALING SURFACE.

3. MINOR DISCREPANCIES EXIST BETWEEN THE LEAK CHECKING PROCEDURES, TECHNIQUES, AND EQUIPMENT AT GRUMMAN AND KSC WHEREBY LEAKAGES OF SIGNIFICANT MAGNITUDE RECORDED AT KSC WERE DETERMINED TO BE OF INSIGNIFICANT MAGNITUDE AT GRUMMAN.

4. LEAKS WERE NOT FOUND AT GRUMMAN DURING COLDFLOW II TESTING BECAUSE THE TEFLON "O" RINGS (CATEGORICALLY THE TYPE FLANGE SEALS FOUND LEAKING AT KSC) WERE STILL ABLE TO PROVIDE A GOOD SEAL, AS THEY HAD NOT COLD FLOWED TO THE POINT THAT ADDITIONAL TORQUING OF THE FLANGE WOULD NOT PROVIDE ADDED SEALING CAPABILITY. THE SUBJECT SEALS WERE ORIGINALLY INSTALLED 13 MONTHS AGO AND A SUBSEQUENT TEFLON VOLDFLOW PROCESS EVOLVED. ELEVEN MONTHS LATER, JUST PRIOR TO GRUMMAN COLDFLOW II TESTING, THE FLANGE BOLTS WERE TORQUE CHECKED. DURING THIS TORQUE

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CHECKING PROCEDURE, IT WAS FOUND THAT EVERY SUBJECT FLANGE CONTAINED BOLTS WITH TORQUE VALUES BELOW THE MINIMUM ALLOWABLE. AT THIS TIME, THE BOLTS WERE TORQUED TO THE MAXIMUM ALLOWABLE VALUE, AND THEREBY SUBJECTED THE TEFLON "O" RINGS TO A FURTHER COLDFLOW PROCESS. SIX WEEKS ELAPSED BEFORE THE FLANGES WERE AGAIN TORQUE CHECKED, THIS TIME AT KSC. SOME TORQUES WERE FOUND TO HAVE RELAXED FROM THE VALUES APPLIED JUST PRIOR TO COLDFLOW II. AS A RESULT OF THESE TORQUE CHECKS ALL BOLTS WERE AGAIN TORQUED TO THE MAXIMUM ALLOWABLE VALUES. LEAKS WERE STILL FOUND TO EXIST. THE RATIONALE IS TWOFOLD: (1) "O" RINGS COLD FLOWED TO SUCH AN EXTENT THAT THE SEALING CAPABILITY WAS GREATLY REDUCED (IN EFFECT, THE "O" RING SEALING AREA HAD BEEN GREATLY INCREASED, THEREBY DECREASING SEAL PRESSURE LOADING AND ULTIMATELY SEALING CAPABILITY), AND (2) NON-FLATNESS OF THE FLANGES IS SUCH THAT ADDITIONAL UNIFORM LOADING OF THE "O" RING CAN NOT BE OBTAINED BY INCREASING THE TORQUE, OR IF METAL-TO-METAL CONTACT EXISTS. ONE EXAMPLE THAT SUBSTANTIATES THE SEAL COLDFLOW THEORY IS THAT TORQUING TO THE MAXIMUM

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ALLOWABLE DID NOT SIGNIFICANTLY DECREASE THE LEAK RATES, BUT WHEN THE PQGS FLANGES WERE TORQUED TO ABOVE THE MAXIMUM NOMINAL TORQUE VALUE OF 75 IN LB., TO A VALUE OF 95 IN LB., THE LEAKAGE RATES DID DECREASE. ANOTHER EXAMPLE THAT SUBSTANTIATES THE SEAL COLDFLOW THEORY IS FROM LTA-5 AT WSTF. RETORQUING OF FLANGE BOLTS OF THIS VEHICLE WAS OFTEN THE ONLY REQUIRED FIX TO EFFECT SOLUTION TO LEAK PROBLEMS BUT NO RETORQUING OF MECHANICAL FITTINGS HAD BEEN PERFORMED ON IT PREVIOUSLY AT GRUMMAN. THEREFORE, THE TEFLON "O" RINGS ON LTA-5 STILL HAD A GOOD BIT OF RESILIENCY LEFT, AND BY APPLYING MORE PRESSURE ON THE SEAL AT WSTF ADDITIONAL SEALING CAPABILITY WAS AFFORDED.

IN CONSIDERATION OF THE ABOVE FOUR HYPOTHESES, KSC CONCLUDES THAT A COMBINATION OF ALL OF THESE, IN VARYING DEGREES, CONTRIBUTED TO THE FACT THAT MANY LEAK PROBLEMS WERE ENCOUNTERED AT KSC AND NOT AT BETHPAGE, WITH NUMBERS 3 AND 4 BEING THE MOST SIGNIFICANT.

CURRENT CORRECTIVE ACTION BEING ATTEMPTED IS TO MACHINE THE FLANGES ON THE DUCTS TO OBTAIN DESIRED FLATNESS,



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POLISHING THE METAL SEAL SURFACES AS REQUIRED, AND  
SELECTING LARGER SIZED TEFLON "O" RINGS. PRELIMINARY  
RESULTS ARE UNSATISFACTORY IN THAT OUT OF SPECIFICA-  
TION LEAKS OF THE SAME GENERAL MAGNITUDE STILL EXIST.

KSC RECOMMENDS FOR LM-1 THAT IMMEDIATE ACTION BE  
INITIATED TO MODIFY THE FLANGE DESIGN TO UTILIZE  
PROVEN, RELIABLE SEALS SUCH AS RACO OR CONCENTRIC  
DUAL TYPES AS ON THE CSM. ADDITIONAL CONSIDERATIONS  
FOR FUTURE LM'S SHOULD BE TO REPLACE AS MANY FLANGE  
JOINTS AS POSSIBLE WITH WELDED OR BRAZED JOINTS.

ED E R MATHEWS ACTING APOLLO PROGRAM MANAGER

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