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72/Systems 24/205-2

ARROW 2 ESCAPE SYSTEM  
DEVELOPMENT PROGRAM  
ISSUE 2

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AVRO AIRCRAFT LIMITED

MALTON - ONTARIO

TECHNICAL DEPARTMENT (Aircraft)

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REPORT NO. 72/Systems 24/205-2

SHEET NO. Index

AIRCRAFT: Arrow 2

Title: ARROW 2 ESCAPE  
SYSTEM DEVELOPMENT  
PROGRAM - ISSUE 2

PREPARED BY

DATE

M. Davis

Jan. 1959

CHECKED BY

DATE

TABLE OF CONTENTS

	<u>PAGE</u>
1. Introduction	1
2. Work to be done by Martin-Baker	1
3. Work to be done by Avro	1
4. Test Program	2
4.3 System Ground Tests	2
4.4 Qualification Tests	3
5. Tests on other systems <u>not</u> to be conducted by Avro	4
6. Presentation of Results	4
7. Conclusion	5



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TECHNICAL DEPARTMENT

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REPORT NO. 72/Systems 24/205-2

SHEET NO. 1

AIRCRAFT: Arrow 2	Title: ARROW 2 ESCAPE SYSTEM DEVELOPMENT PROGRAM - ISSUE 2	PREPARED BY	DATE
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1. Introduction

- 1.1 This report presents the revised program for the development of the Arrow 2 Escape System with reference to the new Statement of Work, AD 53-Issue 2.
- 1.2 It is intended to use the Arrow 1 Escape System as a basis and develop a linked system for the Arrow 2.
- 1.3 Avro have prepared the requirements for such a system and Avrocan Specification E-714 has been sent to the Martin-Baker Aircraft Co. for quotation.
- 1.4 The responsibility for developing this system will be given to the Martin-Baker Aircraft Co. (Preliminary technical discussions were held between Avro and Martin-Baker in August 1958).

2. Work to be done by Martin-Baker

- 2.1 Avro is negotiating with Martin-Baker to modify the MK C-5 Ejection seats to make them suitable for use with a linked system.
- 2.2 Martin-Baker will perform all the development tests on the seats for the linked system.
- 2.3 Martin-Baker do not intend to develop the high speed performance of the MK C-5 seat; but rather to develop the MK A-5 seat and to incorporate these improvements in the MK C-5 seat.

3. Work to be done by Avro

- 3.1 Avro will provide technical assistance and liaison with Martin-Baker as required to ensure a vigorous and effective program. Avro has sent a wooden mockup of that part of the front fuselage containing the two cockpits to Martin-Baker, to aid them in their design work.
- 3.2 Avro will send representatives to witness and obtain the data from rocket-sled and tower tests conducted in the USA and the UK, on similar Martin-Baker seats as part of their liaison function.



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TECHNICAL DEPARTMENT

CONFIDENTIAL  
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REPORT NO. 72/Systems 24/205-2

SHEET NO. 2

AIRCRAFT:	Title: ARROW 2 ESCAPE SYSTEM DEVELOPMENT PROGRAM - ISSUE 2	PREPARED BY	DATE
		CHECKED BY	DATE

3.3 Avro will keep in touch with other Escape Systems Development Programs now being conducted, to ensure that this program is abreast of the best state of the art and engineering.

4. Test Program

4.1 Avro will not conduct dynamic test or demonstration programs to evaluate the capabilities of this system; but will rely on tests made by Martin-Baker. Also data will be obtained on tests conducted by agencies on seats of a similar basic configuration, though they may not necessarily be suitable for use in a linked system.

4.2 Avro will do Systems Ground Tests and Qualification Tests to approve the installation and sound mechanical design of the linked system.

4.3 System Ground Tests

4.3.1 A seat will be placed in an aircraft cockpit, the gun will be replaced by a tube. With a 95th percentile man in the seat, it will be drawn slowly up the tube. The operation of the head, shoulder, arm and leg restraints will be checked and with all these restraints fully operative, a check will be made that the crewman is able to operate the firing control and the restraint manual release. The operation of Composite Leads Disconnect, the Distress Signal Device and any other relevant mechanism, sequence and clearances shall be checked.

4.3.2 The tests of paragraph 4.3.1 will be repeated with a 5th percentile man and conducted in both the Pilot's and Observer's cockpit.

4.3.3 With the canopy cartridges and the primary seat cartridges not installed, the ejection sequence will be initiated. The forces required to remove the sears from the firing mechanisms and the operation of the pilot's gas generator time delay will be checked. The times of the various phases in the sequence will be recorded and examined.



AVRO AIRCRAFT LIMITED  
MALTON - ONTARIO

TECHNICAL DEPARTMENT

REPORT NO. 72/Systems 24/205-2  
SHEET NO. 3

AIRCRAFT:	Title: ARROW 2 ESCAPE SYSTEM DEVELOPMENT PROGRAM - ISSUE 2	PREPARED BY	DATE
		CHECKED BY	DATE

4.4 Qualification Tests

- 4.4.1 Adequate rig testing of the canopy emergency actuation system has already been carried out, referenced: Canopy Functioning Tests Avro, A.T.R. No. 2472/1 etc. A series of tests however, will be carried out to check the performance of the delay for the Pilot's Gas Generator, over the temperature range -65°F to 200°F.
- 4.4.2 The seat shall be examined and given an operational check. This will consist of: running the seat up and down the rails; actuating and measuring the time delay; actuating and timing the drogue gun delay mechanism; checking the seat pan vertical adjustment mechanism; and operating the manual release.
- 4.4.3 The seat shall be soaked at 200°F for 8 hours and then tested as in paragraph 4.4.2.
- 4.4.4 The seat shall be soaked at -65°F for 8 hours then brought to -30°F and test as in paragraph 4.4.2.
- 4.4.5 The seat shall be given a vibration test according to Avrocan Specification E266 and then tested as in paragraph 4.4.2.
- 4.4.6 The seat shall be given a "Sand and Dust" test as in E-266 and tested as in paragraph 4.4.2.
- 4.4.7 The seat shall be given a "Salt Spray" test as in E-266 and tested as in paragraph 4.4.2.
- 4.4.8 The seat shall be given a "Fungus Test" as in E-266 and then tested as in paragraph 4.4.2.
- 4.4.9 Evidence on the structural capabilities of the seat will be requested from Martin-Baker. If this is not available, the test in paragraph 4.4.10 will be conducted by Avro.



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TECHNICAL DEPARTMENT

REPORT NO. 72/Systems 24/205-2

SHEET NO. 4

PREPARED BY

DATE

AIRCRAFT:

Title: ARROW 2 ESCAPE  
SYSTEM DEVELOPMENT  
PROGRAM - ISSUE 2

CHECKED BY

DATE

4.4.10 The seat shall be placed in a rig and shall withstand, without permanent set the loads derived from paragraph 5.5.6.1 of Avrocan Specification E-714 using a 95th percentile man, and without structural failure, the ultimate loads similarly derived from paragraph 5.5.6.2 of E-714. The seat shall then be tested to destruction.

5. Tests on other system not to be conducted by Avro

5.1 In the original program presented in 72/Systems 24/205 Issue 1, Avro intended to conduct a series of dynamic tests to evaluate and demonstrate the capabilities of the system. The U.S. Navy are carrying out such tests on escape systems which use Martin-Baker MK 5 seats, partly unsuitable, however, for use in a linked system.

5.2 Detailed description of the programs to be carried out on similar Martin-Baker seats is not yet known to Avro, but an attempt will be made to evaluate the capabilities of Avro's system by applying those parts of the test results of paragraph 5.1 as can be considered applicable.

5.3 The type of these tests will be:

5.3.1 Tower Tests at N.A.M.C. Philadelphia

5.3.2 Rocket Sled Ejection Tests up to 700 knots E.A.S. at Hurricane Mesa.

6. Presentation of Results

6.1 The results of all the tests of paragraph 2.2, 4 and 5 will be reviewed and will be used by Avro to attempt to define by engineering judgement and analysis the capabilities of the Escape System.

6.2 The presentation of the results of this program will take the form of two envelopes: one in which the structural integrity of the escape system shall be maintained; and one in which the crewman will not be subjected to conditions more severe for aircrew during escape than the R.C.A.F. physiological tolerances.

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REPORT NO. 72/Systems 24/205-2

SHEET NO. 5

AIRCRAFT:	Title: ARROW 2 ESCAPE SYSTEM DEVELOPMENT PROGRAM - ISSUE 2	PREPARED BY	DATE
		CHECKED BY	DATE

6.3 Obviously this program lacks the quantitative data provided by the original program, reference 72/Systems 24/205 Issue 1; but it is consistent with efforts to provide a suitable system at minimum cost. Avro will have no control over the type and conditions of some of the tests and, as Avro's hardware and requirements differ in detail from those of other users of Martin-Baker MK 5 seats, some areas may only be covered by extrapolation and engineering judgement. Table 1 shows how this will be achieved.

7. Conclusion

The escape system produced by this program will be of the same quality and performance as it would have been under the previous program. However, the added insurance of a complete evaluation program and the consequent inputs to its development will be lost.

The known data and expected limitations of the system are contained in Report No. 74/Systems 24/311 (pending of completion), which will be revised periodically as more information becomes available.



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MALTON - ONTARIO

TECHNICAL DEPARTMENT

CONFIDENTIAL

REPORT NO. 72/Systems 24/205-2

SHEET NO. 6

AIRCRAFT:	Title: ARROW 2 ESCAPE SYSTEM DEVELOPMENT PROGRAM - ISSUE 2	PREPARED BY	DATE
		CHECKED BY	DATE

TABLE 1

TESTS OMITTED FROM THE ORIGINAL PROGRAM	ACCEPTED AS A REPLACEMENT	INFORMATION LOST	INFORMATION AVAILABLE
Avro Tower Tests	(1) Tower tests on Martin-Baker MK A5 seat. (2) System Ground Test (3) Martin-Baker development tests	Quantative data on the effect of the RCAF survival pack on spinal accelerations and cockpit clearances.	(1) Performance of the ejection gun under conditions of varying weights and temperature. (2) Operation of restraints.
Wind Tunnel Tests	MIT Wind tunnel tests on a man-seat configuration, .096 full scale	Stability, trajectory and altitude versus time relationship in free flight at altitude for the Arrow configuration.	Drag and pitching moment characteristics of a similar seat at subsonic, transonic and supersonic speeds.
Static Ejection	System Ground Test	Ejection sequence tests and cockpit clearances from an actual aircraft under seat dynamic conditions.	(1) Simulated ejection sequence (2) Non-dynamic cockpit clearances.



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MALTON - ONTARIO

TECHNICAL DEPARTMENT

**CONFIDENTIAL**

REPORT NO. 72/Systems 24/205-2

SHEET NO. 7

AIRCRAFT:	Title: ARROW 2 ESCAPE SYSTEM DEVELOPMENT PROGRAM - ISSUE 2	PREPARED BY	DATE
		CHECKED BY	DATE

TABLE 1 (Cont'd)

TESTS OMITTED FROM THE ORIGINAL PROGRAM	ACCEPTED AS A REPLACEMENT	INFORMATION LOST	INFORMATION AVAILABLE
Sled Test Phase 1	Sled tests from the Coleman utility sled of Martin-Baker MK 5 seats.	Actual dynamic check on the operation and effectiveness of the head and arm restraints and their effect on seatman separation at higher speeds.	Dynamic performance of the seat, trajectory at low altitude and parachute system performance
Sled Test Phase 2	Not replaced	Demonstration check of overall system and especially canopy operation.	None
Flight Test	Flight test at Martin-Baker	Check of the overall system in an actual Arrow aircraft in flight.	Ejection data on a seat fired from a different aircraft.

