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8 June 2025

Subject: Results of the engineering examination of compressor assembly P/N 6890550, S/N CAC-36793 installed on M250-C20F engine CAE 840052 from aircraft N102UM.

Dear Sir/Ma'am,

The purpose of this memo is to provide a summary of the findings from the examination of the above referenced compressor assembly.

Rolls-Royce lifecycle and materials engineering performed a detailed examination of the compressor at the Rolls-Royce failure analysis lab in Indianapolis Indiana. A summary of the findings from this exam follows:

- The compressor rotor exhibited rub on the stage 4 through 6 wheels. The impeller blade tips exhibited tip rub around the full circumference of the impeller. (See Figures 1 through 4)
- The compressor case abradable coating exhibited uneven wear at the stage 5 and 6 blade tracks; the wear on the stage 6 blade track measured approximately 0.002 inch to 0.017 inch in depth on the top and bottom case halves, respectively. The stage 5 and 6 vane tips exhibited rub on the bottom case half, which exhibited the greater extent of abradable coating wear. (See Figures 5 through 7)
- The compressor shroud abradable coating exhibited rub that varied from approximately 0.0008 inch to 0.0162 inch in depth at locations 180° apart. The greater extent of wear was observed on the bottom half of the shroud consistent with the location of more significant abradable coating wear on the case halves. (See Figure 8)
- The total thickness of the four rotor shims that set the rotor running position relative to the shroud measured approximately 0.0254 inch

The rotor assembly forward and aft balance was measured and found to be outside of manual limits.

Table 1 As-Received Rotor Balance

Location	Balance [mg-in]
Forward	71.5 at 120 degrees
Aft	118 at 84 degrees

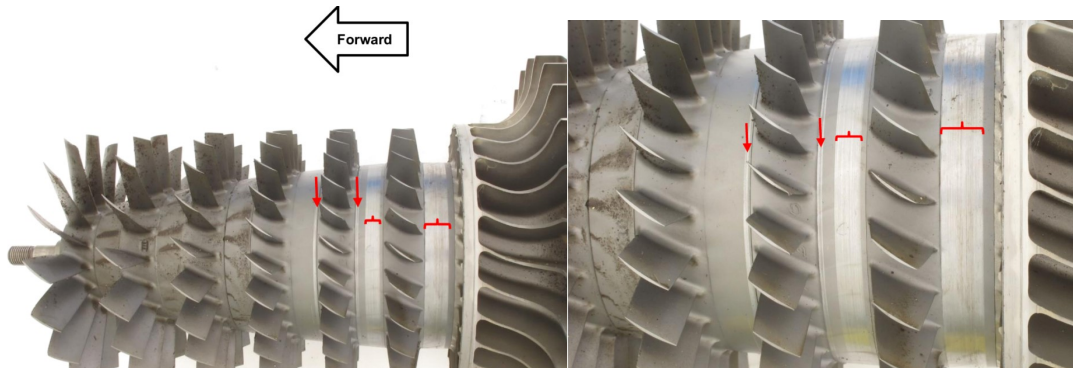


Figure 1. As-received condition of the compressor rotor assembly. Circumferential rub is indicated by the red arrows and braces.



Figure 2. Detailed views of circumferential rub on the compressor impeller.

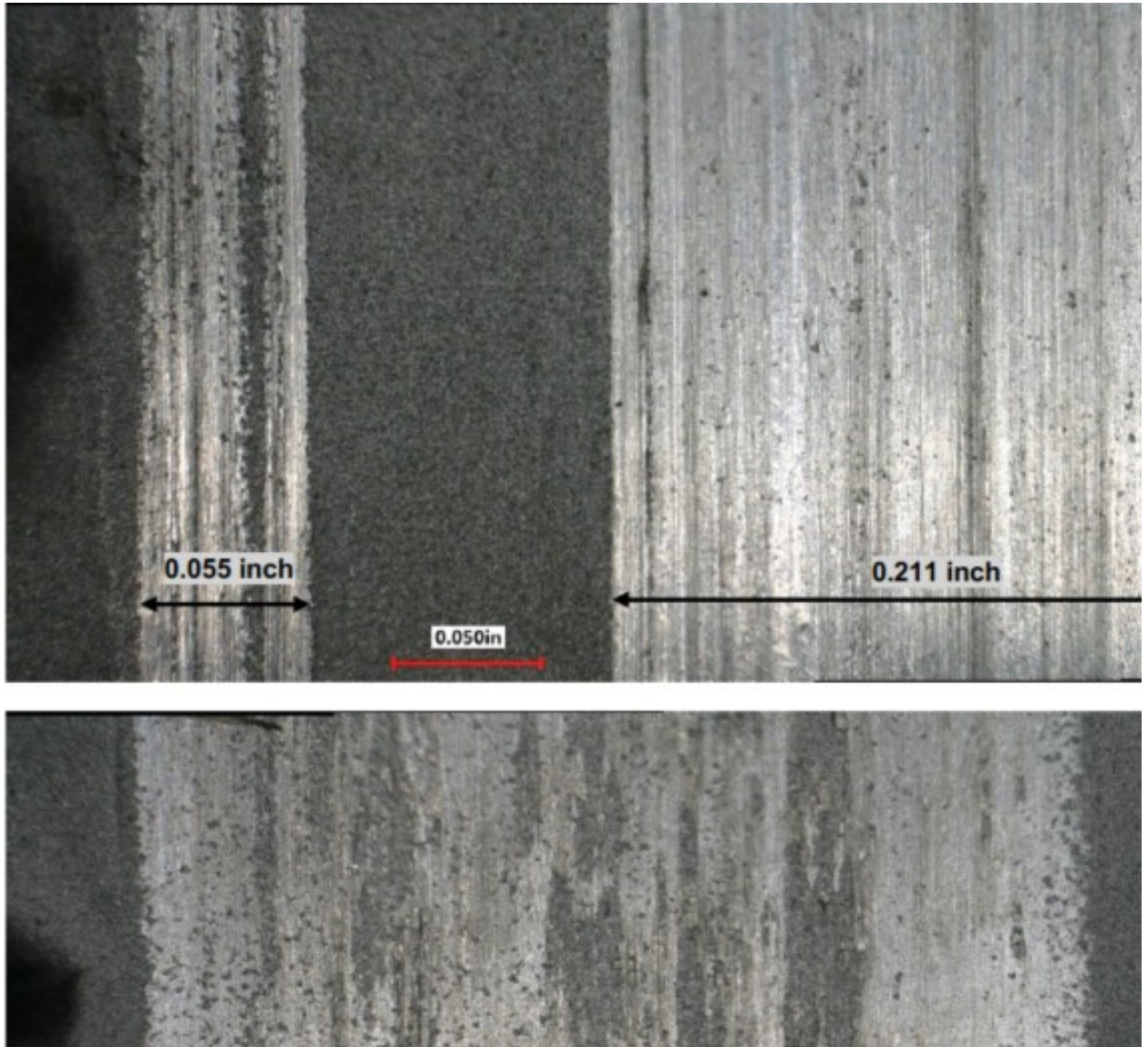


Figure 3. Detailed views of representative rub on the stage 5 compressor wheel (top) and stage 6 compressor wheel (bottom).

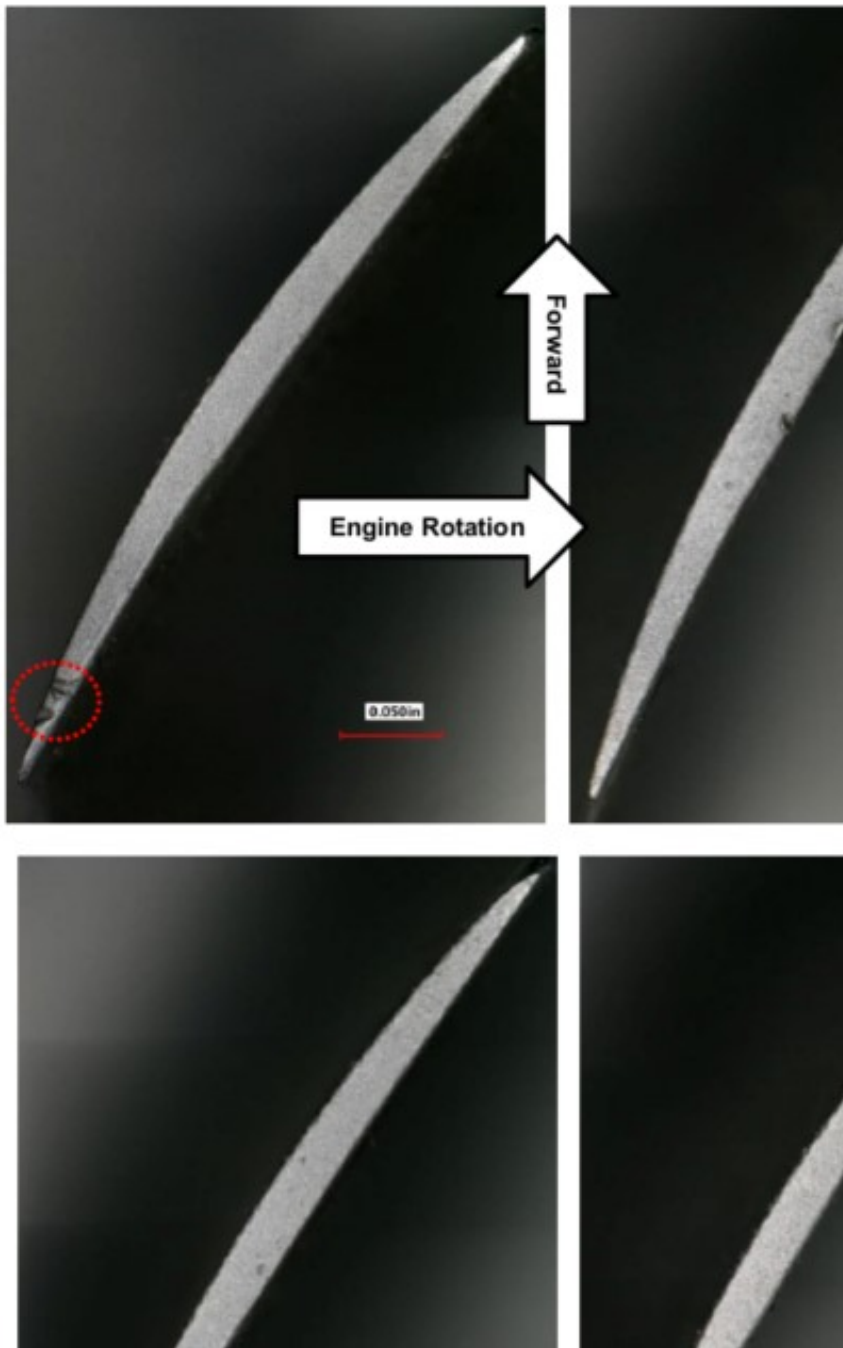


Figure 4. Detailed images of representative stage 5 blade tips. Each blade was approximately 90° from the previous in the direction of engine rotation. Trailing edge impact damage is indicated by the red ovals.

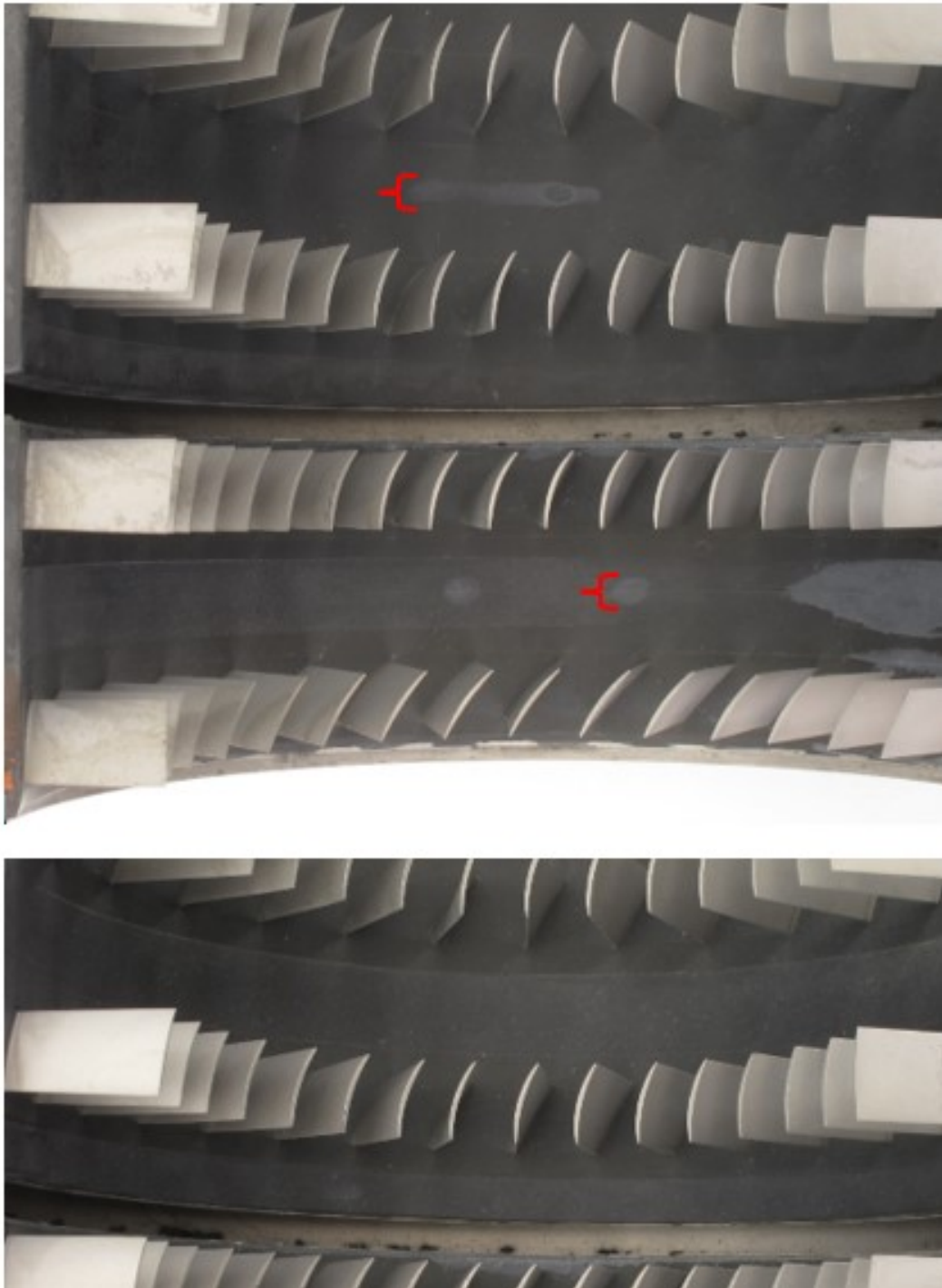


Figure 5. Detailed inboard looking outboard views of stages 3 through 6 of the top case half (top) and bottom case half (bottom) after cleaning. Rub is indicated by the red braces.

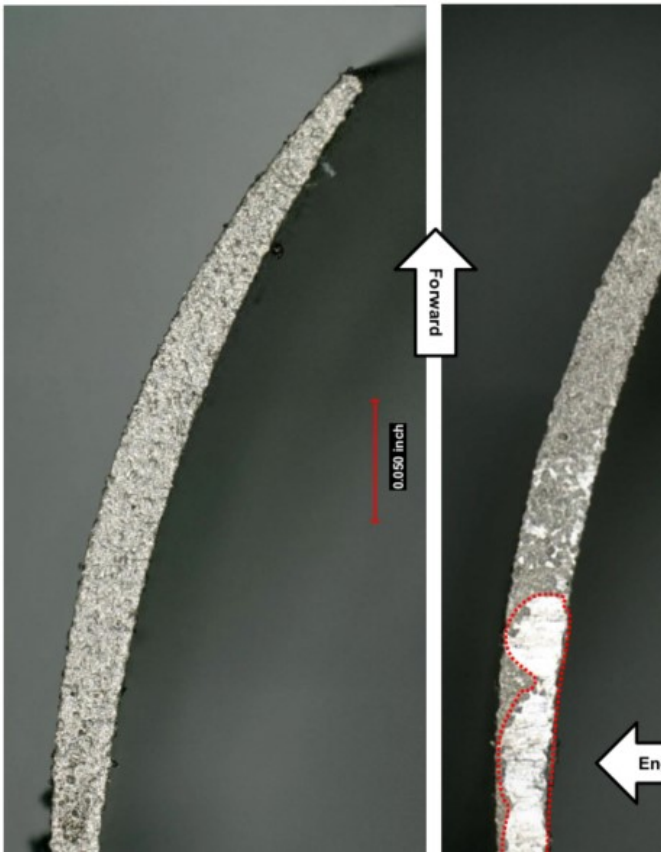


Figure 6. Detailed images of representative stage 5 vane tips from the top case half (left) and bottom case half (right). The vanes were approximately 180° apart in the compressor assembly. Rub is indicated by the red borders.

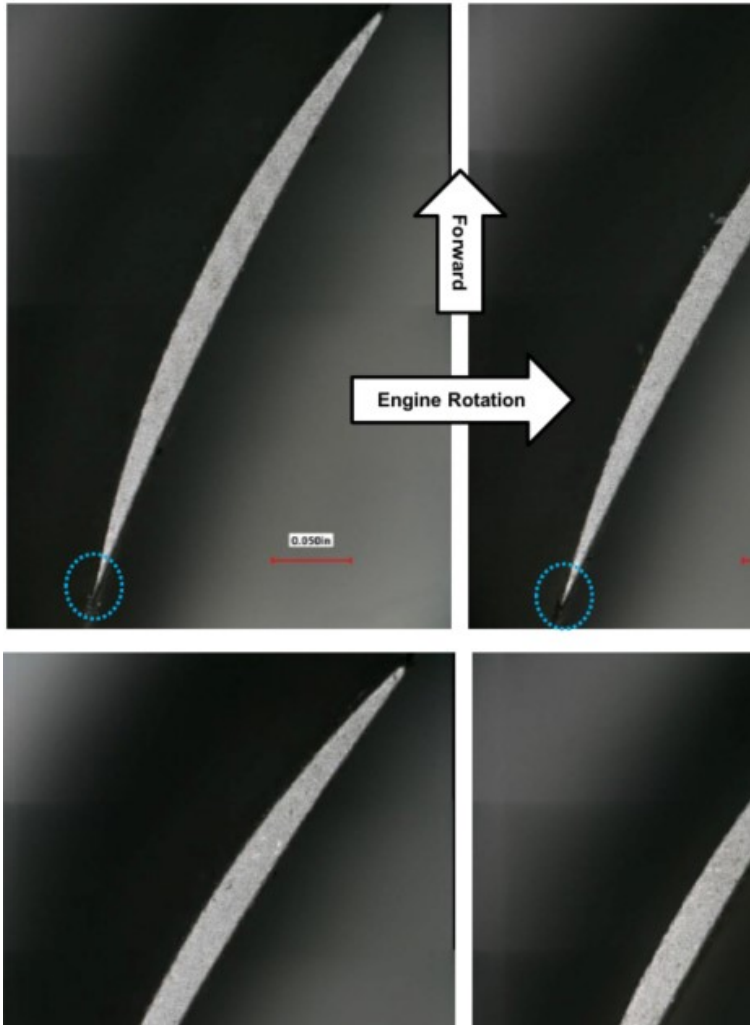


Figure 7. Detailed images of representative stage 6 blade tips. Each blade was approximately 90° from the previous in the direction of engine rotation. The trailing edges indicated by the blue ovals exhibited thinning consistent with erosion. The trailing edge indicated by the red oval also exhibited impact damage.

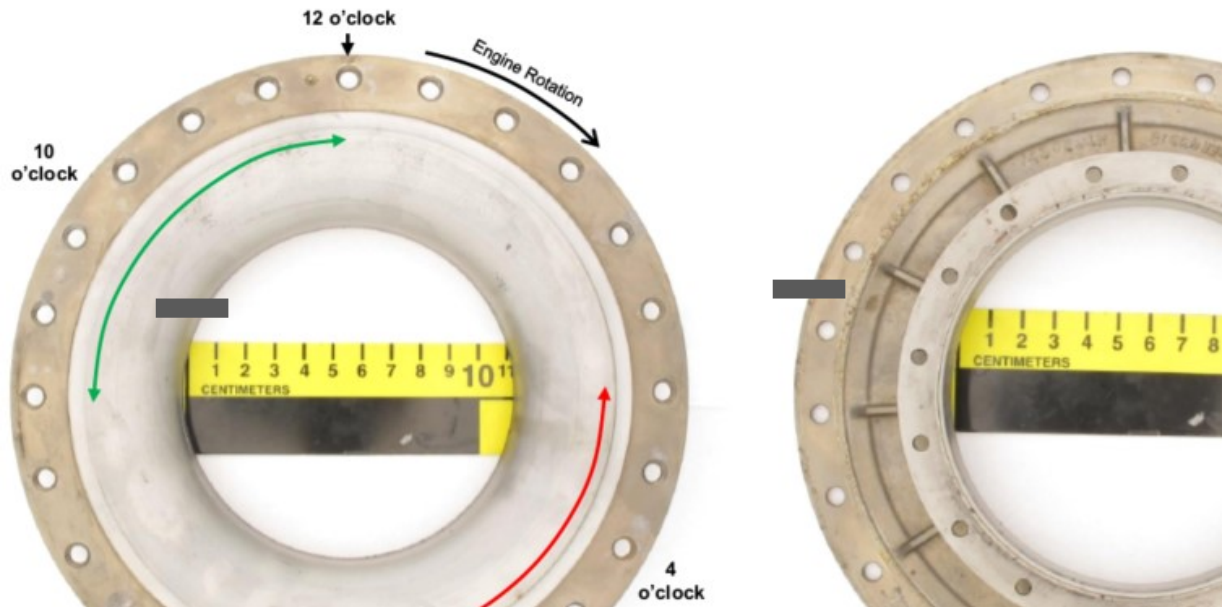


Figure 8. Aft looking forward (left) and forward looking aft (right) views of the compressor front diffuser assembly (shroud) in the as-received condition. The green and red double arrows indicate areas of least and most severe wear, respectively.

The rub on the stage 4 through 6 compressor wheels was likely due to compressor rotor imbalance. The compressor rotor was check balanced as part of the investigation. The measured results were 71.5 mg-in at the forward end and 118 mg-in at the aft end, which are greater than 5 and 8 times the allowable limits respectively. This type of imbalance could lead to the rotor orbiting on its centerline, resulting in the observed metal to metal contact.

The compressor build records detail the measurements taken and the final clearance between the impeller and compressor shroud. This clearance is related to compressor performance and efficiency. The larger the clearance between the impeller and shroud, the less efficient the compressor. According to build measurements, to achieve the documented bump clearance, a 0.034 inch shim stack would have been required. However, the shim stack measured by the Rolls-Royce laboratory removed from the rotor assembly was 0.0254 inches resulting in a difference of 0.0086 inches. The discrepancy in shim thickness would result in an actual clearance of 0.0186 which is >50% larger than the max build standard. An increased bump clearance would likely result in decreased compressor efficiency.

Best regards,

A handwritten signature in blue ink is visible above a grey rectangular redaction box.

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