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Functional Specification and Test Report

THE ATLAS ROMAN POTS INTERLOCK LOGIC IN 2022: TEST RESULTS

Abstract

This document summarizes the commissioning tests performed on the ATLAS-AFP and ATLAS-ALFA interlock system in October 2021 and April 2022. After the October's validation, AFP was ready to take part (be inserted) during the pilot beam (Oct. 2021) while ALFA stayed in the garage. A full set of tests was done again in April to qualify ALFA and AFP movement system to be ready for LHC Run 3 data-taking.

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History of Changes

<i>Version</i>	<i>Date</i>	<i>Comments or Description of Changes</i>
0.1	13-11-2021	First version containing October tests prepared by M. Trzebinski
0.2	09-04-2022	Merged AFP and ALFA reports
1.0	11-04-2022	April tests added by M. Trzebinski

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1. INTRODUCTION

ATLAS-AFP interlock logic is based on ATLAS-ALFA (see [1], [2] and [3]). During LS2 the logic was not changed, thus its validation remained the same as during Run 2 (see [4], [5] and [6]). AFP movement system is kept the same as during Run 2. Due to update to newer LabView version, minor changes were done to PXI software (S. Ravat). Motors and switches were tested during survey in September 2021. Station was tested to retract via springs ("emergency retraction") to HOME position in a full range between "just outside HOME switch" to ~1 mm from the beam center. Mechanical switches and electrical stoppers were tested as well.

In this report the following naming condition will be used:

- A FAR: 12-217-F-H, XRPB.B6L1.B2,
- A NEAR: 12-205-N-H, XRPB.A6L1.B2,
- C NEAR: 12-205-N-H, XRPB.A6R1.B1,
- C FAR: 12-217-F-H, XRPB.B6R1.B1.

ATLAS-ALFA movement system was not changed during LS2. Due to update to newer LabView version, minor changes were done to PXI software (S. Ravat). Motors and switches were tested during the survey in November 2021. Stations were tested to retract via springs ("emergency retraction") to HOME position in a full range between "just outside HOME switch" to ~1 mm from the beam center. Mechanical switches and electrical stoppers were tested as well.

In this report the following naming condition will be used:

- RP1: XRPV.B7L1.B2 LU
- RP2: XRPV.B7L1.B2 RU
- RP3: XRPV.A7L1.B2 LU
- RP4: XRPV.A7L1.B2 RU
- RP5: XRPV.A7R1.B1 LU
- RP6: XRPV.A7R1.B1 RU
- RP7: XRPV.B7R1.B1 LU
- RP8: XRPV.B7R1.B1 RU

Interlock system was validated based on set of tests described in details in [5].

2. TEST OF THE INJECTION PERMIT

It was checked that any single Roman Pot not within the ON-range of the HOME switch withholds the RP INJECTION_PERMIT for its respective beam (B1 or B2). Test is described in details in Ref. [5] section 2.

For AFP tests were done on 06/10/2021 and 23/03/2022. Usually, at a given day, test was repeated 2 times for a given station:

- A FAR: 12:03 and 13:18 (06/10/2021), 10:36 and 10:38 (23/03/2022),
- A NEAR: 11:35 and 11:42 (06/10/2021), 10:33 and 10:35 (23/03/2022),
- C NEAR: 13:48, 13:59 and 14:09 (06/10/2021), 10:28 and 10:30 (23/03/2022),
- C FAR: 14:01 and 14:03 (06/10/2021), 10:26 and 10:27 (23/03/2022).

Tests for ALFA were done 11/10/2021 (first timestamp) and 25/03/2022 (2nd and 3rd timestamp):

- RP1 at 18:34, 15:08, 15:10,
- RP2 at 18:35, 15:09, 15:11,
- RP3 at 18:31, 15:05, 15:06,
- RP4 at 18:32, 15:05, 15:07,
- RP5 at 18:15, 15:01, 15:03,
- RP6 at 18:29, 15:02, 15:03,
- RP7 at 18:08, 14:51, 14:58,
- RP8 at 18:09, 14:58, 14:59.

For each pot it was checked that ATLAS INJECTION_PERMIT is lost when pot is moved outside HOME position and restored once HOME is reached.

Loss and restoration of user permit was also randomly checked during other tests described in this document. **No failure was observed.**

3. TEST OF THE RESPONSE TO THE LVDT-TO-LIMITS COMPARISON

In this test the proper reaction of pot (retraction in case of validation of warning and/or dump limit) and change of USER_PERMIT (going false in case of violation of dump limit, staying true otherwise) was tested. Following Ref. [5] section 3, test was composed of 2 parts:

- a) test of inner dump limit,
- b) test of inner warning limit.

For AFP Test was done on 07/10/2021, 12/10/2021 and 08/04/2022. For last test the proper behavior was confirmed for a one randomly selected station at a given beam. Results are summarized in Table 1, 2 and 3 for each test, respectively.

Table 1. Result of AFP LVDT-to-limits comparison test done on 07/10/2021. Each time warning and/or dump limit is violated pot should be extracted to HOME position. USER_PERMIT loss (resulting in a beam dump) should only be observed in case of dump limit violation.

	part a)			part b)		
	time	extraction to HOME	permit lost/restored	time	extraction to HOME	permit lost
A FAR	18:40	yes	yes/yes	18:43	yes	no
A NEAR	18:35	yes	yes/yes	18:38	yes	no
C NEAR	17:42	yes	yes/yes	18:21	yes	no
C FAR	18:27	yes	yes/yes	18:31	yes	no

Table 2. Result of AFP LVDT-to-limits comparison test done on 12/10/2021.

	part a)			part b)		
	time	extraction to HOME	permit lost/restored	time	extraction to HOME	permit lost
A FAR	17:39	yes	yes/yes	17:42	yes	no
A NEAR	17:32	yes	yes/yes	17:35	yes	no
C NEAR	17:25	yes	yes/yes	17:29	yes	no
C FAR	16:36	yes	yes/yes	17:21	yes	no

Table 3. Result of AFP LVDT-to-limits comparison test done on 08/04/2022.

	part a)			part b)		
	time	extraction to HOME	permit lost/restored	time	extraction to HOME	permit lost
A NEAR	11:20	yes	yes/yes	11:27	yes	no
C FAR	9:57	yes	yes/yes	10:00	yes	no

For ALFA the test was done on 08/04/2022 for one randomly selected station at a given beam. Results are summarized in Table 4.

Table 4. Result of ALFA LVDT-to-limits comparison test done on 08/04/2022.

	part a)			part b)		
	time	extraction to HOME	permit lost/restored	time	extraction to HOME	permit lost
RP 3&4	11:20	yes	yes/yes	11:27	yes	no
RP 7&8	10:04	yes	yes/yes	10:07	yes	no

Observation of USER_PERMIT changing from true to false (and vice versa) was done using BIS history file. For each pot it was checked that USER_PERMIT on the other beam is not affected. It was also checked that each time pot is extracted to HOME position and after reaching it the USER_PERMIT is restored. Similarly to previous tests (cf. Ref. [4-6]), effect of "ringing" was observed.

No unexpected behavior was observed.

4. TEST OF USER_PERMIT AND AUTOMATIC POT EXTRACTION AS A FUNCTION OF ALL INPUT FLAGS

Correct behavior of pots (extraction, loss/no loss of USER_PERMIT) was also tested as a function of various beam modes and state of override key. The test is based on the one described in Ref. [5] section 4, with exception of UNSTABLE_BEAMS mode (state deprecated for Run 3). During tests performed in October, steps with UNSTABLE_BEAMS were omitted. For the ones performed in April the UNSTABLE_BEAMS were changed to DUMP.

Since it is enough to test one station per side for beam 1 it was C FAR and for beam 2 – A NEAR (random selection). Similarly to the previous test, BIS history file was used due to rapid pot extraction and behavior of USER_PERMIT for other beam was checked to be not affected. Test done on 12/10/2021 is summarized in Table 5 and one from 08/04/2022 in Table 6.

Since ALFA stayed in garage for pilot beams, the test was performed only in April (08/04/2022). RP 5&6 were used for beam 1 whereas 1&2 for beam 2. Because test was done simultaneously timestamps summarized in Table 6 are the same (with 1 minute precision) for ALFA.

No unexpected behavior was observed.

Table 5. Result of "USER_PERMIT and automatic pot extraction as a function of input flags" test performed 12/10/2021 for AFP. For the description of state see Ref. [5] Table 3.

state transition	beam mode	override	pot position	action on limits	USER_PERMIT	time beam 1	time beam 2
2	STABLE_BEAMS	no	HOME	open limits: inner warning 22 mm, inner dump 21 mm	true		
-- --			motor reset		true	10:03	11:01
2 to 8			move pot to 30 mm		true	10:05	11:02
8 to 20				illegal limits: inner warning 32 mm, inner dump 31 mm	false	10:36	11:05
20 to 2			automatic extraction		true		
2			motor reset	open limits: inner warning 22 mm, inner dump 21 mm	true	10:39	11:06
2 to 8			move pot to 30 mm		true	10:41	11:08
8 to 12	ADJUST				false	10:43	11:09
12 to 6			automatic extraction		true		
6 to 2	STABLE_BEAMS				true	10:44	11:10
2 to 1		yes			true	10:47	11:11
1			motor reset		true	10:47	11:12
1 to 7			move pot to 30 mm		true	10:49	11:14
7 to 19				illegal limits: inner warning 32 mm, inner dump 31 mm	false	10:50	11:15
19 to 1			automatic extraction		true		
1			motor reset	open limits: inner warning 22 mm, inner dump 21 mm	true	10:52	11:17
1 to 7			move pot to 30 mm		true	10:55	11:20
7 to 11	ADJUST				true	10:56	11:21
11 to 12		no			false	10:57	11:23
12 to 6			automatic extraction		true		

Table 6. Result of "USER_PERMIT and automatic pot extraction as a function of input flags" test performed 08/04/2022 simultaneously for AFP and ALFA.

state transition	beam mode	override	pot position	action on limits	USER_PERMIT	time beam 1	time beam 2
2	STABLE_BEAMS	0	HOME	open limits (e.g. inner warning = 5 mm, inner dump = 4 mm)	true	12:56	11:28
2 to 1		0 to 1			true	12:57	11:30
1		1	motor reset		true	12:57	12:11
1 to 7		1	move pot outside HOME		true	12:59	12:11
7 to 9	DUMP	1			true	13:01	12:13
9 to 21		1		illegal limits (e.g. inner warning = 37 mm, inner dump = 36 mm)	false	13:02	12:20
21 to 3		1	automatic extraction		true	13:03	10:20
3		1	motor reset	open limits	true	13:03	12:22
3 to 1	STABLE_BEAMS	1			true	13:04	12:22
1 to 7		1	move pot outside HOME		true	10:32	12:23
7 to 19		1		illegal limits	false	10:34	12:23
19 to 1		1	automatic extraction		true	10:34	12:25
1		1	motor reset	open limits	true	10:35	12:27
1 to 7		1	move pot outside HOME		true	10:37	12:28
7 to 11	ADJUST	1			true	10:37	12:30
11 to 12		1 to 0			false	10:39	12:33
12 to 6		0	automatic extraction		true	10:39	12:36
6 to 2	STABLE_BEAMS	0	motor reset		true	10:40	12:38
2 to 8		0	move pot outside HOME		true	10:43	12:40
8 to 10	DUMP	0			true	10:44	12:40
10 to 4		0	automatic extraction		true	10:44	12:40
4 to 2	STABLE_BEAMS	0	motor reset		true	10:45	12:42
2 to 8		0	move pot outside HOME		true	10:46	12:44
8 to 20		0		illegal limits	false	10:47	12:45
20 to 2		0	automatic extraction		true	10:49	12:45
2		0	motor reset	open limits	true	10:50	12:47
2 to 8		0	move pot outside HOME		true	10:51	12:48
8 to 12	ADJUST	0			false	10:56	12:49
12 to 6		0	automatic extraction		true	10:56	12:49

5. TEST OF THE LVDT BYPASS BOX

As described in Ref. [5] section 5, 4 tests for AFP were performed 07/10/2021 (1st timestamp) and 23/03/2022 (2nd timestamp):

- 1) *failure during the AFP run* at 11:21 and 10:44,
- 2) *the forbidden use case* at 11:42 and 10:48,
- 3) *the holiday mode* at 11:47 and 10:54,
- 4) *failure when AFP is in STANDBY* at 11:51 and 10:57.

Tests for ALFA were performed 11/10/2021 (1st timestamp) and 08/04/2022 (2nd timestamp):

- 1) *failure during the ALFA run* at 18:59 and 8:19,
- 2) *the forbidden use case* at 19:02 and 8:28,
- 3) *the holiday mode* at 19:04 and 8:32,
- 4) *failure when ALFA is in STANDBY* at 19:07 and 8:45.

In all cases system reacted as expected. **No failure was observed.**

6. TEST OF HARDWARE AND SOFTWARE BUTTONS

This part contains two tests (see Ref. [5] section 6 for details):

a) *extraction by DCS* tested:

- for AFP on 07/10/2021 (1st timestamp) and 23/03/2022 (2nd timestamp):
 - A FAR at 10:59 and 11:06,
 - A NEAR at 10:57 and 11:04,
 - C NEAR at 10:55 and 11:02,
 - C FAR at 10:52 and 11:03.
- for ALFA on 11/10/2021 (1st timestamp) and 08/04/2022 (2nd timestamp):
 - RP1 & RP2 at 18:52 and 13:11,
 - RP3 & RP4 at 18:53 and 13:12,
 - RP5 & RP6 at 18:54 and 13:12,
 - RP7 & RP8 at 18:54 and 13:13.

b) *emergency extraction by hardware button* tested:

- for AFP on 07/10/2021 at 12:28 and 23/03/2022 at 11:10,
- for ALFA on 11/10/2021 at 18:38 and 08/04/2022 at 13:16.

In all cases system reacted as expected. **No failure was observed.**

7. CONCLUSION

For all tested situations and input combinations, behavior of the ATLAS-AFP and ATLAS-ALFA interlocks was as expected. Therefore, both AFP and ALFA are ready to take part (be inserted) during the LHC Run 3 data taking. These tests are valid as long as there are no hardware nor software changes in the movement systems.

REFERENCES

- [1] Functional Specification and Test Report THE ATLAS-ALFA INTERLOCK LOGIC IN 2012: SPECIFICATION AND TEST RESULTS, EDMS 1205861 v.1, ATLAS Project Document Number ATL-UR-ER-0002 14 June 2012.
- [2] The Movement Control of the TOTEM and ALFA Roman Pots – Revision 2012, EDMS 1203969.
- [3] Functional Specification and Test Report THE ATLAS-ALFA INTERLOCK LOGIC IN 2016: SPECIFICATION AND TEST RESULTS, EDMS 1607453.
- [4] Specification and Validation of the Motion Control System of the ATLAS Forward Proton Roman Pots, EDMS 1608103.
- [5] Functional Specification and Test Report THE ATLAS-AFP INTERLOCK LOGIC IN 2017: SPECIFICATION AND TEST RESULTS, EDMS 1808750.
- [6] ATLAS-AFP Interlock Logic in 2018: Additional Test Results after TS1-2018, EDMS 1996432.