

Security classification^{#01}
Unclassified



Rolls-Royce

TECHNICAL REPORT

Discipline or report series ^{#10} East Kilbride Technical Report	Document number ^{#12}	Report number ^{#52} DNS140121	Issue ^{#13} 1
Title ^{#15} ECU748 Performance Investigation			
Authors ^{#20} X X X	Telephone: X X X X	Date ^{#20} 15 th February 2008	

540

Summary^{#60}

This report details the investigation carried out on Spey Mk.251 engine serial number 748 at Rolls-Royce East Kilbride.

The subject engine was rejected from service due to excessive vibration.

As the result of an on-aircraft fault which is subject to F765B (Flight Safety) investigation, the engine was consigned to Rolls-Royce East Kilbride for as-received testing.

In summary, the engine was outwith limits to the current vibration acceptance standards and will require rework to address this issue. The T3 and P3 readings were within normal test scatter and are not considered unusual.

The overall performance of the engine would meet the current pass-off limits for production engines.

Additional keywords ^{#90}			Retention category A
Circulation:	Technical Library	R-R EK	EW-22
X X X	WH-18	X X X	WH-27
X X X	WH-27	WH40-2	WH-71
X X X	WH-27	WH40-2	R-R EK
X X X	WH-27	EK-6	R-R EK
X X X	IPT W yton	RR Kinloss	R-R EK
X X X	R-R EK	RR Kinloss	R-R EK
		EW-21	WH-53
			Approved by: X X X X X X X X X X Fleet Manager TSP and BR710

ALL 540

Project Spey TSP	Sub-system Engine	Process	Part number
Engine types ^{#24} Spey	Engine marks/vehicle name Mk251	Vehicle number/build ^{#28} 748	Module
Material	Design definition	Design def. issue	File/folder ^{#18}
		CTP ^{#32}	ATP ^{#36}
			Dept ^{#14}

Security classification^{#01}
Unclassified

1. History and Background

Engine serial number 748 was removed from aircraft XV249 position number 3 on January 22 2008. The primary rejection reason was excessive vibration which was later confirmed during installed engine ground runs.

Prior to this rejection an incident had occurred on aircraft XV249 which is currently subject to an F765B (Flight Safety) investigation. It was not believed that the incident was directly related to the engine and the objective of this testing was to rule out any potential engine involvement.

In support of the flight safety investigation the Nimrod IPT requested Rolls-Royce Plc to carry out an investigation to understand the performance of the subject engine in relation to a standard pass off engine in terms of P3 and T3 (HP compressor delivery pressure and temperature respectively).

At the time of removal the engine had achieved a life of 11178 power hours and 11300 total hours since new; 4387 power hours and 4632 total hours since repair. The engine was installed into XV249 at RAF Waddington on July 16 1998.

The engine was transported to Rolls-Royce East Kilbride for this investigation to be carried out and was received at the facility on February 7 2008.

The workscope for the investigation was agreed with the EK RPO Office and Nimrod IPT.

2. Pre-Test Inspection

Prior to as received testing being carried out the engine was subject to a number of checks to ensure that the engine was in a condition suitable for test.

2.1 LP Compressor / LP Turbine Inspection

The LP Compressor was inspected for any obvious excessive damage that would prevent engine running and found to be satisfactory. Apart from a build up of dirt on the airfoil surfaces and moderate leading edge erosion, the LP compressor was in a good condition.

The LP Turbine was also inspected for any obvious damage and found to be in a satisfactory condition.

2.2 Freedom of Rotation

Both the LP and HP systems were rotated by hand and found to be free with no unusual rubbing or noises heard.

2.3 Oil System Checks

The magnetic chip detectors (MCD's) and the scavenge strainers were removed from the engine and inspected. These were in a satisfactory condition with no indication of any internal failure.

2.4 LP System End Float

The RAF rejection note highlighted the possibility of excessive LP system end float indicating the possibility of LP thrust bearing wear. The end float was checked and found to be 0.030 which is acceptable to the AP101B-0503-1DJ requirements.

Document number DNS140121	Issue 1	Security classification Unclassified	Page 2 of 13
------------------------------	------------	---	--------------

©2008 Rolls-Royce plc

The information in this document is the property of Rolls-Royce plc and may not be copied, or communicated to a third party, or used for any purpose other than that for which it is supplied, without the express written consent of Rolls-Royce plc.

3. Summary of Testing

The engine was tested in accordance with TSP project repair instruction 17030 which was locally approved by RPO ~~X~~ ~~X~~ ~~X~~ 540

This instructed the following:

The following testing should be carried out in accordance with PATS RT08-100 (Issue 1).

NOTE: The testing detailed below is to be witnessed by the EK RPO.

NOTE: Carry out all standard pre-run engine and cell readiness checks.

NOTE: All running to be carried out in as-received condition. Do not make any adjustments.

1. Pre-run checks in accordance with PATS section 3.2.
2. Functional check in accordance with PATS section 3.4
3. Carry out a performance curve in accordance with PATS section 3.9.
4. Slowly accelerate the engine from ground idle to maximum conditions for the day observing all applicable mechanical limits and controlling at whichever limit is first encountered.
5. Stabilise for 3 minutes.
6. Take a steady state performance scan.
7. Slowly decrease the NH speed by 5% ($\pm 0.5\%$)
8. Stabilise for 3 minutes.
9. Take a steady state performance scan.
10. Repeat steps 7 through 9 until ground idle is reached.

Transiently recording at a rate of 40Hz carry out the following running:

11. Slowly accelerate the engine from ground idle to maximum conditions for the day.
12. Stabilise at maximum conditions for 1 minute.
13. Slowly decelerate the engine from maximum conditions to ground idle.

On completion of the above testing, the engine is to be inhibited, de-rigged and consigned to shop. The engine is to be held in quarantine at RAF Kinloss pending formal closure of the F765B (Flight Safety Investigation)

All data recorded above is to be converted to Microsoft Excel format and passed to overhaul engineering.

Document number DNS 140121	Issue 1	Security classification Unclassified	Page 3 of 13
-------------------------------	------------	---	--------------

©2008 Rolls-Royce plc

The information in this document is the property of Rolls-Royce plc and may not be copied, or communicated to a third party, or used for any purpose other than that for which it is supplied, without the express written consent of Rolls-Royce plc.

4. Analysis of Test Results

The full set of test results are attached in appendices 1 and 2.

4.1 Vibration Levels

The engine was found to be outwith acceptance limits for broadband vibration. On the tail bearing transducer the maximum amplitude of broadband vibration recorded was 0.0034 at approximately 53%NH speed. The maximum acceptance limit for this condition is 0.0028”.

Analysis of the composite vibration frequencies found that the biggest driver was approximately 0.0022 of non-integral vibration.

Above this speed the vibration amplitude decayed and the engine did not exceed acceptance limits.

4.2 HP Compressor Delivery Temperature (T3)

The uncorrected data for T3 is detailed in appendix 2.

For the purposes of comparison with normal pass off engines, the data was corrected to ISA, SLS conditions in accordance with standard correction routines as detailed in the engine overhaul manual.

Across the standard range of performance curve running T3 was found to be within the test scatter of a standard pass off engine as shown below:

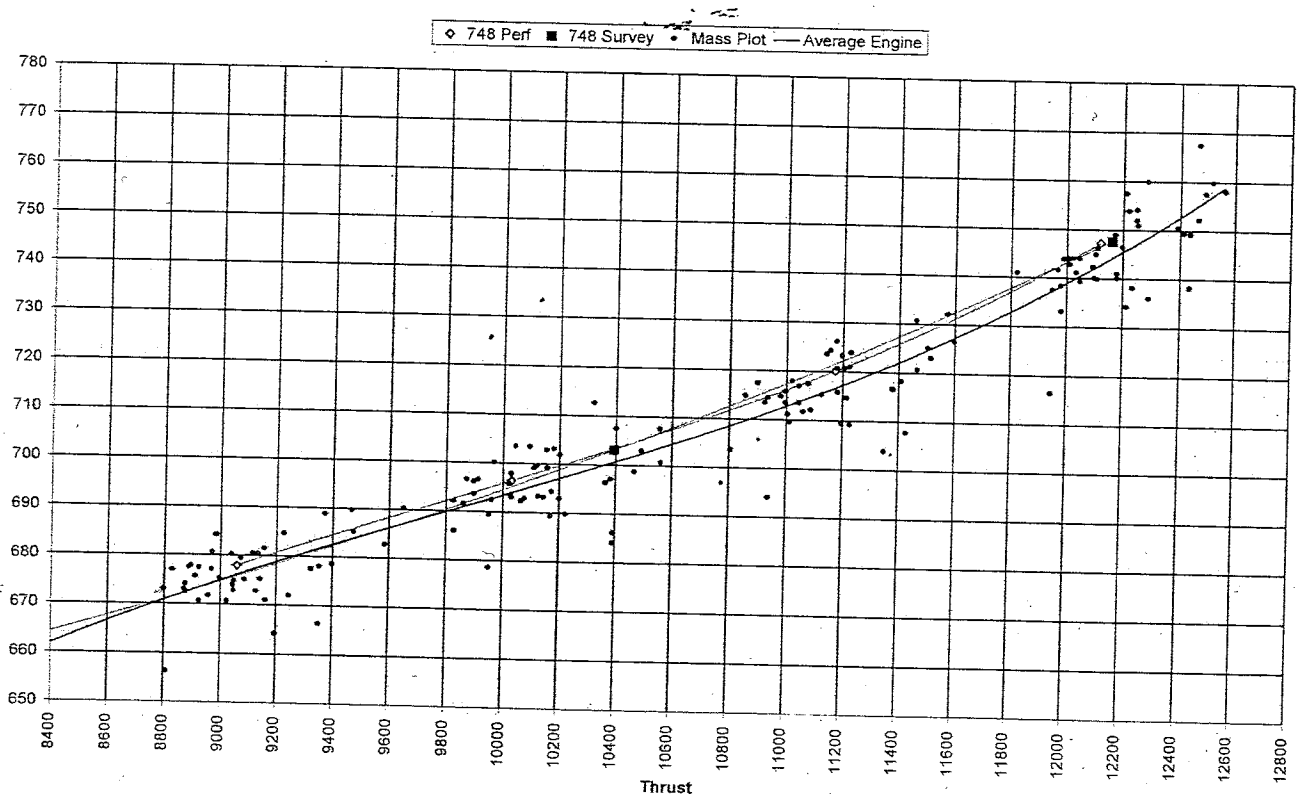


Figure 1: T3 Results

Document number DNS 140121.	Issue 1	Security classification Unclassified	Page 4 of 13
--------------------------------	------------	---	--------------

©2008 Rolls-Royce plc

The information in this document is the property of Rolls-Royce plc and may not be copied, or communicated to a third party, or used for any purpose other than that for which it is supplied, without the express written consent of Rolls-Royce plc.

At the worst point the actual figures recorded for engine 748 were approximately 5°K above the average pass off engine but still within what would be considered to be normal test scatter.

4.2 HP Compressor Delivery Pressure (P3)

The uncorrected data for P3 is detailed in appendix 2.

For the purposes of comparison with normal pass off engines, the data was corrected to ISA, SLS conditions in accordance with standard correction routines as detailed in the engine overhaul manual.

Across the standard range of performance curve running P3 was found to be within the test scatter of a standard pass off engine as shown below:

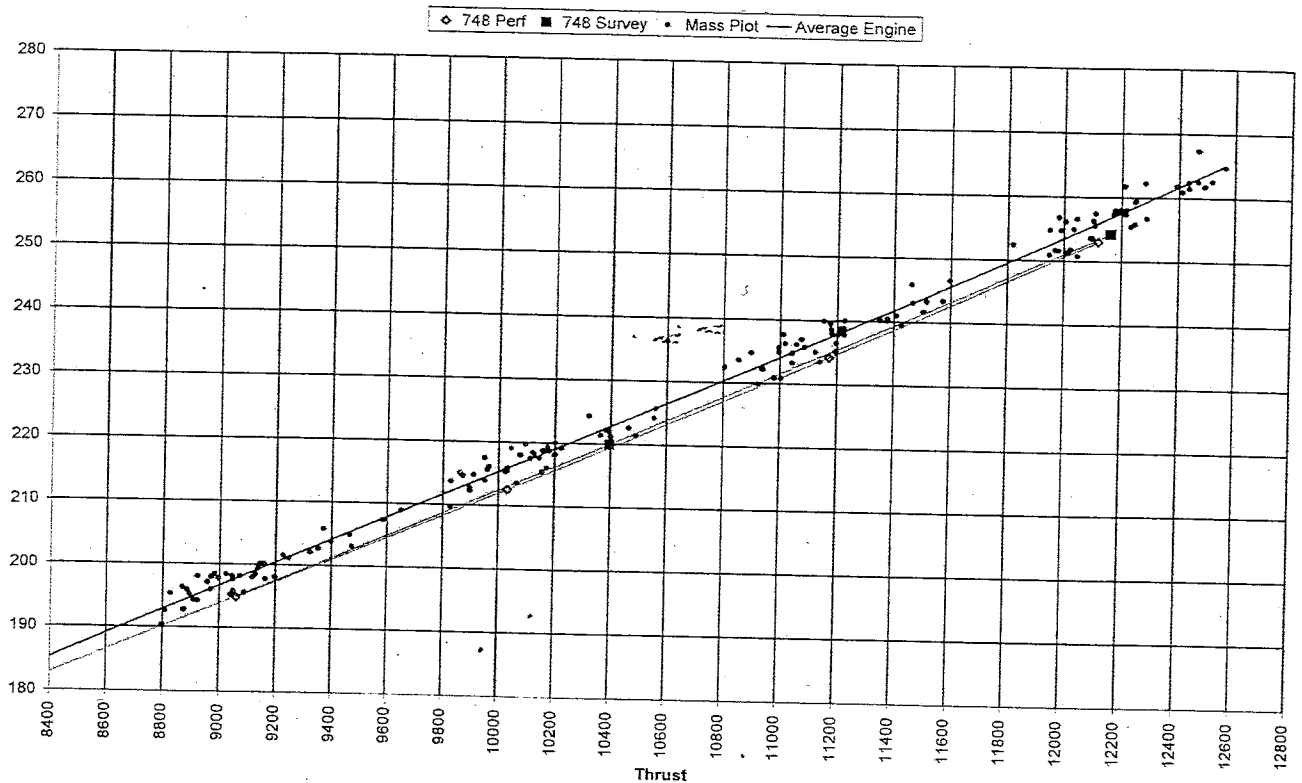


Figure 2: P3 Results

At the worst point, the recorded P3 is approximately 4psi lower than the average pass off engine. Again though this is still considered to be in the normal test scatter although at the lower end.

Any deviation in engine performance from the average can be explained by engine deterioration over the engines 10 year operational life since installation coupled with normal engine test scatter.

Document number DNS 140121	Issue 1	Security classification Unclassified	Page 5 of 13
-------------------------------	------------	---	--------------

©2008 Rolls-Royce plc

The information in this document is the property of Rolls-Royce plc and may not be copied, or communicated to a third party, or used for any purpose other than that for which it is supplied, without the express written consent of Rolls-Royce plc.

5. Conclusions

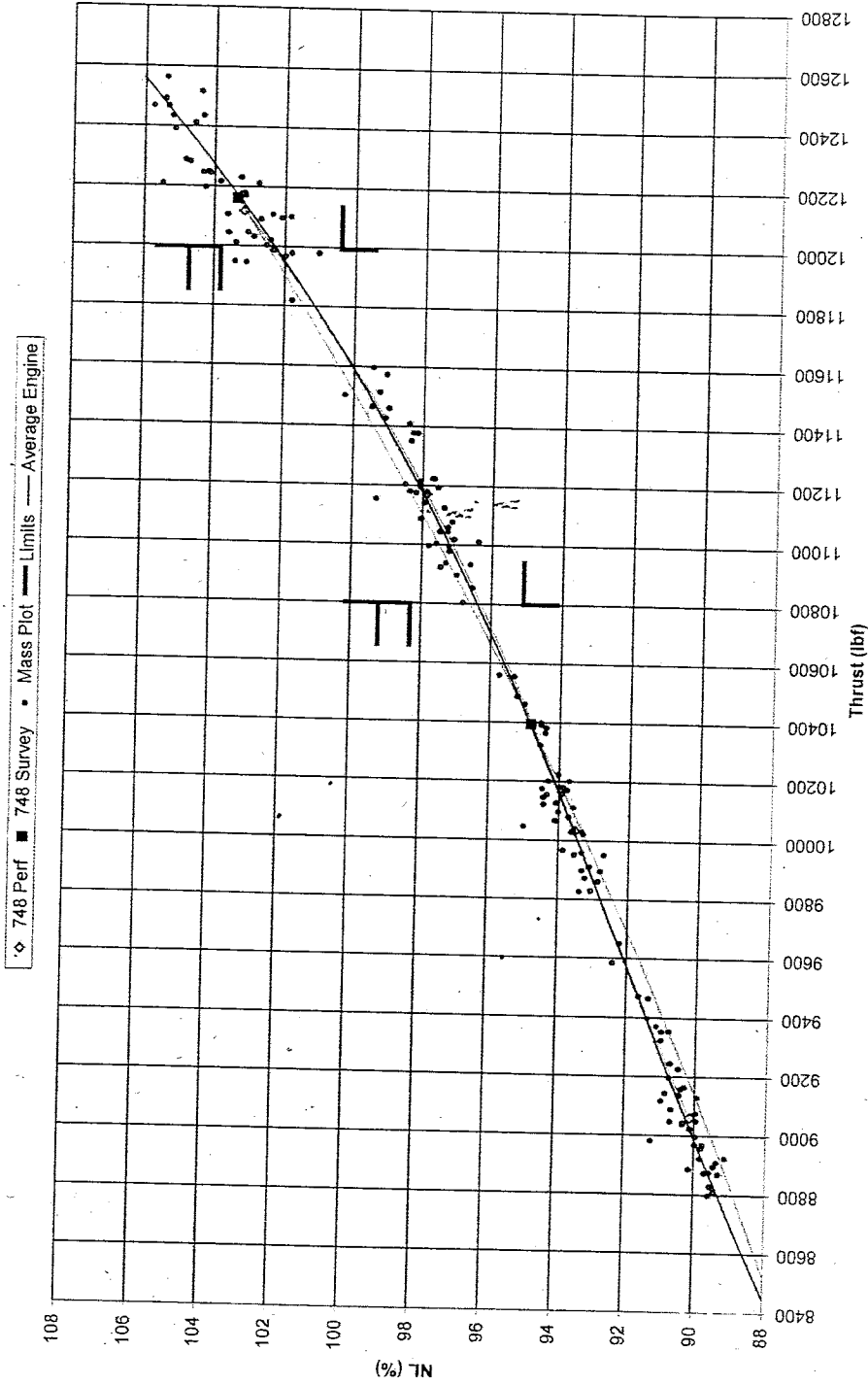
- The engine was outwith limits to the current vibration acceptance standards and will require rework to address this issue.
- The T3 readings were within normal test scatter, slightly above average, but are not considered unusual.
- The P3 readings were within normal test scatter, below average, but are not considered unusual.
- The overall performance of the engine would meet the current pass-off limits for production engines.

Document number DNS 140121	Issue 1	Security classification Unclassified	Page 6 of 13
-------------------------------	------------	---	--------------

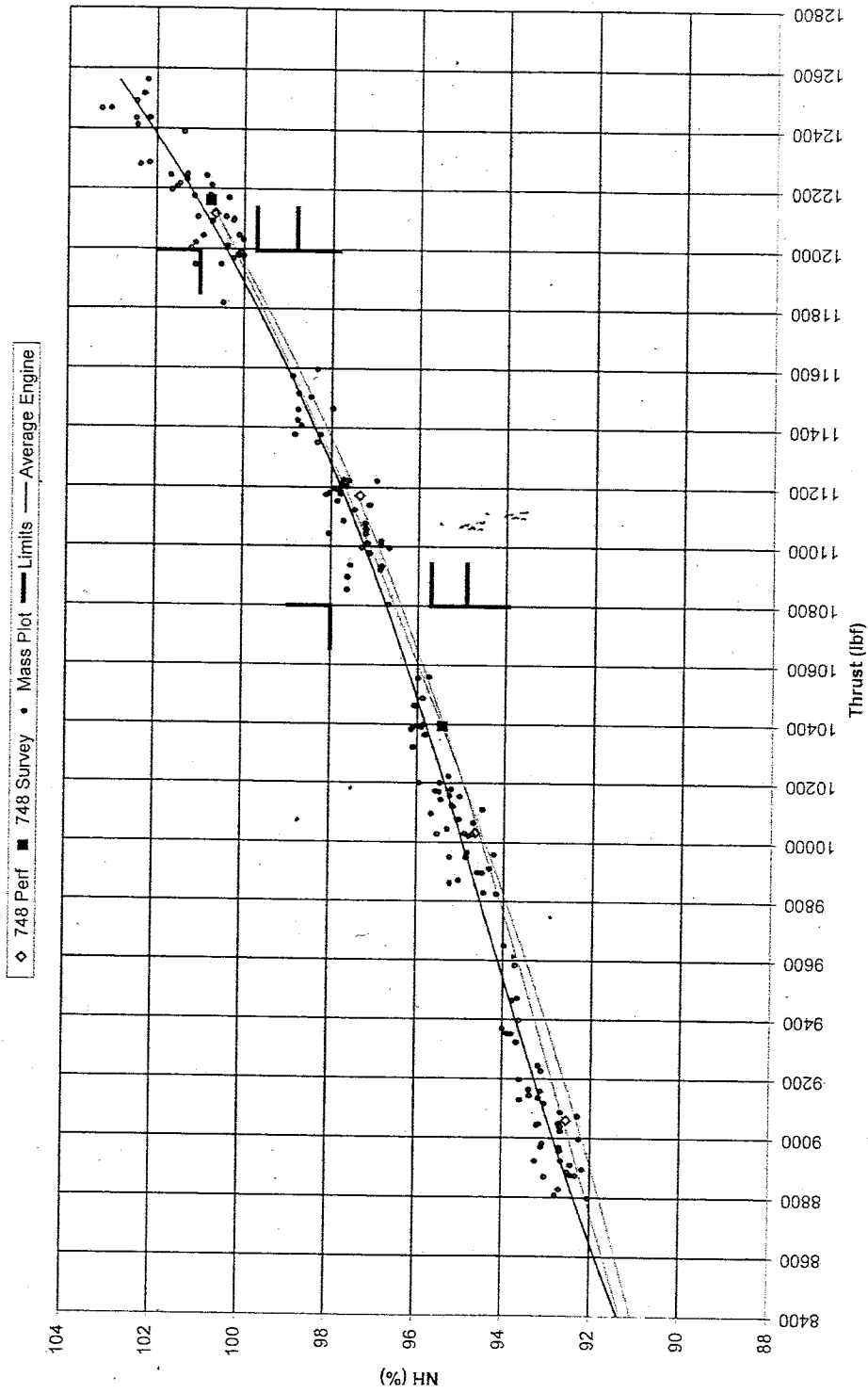
©2008 Rolls-Royce plc

The information in this document is the property of Rolls-Royce plc and may not be copied, or communicated to a third party, or used for any purpose other than that for which it is supplied, without the express written consent of Rolls-Royce plc.

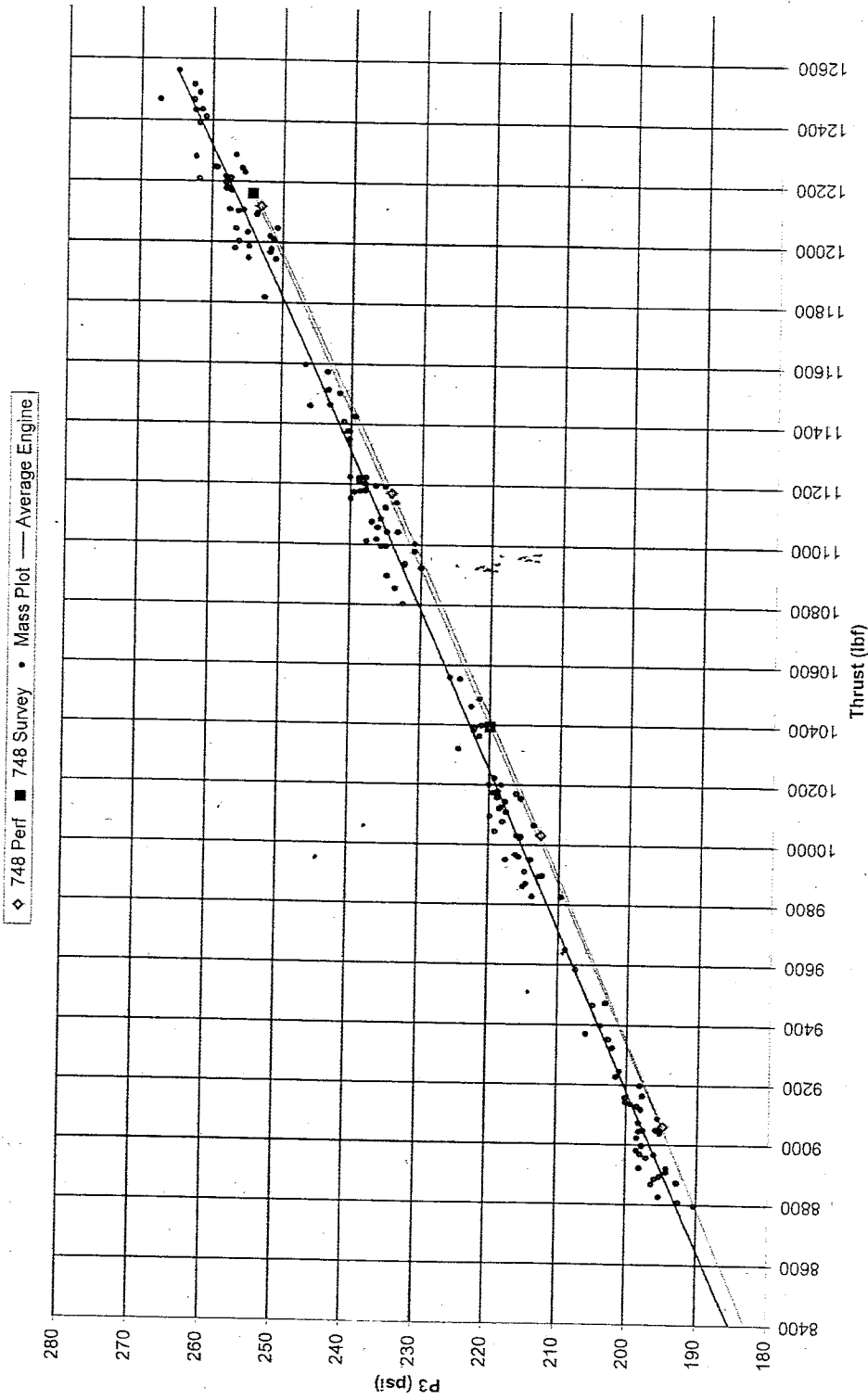
Appendix 1: Corrected Performance Data – LP Speed v Thrust



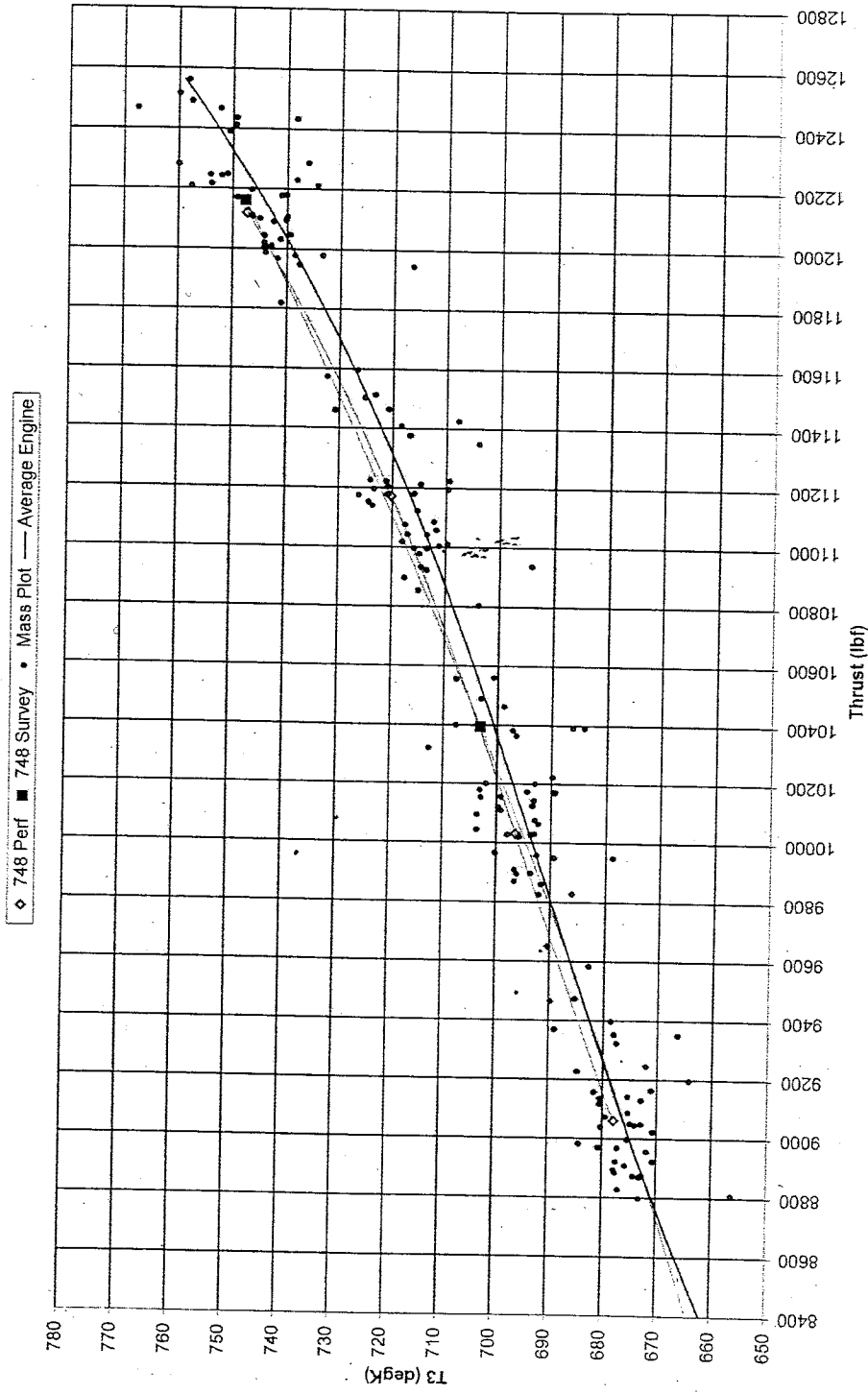
Appendix 1: Corrected Performance Data -- HP Speed v Thrust



Appendix 1: Corrected Performance Data – P3 v Thrust



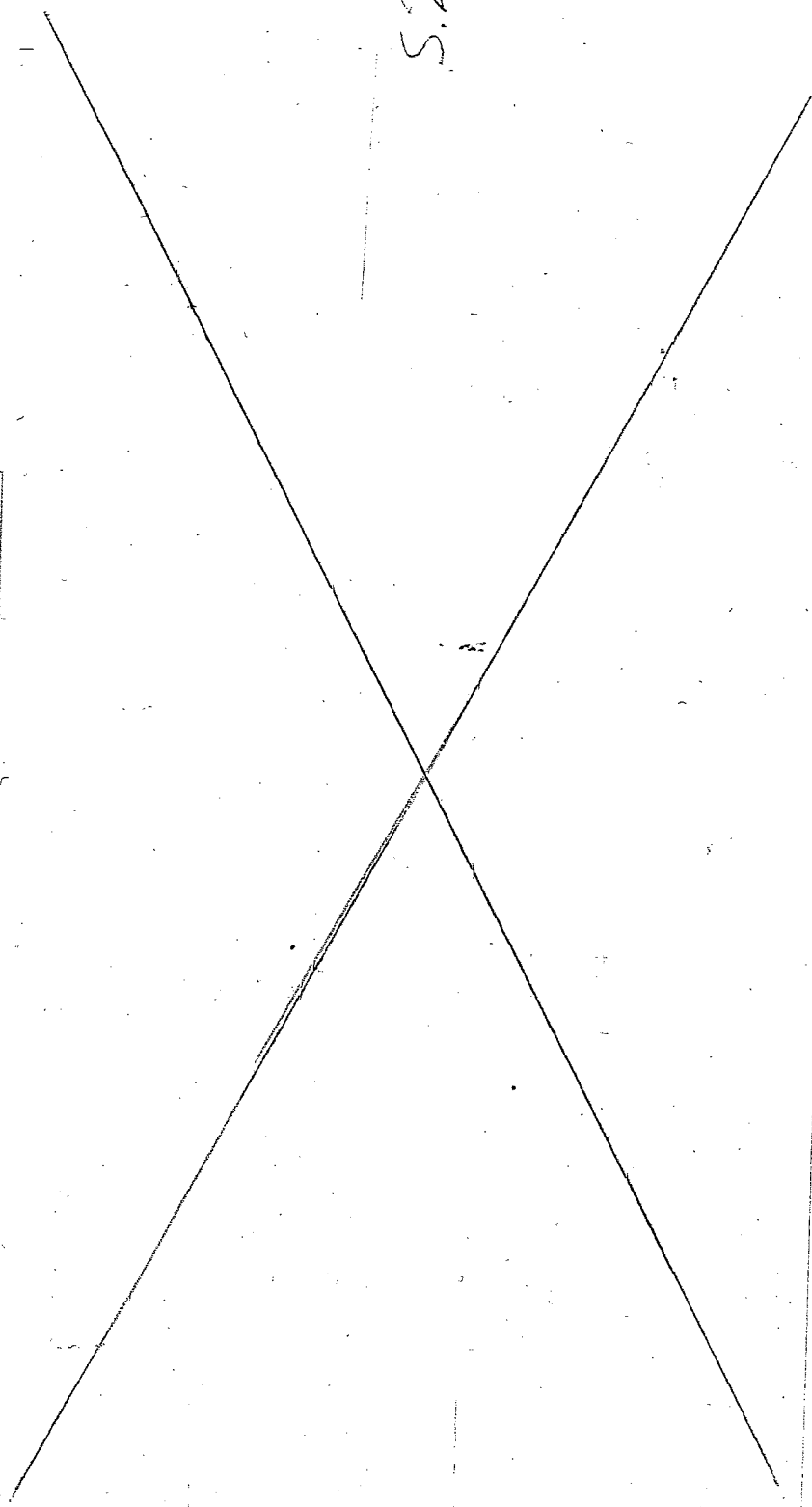
Appendix 1: Corrected Performance Data – T3 v Thrust



Security classification
Unclassified

Appendix 1: Corrected Performance Data – TGT v Thrust

◇ 748 Perf ■ 748 Survey • Mass Plot — Average Engine

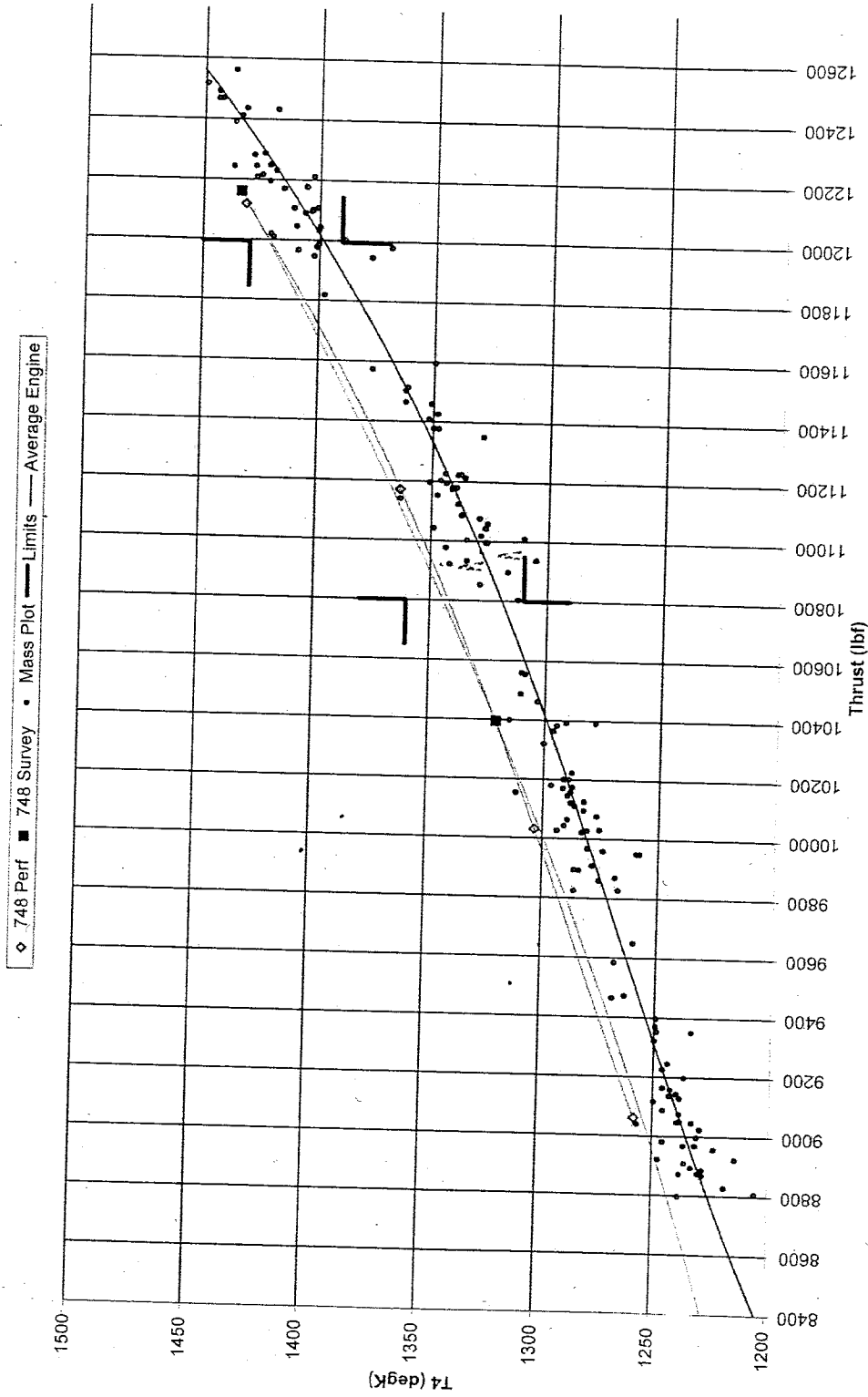


S.26

The information in this document is the property of Rolls-Royce plc and may not be copied, or communicated to a third party, or used for any purpose other than that for which it is supplied, without the express written consent of Rolls-Royce plc.

Security classification
Unclassified

Appendix 1: Corrected Performance Data - T4 v Thrust



Document number
DNS 140121

Issue
1

Security classification
Unclassified

Page 12 of 13

©2008 Rolls-Royce plc

The information in this document is the property of Rolls-Royce plc and may not be copied, or communicated to a third party, or used for any purpose other than that for which it is supplied, without the express written consent of Rolls-Royce plc.

Security classification
Unclassified

Appendix 2: Uncorrected Performance Data

~~T0 (°K) P0 (psi) Fuel Flow (lb/hr) NH (%) NH (RPM) NL (%) NL (RPM) P1 (psi) P2 (psi) P3 (psi) P7 (psi) T1 (°K) T2 (°K) T3 (°K) T6 (°K) Thrust (lbf)~~

5.26

Document number DNS 140121	Issue 1	Security classification Unclassified	Page 13 of 13
-------------------------------	------------	---	---------------

©2008 Rolls-Royce plc

The information in this document is the property of Rolls-Royce plc and may not be copied, or communicated to a third party, or used for any purpose other than that for which it is supplied, without the express written consent of Rolls-Royce plc.