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March 1999

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Integrated Advanced Microwave Sounding Unit-A (AMSU-A)

Engineering Test Report

AMSU-A2 METSAT Instrument (S/N 105) Vibration Tests Summary

P/N 1331200-2

Contract No. NAS 5-32314
CDRL 207

Submitted to:

National Aeronautics and Space Administration
Goddard Space Flight Center
Greenbelt, Maryland 20771

Submitted by:

Aerojet
1100 West Hollyvale Street
Azusa, California 91702

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INTEROFFICE MEMO

TO: L. T. Paliwoda

DATE: 11-Oct-1998
a2vibmet-sn105.doc
170:8411#98-744

FROM: R. J. Heffner

SUBJECT: AMSU-A2 METSAT Instrument (S/N 105) Qualification Level Vibration Tests of September 1998 (S/O 591397, OC-420)

COPIES TO: J. .A. Alvarez, D. H. Brest, D. B. Chi, R. V. Hauerwass, D. L. Tran, Writer, File

REFERENCES:

1. "AMSU-A2 Report on Shop Order VIB010 (OC-442) Engineering Model Reflector Vibration Tests of September/October", R.J. Heffner to D.H. Brest, 97-8611:#98-21, 13 January 1998.
2. "Advanced Microwave Sounding Unit-A2 (AMSU-A2) Instrument Assembly METSAT Qualification Level Vibration Testing", Shop Order 591397 (OC-420), August 1998.
3. "METSAT/AMSU Assy, A2", Dwg. 1331200.
4. "Vibration and Sine Burst Qualification and Acceptance Test Procedure for the AMSU-A System", Aerojet Process Specification AE-26151/1C, 1 July 1998.
5. "Failure Review Board (FRB) METSAT/AMSU-A2 S/N 105 (F/AR 152)", IOM 6107/98#735, E. Lorenz, 7 October 1998.
6. "AMSU-A2 EOS Instrument (S/N 202) Qualification Level Vibration Tests of May/June 1998 (S/O 523368, OC-418)", R.J. Heffner to L. T. Paliwoda, 98-8411:#98-429, 25 June 1998.

PURPOSE

The purpose of this memo is to present a summary of the qualification level vibration testing performed on the S/N 105 AMSU-A2 Ref. 3 Instrument during the September 1998 time frame.

SUMMARY

The Ref. 3, S/N 105, METSAT AMSU-A2 Qualification Instrument began vibration testing on 9/15/98 oriented in the METSAT Y-Axis. This is the 1st AMSU unit tested with the ultra high strength mounting bolts, torqued to 83 in-lb. Both G10 thermal isolators and G-10 washers withstood the high preload plus Y-Axis qualification random vibration loads without failure. This is also the 1st AMSU-A2 unit with the new, larger hub clamp with larger screw (#10) and higher preload (80 in-lb).

The test sequence commenced with a low level sine sweep, which produced some interesting reflector responses, which would later be shown as evidence of probable motor realignment during the instrument random vibration tests. After successfully completing the -6 dB and -0 dB full level 8.8 Grms random vibration, another low level sine sweep was run, with reflector responses somewhat different from their initial values.

In the investigation of the reflector response variances, the reflector shroud was found to have translated 0.010 in. toward the motor panel, probably during the Y-Axis random tests. While positioning the reflector to make the gap measurements (carefully rotating it by hand), the resistance to rotate built up until a click sound was heard whereupon the reflector then rotated easily.

With these abnormalities experienced (variance in low level sine reflector responses, excessive reflector rotation resistance with an audible "click" followed by ease of rotation), some added instrument testing was warranted. An additional low level sine sweep was run to verify the previous responses. The new responses were almost identical to the previous (post random) sine sweep. The sine burst test was cautiously modified to stop at the -12 dB -6 dB, and -3 dB (1/4 power or 4.1g, 1/2 power or 8.2g, and nearly 3/4 power or 11.5g)) and print out all responses. By 1/2 power it was readily seen that non-symmetric responses were evident at the reflector, possibly indicative of a reflector and/or motor anomaly. Another added low level sine sweep was run and identified no new response changes.

Qualification testing was stopped and diagnostic tests were begun. A Bode plot was run, identifying a 10 Hz increase (was 223 Hz now 233 Hz) in 1st natural frequency from the same test run in May of 1998. The motor was then subjected to (1) an electrical test - result normal, (2) a low level sine sweep - result a 1st f_n back down at 584 Hz, like the component pre-random low level sine sweep measurement (the component post random f_{n1} was 667 Hz, an increase of 83 Hz), and (3) the disassembly of the motor - results one minute piece of tape found in the resolver area and the housing bore diameter 1 or 2 tenths of a mil undersized, and (4) reassembly of the motor with new bearings, whereupon an electrical test was run - results normal, the workmanship component random tests were run with results a pre-random low level sine sweep f_{n1} of 572 Hz with a post random f_{n1} of 584 Hz, and a post workmanship component random electrical test - results normal. The motor now acted like the other three motors tested for workmanship component random vibration, with only a nominal rise in f_{n1} after the random run.

The reflector was isolated and evaluated with low level sine sweeps restrained by the new hub clamp - result f_{n1} of 172 Hz, and by the old hub clamp - result f_{n1} of 169 Hz, comparing to the Wyle test of early 1998, where a f_{n1} of 165 Hz was seen. A 1/2 power 8.2g sine burst test was run - results symmetric reflector responses.

The monitored gaps around the reflector showed no problems, with only two gaps with significant displacements. Gap 1, representing the enclosure to reflector secondary shroud clearance, had a closure of 0.0792 in. at full level Y-Axis random, with an initial clearance of 0.108 to 0.135 in. Gap 5, the shroud plate/secondary shroud bond line to motor panel clearance, had a closure of 0.0730 in. with a final static gap of 0.124 in., after 0.010 in. translation and/or closure.

Calculated reflector angular accelerations at full level random for the Y-Axis run were a θ_{DD-Z} of 6178 rad/sec^2 and a θ_{DD-X} of 3656 rad/sec^2. This compares to Ref. 1 calculated θ_{DD-Z} of 7065 rad/sec^2 and θ_{DD-X} of 2739 rad/sec^2, and to Ref. 6 calculated θ_{DD-Y} of 6872 rad/sec^2 and θ_{DD-Z} of 2433 rad/sec^2 for the EOS X-Axis run.

DISCUSSION

METSAT qualification level vibration testing was performed on the S/N 105 A2 assembly on September 15 through 17, 1998. The test sequence, for each axis, per the Ref. 2 shop order was the following:

1. Low level sine sweep (0.25 g).
2. Low level random vibration (-6 dB of full level 8.8 Grms, or 4.4 Grms).
3. Full level random vibration (8.8 Grms spec.).
4. Low level sine sweep (0.25g).
5. Acceleration/sine burst (16.3 g).
6. Low level sine sweep (0.25g).

Note the absence of the 8g sine sweep, required for EOS (Ref. 6) but not for METSAT.

Testing commenced on 15 September 1998 with the instrument mounted on the vibration shaker in the Ref. 2 Y-Axis orientation (vibration in direction of the reflector shaft). In comparisons to Ref. 1 METSAT data, note that the METSAT axes orientation is also used with all Ref. 1 data. Ref. 6, the recently completed EOS qualification test report utilizes its own axes orientation. A comparison of directions is shown below.

EOS Axis	METSAT Axis	
X	Y	(Shaft)
Y	Z	(Lateral)
Z	X	(Vertical)

The following is a chronology of notes taken throughout the testing.

Y-Axis Vibration Testing

1. Initial low level 0.25g sine sweep run 9/15/98. Accelerometer (Acc) A2Z is noted as suspect. All other Accs appear reasonable. Accs to be used for rotation/bending moment calculations (A6Y, A8Y, A7Z, A9Z) are also plotted for phase (A6Y/A8Y and A7Z/A9Z), with both plots appearing 180 degrees out of phase. A6Y/A8Y appear out of phase from about 90 to 210 Hz, which will be used in angular acceleration calculations. Also agreed to use same 90 to 210 Hz for A7Z/A9Z. f_1 for the

instrument is 110 Hz (per Acc 20Y). Engineering model Ref. 1 data showed f_1 at 99 Hz by the time the Y-Axis METSAT was run, while the Ref. 6 EOS qualification unit was recorded at 114 Hz. The Ref. 1 data showed a gradual reduction in instrument f_1 as the number of tests increased. The Ref. 1 Y-Axis METSAT test case, was one of the latter runs.

2. Low level (-6 dB, 4.4 Grms) random run 9/16/98. Data on small gaps and rotations shows more gap closure than seen with the engineering model. New gap 1, representing vertical (X) movement of the warmload to secondary shroud and the forward cone to compensator panel penetration shows 0.0469 in. closure at -6 dB. This compares to Ref. 1, gap 1 (which used different accelerometers in the gap) for the warmload/secondary shroud and Ref. 1, gap 4 for the forward cone/penetration, with recorded -3 dB readings of 0.0553 and 0.0548 in. closures, respectively, predicted. Note that the Ref. 6 EOS -6 dB reading was 0.0461 in. In Addition, new gap 5 (Y-direction reflector bond line to motor panel) shows 0.0440 in. closure at -6 dB, and compares to Ref. 1, gap 8 with only 0.0503 in. at the -3 dB level. Again, the Ref. 6 EOS -6 dB reading was 0.0423 in.

   Rotational moments also demonstrate greater movement predicted for the S/N 105 instrument. The calculated θ_{DD-Z} 3σ angular acceleration (producing the so called "yes" moment about the Z-axis, causing reflector movement like a head nod) is 3791 rad/sec^2 at -6 dB, which calculates to 5361 rad/sec^2 at -3 dB, 6 % higher than the Ref. 1, -3 dB, θ_{DD-Z} of 5229 rad/sec^2. Note that this is not alarming. Greater dampening at the higher -3 dB level would bring the current level to within 1 or 2 % of the Ref. 1 value. EOS -6 dB reading was 3448 rad/sec^2 at -6 dB. The calculated θ_{DD-X} 3σ angular acceleration (producing the so called "no moment about the X-Axis, causing reflector movement like shaking your head no) is 2124 rad/sec^2 at -6 dB (projects to 3004 rad/sec^2 at -3 dB) 21 % higher than the Ref. 1 θ_{DD-X} of 2469 rad/sec^2 at -3 dB. This increase is due to the conservative bandwith used for the S/N 105 θ_{DD-X} calculation. EOS -6 dB reading was 1996 rad/sec^2 at -6 dB. Results, although predicted to be somewhat higher than Ref. 1 & 6, however, do not indicate that it is not OK to go to full level random.

3. Full level (8.8 Grms) random run 9/16/98. Gap and rotation data dampened out considerably at 0 dB. Max. movement is calculated at 0.0792 in. at gap 1 with 0.0730 in. at gap 5. The warmload to secondary shroud gap (gap 1), although not measured, is 0.108/0.135 in. per assembly procedure. Data on gaps and rotations again shows more gap closure than seen with the engineering model. Ref. 1, gap 1 and gap 4 indicated closures were 0.0707 and 0.0678 in., respectively, less than the 0.0792 in. current prediction. Ref. 1, gap 8 calculated to 0.0610 in., also less than the S/N 105 0.0730 in. prediction at the same location. Results, however are not as severe as the recent Ref. 6 EOS test, with gap 1, 0.0986 in. and gap 5, 0.0902 in. closures.

   Rotational moments did dampen from the -6 dB levels for θ_{DD-Z}. The calculated θ_{DD-Z} "yes moment" 3σ angular acceleration is 6178 rad/sec^2, 13 % lower than the Ref. 1

$\theta_{DD\text{-}Z}$ of 7065 rad/sec^2, and 9 % lower than the recent Ref. 6 EOS 6802 rad/sec^2. The calculated $\theta_{DD\text{-}X}$ "no moment" 3σ angular acceleration is 3656 rad/sec^2, larger by 33 % than the Ref. 1 2739 rad/sec^2, and 19 % larger than the recent Ref. 6 EOS 3063 rad/sec^2. This increase is due to the conservative bandwidth used for S/N 105 $\theta_{DD\text{-}X}$ calculation. Results indicate no failures.

In terms of the root sum squared (RSS), the current METSAT data (RSS = 7179 rad/sec^2) actually lags the Ref. 1 METSAT data (RSS = 7577 rad/sec^2) and Ref. 6 EOS predictions (RSS = 7290 rad/sec^2).

4. Post random low level 0.25g sine sweep run 9/16/98. No significant change in signature seen for the instrument structure mounted accelerometers. f_1 was 110 Hz before random, and now registers 109 Hz. Reflector accelerometers however, show changes in response from the initial sine sweep. The instrument fundamental frequency is generally unchanged, however, the responses in the 130 to 200 Hz frequencies, (where the reflector natural frequencies are), are different. The responses now are more in line with Ref. 6 responses.

   The change in reflector response is significant enough to suspend further testing and call together a Failure Review Board (FRB) to discuss the apparent anomaly. Prior to the FRB meeting, the reflector clearances to compensator and motor panels were measured identifying a 0.010 in. shift toward the motor panel. In measuring the gaps, the reflector was rotated by hand to properly align for measurement when a click sound was heard. The reflector was harder than usual to rotate until after the click sound was heard.

5. One added low level sine sweep was run 9/16/95 before the FRB, with results showing the same responses as the previous.

6. Per FRB (F/AR 152), the 16.3g sine burst test was allowed to be run, but run in progressive increments of power. Plotting response data at all accelerometers was also done. Run on 9/17/98 at -12 dB (4.2g), there was a slight indication of an asymmetrical response at reflector Acc A8Y.

   At -6 dB of the sine burst (8.4g), more reflector accelerometers responded asymmetrically, causing another halt to the vibration testing.

7. Prior to the stoppage, one more low level sine sweep was run, demonstrating no changes from the pre sine burst low level sine sweep.

8. At this time the FRB determined that further qualification level instrument testing would be suspended. A series of diagnostic tests would be made to attempt to find the cause of the apparent anomaly. A motor test, a Bode Plot, was run to determine the resonant frequency of the reflector/motor. Bode plot results showed a 10 Hz change in f_1 from the pre-vibration measurement (233 Hz currently vs. 223 Hz).

9. Two components, the motor and the reflector, would each be isolated, to identify any possible anomalies in that component. The motor was removed from the assembly and first subjected to the motor current wave form and no-load speed test which were both passed with results similar to previous tests.

10. The motor was then mounted on the vibration shaker via its fixture and subjected to a low level sine sweep. As a direct comparison, this case was compared to the sine sweeps run before and after the component workmanship random test (Sept. 1997). The 1st natural frequencies in the Sept. 1997 pre and post random sine's were 584 and 667 Hz. This was a unique motor (S/N F02), with its natural frequency rising by more than 80 Hz. There are 3 other tested motors. In these other 3 motors, the natural frequency also rose, but only 6-13 Hz. The current testing of the S/N F02 motor indicated a f_1 of 584 Hz again. Thus the S/N F02 motor appeared to "return" to its original state.

11. The reflector was removed from the instrument and closely inspected. One item of interest was found. On a longitudinal reflector rib, near the hub clamp, a slight marring of the rib was found. Thinking that the slight indentation may have been caused by the hub clamp contacting the rib during vibration, a study to resolve the issue was begun. The gap between the hub clamp and rib was measured as 0.034 in. The latest COI finite element model was used to evaluate the displacement predicted. Owing to the close proximity of the suspect contact point to the hub/hub clamp boundary, there was negligible predicted movement between rib and adjacent hub/hub clamp fixed boundary. For 16.3g (the sine burst load) the predicted relative movement was < 0.0001 in. Considering the larger load at random vibration, where a g-load no higher than 100g is predicted, the predicted relative displacement would remain < 0.001 in. Thus the hub clamp to reflector rib should remain contact free during all loading conditions. The rib mar is not considered the cause of the non-symmetric sine burst reflector response, and was quite possibly the result of handling and/or preload torquing.

    To insure a "large" initial gap (>0.020 in.) at the hub clamp to rib, the dimension the length of hub extending outboard of the hub clamp is decreased from 0.060/0.090 to 0.060/0.070 in. This should not impact any assembly because a hub overhang of 0.062 to 0.065 in. was used in all units.

12. The reflector was subjected to a low level sine sweep while attached to its fixture. Instrumented similarly to tests run at Wyle Labs for COI, in early 1998, for S/N F03, the reflector response was measured with using both the new and old hub clamps. The 1st natural frequency achieved by Wyle was 165 Hz. With the new hub clamp, a 172 Hz f_1 was found. Replacing hub clamps saw f_1 reduce only 169 Hz. Thus the reflector is still considered intact.

13. Running the sine burst (-6 dB or 8.2g) on the isolated reflector was next done to see if the non-symmetric reflector response while mounted to the instrument is attributed to the reflector itself or to the reflector attachment point. The isolated reflector produced symmetric plots, leading to the conclusion that it was the reflector mount

(the motor) and not the reflector that caused the imbalanced load seen at instrument level, -6 dB sine burst.

14. The motor (S/N F02) was completely disassembled to check for missing/broken components, any loose debris, or other such anomalies. All that was found was 1 minute piece of tape (~ 0.10 in. x 0.05 in.) in the resolver region, and a bearing bore diameter undersized by a few tenths of a mil. The motor was re-assembled with new bearings and an enlarged bore diameter. An electrical test was performed and passed. A workmanship component vibration test was performed on the rebuilt motor. Initial sine sweep had a f_1 = 572 Hz. With random run at 20 to 1000 Hz (5.7 Grms), the post random sine sweep found its f_1 raise to 584 Hz. The S/N F02 motor is now no longer unique, with its natural frequencies and change of natural frequencies like the other three built and tested motors.

15. A post workmanship vibration electrical test was performed on the rebuilt S/N F02 motor - results passed.

16. The rebuilt motor along with the reflector were reassembled into the METSAT S/N 105 qualification unit. A Bode plot was again generated on 10/6/98 with 1st natural frequency at 223 Hz now, equal to the 1st natural frequency measured in the 5/28/98 Bode plot. Note that the Bode plot recorded 9/21/98, after the Y-axis vibration, with the motor yet to be disassembled and then reassembled gave a 233 Hz 1st f_n.

17. Thus fully assembled rebuilt S/N 105 METSAT qualification unit was next subjected to a Limited Performance Test (LPT), with the rebuilt motor on 10/08/98. The instrument passed the LPT and was sent to the environmental lab for instrumentation for the continuation of the qualification vibration.

RESULTS

Table 1 displays the primary reflector gap definitions and initial & final measurements performed. Five gaps were monitored throughout the S/N 105 vibration testing. Gap 1 is a vertical gap (X-Axis) used for warmload to secondary shroud and for reflector forward cone to compensator panel bore diameter clearance measurements, gaps 2 and 4 are lateral Z-axis gaps, with gap 2 determining the movement between the reflector main shroud and the side panel/shade strip, while gap 4 is used for reflector forward cone to compensator panel bore diameter clearance measurements. Gaps 3 and 5 are lateral Y-axis gaps, with gap 3 measuring reflector secondary shroud/shroud plate bond line to compensator panel movement and Gap 5 used for reflector secondary shroud/shroud plate bond line to motor panel movement.

Table 2 is the gap deflection summary table for random vibration loads. For the axis evaluated, the predicted 4σ gap deflections are found for the -6 dB and full level (-0 dB) random vibration.

Table 3 is the 3σ rotational acceleration summary table. The reflector is shown to rotate about the vertical (X) axis and lateral (Z) axis. Angular acceleration terms θ_{DD-X} ("no" moment) and

θ_{DD-Z} ("yes" moment) are determined for the evaluated Y-axis for -6 dB and full level (-0 dB) random vibration.

Comparing S/N 105 Table 2 gap deflections and Table 3 angular accelerations to Ref. 1 engineering model data, for full level random vibration tests, shows

Comparison of S/N 105 METSAT Qual Gap Displacements to the Ref. 1 Engineering model;

Gap	Vib. Test	S/N 105 METSAT	Ref. 1 METSAT	
1	Y	0.0792 in.	0.0707 in.	X
2		0.0268	0.0426	Z
3		0.0509	0.0837	Y
4		0.0308	0.0426	Z
5		0.0730	0.0610	Y

Comparison of S/N 105 METSAT Qual Reflector Rotations to the Ref. 1 Engineering Model

	S/N 105 METSAT		Ref. 1 METSAT	
	-6 dB	-0 dB	-6 dB	-0 dB
Y-Axis	rad/sec^2	rad/sec^2	rad/sec^2	rad/sec^2
θ_{DD-X}	3791	6178	5229	7065
θ_{DD-Z}	2124	3656	2469	2739
RSS	4345	7179	5782	7577

CONCLUSIONS and RECOMMENDATIONS

On the basis of the shortened qualification level vibration sequence performed on the S/N 105 AMSU-A2 METSAT instrument, and the numerous diagnostic tests on the motor and/or reflector, it is concluded that the S/N 105 instrument was being tested during the September 1998 qualification tests with a deficient motor. It is equally concluded that the rebuilt motor (motor S/N F02 of October 1998) has corrected the motor deficiencies and when assembled into the S/N 105 instrument presents an instrument ready for further (qualification level) testing.

The S/N F02 motor used on the September 1998 tests exhibited a natural frequency of 584 Hz when tested as a component in September 1997. After subjecting the motor to the workmanship random vibration (then a 20-2000 Hz, 6.6 Grms , 30 sec. Test) the motor apparently re-seated itself, because the natural frequency of the motor increased substantially to 667 Hz. This was unlike any of the other tested A2 motors, where a rise of 6-12 Hz after component random was the result. Apparently during the instrument random vibration test, the motor re-positioned itself back to its initial (584 Hz) state. This was verified after the motor was removed from the S/N 105 assembly and checked for frequency via a low level sine sweep, where 584 Hz was again measured. It is also concluded that the "click" sound heard while manipulating the reflector after the full level instrument random was probably the motor readjusting. Also attributed to the motor are the reflector's apparent translation 0.010 in. towards the motor, and the non-symmetric sine burst response of the reflector.

It is also concluded that no damage has been done to the S/N 105 instrument S/N 03 reflector. All diagnostic tests show a reflector still meeting the design standards. The natural frequency of the component reflector was checked after the S/N 105 instrument tests (Y-axis random vibration and -6 dB sine burst), with 172 Hz w/new hub clamp and 169 Hz w/old hub clamp, comparing well to the 165 Hz measured during component acceptance testing. A -6 dB sine burst test on the isolated reflector showed a symmetric response w/o the motor. The hub clamp also retained its preload during the instrument qualification vibration.

With rebuilt component S/N F02 motor and structurally sound component S/N 03 reflector reinstalled into the S/N 105 instrument, and after successful completion of a limited performance test (LPT) on the reassembled instrument, it is recommended to resume qualification vibration testing, using the following plan:

Vibration testing will be restarted in the Y-Axis, with the following scheduled tests:

1) Low level sine sweep.
2) Sine burst at -6dB (8.2g) with full response printout.
3) Full level sine burst (16.3g) with full response printout.
4) Low level sine sweep.
5) Acceptance level (5.9 Grms) random vibration.
6) Low level sine sweep.

The remaining two test axes, X and Z, will follow the OC-420 plan, with the inclusion of the complete response printout for the sine burst test:

1) Low level sine sweep.
2) -6 dB of qualification level (4.4 Grms) random vibration.
3) Full qualification level (8.8 Grms) random vibration.
4) Low level sine sweep.
5) Full level sine burst at (16.3g) with full response printout.
6) Low level sine sweep.

R J Heffner

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Mechanical Design and Analysis

Table 1 Primary Reflector Gap Definitions and Initial & Final Measurements

Gap No.	Accelerometers and Axis of Measurement	Gap Locations	Initial Static Gap (in)	Post Y-Axis Gap (in)	Post Y-axis Gap (in)	Final Static Gap (in)
1	A2X to A6X	Warmload Enclosure to Reflector Secondary Shroud	.108/.135[1]	n/a	n/a	n/a
		1331215 Rear Panel Bore Dia. to Reflector Forward Cone Dia.	0.155[2]	n/a	n/a	n/a
2	A3Z to A7Z	1331218 Side Panel & 1331221 Shade Strip to Reflector Primary Shroud	0.126[3]	n/a	n/a	n/a
3	A2Y to A7Y	1331215 Rear Panel to Reflector Shroud Plate Bond Line	0.137	0.147	n/a	n/a
4	A2Z to A7Z	1331215 Rear Panel Bore Dia. to Reflector Forward Cone Dia.	.158[2]	n/a	n/a	n/a
5	20Y to A9Y	1331214 Motor Panel to Reflector Shroud Plate Bond Line	0.134	0.124	n/a	n/a

n/a = not available

[1] Per assembly procedure

[2] Typical magnitude from other units.

[3] 1 in. from motor panel 0.126 in., 1 in. from compensator panel 0.131 in.

Table 2 METSAT 4σ Gap Deflections for -6 & -0 dB Y- Axes Random Vibration

Gap No.	X-Axis Calc. 4 σ Disp METSAT -6 dB (in)	**Calc. 4 σ Disp METSAT -0 dB (in)**	Y-Axis Calc. 4 σ Disp METSAT -6 dB (in)	**Calc. 4 σ Disp METSAT -0 dB (in)**	Z-Axis Calc. 4 σ Disp METSAT -6 dB (in)	**Calc. 4 σ Disp METSAT -0 dB (in)**	Initial Static Gap (in)	Post Y-Axis Static Gap (in)	Post X-Axis Static Gap (in)	Final Static Gap (in)	Accels.
1			0.0469	**0.0792**			.108/.135	.108/.135			A2X-A6X
2			0.0163	**0.0268**			.126/.131	.126/.131			A3Z-A7Z
3			0.0301	**0.0509**			0.137	0.147			A2Y-A7Y
4			0.0197	**0.0308**			.158	n/a			A2Z-A7Z
5			0.0440	**0.0730**			0.134	0.124			20Y-A9Y

n/a = not available

Table 6 3σ Rotational Accelerations of COI Reflector During AMSU A2 S/N 105 Random Vibration Tests (Sept 1998) METSAT

	Distances to accelerometers from hub (inches)
d6	7.073
d8	7.198
d7	5.149
d9	2.189

Test	Level (dB)	Notch (dB)	RV Spec	RMS Acceleration on Reflector (over narrow band freq. range stated below) g's				3 Sigma Rotational Accelerations (rad/sec^2)		
				A6Y	A8Y	A7Z	A9Z	Theta-DD-Z	Theta-DD-X	RSS
X Axis, -6 dB	-6		METSAT							
X Axis, 0 dB	Full		METSAT							
Y Axis, -6 dB	-6		METSAT	**21.50**	**25.22**	**9.31**	**4.15**	**3791**	**2124**	**4345**
Y Axis, 0 dB	Full		METSAT	**35.68**	**40.46**	**15.05**	**8.12**	**6178**	**3656**	**7179**
Z Axis, -6 dB	-6		METSAT							
Z Axis, 0 dB	Full		METSAT							

1) Axes are test axes (METSAT)

2) Accel responses integrated over a frequency band where the accel pairs (A6Y, A8Y) and (A7Z, A9Z) were shown to be 180 deg out of phase (based on low level sine sweep data)

a) For accelerometer pair (A7Z, A9Z) this was from 90 to 145 Hz, however, the same 90-210 Hz as used with Theta-DD-Z are used

b) For accelerometer pair (A6Y, A8Y) this was from 90 to 210 Hz.

3) Unless otherwise stated, all accel responses were integrated over the above frequencies from the test analog tape data digitized using 5 Hz resolution.

4) Acceleration values that are bold are actual measured values. Others are projected, or estimated, based on those measured values.

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TO: L. T. Paliwoda

DATE: 19-Mar-1999
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COPIES TO: J. .A. Alvarez, D. H. Brest, D. B. Chi, R. Nieto, D. L. Tran, Writer, File

REFERENCES:

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PURPOSE

The purpose of this memo is to present a summary of the qualification level vibration testing performed on the S/N 105 AMSU-A2 Ref. 3 Instrument during the October 1998 time frame. The October tests are a continuation of the September 1998 tests. The September tests were incomplete, stopped by the test anomaly (low level sine sweep response changes) traced to a discrepant motor. The October tests use a refurbished S/N F02 motor.

SUMMARY

The Ref. 3, S/N 105, METSAT AMSU-A2 Qualification Instrument began vibration testing in mid-September, only to see problems in the 1st Y-Axis low-level sine sweep responses before and after random vibration. Disagreement in successive sine sweep responses caused a delay in testing, and the subsequent investigation and rework of the assembly's motor assembly.

The rebuilt assembly began vibration testing again in mid-October, to the Ref. 8 test sequence. Starting in the Y-Axis, with NASA approval, an acceptance level (5.9 Grms) random vibration is substituted for the qualification level (8.8 Grms) random vibration. Y-Axis tests produce no change in structure or reflector. Pre and post-random sine sweep response agree.

Z-Axis tests, however, at qual. level, are much more severe for the reflector, with significant frequency degradation seen when pre and post-random sine sweeps are compared. Also, the A7Z/A9Z out-of-phase relationship reduces in frequency from 140-185 Hz. (pre random) to 121-148 Hz. (post random). The structure, however, shows no permanent effects from Z-Axis tests, locations such as at the top panel (6Z) the pre random and post-random 1st freq. remains constant (at 138 Hz.).

X-Axis tests are much less severe than Y or Z-Axes tests. No problems in the reflector or structure result from the qual. level X-Axis tests.

The relative reflector/structure deflections at the monitored gap locations are all within the actual physical spaces. That is, no reflector to structure contact problems are predicted.

The angular accelerations determined for the Z-Axis random vibration runs are significant. First, the magnitude of the RSS $((\theta_{DD\text{-}X}^2 + \theta_{DD\text{-}Z}^2)^{1/2})$ of 9142 rad/sec^2 at full qualification level is the highest seen to date (Ref. 1 engr. model RSS was 7577 rad/sec^2). Also, the angular acceleration, $\theta_{DD\text{-}X}$, at the -6 dB level (7915 rad/sec^2) is higher than the full qual. level value (6442 rad/sec^2).

Because of the Z-Axis test results and the suspect reflector responses, the reflector was removed from the instrument and closely examined. This examination located the probable cause of the reflector's response problems, when a crack was found between the reflector aft cone and reflector rib bond.

The reflector was transported back to the vendor (COI) whereupon more extensive inspections were performed, the precise location of the crack(s) was determined, a plan was devised to repair the S/N F03 reflector, and a rework design was established.

DISCUSSION

The Ref. 3, S/N 105, METSAT AMSU-A2 Qualification Instrument began vibration testing in mid-September, only to see problems in the Y-Axis (1st axis tested) low-level sine sweep responses before and after random vibration. As discussed in Ref. 7, disagreement in successive sine sweep responses before and after random vibration caused a delay in testing, and the subsequent investigation and rework of the assembly's motor assembly.

The modified S/N 105 instrument, with rebuilt motor assembly, began vibration testing again in mid-October, following the test sequence of Ref. 8, outlined below. Vibration testing was restarted in the Y-Axis, with the following scheduled tests. Note that per NASA direction, the Y-Axis random vibration run is run at acceptance level (5.9 Grms):

1) Low level sine sweep.
2) Sine burst at -6dB (8.2g) with full response printout.
3) Full level sine burst (16.3g) with full response printout.
4) Low level sine sweep.
5) Acceptance level (5.9 Grms) random vibration.
6) Low level sine sweep.

The METSAT axes orientation is as follows:

X axis	Vertical, perpendicular to baseplate
Y axis	Lateral, perpendicular to motor drive shaft
Z axis	In line with motor drive shaft

The remaining two axes (Z and X) are run at qualification level, following the sequence of tests contained in Ref. 2, as outlined below.

1. Low level sine sweep (0.25 g).
2. Low level random vibration (-6 dB of full level 8.8 Grms, or 4.4 Grms).
3. Full level random vibration (8.8 Grms spec.).
4. Low level sine sweep (0.25g).
5. Acceleration/sine burst (16.3 g).
6. Low level sine sweep (0.25g).

Recalling from Ref. 7 that this (S/N 105) is the 1st AMSU unit tested with the ultra high strength mounting bolts, torqued to 83 in-lb. Both G10 thermal isolators and G-10 washers withstood the high preload plus qualification random vibration loads without failure. This is also the 1st AMSU-A2 unit with the new, larger hub clamp with larger screw (#10) and higher preload (80 in-lb.).

Y-Axis Vibration Tests

(1) The October 1998 test sequence commenced with a low level sine sweep in the Y-axis on 10/12/98. Reflector responses (A6X, A6Y, A7X, A7Y, A7Z, A8X, A8Y, A9Y, A9Z) were all similar to sine sweeps #2, #3, and #4 of Ref. 7, and were different than the 1st Ref. 7 sine

sweep run. Sine sweep #1 of Ref. 7 is considered the discrepant condition, thus now having an initial response like the #2, #3, and #4 Ref. 7 sine sweeps is what was looked for.

(2) The sine burst 16.3 g run was run to -6 dB with responses printed out. Run 10/12/98, the reflector response data is unique, with amplified levels as high as 2 on Accel. A6Y, where an input 8.6/-8.6 g develops -15.7/15.0 g reflector response. As discovered in Ref. 9, a comparison of the transfer functions at sine burst to the transfer functions at low level sine sweep (printed below), there is correlation for the instrument structure mounted accels. As for reflector mounted accels., there is what appears to be 4th harmonic noise to the 35 Hz input frequency superimposed with the basic response, greatly enlarging the responses on the reflector.

Accel No.	+/- Peaks in Sine Burst		Description Of Response	Sine Burst Transfer F_{cn} = +/- Peak Avg/ Input Avg	Asymmetry = +/- Peak Sum/ Input Avg	Transfer Fcn From 1st Sine Sweep at 35 Hz
Input	8.564	-8.583	35 Hz Fund.	100%	0.2%	100%
6Y	9.451	-9.336	35 Hz Fund.	110%	1.3%	108%
20Y	12.019	-11.378	35 Hz Fund.	136%	7.5%	132%
A2Y	10.05	-9.674	35 Hz Fund.	115%	4.4%	112%
A6Y	15.038	-15.739	Fund + 4th Harm.	179%	-8.2%	100%
A7Y	9.787	-11.436	Fund + 4th Harm.	124%	-19.2%	112%
A8Y	13.234	-10.562	Fund + 4th Harm.	139%	31.2%	116%
A9Y	11.717	-10.543	Fund + 4th Harm.	130%	13.7%	112%
17Y	9.87	-9.745	35 Hz Fund.	114%	1.5%	noisy

(3) Reran sine burst to –6dB but with bandwidth of test increased from 125 Hz to 500 Hz to try to capture the higher frequency responses seen on the reflector. Run 10/12/98. Responses are similar to the initial run. Accel. A7Y acting up.

Accel No.	+/- Peaks in Sine Burst		Description Of Response	Sine Burst Transfer F_{cn} = +/- Peak Avg/ Input Avg	Asymmetry = +/- Peak Sum/ Input Avg	Transfer Fcn From 1st Sine Sweep at 35 Hz
Input	8.583	-8.613	35 Hz Fund.	100%	-0.35%	
6Y	9.4	-9.379	35 Hz Fund.	109%	0.24%	108%
20Y	11.792	-11.555	35 Hz Fund.	136%	2.76%	132%
A2Y	9.879	-9.749	35 Hz Fund.	114%	1.51%	112%
A6Y	14.714	-15.979	Fund + 4th Harm.	178%	-14.71%	
A7Y	3.755	-4.017	Fund + 4th Harm.	45%	3.34%	
A8Y	12.666	-10.924	Fund + 4th Harm.	137%	20.26%	
A9Y	11.763	-11.302	Fund + 4th Harm.	134%	5.36%	
17Y	9.726	-9.796	35 Hz Fund.	114%	-0.81%	noisy

(4) On 10/12/98, ran sine burst to full level (-0dB at 500 Hz bandwidth). Responses acting similar to -6 dB runs. With -15.3/15.4 g input, the largest response is at A6Y with -32.3/27.8 g. Although much higher than expected, these high responses are still bounded by the acceleration levels seen during the component qualification acceleration tests, where 45 g loads were experienced.

Accel No.	+/- Peaks in Sine Burst		Description Of Response	Sine Burst Transfer F_{cn} = +/- Peak Avg/ Input Avg	Asymmetry = +/- Peak Sum/ Input Avg	Transfer Fcn From 1st Sine Sweep at 35 Hz
Input	15.289	-15.38	35 Hz Fund.	100%	-0.59%	
6Y	17.898	-17.167	35 Hz Fund.	114%	4.77%	108%
20Y	22.567	-21.33	35 Hz Fund.	143%	8.07%	132%
A2Y	17.57	-17.847	35 Hz Fund.	115%	-1.81%	112%
A6Y	27.81	-32.332	Fund + 4th Harm.	196%	-29.49%	
A7Y	15.705	-15.699	Fund + 4th Harm.	102%	0.04%	
A8Y	24.972	-20.422	Fund + 4th Harm.	148%	29.67%	
A9Y	21.967	-21.433	Fund + 4th Harm.	142%	3.48%	
17Y	17.729	-19.055	35 Hz Fund.	120%	-8.65%	noisy

Instrument to fixture bolt torques were measured after full level sine burst. (A requirement since there was no locking feature employed on the instrument mounting bolts). Preloads remain OK with largest change 1.5 in-lb. from 83 in-lb. to 81.5 in-lb.

(5) On 10/13/98 the low level sine sweep following sine burst was run with no significant changes from the pre-sine burst low-level sine sweep.

(6) On 10/13/98, ran random vibration at acceptance level (5.9 Grms), per NASA approval. Response data compares well to Ref. 7 data which was run at -6 dB (qualification) and full qualification level. The 10/13/98 data appears a little high, however, when the transfer functions of the accels. between the earlier sine sweeps of Ref. 7 and the current one are compared, it is seen that the transmissibilities have increased slightly. Thus response levels should also increase. Response shapes are very similar.

(7) The final Y-axis low level sine sweep following random vibration at acceptance level, run on 10/13/98, shows no appreciable change. In fact, a check of a reflector accelerometer, such as A6Y, shows the identical 1st natural frequency of 109.4 Hz, at the post acceptance random sine sweep as at the initial October 12, 1998 sine sweep, where 109.4 Hz is also recorded.

(8) Preload torques are again checked, with no appreciable changes found.

Z-Axis Vibration Tests

(1) The Z-Axis initial low-level sine sweep was run 10/14/98. Initial natural frequencies are noted in the reflector (A7Z) as 138.6, 143.6, and 158.8 Hz. The reflector accelerometer pair used to determine the phase relationship in determining the calculated θ_{DD-X} 3σ angular acceleration is A7Z/A9Z. This pair is used in producing the so called "no moment about the X-Axis, causing reflector movement like shaking your head no, and is seen to be 180 deg. out-of-phase at frequency band 140 to 185 Hz.

(2) The qual. level random vibration spectrum at –6 dB is next, run 10/14/98. Large G^2/Hz. responses are seen in the reflector, with a 50.5 Grms response at A6Y and a local 141 Hz. peak of 50 G^2/Hz at A7Z.

(3) Later on 10/14/98 the full level qual. level random vibration spectrum is run, with A6y response at 106.5 Grms, nearly twice the -6 dB response, but local A7Z peak reduces in magnitude to 26 G^2/Hz at reduced frequency of 121 Hz.

(4) The post random vibration sine sweep, also run on 10/14/98 identifies certain potential problems in the reflector. At A9Z, the sine sweep #1 138.6, 143.6, and 158.8 Hz. three natural frequencies deteriorate to 126.2, 138.6, and 151.0 Hz., respectively, from 5 to 12 Hz. reductions. The 180 deg. out-of-phase relationship of A7Z/A9Z also looses frequency, with bandwidth reduced to 121 to 148 Hz. These are signs of structural changes in the reflector. The structure, such as 6Z, shows a pre-random 1st frequency of 138 Hz. that remains constant at 138 Hz. during the post random sine sweep.

(5) Running the 16.3 g sine burst, showed responses that did not have amplification factors much greater than 1.0.

(6) The post sine burst sine sweep showed only slight additional degradation, with A9Z 1st three natural frequencies 142, 138, and 150 Hz. The 121 to 147 Hz. out-of-phase remains essentially constant for accel. pair A7Z/A9Z. The structure, such as 6Z, shows a post sine burst 1st frequency of 138 Hz., the same level as recorded in pre-random and post random sine sweeps.

Thus it could be concluded that some stiffness reduction occurred in the reflector during the Z-Axis full level random while the structure remains in tact.

X-Axis Vibration Tests

(1) The X-Axis initial low-level sine sweep was run 10/15/98. Initial natural frequencies are noted in the reflector (A7Y) as 130.8 and 149.9 Hz. The structure (20Y) sees a 1st natural freq. of 132 Hz.

(2) The qual. level random vibration spectrum at –6 dB is next, run 10/15/98. Large Grms responses are seen in the reflector, with a 42.9 Grms response at A6Y, 86.1 Grms at A7Y, with a local 540 Hz. peak of beyond 100 G^2/Hz at A7Y.

(3) Later on 10/15/98 the full qual. level random vibration spectrum is run, with A6Y response at 65.5 Grms, about 1.4 times the -6 dB response, but A7Y does not function properly. Looking at A8Y, the full level random response is 48.4 Grms with a local 15 G^2/Hz peak at 133 Hz., while the -6 dB response was 23.7 Grms, with a peak of only 4 G^2/Hz resonating at 132 Hz.

(4) The post random vibration sine sweep, also run on 10/15/98, shows, at A7Y, the sine sweep #1 130.8 and 149.9 Hz. two natural frequencies deteriorate to 125.3 and 131.8 Hz., respectively, from 5 to 18 Hz. reductions. These are signs of structural changes in the reflector. The structure, 20Y, shows a pre-random 1st frequency of 147 Hz. that remains constant at 147 Hz. during the post random sine sweep.

(5) Running the 16.3 g sine burst in two steps, first to the -6 dB level of 8.2 g, then at full level of 16.3 g, showed responses that did not have amplification factors much greater than 1.0.

(6) The post sine burst sine sweep showed a reversal, (a frequency gain), with A7Y 1st two natural frequencies changing from 125,3 and 131.8 Hz. at post random, back to 131 and 149 Hz., at post sine burst. These levels agree with the pre random levels, suggesting erroneous readings at the post random A7Y response. A better comparison would be A6X, where no appreciable change in frequency is seen from pre random to post random to post sine sweep.

Thus it could be concluded that no appreciable reduction in stiffness occurred in the reflector during the X-Axis full level random and X-Axis sine burst.

RESULTS

Table 1 displays the primary reflector gap definitions and initial & final measurements performed. Five gaps were monitored throughout the S/N 105 vibration testing. Gap 1 is a vertical gap (X-Axis) used for warmload to secondary shroud and for reflector forward cone to compensator panel bore diameter clearance measurements. Gaps 2 and 4 are lateral Z-axis gaps, with Gap 2 determining the movement between the reflector main shroud and the side panel/shade strip, while Gap 4 is used for reflector forward cone to compensator panel bore diameter clearance measurements. Gaps 3 and 5 are lateral Y-axis gaps, with gap 3 measuring reflector secondary shroud/shroud plate bond line to compensator panel movement and Gap 5 used for reflector secondary shroud/shroud plate bond line to motor panel movement.

Table 2 is the gap deflection summary table for random vibration loads. For the axis evaluated, the predicted 4σ gap deflections are found for the -6 dB and full level (-0 dB) random vibration.

The monitored gaps around the reflector showed no problems, with only two gaps with significant displacements (see Tables 1 and 2). Gap 1, representing the enclosure to reflector secondary shroud clearance (vertical (X) movement), had a closure of 0.0792 in. at full level Y-Axis random, with an initial clearance of 0.108 to 0.135 in. The added acceptance level Y-Axis run identified a Gap 1 displacement of 0.0668 in., which would, even without added dampening, project to only 0.0945 in. displacement, still less than the minimum gap (0.108 in.). Added dampening does, however, generally occur, such that the 0.0945 in. displacement is a conservative estimate. This is verified in the Ref. 7 data, where the linear extrapolation of the -6 dB closure of 0.0469 in. to full level would calculate to 0.0938 in., greater than the 0.0792 in. determined from actual test data.

Gap 5, the shroud plate/secondary shroud bond line to motor panel clearance, had a closure of 0.0730 in. with a final static gap of 0.129 in., after 0.003 in. translation and/or closure. The added acceptance level Y-Axis run produced a Gap 5 displacement of 0.0728 in., which would, even without added dampening, project to 0.103 in. displacement, still less than the minimum gap (0.129 in.). Added dampening does, however, generally occur, such that the 0.103 in. displacement is also a conservative estimate.

Rotational moments (see Table 3) also demonstrate greater movement predicted for the current S/N 105 instrument, than determined in Ref. 7. The calculated Y-Axis run θ_{DD-Z} 3σ angular acceleration (producing the so called "yes" moment about the Z-axis, causing reflector movement like a head nod) is 5301 rad/sec^2 at full acceptance level (or -3 dB of full qual. level). Ref. 7 calculated values were 3791 rad/sec^2 at -6 dB and 6178 rad/sec^2 at full qualification level. The extrapolated full qual. level θ_{DD-Z} 3σ angular acceleration, assuming no increase in dampening becomes 7421 rad/sec^2 per current instrument. Ref. 1 reached a level of 7065 rad/sec^2. Dampening increases will limit the current inst. full qual. level value to the Ref. 1 level.

The calculated Y-Axis run θ_{DD-X} 3σ angular acceleration (producing the so called "no moment about the X-Axis, causing reflector movement like shaking your head no) is 3232 rad/sec^2 at full acceptance level, projecting to 4571 rad/sec^2 at full qualification level. Ref. 7 -6 dB and full level calculated values were 2124 and 3656 rad/sec^2. Dampening increases should limit the current instrument full qual. level value somewhat, however, the projected full level qual. level will probably remain above 4000 rad/sec^2.

The Z-Axis run θ_{DD-Z} 3σ angular acceleration is 6486 rad/sec^2 at full qualification level, 4508 rad/sec^2 at -6 dB of qualification level. The Z-Axis θ_{DD-X} 3σ angular acceleration is 7915 rad/sec^2 at -6 dB of qualification level, but only 6442 rad/sec^2 at full qualification level. The reduction in θ_{DD-X} with stepping up from the -6 dB to full level is indicative of a stiffness change in the reflector.

The X-Axis -6dB and full random runs produced small θ_{DD-Z} and θ_{DD-X} 3σ angular accelerations (see Table 3). From Table 2, at full level, the θ_{DD-Z} 3σ angular acceleration from the X-Axis run is 2985 rad/sec^2, while, θ_{DD-X} is 1549 in-lb.

The calculated reflector angular accelerations at full level random for the Z-Axis run were a θ_{DD-Z} of 6486 rad/sec^2 and a θ_{DD-X} of 6442 rad/sec^2. This compares to Ref. 1 calculated θ_{DD-Z} of 7065 rad/sec^2 and θ_{DD-X} of 2739 rad/sec^2, and to Ref. 6 calculated θ_{DD-Y} of 6872 rad/sec^2 and θ_{DD-Z} of 2433 rad/sec^2 for the EOS X-Axis run.

Comparison of S/N 105 METSAT Qual. Reflector Rotations to the Ref. 1 Engineering Model, for the Z-Axis runs,

Y-Axis	S/N 105 METSAT -6 dB rad/sec^2	S/N 105 METSAT -0 dB rad/sec^2	Ref. 1 METSAT -6 dB rad/sec^2	Ref. 1 METSAT -0 dB rad/sec^2
$\theta_{DD\text{-}X}$	7915	6442	5229	7065
$\theta_{DD\text{-}Z}$	4508	6486	2469	2739
RSS	9109	9142	5782	7577

CONCLUSIONS and RECOMMENDATIONS

The Ref. 7 S/N 105 AMSU-A2 instrument qualification vibration tests were stopped in the 1st axis because of a discrepant motor (S/N F02). After refurbishing the S/N F02 motor, the S/N 105 instrument qualification vibration tests were resumed, with new problems found, in the reflector responses, in the Z-Axis tests. Subsequent investigation of the reflector response problems, led to the finding of a crack in the reflector at an aft cone to reflector rib bonded joint.

Although the investigation of the reflector did show the good possibility of a workmanship problem in the affected bond region (the reflector rib and aft cone slot in question was offset ¼ to ½ inch and the rib was off to one side of the slot, most probably improperly bonded to the aft cone), the problem was treated as a design flaw. The S/N 003 reflector repaired, and a series of doublers proposed as rework options to strengthen the local region. The rework option was proposed for all reflectors, not just the S/N 003 reflector with the actual cracking.

It is concluded that the rework option of strengthening all reflectors is the recommended course of action. Although the S/N003 reflector problems are magnified by the poor workmanship displayed in the problem region, there is no guarantee of no other 'suspect' workmanship in other reflectors. Therefore, the doublers would be recommended for all reflectors.

The parallel stress analysis, performed by the vendor, shows a vast improvement in the local repair region. However, other areas in the vendor analysis exhibit high stresses, and are not affected by the rework plan. The COI analysis is done with a model that has poor element definition at various locations. It predicts conservatively high stresses. The loading conditions (angular accelerations of 7279 and 8279 rad/sec^2 either individually or acting in tandem) are not the exact levels seen in the S/N 105 or other flight units. Therefore, although the repair and rework plan as presented by the reflector vendor is recommended, there is the possibility that more rework may be required.

R. J. Heffner

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Mechanical Design and Analysis

Table 1 Primary Reflector Gap Definitions and Initial & Final Measurements

Gap No.	Accelerometers and Axis of Measurement	Gap Locations	Initial Static Gap (in)	Post Y-Axis Gap (in)	Post Z-axis Gap (in)	Final Static Gap (in)
1	A2X to A6X	Warmload Enclosure to Reflector Secondary Shroud	.108/.135[1]	n/a	n/a	n/a
		1331215 Rear Panel Bore Dia. to Reflector Forward Cone Dia.	0.155[2]	n/a	n/a	n/a
2	A3Z to A7Z	1331218 Side Panel & 1331221 Shade Strip to Reflector Primary Shroud	0.130[3]	0.128[4]	0.123[5]	0.123[6]
3	A2Y to A7Y	1331215 Rear Panel to Reflector Shroud Plate Bond Line	0.135	0.138	0.138	0.138
4	A2Z to A7Z	1331215 Rear Panel Bore Dia. to Reflector Forward Cone Dia.	.158[2]	n/a	n/a	n/a
5	20Y to A9Y	1331214 Motor Panel to Reflector Shroud Plate Bond Line	0.132	0.129	0.129	0.129

n/a = not available

[1] Per assembly procedure

[2] Typical magnitude from other units.

[3] 1 in. from motor panel 0.130 in., 1 in. from compensator panel 0.133 in.

[4] 1 in. from motor panel 0.132 in., 1 in. from compensator panel 0.128 in.

[5] 1 in. from motor panel 0.135 in., 1 in. from compensator panel 0.123 in.

[6] 1 in. from motor panel 0.135 in., 1 in. from compensator panel 0.123 in.

Table 2 METSAT 4σ Gap Deflections for X, Y & Z Axes Qualification Level Random Vibration

Oct-98

Gap No.	X-Axis: Calc. 4σ Disp METSAT @ -6 dB (in)	X-Axis: Calc. 4σ Disp METSAT @ 0 dB (in)	Y-Axis*: Calc. 4σ Disp METSAT @ -6 dB (in)	Y-Axis*: Calc. 4σ Disp METSAT @ 0 dB (in)	Y-Axis*: Calc. 4σ Disp METSAT Accept. @ 0 dB (in)	Z - Axis: Calc. 4σ Disp METSAT @ -6 dB (in)	Z - Axis: Calc. 4σ Disp METSAT @ 0 dB (in)	Initial Static Gap (in)	Final Static Gap (in)	
1	0.0198	0.0388	0.0469	0.0792	0.0668	0.0572	0.0683	.135/.108	na	A2X-A6X
2	0.0084	0.0175	0.0163	0.0268	0.0185	0.0585	0.0488	.133/.130	.123/.135	A3Z-A7Z
3	0.0214	0.0144	0.0301	0.0509	0.0478	0.0462	0.0899	0.1350	0.1380	A2Y-A7Y
4	0.0094	0.0197	0.0197	0.0308	0.0210	0.0717	0.0607	na	na	A2Z-A7Z
5	0.0225	0.0449	0.0440	0.0730	0.0728	0.0459	0.0996	0.1320	0.1290	20Y-A9Y

METSAT Random Vibration Spectrum, Qual. Level, 8.8 Grms.
*Y-Axis at 5.9 Grms Acceptance Level, 3rd column.
Gap 2, measurements 1 in from compensator panel/1 in from motor panel

Table 3 3σ Rotational Accelerations of COI Reflector During AMSU A2 S/N 105 Random Vibration Tests (Oct 1998) METSAT

Distances to accelerometers from hub (inches)

d6	7.073
d8	7.198
d7	5.149
d9	2.189

Test	Level (dB)	Notch (dB)	RV Spec	RMS Acceleration on Reflector (over narrow band freq. range stated below)				3 Sigma Rotational Accelerations		
				g's	g's	g's	g's	(rad/sec^2)	(rad/sec^2)	(rad/sec^2)
				A6Y	A8Y	A7Z	A9Z	Theta-DD-Z	Theta-DD-X	RSS
X Axis, -6 dB	-6		METSAT	**10.83**	**9.83**	**3.65**	**.97**	**1676**	**728**	**1828**
X Axis, 0 dB	Full		METSAT	**19.04**	**17.75**	**7.44**	**2.37**	**2985**	**1549**	**3363**
Y Axis, -6 dB	-6		METSAT	**21.50**	**25.22**	**9.31**	**4.15**	**3791**	**2124**	**4345**
Y Axis 0 dB	Full		METSAT	**35.68**	**40.46**	**15.05**	**8.12**	**6178**	**3656**	**7179**
Y Axis, 0 dB Acceptance Level (5.9 Grms)	Full		METSAT	**28.86**	**36.47**	**11.73**	**8.75**	**5301**	**3232**	**6209**
Z Axis, -6 dB	-6		METSAT	**30.90**	**24.66**	**25.87**	**24.29**	**4508**	**7915**	**9109**
Z Axis, 0 dB	Full		METSAT	**45.12**	**34.82**	**16.11**	**24.71**	**6486**	**6442**	**9142**

1) *Axes* are test axes (METSAT)

2) Accel responses were integrated over a freq. band where the accel pairs (A6Y, A8Y) and (A7Z, A9Z) were shown to be 180 deg out of phase (based on low level sine sweep data)

a) For accelerometer pair (A7Z, A9Z) this was from 145 to 185 Hz. for Y-axis and Z-axis -6 dB

b) For accelerometer pair (A7Z, A9Z) this was from 120 to 145 Hz. for X-axis and Z-axis -0 dB

c) For accelerometer pair (A6Y, A8Y) this was from 90 to 210 Hz.

3) Unless otherwise stated, all accel responses were integrated over the above frequencies from the test analog tape data digitized using 5 Hz resolution.

4) Acceleration values that are bold are actual measured values. Others are projected, or estimated, based on those measured values.

5) All reflector rotational accel. values are calculated based on RMS acceleration values and distances to accels from the hub (d6, d8, d7, d9)

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INTEROFFICE MEMORANDUM

TO: L. Paliwoda

DATE: 10 March 1999
Amsua2sn105vib99#139.doc
170:8411#1999-#139

FROM: B.R. Morris and R.J. Heffner

SUBJECT: AMSU-A2 (S/N 105) Acceptance Level Vibration Tests

COPIES TO: J. Alvarez, D. Brest, D. Chi, D. Tran, Writer, file

REFERENCE: (a) Vibration and Sine Burst Qualification and Acceptance Test Procedure for the AMSU-A System, Process Specification AE-26151/1D, Dated 17 September 1998.

ENCLOSURE: Appendix A, AMSU-A2 S/N 105 Instrument Response Plots for Acceptance Level Vibration Test.

PURPOSE

To report the results of the acceptance level random and sine burst vibration tests performed on AMSU-A2, S/N 105 the 28-30 January 1999.

SUMMARY

The acceptance level vibration tests (random and sine burst) were successfully completed with no structural or functional failures. The response of the stiffened main reflector was similar to the serial number 106 unit which also had a modified reflector.

DISCUSSION

The AMSU-A2 unit, serial number 105, was subjected to the acceptance level vibration tests contained in the process specification AE-26151/1D(Reference a). The tests consist of the acceptance level random vibration (5.9 g_{RMS}) and the acceptance level sine burst (13.1 g). All tests were preceded by a low level sine sweep (0.25 g) and a final low level sine sweep at the conclusion of each test axis.

The Z axis test was preformed first, since the main reflector experiences its highest response in this axis. Appendix A contains response graphics for all three tests. The reflector accels A7 and A9 were the primary accelerometers monitored during the tests.

The first sine sweep for the Z axis test produced responses at accels A7 and A9 that are in good agreement with the results from AMSU-A2, s/n 106 (test date 19/12/98) which also had a stiffened main reflector. Table 1 shows the comparison of the responses at A7 and A9 accel. The Z axis response at accel A7 shows three frequencies (138.6, 144.7, and 162.2 Hz) with approximately the same magnitude of response as observed in the S/N 106 test. Accel A9 shows a peak response at 162.2 Hz. The random vibration test was performed next; the Z axis response at accels A7 and A9 were 52.6 and 32.4 g_{RMS}, respectively. These levels are comparable to the –6 dB test on the 106 unit. The following low level sine sweep showed some decease in the response frequencies at accels A7 and A9, with the greatest frequency shift occurring at A9 (162.2 Hz to 157.7 Hz). The sine burst test was next; the response at accels A7 and A9 are both symmetrical about the 0.0 g level in the graphics. A peak response of 15.7 g's was recorded at accel A7. The final sine sweep shows little change in the response at accel A7 and A9. At the conclusion of the test, the gap at motor support panel to reflector edge increase by 0.001 inches

The Y axis test was preformed next. The first sine sweep for the Y axis test produced responses at accels A7 and A9 that are in good agreement with the 106 unit. The y axis response at accel A7 showed three significant responses at 108.6, 133.7, and 154.3 Hz (for unit 106; 110.9, 139.0 and 154.0 Hz). The random vibration test was performed next; the Y-axis responses at accels A7 and A9 were 45.4 and 30.9 g_{RMS}, respectively. The second sine sweep resulted in response at accels A7 and A9 that closely matched the first sine sweep. The sine burst test was preformed next, the resulting peak responses at accels A7 and A9 in the Y axis were: 16.8 and 16.2 g's, respectively. The third sine sweep resulted in the same responses as observed in the previous sine sweep tests.

The X axis tests were preformed next. The x axis response for the low level sine sweep showed the reflector had peak responses at 132.7 and 159.9 Hz's (unit 106, 131.8 and 158.8 Hz). The random vibration test was preformed next; the y axis response at accel A7 showed a peak response at 550-600 Hz range (>100 g^2/Hz). In comparison, the 106 unit had a response at accel A7 in the y axis of approximately 25 g^2/Hz. This was a qualification test, which is +3 dB higher then acceptance level. The difference in amplitude is probably due to placement of the accel on the forward bulkhead and local displacement of the bulkhead (oil canning). The following low level sine sweep showed a 1 Hz decrease in the fundamental frequency at accel A7 for x axis response (132.7 vs. 131.8 Hz). The sine burst was performed next, the resulting peak responses at accels A7 and A9 in the x direction were: 12.87 and 12.92 g's, respectively. The final low level sine sweep showed no response changes in comparison with the previous sine sweep test. The total change in gap measured at the motor support panel to aft edge of reflector was 0.004 inches. This is significantly lower than previous gap changes measured in other test.

CONCLUSION
With no significant change in fundamental frequencies at the main reflector or primary support structure, the AMSU-A2 unit 105 is deemed structurally sound. All post tests' LPT's found no discrepancies in the instrument.

BR Morris
Applied Mechanics

R J Heffner
RJ Heffner
Applied Mechanics

Table 1
Z Axis Low Level Sine Sweep
Comparison of Main Reflector Response
AMSU-A2, Unit 105 and 106

RESPONSE	UNIT	105	UNIT	106
PEAK	Accel A7	Accel A9	Accel A7	Accel A9
	Freq/Ratio	Freq/Ratio	Freq/Ratio	Freq/Ratio
1st	138.6 / 65.8	137.6 / 8.5	139.6 / 62.1	139.6 / 7.9
2nd	144.7 / 105.7	162.2 / 68.2	144.7 / 93.1	163.4 / 54.2
3rd	162 / 84.9		162.2 / 60.3	

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