NOTICE TO OPERATORS
BR710 ENGINES
NTO No.: 244
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Rolls-Royce

TITLE: **Ignition System Logic and Improved Troubleshooting Sequence for Ignition System related Starting Issues**

Valid until: N/A **ATA Area: 74-00-00 / 74-20-02**

EFFECTIVITY: **BR700-710A2-20 Operators**

Purpose: **To describe the BR700-710A2-20 ignition system and to give mitigation and troubleshooting options on ignition system related starting issues**

Introduction

Over the last few years there has been a gradual increase of reported starting issues and ignitor plug removals on BR710 engines, causing delays or even missed trips. Rolls-Royce has launched an investigation with the objective to restore the BR710 ignitor plug reliability.

This NTO provides information and recommendations to minimise the operational disruption in case of ignition system related starting issues. It describes the ignition system logic for BR700-710A2-20 engines and provides the recommended mitigation options to avoid missed trips. In addition, it provides an improved troubleshooting procedure to avoid unnecessary replacement of both ignitor plugs.

Furthermore, this NTO provides an overview of the current investigation status and the planned way forward. An ignitor plug rejection report is attached to the digital version of this NTO. It gives each operator the opportunity to provide further details about rejected ignitor plugs, supporting the investigation of the decreased BR710 ignitor plug reliability.

Ignition System Description

Note: Please refer always to Figure 1: BR700-710A2-20 - Ignition System Schematic

The ignition system of BR700-710A2-20 engines consists of two high-energy ignition boxes, two high-energy ignition leads and two ignitor plugs with a built-in redundancy. Each ignition box is connected to only one ignitor plug via one ignition lead. Both ignition leads are routed down the outboard side of the bypass duct to the interservices fairing and then through to the core engine mounted ignitor plugs. These two ignition paths are defined as ignition system 1 and ignition system 2 which can be operated independently.

Figure 1 illustrates which ignition box, ignition lead and ignitor plug belong to which ignition system. The numbering of the ignitor plugs has often led to misunderstandings with regard to the ignitor plug position and its allocation to the correct ignition system. It is recommended to identify each ignitor plug only by its position. The ignition unit numbering defines the ignition system that contains the respective ignitor plug.

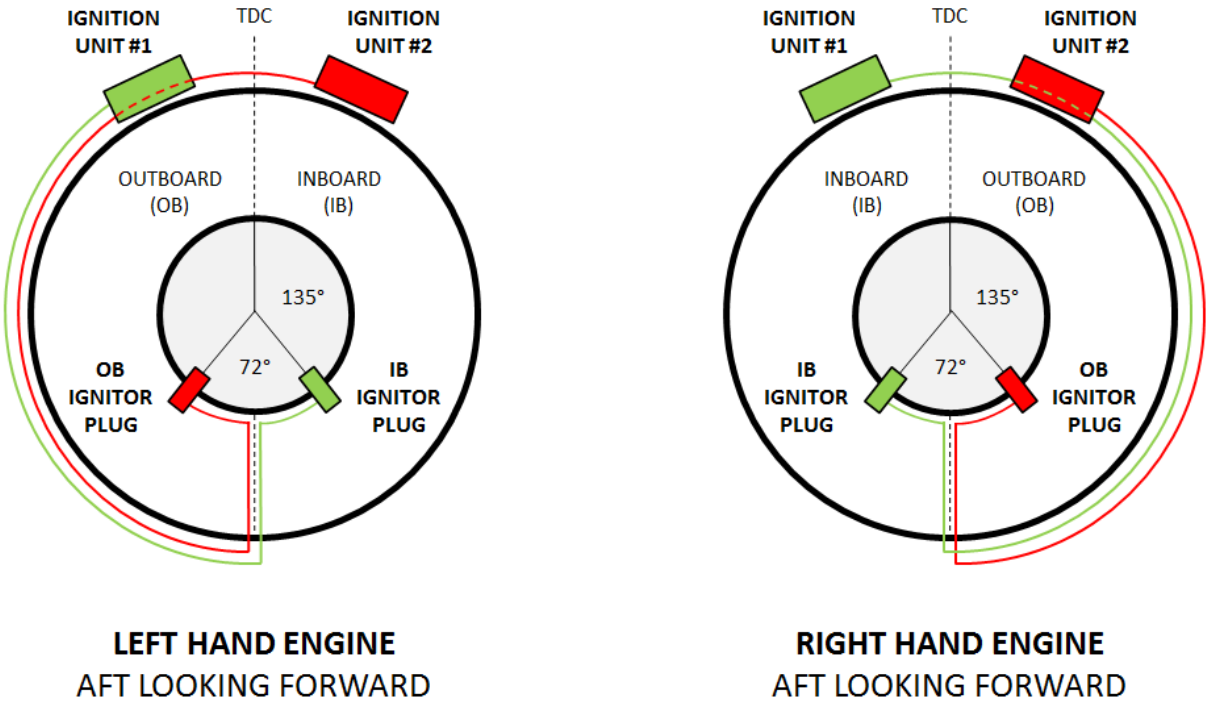


Figure 1: BR700-710A2-20 - Ignition System Schematic

Following this recommendation the rules below apply for both engine positions and will contribute to a common understanding of the BR700-710A2-20 ignition system.

Ignition System 1:

- The ignition unit 1 is installed left from Top Dead Centre (TDC), aft looking forward.
- The inboard ignitor plug is connected to ignition unit 1, thus being part of ignition system 1.

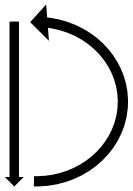
Ignition System 2:

- The ignition unit 2 is installed right from TDC, aft looking forward.
- The outboard ignitor plug is connected to ignition unit 2, thus being part of ignition system 2.

To harmonise training materials covering the description of the BR700-710A2-20 ignition system, Rolls-Royce has initiated their revision.

The ignition systems are controlled by the EEC which is responsible for selecting both the EEC channel and the ignition system in control. Each EEC channel can either control one or both ignition systems. For normal automatic ground starts only one ignitor plug is used. The EEC alternates channels and ignitor plugs after each start according to the following continuous sequence:

EEC Channel **A** & Ignition System **1**
EEC Channel **B** & Ignition System **1**
EEC Channel **A** & Ignition System **2**
EEC Channel **B** & Ignition System **2**



Regardless whether a normal automatic ground start attempt was successful or not, the EEC selects automatically the next combination on the following normal ground start attempt. Therefore, when performing automatic ground starts one inoperative ignition system would result in a maximum of two consecutive failed start attempts. Note that the above sequence only applies if there are no failures within the FADEC system that could prevent the selection of an alternate EEC channel and/or ignition system.

During manual engine ground start both ignitor plugs are commanded to ignite (continuous ignition) so that affected engines should start even with one inoperative ignition system. Same applies for all air starts.

Ignition System related Starting Issues

Ignition system related starting issues occur when parts of the ignition system are inoperative. The EEC is able to detect if the ignition system in control is inoperative on its low or high tension side. The low tension side represents the connection between the EEC and ignition units. The high tension side represents the connection between the ignition units and ignitor plugs.

Depending on the EEC channel and ignition system in control, a failure of the low tension side leads to the EICAS indication ‘FADEC FAULT’ with the related CAIMS message ‘Ignition System 1/2 (Low Tension) (Channel A/B)’. If only one EEC channel is inoperative the indicated dispatch category is ‘STD (Short Term Dispatch)’. If both EEC channels are inoperative, starting the engine is not possible and the indicated dispatch category is ‘DND (Do Not Dispatch)’.

A failure of the high tension side of the ignition system in control leads to an EEC commanded abort of an automatic ground start attempt which is indicated by the EICAS message ‘FADEC FAULT AUTOSTART ABORT’ (STD). The related CAIMS message is ‘L (R) HIGH TENSION IGNITION [1/2]’. If both ignition systems are affected the dispatch category is ‘DND’.

In this context it is worth mentioning that no cockpit indication was reported for the majority of ignitor plug related starting issues on the BR710 fleet. This prevented the flight and maintenance crews from isolating the faulty part in the ignition system. This is a known issue due to the fact that the EEC aborts an automatic start only if the engine does not reach idle within 120 seconds after ignition (IGN) illuminates on the EICAS. This threshold is perceived too long when compared to normal starting times and therefore starts are usually manually aborted by the flight crew before the 120 seconds are reached.

Troubleshooting

In order to troubleshoot ignition system related starting issues, the EMM TASK 74-00-00-710-801 (Operational Test of the Ignition System) already provides an acoustic test method. This should enable the isolation of the faulty ignition system causing the reported starting issues. An increasing number of occurrences has shown that this test method is not always suitable. Particularly with regard to the troubleshooting of ignitor plug failures, a pure acoustic test is often not sufficient to isolate the faulty ignitor plug. The improved troubleshooting procedure is capable to test the functionality of one ignition system by starting the respective engine manually whilst the circuit breaker of the other ignition system is pulled. This will allow identification of the faulty ignition system, even if the automatic ground start attempt was manually aborted and no fault message was set by the EEC.

To implement this troubleshooting procedure the aforementioned EMM TASK 74-00-00-710-801 has been revised via Repeater Technical Variance 185181 Issue 2 which is attached to the digital version of this NTO. This improved troubleshooting procedure addresses those cases of starting issues where the crew aborts the automatic ground start manually.

Mitigation

To minimise operational disruption, operators are advised to follow the applicable Master Minimum Equipment List (MMEL) chapter 74 – Ignition which allows continued operation of the Bombardier Global aircraft as long as the respective requirements are met. In case of ignition system related starting issues the built-in redundancy of the BR700-710A2-20 ignition system enables each operator to start an engine with only one operative ignition system by following the manual engine start procedure (FCOM1 07-03 Procedure A). Therefore, it is generally recommended to operate an affected aircraft as per MMEL, thus avoiding missed trips. This recommendation applies especially to those aircrafts and their operators who are experiencing ignition system related starting issues at remote locations.

Reliability Investigation of BR710 Ignitor Plugs

The investigation of BR710 ignitor plugs initially launched in 2017 is ongoing and aims at identifying the root cause for the decreased reliability. The limited data quality with regard to the ignitor plug removals across the whole BR710 fleet makes it challenging to derive meaningful fleet statistics. This lack of data is driven by the fact that ignitor plugs count as consumables. Therefore, their replacement is only rarely reported. To address this, Rolls-Royce has elected to obtain more accurate BR710 field reports and to use those in order to investigate the decreased BR710 ignitor plug reliability. The improved troubleshooting procedure for ignition system related starting issues is part of this revised investigation strategy. It will help returning and investigating mainly faulty ignitor plugs. In addition, collecting the relevant information about each ignitor plug removal will contribute to the identification of potential patterns, thus helping to focus on certain areas of possible root causes.

The ongoing investigation of returned ignitor plugs is agreed and done in collaboration with the supplier of the BR710 ignitor plugs. This includes the following steps:

At Rolls-Royce:

- Inspection of the as received condition by focussing on abnormal findings and measuring the wear with regard to the applicable wear limits for the firing end tip.
- Initial bench testing to isolate faulty ignitor plugs (dry spark test without fuel on firing end tip).

At supplier:

- Inspection of the as received condition by focussing on abnormal findings and measuring the wear with regard to the applicable wear limits for the firing end tip.
- Leakage testing as per Component Maintenance Manual (CMM) to isolate faulty ignitor plugs.
- Bench testing to isolate faulty ignitor plugs (dry spark test without fuel on firing end tip).
- Bench testing as per CMM acceptance test procedure to isolate faulty ignitor plugs by more realistic test conditions (wet spark test with fuel on firing end tip).
- Bench testing to isolate faulty ignitor plugs by more realistic test conditions with regard to the pressure and temperature level present during engine ground starts.
- Investigation of the internal condition of all ignitor plugs which failed at least one of the above mentioned tests in order to identify the root cause for each failure.
- If necessary, further investigation of ignitor plugs which passed the above mentioned tests.

Investigation status and further information as of 18-July-2018:

- Ongoing return of ignitor plugs which caused starting issues in-service. After the majority of those starting issues both ignitor plugs of the affected engines are replaced and returned because the faulty ignitor plug is usually unknown. This will be addressed by the improved troubleshooting procedure.
- All returned ignitor plugs are within the applicable wear limits for the firing end tip.
- 25% of returned ignitor plugs failed initial bench testing at Rolls-Royce, thus explaining only 50% of the ignition system related starting issues.
- The majority of returned ignitor plugs are with the supplier for further ongoing investigation.
- A lab investigation including materials analyses was conducted to compare new ignitor plugs with two families of used ignitor plugs - confirmed failed ones and still functional ones. For the moment, the outcomes of this lab investigation have not revealed any possible root cause which would explain the failures of other returned ignitor plugs. The only root cause identified so far on confirmed failed ignitor plugs was an internal sparking caused by an alternate conductive pathway which resulted in a hole in the outer electrode. This condition has not been observed on other returned ignitor plugs that are currently under investigation.

- Based on both the reporting of several operators and the visual inspection of returned ignitor plugs, the following has been repeatedly observed. The removed inboard and outboard ignitor plugs of the same engine have worn differently, although both were installed for the same amount of flight hours and cycles. The example in Figure 2 shows that the electrode wear of the inboard ignitor plug is heavier than on the outboard one. But the wear of the semiconductor sitting between the electrodes is much more pronounced on the outboard ignitor plug. It is worth mentioning that the wear of both ignitor plugs shown below is still within the applicable wear limits. For the moment, the data quality regarding the installation position of the removed and returned ignitor plugs does not allow identifying a real pattern.

Inboard Ignitor Plug

Outboard Ignitor Plug

Figure 2: Example for different wear of inboard and outboard ignitor plug

- Additionally, several operators observed that the outer electrode of a removed ignitor plug has unevenly worn, thus losing its design intended circular form. Consequently, this results in a more oval shape of the outer electrode. For the moment, the returned ignitor plugs do not confirm this observation.

Ignitor Plug Rejection Report

This NTO includes an ignitor plug rejection report which operators are kindly requested to complete in order to assist Rolls-Royce with the BR710 ignitor plug reliability investigation. The information provided with this rejection report will contribute to an improving data quality which is necessary to identify potential patterns and to focus on certain areas of possible root causes. In addition, this rejection report will help to implement a more efficient ignitor plug return process. An electronic copy of this rejection report is attached to the digital version of this NTO.

Keeping the information and recommendations provided with this NTO in mind, please fill the rejection report only in case of an ignitor plug removal due to ignition system related starting issues. If, as recommended, only the faulty ignitor plug which caused the starting issues needs replacement, please fill the rejection report only with the details related to this ignitor plug. If both ignitor plugs are replaced due to an individual replacement policy, please provide the details about both ignitor plugs. In this case, please clarify which ignitor plug is the faulty one. Additionally, do not scrap faulty ignitor plugs as they are beneficial to support the ongoing investigation. If both ignitor plugs need replacement, please keep the operative one as well.

If practical prior to an ignitor plug removal, mark on the terminal threads of the respective ignitor plug the section which is looking forward in flow direction. The terminal threads are used to connect the ignitor plug with the ignition lead. This additional information will be used to establish a potential dependency between the installed ignitor plug orientation and the observed uneven wear of the outer electrode.

In case the ignitor plug replacement does not solve the ignition system related starting issues, please use the same rejection report to provide information about the identified root cause.

Please add contact details (email, phone) to the rejection report so that Rolls-Royce Deutschland Service Engineering can request the return of the removed ignitor plugs. Rolls-Royce will use those contact details to inform customers about the findings on their returned ignitor plugs if requested.

Please use the following email address of Rolls-Royce Deutschland Service Engineering to provide the filled rejection report:

RRD.SBFeedback@Rolls-Royce.com (Subject: NTO 244)

This document does not contain data approved by an Aviation Authority. It may neither override nor supersede any formal instructions provided by Technical Publications, such as Manuals or Service Bulletins. Should there be conflicting information, the approved Manuals or Service Bulletins always take precedence over the NTO. Operators should contact Rolls-Royce Deutschland Engineering for Services immediately in such a case.