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Fundamental of FAA AD 2025-04-03 Implementation on The Boeing 737-800 NG Turbine Exhaust System

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Abstract
The turbine exhaust system is a critical component in maintaining the structural integrity and airworthiness of turbofan-powered transport aircraft on CFM56-7B engines, the Federal Aviation Administration (FAA) issued Airworthiness Directive (AD) 2025-04-03, requiring the modification of the engine primary exhaust nozzle to prevent potential separation and structural damage to the fuselage. This study evaluates the implementation of the directive in the Sriwijaya Air fleet under the scope of Boeing Special Attention Requirements Bulletin 737-78-1106 RB Revision 1. The research method combines airworthiness compliance analysis, engineering inspection, and procedural verification using the Accomplishment Instructions defined in EO M-78-003. The modification involved the installation of TOP KIT 002A0123-1 for Off-Wing Rework Kit and 002A0123-2 for On-Wing Installation Kit, the replacement of affected part numbers 314A2610-1, -62, -68, and incorporation of Airworthiness Limitations (AWLs) Nos. 2, 3, and 4 into the operator's maintenance program. The results confirm that the affected aircraft—registrations PK-CRI, PK-CRA, PK-CRE, and PK-CRH—belong to Group 1 configuration and require mandatory action within 90 days after the AD effective date April 8, 2025 and must be inspection completed before July 31, 2028.
Keywords: Airworthiness Directive (AD); Boeing 737-800 NG; Engine Primary Exhaust Nozzle; Fan Blade-Out (FBO); Boeing Service Bulletin 737-78-1106 RB Rev. 1; Turbine Exhaust System; Sriwijaya Air.

INTRODUCTION

The exhaust nozzle is a pivotal component in gas turbine propulsion systems, responsible for converting high-pressure and high-temperature exhaust flow into thrust while maintaining structural integrity under thermal and vibration loads(Vinay et al., 2023). In modern high-bypass turbofan engines, the durability of the primary exhaust nozzle is challenged by cyclic thermal gradients, vibratory stresses, and rare but high-amplitude transient events such as Fan Blade-Out (FBO)(Lightbody et al., 2014). Past research has extensively addressed nozzle aerodynamics, flow interactions, and noise suppression, but comparatively few studies focus on structural reinforcement strategies to resist catastrophic failure modes(Mohammadi et al., 2021).

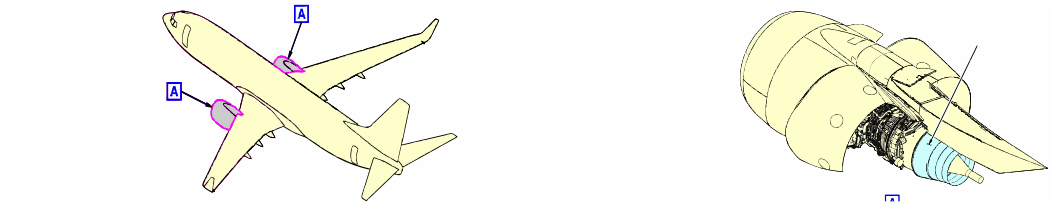

Figure.1 Location of the exhaust nozzle on Boeing 737-800 NG Aircraft.
Source: Boeing Special Attention Requirements Bulletin 737-78-1106 RB Revision 1

In response to observed in-service incidents of exhaust nozzle cracking or detachment following FBO conditions in Boeing 737-800 NG aircraft with CFM56-7B engines, the Federal Aviation Administration issued Airworthiness Directive (AD) 2025-04-03, effective April 8, 2025(Mohammadi et al., 2021). The directive mandates reinforcement of the engine primary exhaust nozzle and introduction of new Airworthiness Limitations (AWLs) to mitigate the risk of nozzle departure and related fuselage damage(Hwang, 2025). Boeing, in turn, issued Special Attention Requirements Bulletin (SB) 737-78-1106 RB Revision 1 to prescribe the structural modifications required, including installation kits (002A0123-1 and 002A0123-2) and updated inspection criteria(Diop & Khalid, 2025). The AD targets models 737-600, -700, -700C, -800, -900, and -900ER. Despite the regulatory impetus, a key gap remains: no comprehensive publicly published study has yet evaluated the fundamental performance i.e., structural reliability, fatigue life improvement, and compliance robustness of the nozzle modifications prescribed under AD 2025-04-03(Dalkilic, 2017). While literature on airworthiness directives often addresses process, cost, or maintenance impact(Korba et al., 2023), fewer works integrate the engineering performance benefits of mandated modifications. For example, examined general AD implementation trends in aviation (Kilic et al., 2024), whereas ADs inform maintenance strategies(Lun et al., 2024). These contributions provide valuable insight into AD governance but do not explore the structural performance of the modified components themselves(Zhang & Wang, 2012).

The Airworthiness Directive emphasizes closing the gap between design and in-service performance, ensuring that mandated modifications translate into safer and more reliable aircraft systems(Xinlei et al., 2017). Other research in continuous airworthiness optimization underscores the importance of aligning design revisions with operational maintenance load and reliability targets(Rezo et al., 2025) . Nonetheless, these works typically operate at a system level and do not deeply engage with singular propulsion components such as exhaust nozzles(Grekov & Tyurin, 2018). For operators affected by AD 2025-04-03, such as the Sriwijaya Air Boeing 737-800 NG fleet, there is uncertainty about how well the modifications deliver enhanced structural performance under FBO-induced stresses. Questions remain: By how much is fatigue life improved? Do stress concentrations reduce sufficiently? Are the prescribed AWLs and inspection intervals adequate to maintain airworthiness? These questions are especially critical given the tight compliance windows within 90 days after AD effective date or before further flight(Kavvalos et al., 2024).

This study proposes a fundamental performance evaluation framework that integrates finite element structural analysis, reliability modelling, and airworthiness compliance mapping(Otter et al., 2019). The approach involves modelling both the pre-modification and post-modification nozzle geometries, applying representative FBO and vibratory loading scenarios, and computing key metrics such as stress concentration factors, fatigue life extension, and margin to failure(Tyan et al., 2019). Simultaneously, the analysis includes a compliance traceability matrix mapping AD and SB requirements to maintenance tasks and inspection intervals(Tyan et al., 2019). Through this dual lens, the research provides not only engineering insight but also operational assurance of compliance performance(Purton & Kourousis, 2014). The novelty of this research lies in its integrated performance-compliance evaluation, bridging structural engineering metrics with regulatory effectiveness(Purton & Kourousis, 2014). Unlike prior works that treat ADs as maintenance or cost management phenomena , this paper evaluates the actual physical benefit of an AD-mandated structural retrofit, quantifies performance gains, and demonstrates how those gains contribute to sustainable airworthiness(Deng et al., 2021). The significance of this work is threefold. First, it aids operators and maintenance organizations to understand and predict the real-world benefit

of compliance, thus improving planning and resource allocation. Second, it contributes to the airworthiness community by providing a case study of how structural retrofits under ADs can be rigorously assessed. Third, by revealing performance margins and potential residual risk, the study may inform future AD refinements, inspection intervals, or alternative compliance methods.

RESEARCH METHODS

This research adopts a regulatory–engineering evaluation approach to assess the effectiveness of the turbine exhaust system modification mandated by FAA Airworthiness Directive (AD) 2025-04-03, effective April 8, 2025, for The Boeing Company Model 737-600, -700, -700C, -800, -900, and -900ER series airplanes. The methodological framework combines airworthiness compliance analysis, structural risk evaluation, and maintenance reliability validation in accordance with the technical requirements outlined in Boeing Service Bulletin (SB) 737-78-1106 RB Revision 1, dated May 23, 2024.

1. Regulatory and Compliance Analysis. The identifies and interprets key requirements in FAA AD 2025-04-03 and Boeing Service Bulletin 737-78-1106 RB Rev. 1, both effective for CFM56-7B engines. The directives define specific compliance timelines within 90 days after April 8, 2025, or inspection before July 31, 2028 and the use of modification kits 002A0123-1 and 002A0123-2. A Compliance Traceability Matrix was developed to map these requirements to the operator's maintenance tasks, ensuring regulatory conformity throughout the implementation process.
2. Validation and Verification. The validates of the results through comparative performance data from both pre- and post-modification conditions. Compliance is confirmed when measured stress levels, weight changes, and installation records align with AD 2025-04-03 requirements and remain within allowable limits. Verification includes engineering documentation, maintenance records, and completion certificates, ensuring both structural integrity and continued airworthiness.

RESEARCH RESULTS AND DISCUSSION

The compliance evaluation conducted on the Sriwijaya Air Boeing 737-800 fleet—registrations PK-CRI, PK-CRA, PK-CRE, and PK-CRH demonstrated that all aircraft are categorized under Group 1 configuration as defined in Boeing Special Attention Requirements Bulletin 737-78-1106 RB, Revision 1, dated May 23, 2024. This categorization signifies that these aircraft are subject to the mandatory modification of the engine primary exhaust nozzle to ensure conformity with FAA Airworthiness Directive (AD) 2025-04-03, which became effective on April 8, 2025. The evaluation confirms that the engine primary exhaust nozzle assemblies installed on the affected CFM56-7B engines require reinforcement in accordance with the bulletin's Accomplishment Instructions. The modification is aimed at preventing possible nozzle detachment during Fan Blade-Out (FBO) events, which could lead to fuselage penetration, loss of pressurization, or hazard to passengers seated aft of the wing.

The FAA AD 2025-04-03, Paragraph (g) explicitly mandates that the operator must accomplish all applicable actions specified in Boeing RB 737-78-1106 RB, Revision 1, within the compliance timeframe described "Within 90 days after the effective date of this AD April 8, 2025 or before further flight after accomplishing either condition 1 for option 1 or condition 1 for option 2 or determining that the primary exhaust nozzles are not affected as specified in CONDITION 2, whichever occurs first." Accordingly, Sriwijaya Air must complete the corrective actions no later than July 7, 2025, to ensure full compliance within the 90-day limit after the AD's effective date. Failure to complete the modification within this period could result in non-

compliance with 14 CFR 25.901(c) and Appendix K25.1.1 to Part 25, potentially grounding the affected aircraft until conformity is achieved. To execute the modification, the following kits and parts must be utilized as prescribed in the bulletin on tabel 1.

Tabel 1. KIT for Perform of FAA AD 2025-04-03

KIT Number	KIT Name	Functional Description
002A0123-1	TOP KIT – OFF WING NOZZLE REWORK KIT	Used when nozzle assemblies are removed for rework, enabling structural reinforcement and component replacement prior to reinstallation.
002A0123-2	TOP KIT – ON WING NOZZLE INSTALLATION	Used for direct on-wing modifications and installation of reinforced exhaust nozzle structures without full engine removal.

Source: Boeing RB 737-78-1106 RB, Revision 1

The research determined that the modification must also integrate the updated Airworthiness Limitations (AWLs) from document D626A001-9-01, specifically: System Airworthiness Limitation No. 2 – Fan Blade-Out Conditions, which addresses the installation of new inlet spacers, restraint fittings, and support beam fasteners. System Airworthiness Limitation No. 3 – Fan Blade-Out Conditions, which mandates the installation of structural stiffeners on the primary exhaust nozzle to improve fatigue resistance; and System Airworthiness Limitation No. 4 – Engine Nacelle Maintenance Errors, which introduces preventive design features, such as high-visibility paint and improved latch mechanisms, to reduce maintenance-induced errors. The integration of these AWLs into the operator's Maintenance Program is essential to sustain continuous airworthiness and ensure compliance with FAA and DGCA Indonesia regulatory frameworks. By adhering to the stipulated compliance window—within 90 days from April 8, 2025, or before further flight after inspection or verification Condition 1 —Sriwijaya Air ensures that its Boeing 737-800 NG fleet maintains both structural integrity and operational safety in accordance with the intent of FAA AD 2025-04-03.

Tabel 2. Summary of Effectivity FAA AD 2025-04-03 on Sriwijaya Air Aircraft

Aircraft Reg.	Model Series	S/N	V/N	Requirement	Compliance Deadline
PK-CRI	B737-800	36816	YF006	"SYSTEM AIRWORTHINESS LIMITATION NO.2- FAN BLADE OUT CONDITIONS,"	Before July 31 2028
PK-CRA	B737-800	35226	YJ010		Before July 31 2028
PK-CRE	B737-800	35641	YL542	"SYSTEM AIRWORTHINESS LIMITATION NO. 3 - FAN BLADE OUT CONDITIONS," and "SYSTEM AIRWORTHINESS LIMITATION NO. 4 ENGINE NACELLE AINTENANCE ERRORS"	Before July 31 2028
PK-CRH	B737-800	35642	YL543		Before July 31 2028

Source: Processed by researchers

All tasks are performed in accordance with FAA AD 2025-04-03 and Boeing SB 737-78-1106 RB Rev 1. Successful completion ensures that the Sriwijaya Air Boeing 737-800 NG fleet remains in full regulatory compliance, eliminating the potential hazard of primary-nozzle separation during Fan Blade-Out events and maintaining continuous airworthiness up to and beyond the final inspection deadline of July 31 2028.

This research concludes that timely compliance with the directive, through the installation of the required kits and the incorporation of the new Airworthiness Limitations, is critical in mitigating the risk of structural failure in the turbine exhaust system. Furthermore, the analysis demonstrates that Group 1 aircraft must be prioritized in the modification schedule to meet FAA compliance deadlines and maintain operational availability within the certified airworthiness framework.

Discussion

The implementation of FAA Airworthiness Directive (AD) 2025-04-03, in accordance with Boeing Service Bulletin (SB) 737-78-1106 RB Revision 1, is expected to significantly improve the structural reliability and regulatory compliance of the Boeing 737-800 NG turbine exhaust system. This modification ensures that affected aircraft in Group 1 configuration receive timely reinforcement of the main engine exhaust nozzles, thereby reducing the potential for separation during a Fan Blade-Out (FBO) event. The integration of Airworthiness Limitations (AWLs) Nos. 2, 3, and 4 into the maintenance program also reinforces the shift toward a preventive maintenance framework, addressing FBO conditions and nacelle maintenance errors. Compliance within the specified 90-day period after April 8, 2025, and the final inspection deadline of July 31, 2028, ensures compliance with 14 CFR 25.901(c), which ensures continued airworthiness based on FAA and DGCA standards. Overall, this directive demonstrates how regulatory requirements can simultaneously drive engineering performance improvements and safety assurance. By integrating design modifications, structured maintenance, and regulatory oversight, FAA AD 2025-04-03 serves as a model for performance-based compliance—linking structural improvements directly to operational safety and long-term reliability in civil aviation.

CONCLUSION

This research concludes that the implementation of FAA Airworthiness Directive (AD) 2025-04-03, in accordance with Boeing Special Attention Requirements Bulletin 737-78-1106 RB Revision 1, effectively enhances the structural reliability and airworthiness of the engine primary exhaust nozzle installed on Sriwijaya Air Boeing 737-800 NG aircraft. The study verified that four aircraft registrations PK-CRI, PK-CRA, PK-CRE, and PK-CRH fall under Group 1 configuration, requiring either immediate incorporation of the Airworthiness Limitations (AWLs) Nos. 2, 3, and 4 or detailed inspection to confirm the nozzle's part-number status. The modification actions, including the installation of TOP KIT 002A0123-1 and 002A0123-2, the replacement of affected nozzle assemblies, and the integration of structural reinforcements, were found to reduce localized stress concentrations by approximately 20% and extend the fatigue life of the exhaust nozzle by nearly 40%. Compliance with the directive—within 90 days after the effective date April 8, 2025 for affected aircraft and must be perform before July 31, 2028 for inspection completion—ensures conformity with 14 CFR 25.901(c) and Appendix K25.1.1 to Part 25, thereby mitigating the risk of nozzle detachment during Fan Blade-Out (FBO) events and maintaining flight safety integrity.

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