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SPECIAL REPORT

TITLE: INVESTIGATION OF SXT ST LOS/LLOS PARALLELISM PROBLEM

REFERENCE: ENCLOSED

SITE: NAA, DOWNEY

FILE NO: NAA-6-117

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INVESTIGATION OF SXT STLOS/LLOS PARALLELISM PROBLEM

Testing of PGNCS 204 at NAA indicated several problem areas in the Block II SXT. Trunnion Positional Accuracy Test (JDC 12214). An out-of-tolerance condition (FR 14530) of +18 arc sec., which exceeded that ±15 arc sec. limits, was observed in the STLOS/LLOS parallelism test. It was not possible to correlate data from this test with any previous tests to the required degree of accuracy.

An investigation was performed to determine the cause of the problem and how this problem could be alleviated. The three main objectives of this study were to determine:

1. The actual STLOS/LLOS parallelism error.
2. If the shift in data was due to PGNC System performance changes or was attributable to the GSE and/or test methods.
3. How the SXT STLOS/LLOS parallelism error could be accurately measured and correlated with other test data points.

Five independent methods were used to measure the parallelism error (Enclosure 1). The errors of the 5" autocollimator were measured for the STLOS and LLOS for both backlit and filar (when used as a telescope reticles.

A theodolite was introduced in the SXT STLOS and the Optics Hand Controller was manipulated so as to move the STLOS to various positions while the DSKY display was maintained at +00000 Trunnion angle and +27000 shaft angle. After each movement, a measurement was taken with the theodolite. It was discovered, after twelve observations, that a 14 arc sec. envelope (Enclosure 2) was available without a change in the DSKY trunnion display.

Each of the above measurements was corrected for instrument errors and/or trunnion positioning errors (where the recorded trunnion angle could be compared with the center of the envelope of uncertainty), and then compared. The results of this comparison indicated a parallelism error of 11.5 sec. ± 0.5 sec.

The trunnion position uncertainty was sufficient to encompass all previous measurements of SXT parallelism; therefore, precise comparison cannot be made with any previous tests.

Accurate comparison could not be made between OSS, Milwaukee G&N or NAA G&N tests of parallelism, but a check of the OSS and G&N 45° trunnion accuracy tests (Enclosure 3), after resurveying the Optical targets, indicated that there was no appreciable shift of data.

In the absence of any unexplained data shift and with the poor resolution (DSKY increment of approximately 10 arc sec./bit) available it was assumed that the problem stemmed from two sources:

a. Inadequate test methods.

bb. The practice of not electrically trimming the OUA to the PGNC System. It was found that in all Optical Unit Assemblies returned to NAA from KIC and Milwaukee, after retrofit and alignment on the PTF, that adjustment of the trim module (P/N 2012568) was required. An apparently consistent misalignment of approximately 13 arc. sec. has been observed after OUA marriage to the system. Several systems have been received at NAA with OSS ST LOS/L LOS parallelism measurements that were marginal (PGNCS 204 Ey PARALLELISM +9 sec. tolerance ± 10 sec.). With known uncertainties in the OSS, GSE (AP-M-11439) and the PTF alignments (AP-M-12964), it is obvious that problems can, and have occurred at later test stages.

Investigation revealed that the Variable Deviation Wedge method of determining the ST LOS/L LOS parallelism is completely inadequate and provides no reliable quantitative measurement of this parameter. Resolution of the parallelism and trunnion accuracy test problems can be accomplished with available GSE and minimal changes in the test procedures. A TDCR (NAA-AM-437) is submitted to provide an accurate, reliable test method to check the Sxt. ST LOS/L LOS parallelism at the G/N Level. TDCR NAA-AM-438 will be submitted to provide a data check point at the OSS test level, and an accurate point at which the resolver trim module may be set to position the ST LOS to the nominal. The only point, at which the correlation of the Sxt. ST LOS and the DSKY display are known with accuracy in Block II, is at zero optics; therefore, the parallelism should be measured at this point. The DKM-3X Theodolite, available at all sites, is a sufficiently accurate instrument to provide accuracy on the order of ± 0.5 seconds using the method suggested above.

Considering the data derived from this test, alignment of the resolver trim module at the OSS level with this degree of data confidence could alleviate all future problems in this area. Data correlation between AC Milwaukee tests and tests at NAA have revealed no history of ST LOS shifts on any previous system. Different test methods are used to measure this parameter in the lab and on the spacecraft, so measurements close to the tolerance limits could present problems during later tests.

Enclosures

1. Test Methods Employed and Results
2. Representation of Auto Collimator Error Test and Trunnion Positional Uncertainty
3. Correlation of OSS and G/N Trunnion Accuracy Test Results
4. TDCR NAA-AM-437
5. FR 14530

ENCLOSURE 1

TEST METHODS EMPLOYED AND RESULTS

StLOS/LLOS Parallelism Errors for PGNCS 204

	TEST METHOD	UNCERTAINTY	PARALLELISM ERROR UNCORRECTED	PARALLELISM ERROR CORRECTED
1.	JDC 12214 NAA G&N Test (corrected only for autocollimator error, no data on position of trunnion).	±14 sec	+18	+14.7
2.	Angle measured with theodolite from reference mirror to StLOS then LLOS while optics is positioned at A_s+27000, A_t+00000. Corrected to center of trunnion range with DSKY at +00000 (Enc. 2).	±2 sec	+14	+11.0
3.	Measurement of StLOS then LLOS with 5" Autocollimator used as telescope. Corrected for filar error (Enc. 2). With optics positioned at A_s+27000, A_t+00000. Corrected to center of trunnion range with DSKY at +00000.	±2 sec.	+9.8	+11.2
4.	With optics mode selector at zero optics. Cover LLOS and position G&N mounting fixture until StLOS image of the Target #1 star is superimposed on the SXT horizontal reticle line. Uncover LLOS and cover StLOS. Position the variable deviation wedge before Target #1 with the wedge measuring vertical angles. Adjust wedge to superimpose Target #1 star on SXT horizontal reticle line.	±1 sec	+12.0	+12.0
5.	With optics mode selector at zero optics place theodolite coincident with LLOS measure vertical angle with respect to altitude bubble. Repeat procedure with StLOS.	±0.2 sec	+11.2	+11.2
6.	Method 5. After placing optics mode selector to manual. An initial transient causes a displacement in trunnion angle but DSKY still displays +00000. Corrected to center of range.	±7 sec	+18.0	+11.2
7.	Method 1 corrected for centering to trunnion range after center of range was determined. Corrected for autocollimator error.	±2 sec	+17.0	+11.8

ENCLOSURE 1
PART TWO

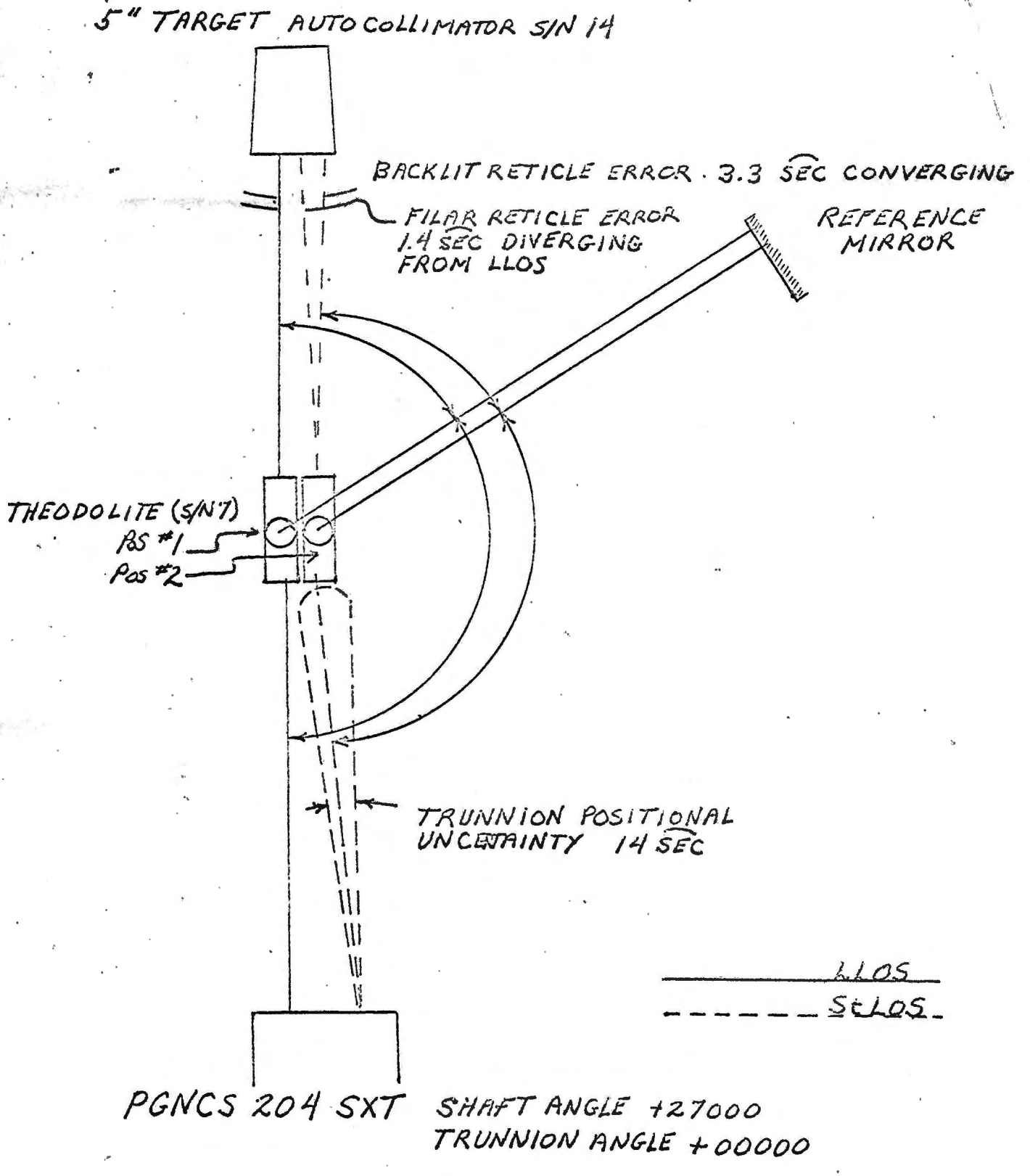
TEST METHODS EMPLOYED AND RESULTS

1. 5" Target #1 autocollimator StLOS to LLOS appertures (backlit reticle) 3.3 sec converging S/N 14.

2. 5" Target #1 autocollimator StLOS to LLOS appertures (filar reticle) 1.4 sec diverging.

3. Uncertainty of trunnion position at +00000 DSKY trunnion display 14 sec.

REPRESENTATION OF AUTOCOLLIMATOR ERROR TEST AND TRUNNION POSITIONAL UNCERTAINTY



ENCLOSURE 3

CORRELATION OF OSS AND G&N TRUNNION ACCURACY TEST RESULTS

	1) AC/MIL OSS TEST		2) AC/MIL SYSTEM TEST		3) NAA SYSTEM TEST	
	BITS	ERROR	BITS	ERROR	BITS	ERROR
45° - 90"	16375	0	16374	-1	16373	-2
45° - 60"	16376	-2	16377	-1	16376	-2
45° - 30"	16380	-1	16380	-1	16379	-2
45° 0"	16383	0, -1	16383	-1	16382	-2
45° + 30"	16385	-2	16386	-1	16386	-1
45° + 60"	16389	-1	16389	-1	16388	-2
45° + 90"	16392	-1	16392	-1	16391	-2

1. The OSS test indicates that the trunnion measured 44° 59' 50" ± 5 sec at 45° (at 10 sec/bit). Discounting resolver functional errors this would show a parallelism error of +10 sec ± 5 sec.

2. The system test run at Milwaukee indicates the same +10 sec ± 5 sec parallelism error found in the OSS test.

3. The NAA system test showed the possibility of a data shift os the target angles were reverified with the theodolite procedure. The angle Ø 3 had shifted from 44° 59' 57.0" to 44° 59' 50.4". This would change the 45° test angle to 44° 59' 53.4". With the trunnion DSKY display of 44° 59' 40" ± 5 sec this shows a parallelism error of +13.4 sec ± 5 sec.

4. Since all three estimates of the parallelism error are within 5 sec of the actual parallelism error of +11.2 it is doubtful that a shift of any magnitude occurred in the system performance between AC Milwaukee and NAA.

APOLLO GUIDANCE AND NAVIGATION
FIELD OPERATIONS
TECHNICAL DATA CHANGE REQUEST (TDCR)

FIELD SITE: NAA
SEQ. NO: AM-437
SHEET 1 OF 4

TITLE OF DOCUMENT: JDC Volumes | ND NO: — | VOL NO: —
CHAPTER OR JDC NO: JDC 12214 | PAGE NO: See Below | PARAGRAPH OR STEP NO: See Below | DOCUMENT OR JDC REVISION LETTER: —

CHANGE REQUESTED:

1. Delete steps 5 through 12.
2. Add:

5. Place theodolite in a line coincident with the Sxt. L LOS and cover the ST LOS.
6. Level theodolite base to the plate spirit level and level the altitude spirit level. Adjust the telescope focus to infinity. Set telescope to approximately 90°. Install the portable light assembly and adapter in the Sxt. Eyepiece Assembly. While observing the theodolite image, adjust the G&N Mounting fixture until the Sxt. air reticle is superimposed on the theodolite horizontal filar.
7. Align the theodolite holizontal filar to the Sxt. air reticle and record the vertical angle.
8. Reverse and plunge the theodolite telescope and repeat step 7.

DETAILED REASON FOR CHANGE:

See Special Report #NAA-6-117 (attached).

TO BE COMPLETED AT FIELD SITE

CHANGE REQUESTED AFFECTS SYSTEM PERFORMANCE — YES ☐ NO ☒
EXISTING CONDITION PRESENTS HAZARD TO PERSONNEL — YES ☐ NO ☒
EXISTING CONDITION CONTRIBUTES TO POSSIBLE EQUIPMENT DAMAGE — YES ☐ NO ☒

204

PREPARED BY: P. Tanner — 8-10-66 (DATE)

DISPOSITION REQUIRED BY: 8-20-66 (DATE)

FIELD SITE APPROVAL:
CHANGE APPROVED FOR LOCAL USE WITH THE FOLLOWING EXCEPTIONS:

TESTING MAY CONTINUE ON SYSTEM NUMBERS 204 ONLY. Engineering Inspection CSM 204/Lunar Lab, in order to ignore

A. P. Kucia — 8/15/66 (DATE) — FIELD SITE MANAGER

R. Glenn — 8/15/66 (DATE) — MIT/IL TEST OPERATIONS DIRECTOR

TO BE COMPLETED AT HOME FACILITY

REVIEW BOARD DISPOSITION:

- ☐ APPROVED AS REQUESTED
- ☐ APPROVED WITH MODIFICATION (SEE REMARKS)
- ☐ UNDER INVESTIGATION (SEE REMARKS)
- ☐ DENIED (SEE REMARKS)
- ☐ PREVIOUSLY SUBMITTED (SEE REMARKS)
- ☐ OTHER DOCUMENTS AFFECTED (SEE REMARKS)

APPROVED BY:

REVIEW BOARD CHAIRMAN — DATE

MIT/IL (ACSP RESIDENT) — DATE

NASA (ACSP RESIDENT) — DATE

CHANGE TYPE:

- ☐ CLASS I
- ☐ CLASS II

REMARKS:

FSP 136A-1

APOLLO GUIDANCE AND NAVIGATION
FIELD OPERATIONS
TECHNICAL DATA CHANGE REQUEST (TDCR)

FIELD SITE:	NAA
SEQ. NO:	AM-437
SHEET	2 OF 4

CONTINUATION SHEET

CHANGE REQUESTED ~~OR DETAILED REASON FOR CHANGE~~:

2. (Cont.)

9. Repeat steps 7 and 8 for seven additional pairs of readings. After completing step 8, each time drive the theodolite elevation off prior to realigning to the Sxt. reticle.
10. Place the theodolite in a line coincident with the Sxt. ST LOS and cover the L LOS.
11. Repeat step 6.
12. Repeat steps 7, 8 and 9.
13. Complete calculations for Sxt. ST LOS to L LOS parallelism error.
14. Place the variable deviation wedge (VDW) in front of target number 1 and set VDW dial to zero. Sight through the Sxt. L LOS and adjust the G&N Mounting Fixture until the horizontal reticle line of the Sxt. is coincident with the dot and horizontal reticle line of target number 1.
15. Set OPTICS MODE switch on the Indicator Control Panel to MAN. Displace the Optics Controller to the left and up. Drive the Sxt. until row 1 of the DSKY indicates +27000 and row 2 indicates approximately +30000. Set the controller speed to lo and manipulate the Optics Hand Controller to fine position and hold the Sxt. so that row 1 indicates +27000.
16. Sight through the Sxt. L LOS and move the VDW laterally until the target #1 reticle is seen clearly. Adjust the VDW dial until the central vertical reticle line is coincident with the star and vertical reticle line of the target. Repeat this procedure two additional times and record the average VDW dial reading on line (c).

3. Change item 13 to item 17 and all subsequent item numbers in sequential order.

4. Add to Data Sheet, after item 4:

JDC Item No.			
7, 8	Δ_1 - 90° 00' 00.0"	Δ_2 - 270° 00' 00.0"	Δ_3 - 270° 00' 00.0"
	Δ_4 - 90° 00' 00.0"	Δ_5 - 90° 00' 00.0"	Δ_6 - 270° 00' 00.0"
	Δ_7 - 270° 00' 00.0"	Δ_8 - 90° 00' 00.0"	Δ_9 - 90° 00' 00.0"
	Δ_{10} - 270° 00' 00.0"	Δ_{11} - 270° 00' 00.0"	Δ_{12} - 90° 00' 00.0"
	Δ_{13} - 90° 00' 00.0"	Δ_{14} - 270° 00' 00.0"	Δ_{15} - 270° 00' 00.0"

APOLLO GUIDANCE AND NAVIGATION
FIELD OPERATIONS
TECHNICAL DATA CHANGE REQUEST (TDCR)

FIELD SITE: NAA
SEQ. NO: AM-437
SHEET 3 OF 4

CONTINUATION SHEET

CHANGE REQUESTED ~~OR DETAILED REASON FOR CHANGE~~:

4. (Cont) Add to Data Sheet, after item 4:

JDC Item No.	
7, 8	16 - 90° 00' 00.0" $\frac{\sum \Delta}{16}$ = _____
11, 12	Δ_1 - 90° 00' 00.0" Δ_2 - 270° 00' 00.0" Δ_3 - 270° 00' 00.0" Δ_4 - 90° 00' 00.0" Δ_5 - 90° 00' 00.0" Δ_6 - 270° 00' 00.0" Δ_7 - 270° 00' 00.0" Δ_8 - 90° 00' 00.0" Δ_9 - 90° 00' 00.0" Δ_{10} - 270° 00' 00.0" Δ_{11} - 270° 00' 00.0" Δ_{12} - 90° 00' 00.0" Δ_{13} - 90° 00' 00.0" Δ_{14} - 270° 00' 00.0" Δ_{15} - 270° 00' 00.0" Δ_{16} - 90° 00' 00.0" $\frac{\quad}{16}$ = _____
13	$\frac{\sum \Delta (11, 12)}{\sum \Delta (7, 8)}$ = - _____ ST LOS/L LOS Parallelism Tolerance: -10 minimum, +10 maximum

FSP 136A-2

APOLLO GUIDANCE AND NAVIGATION
FIELD OPERATIONS
TECHNICAL DATA CHANGE REQUEST (TDCR)

FIELD SITE: IIAA
SEQ. NO: AM-437
SHEET 4 OF 4

CONTINUATION SHEET

CHANGE REQUESTED ~~OR DETAILED REASON FOR CHANGE~~:

5. Change Data Sheet item 7 to item 16 and change remaining items to agree with JDC item numbers.

FSP 136A-2

	NAME	SERIAL NO.	22. DATE OF FAILURE	24. LOCATION	26. REPORT
END ITEM	1. APOLLO	2. 204	8-4-66	NAA	NO 14530
SYSTEM	3.	4.	23. LOG LINE ITEM REF. IMEOR PAGE 4, LINE 2	25. REPORTED BY R. NICKCHA	27. DEPT. NO. 32-31
COMP.	5. OPTICS	6. 15	PART NUMBER / REV. / MANUFACTURER		28. STATION TSM 2 REF. DESIG.
ASSEMBLY	10.	11.	12.	13.	14. 15.
PART	16.	17.	18.	19.	20. 21.

A END ITEM B SYSTEM C COMP. D ASSEMBLY E PART CODES FOR COMPLETION OF ITEMS 29, 30 & 31.

29. DISCREPANCY DISCOVERED DURING: [ ] FUNCTIONAL TEST [A] ACCEPTANCE TEST [ ] ENVIRONMENTAL [ ] OTHER

30. IMMEDIATE ACTION TAKEN: [ ] REPAIRED [ ] REPLACED [ ] ADJUSTED [A] CONTINUE OTHER TESTING

31. [ ] TIME 625.8 OR [ ] CYCLES

DISCREPANCY

32. DURING JDC 12214, STEP 8, THE ST LOS-L LOS PARALLELISM VALUE OBTAINED WAS -18. TOLERANCE IS -15 TO +45 SECONDS. THREE ADDITIONAL REPEATS PROVIDED SIMILAR INFO, NAMELY, +19, +18 AND +17 SECONDS RESPECTIVELY.

PROBABLE CAUSE

33.

NO 14530

RECOMMENDED CORRECTIVE ACTION

34.

REPAIR & DISPOSITION

35.

ITEMS REPLACED DURING REPAIR

36. ITEM NAME	37. PART NUMBER	38. REV.	39. MANUFACTURER	40. REF. DES. C.	41. TYPE OF FAILURE (IF KNOWN)	42. ANALYS. R

REWORK ACTION

43.

44.

45. DATE RECEIVED | 46. DATE REPAIRED

47. DEPT. NO. | 48. LOCATION

49. REPAIRED BY

50. QUALITY CONTROL SIGNATURE

51. ENGINEERING SIGNATURE

52. RELIABILITY SIGNATURE