HIGH MISALIGNMENT CARBON SEALS FOR THE FAN DRIVE GEAR SYSTEM TECHNOLOGIES

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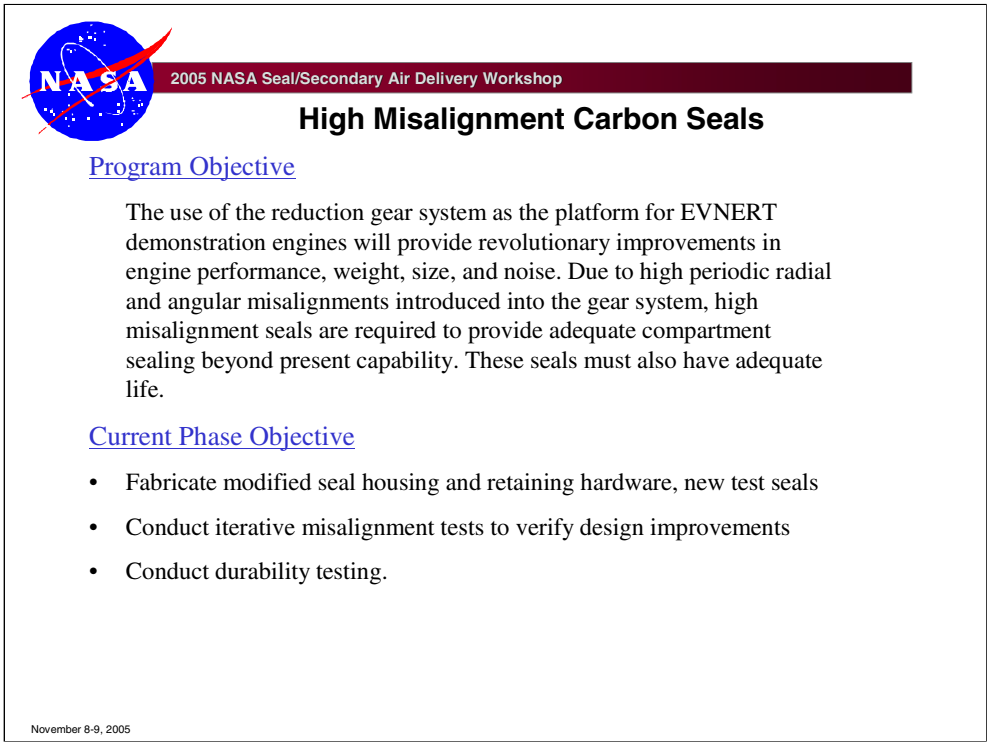
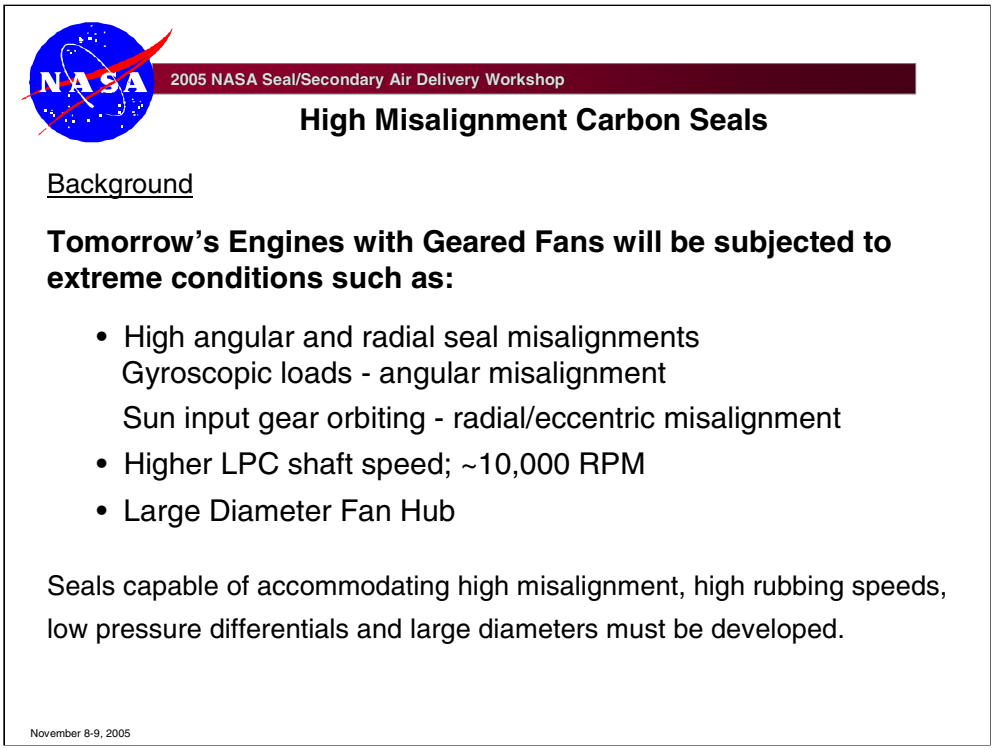
Aircraft engines of the future will require capability bearing compartment seals than found in current engines. Geared systems driving the fan will be subjected to inertia and gyroscopic forces resulting in extremely high angular and radial misalignments. Because of the high misalignment levels, compartment seals capable of accommodating angularities and eccentricities are required. Pratt & Whitney and Stein Seal Company selected the segmented circumferential carbon seal as the best candidate to operate at highly misaligned conditions. Initial seal tests established the misalignment limits of the current technology circumferential seal. From these results a more compliant seal configuration was conceived, designed, fabricated, and tested. Further improvements to the design are underway and plans are to conduct a durability test of the next phase configuration. A technical approach is presented, including design modification to a “baseline” seal, carbon grade selection, test rig configuration, test plan and results of analysis of seal testing.

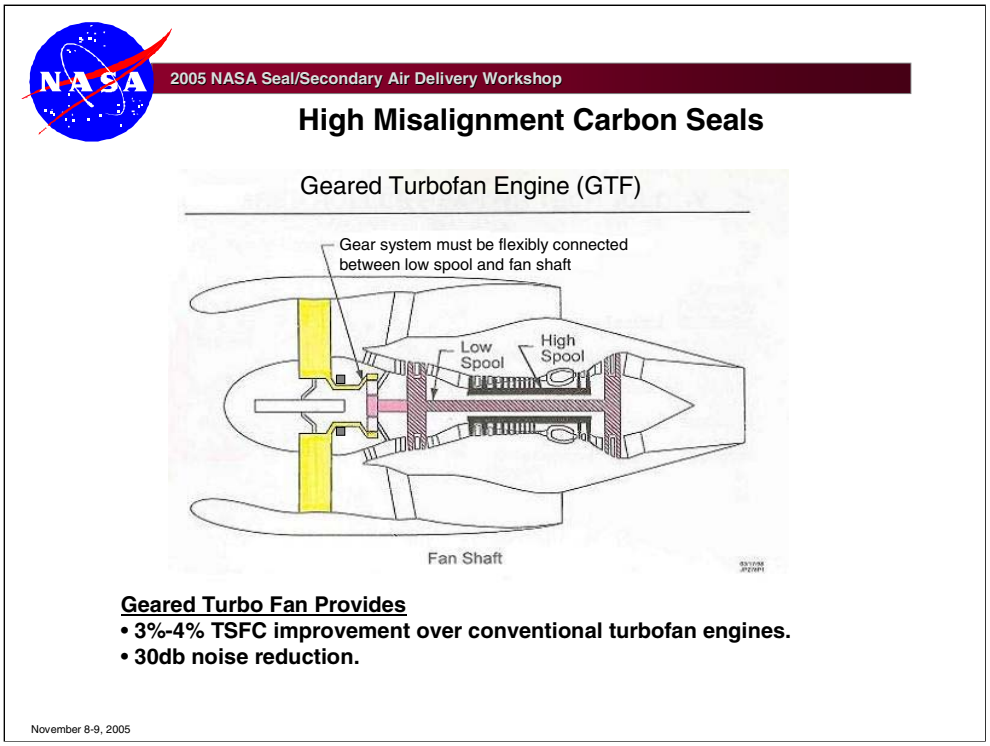


Overall program objective identifies the need for seals capable of periodic high radial and angular misalignment.

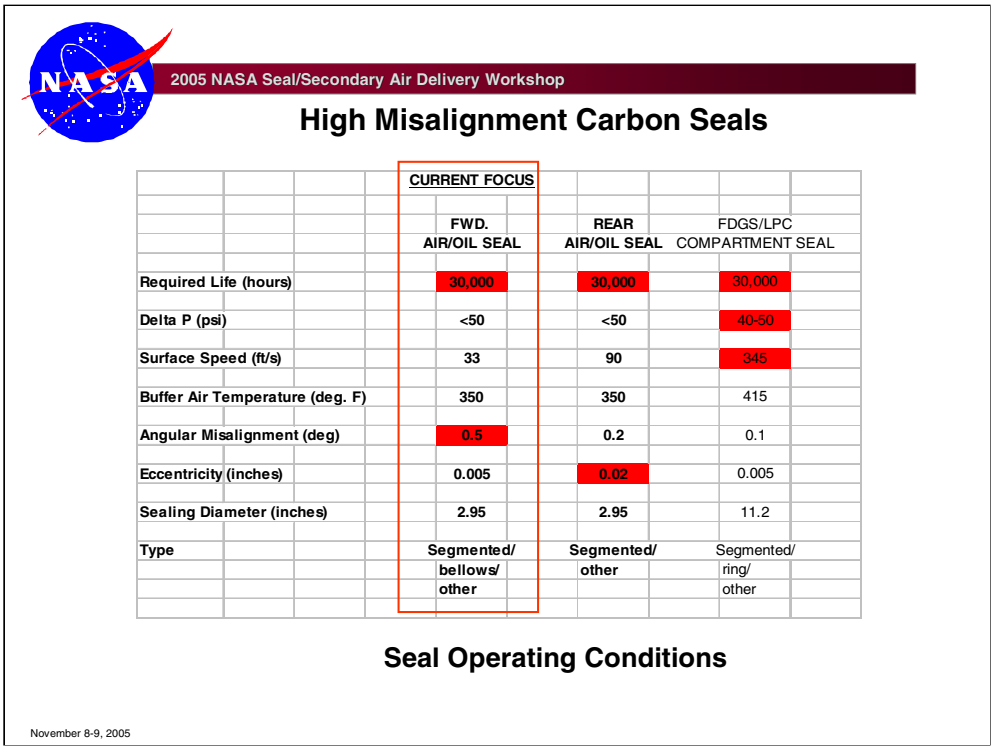
The current phase objective are to fabricate a modified seal housing and retaining hardware, conduct iterative misalignment tests, and durability tests.



Background information on principal causes of extreme conditions in Advanced Commercial Engines. Such conditions impose on seals high misalignment, high rubbing speed, large diameters and low pressure differentials.

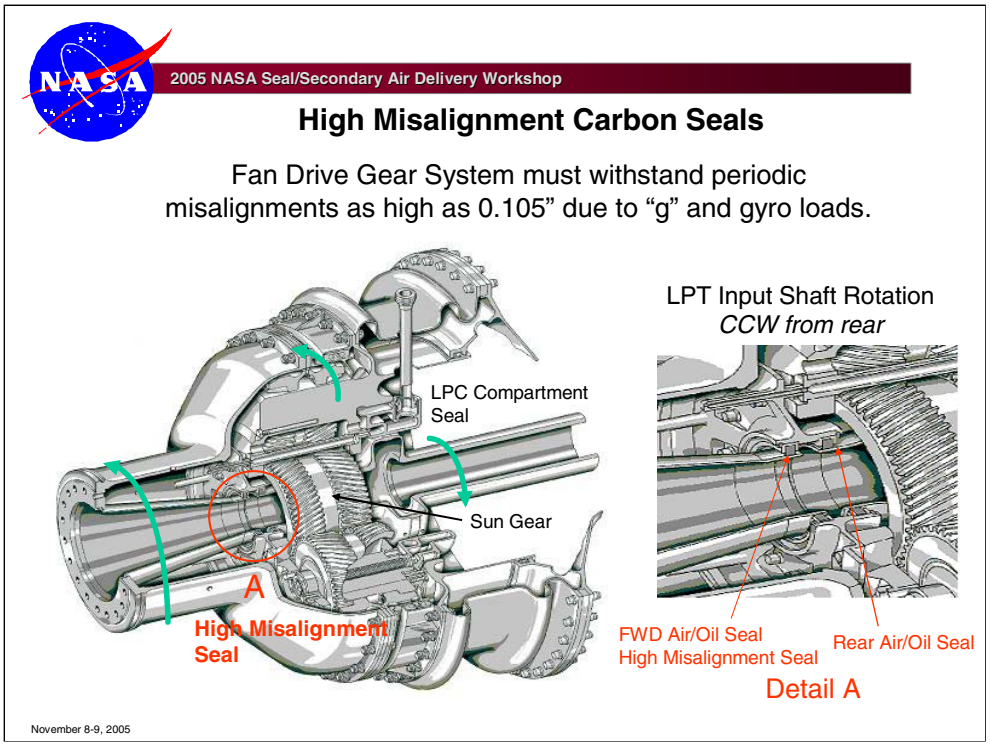


Misalignment seals are located along the flexible shaft between the low spool and fan shaft.

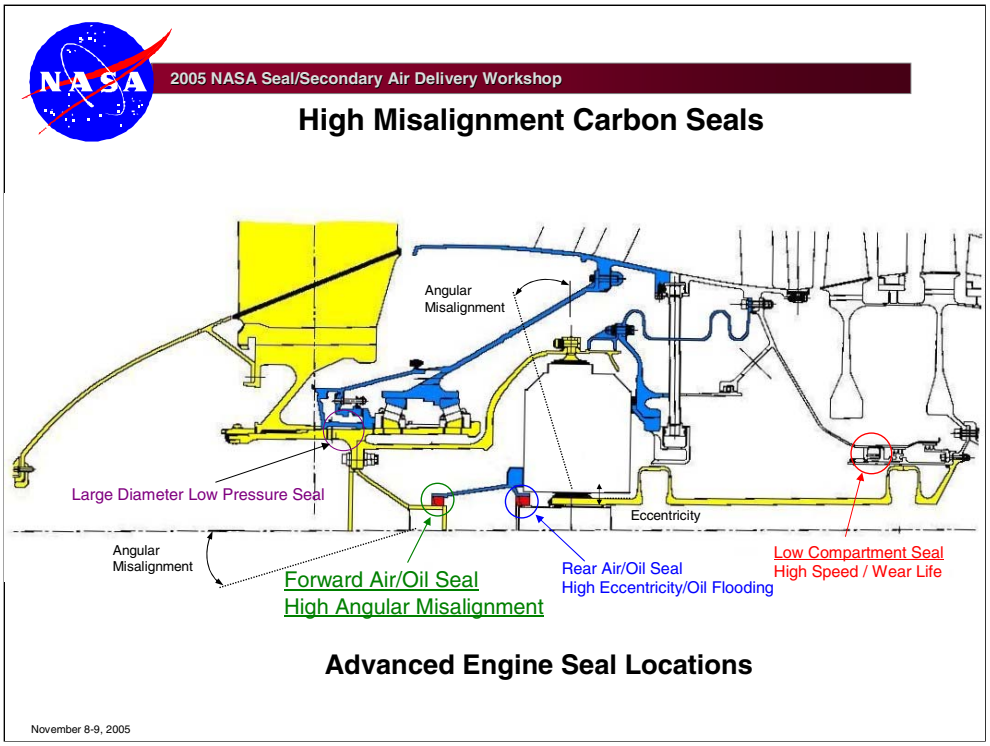


Seal operating conditions (required life, pressure differentials, speeds, misalignment levels and others).

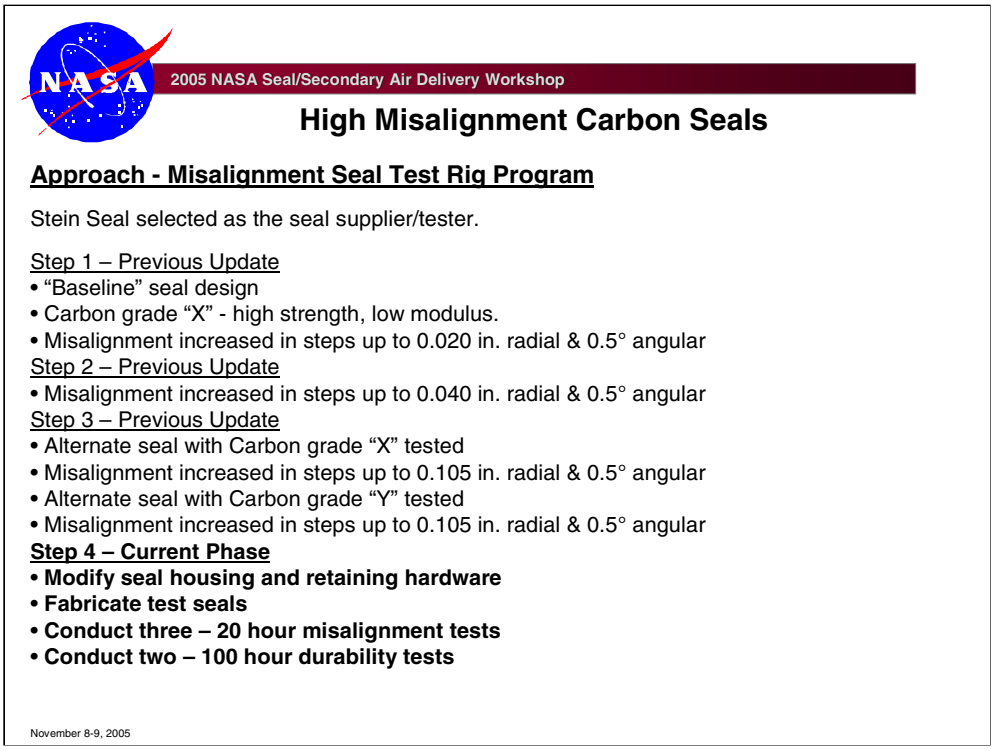
Critical requirements are highlighted.



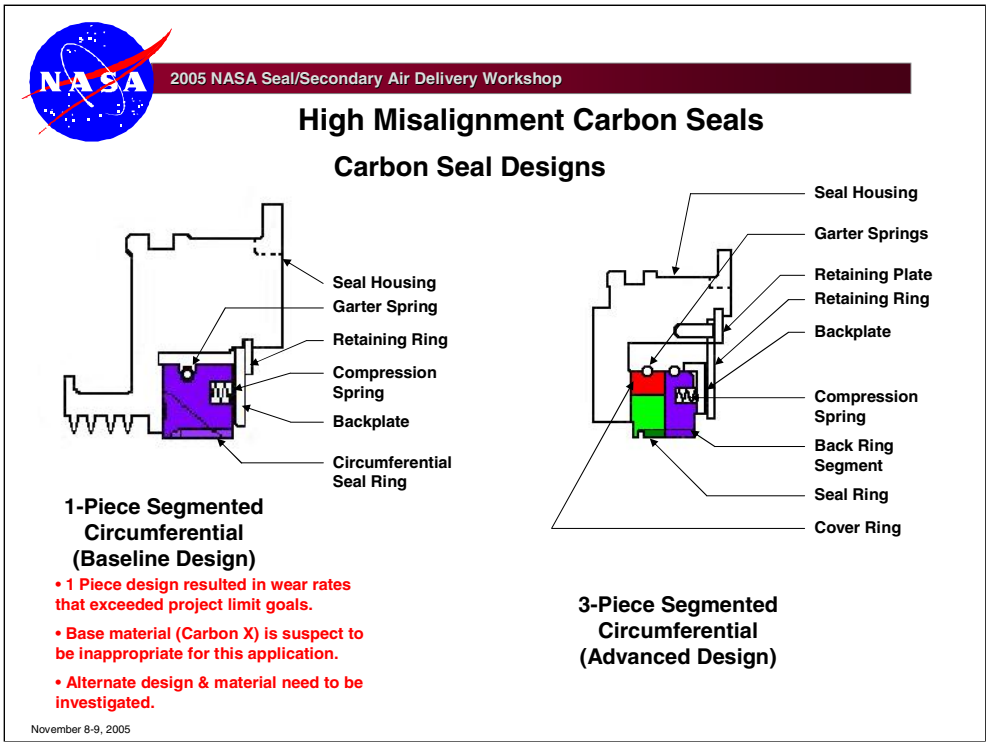
Fan drive gear systems must withstand periodic misalignments as high as 0.105” due to “g” and gyro loads.



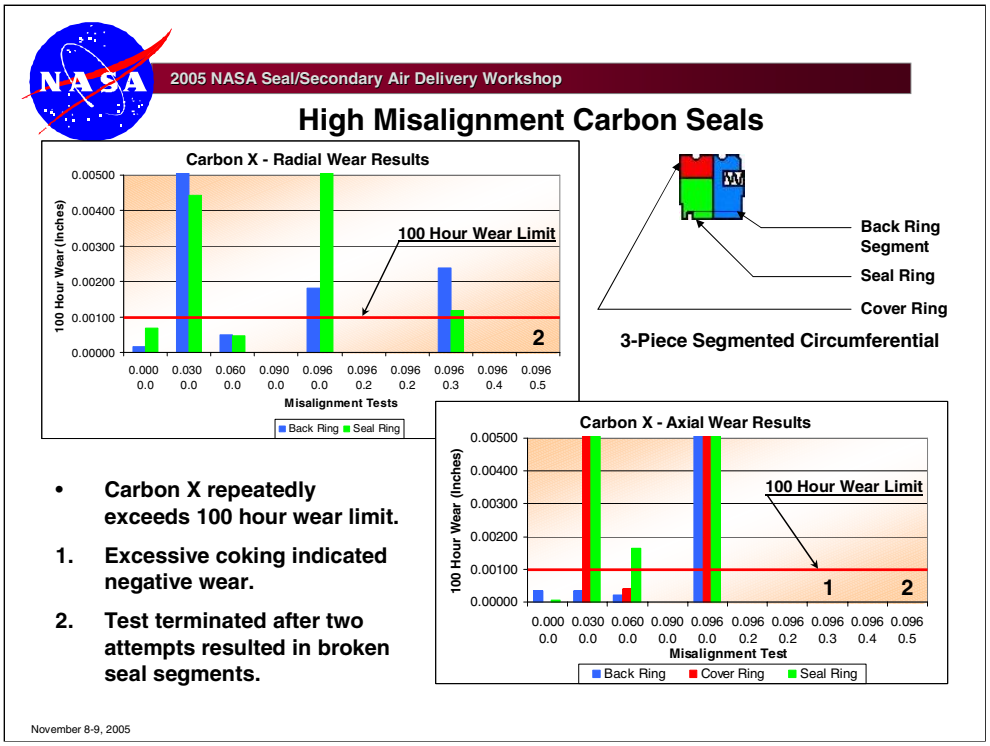
Seal locations within the forward compartments of the fan drive geared engine. Forward air/oil seal represents the location of the highest source of angular and radial misalignment.



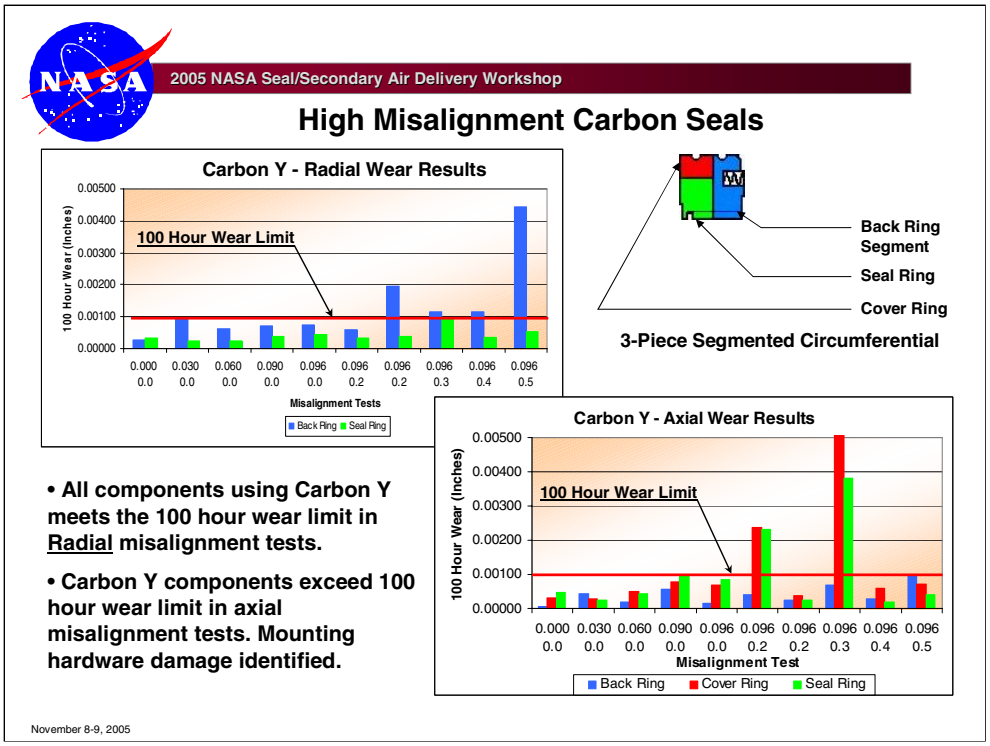
Technical approach of misalignment seal development program. The current phase represents the fourth main step since starting from "baseline" seal testing.



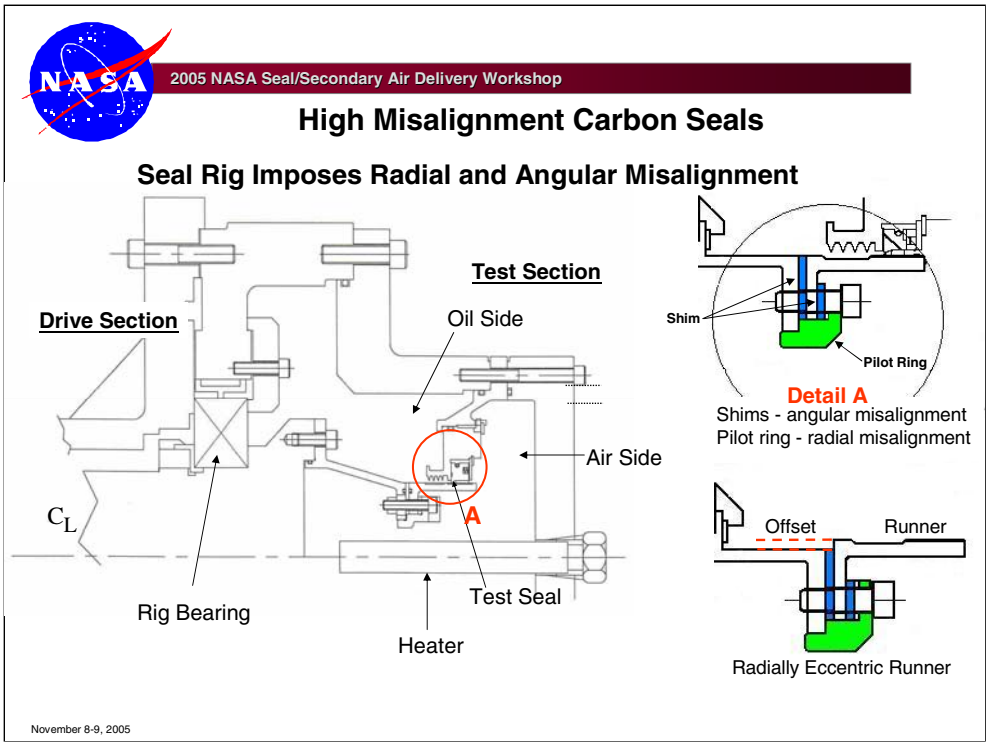
Baseline seal was compose of a one-piece 4 segmented seal. Alternate design is composed of a three-piece design, each piece consisting of four segments.



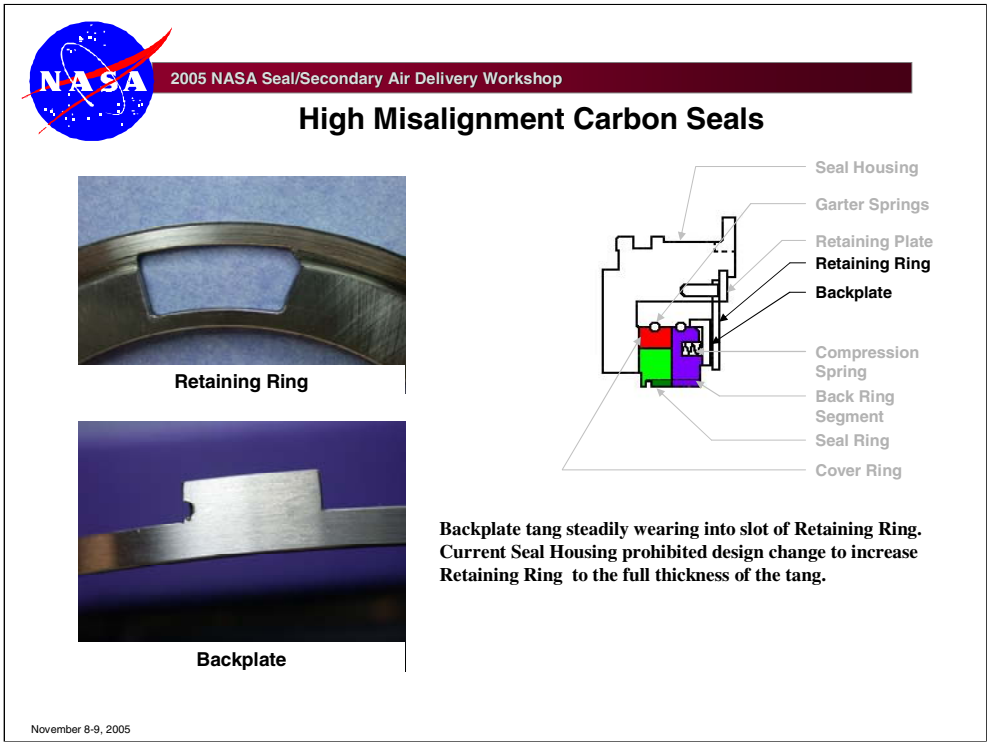
Carbon X repeatedly exceeds the 100 hour wear limit goal and testing was terminated after multiple failures.



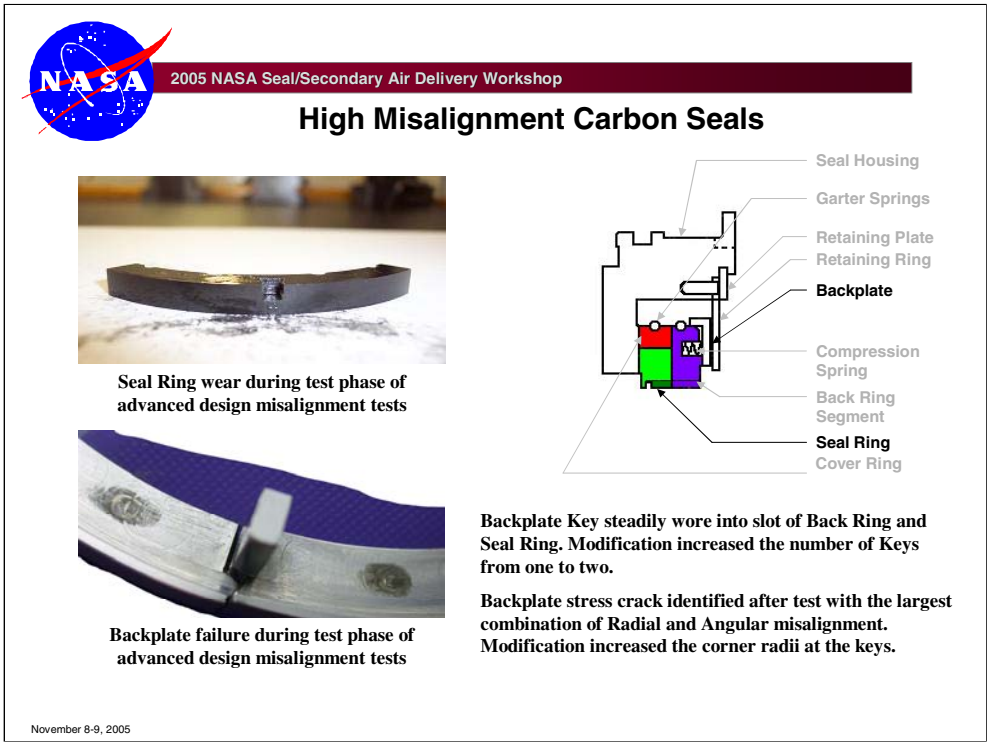
Carbon Y meets the 100 hour wear limit under purely radial misalignment conditions. Seal retaining hardware suffered fatigue and failure during combination radial & angular misalignment tests. These failures are to be investigated at the potential reasons for the 100 hour wear limit to be exceeded.



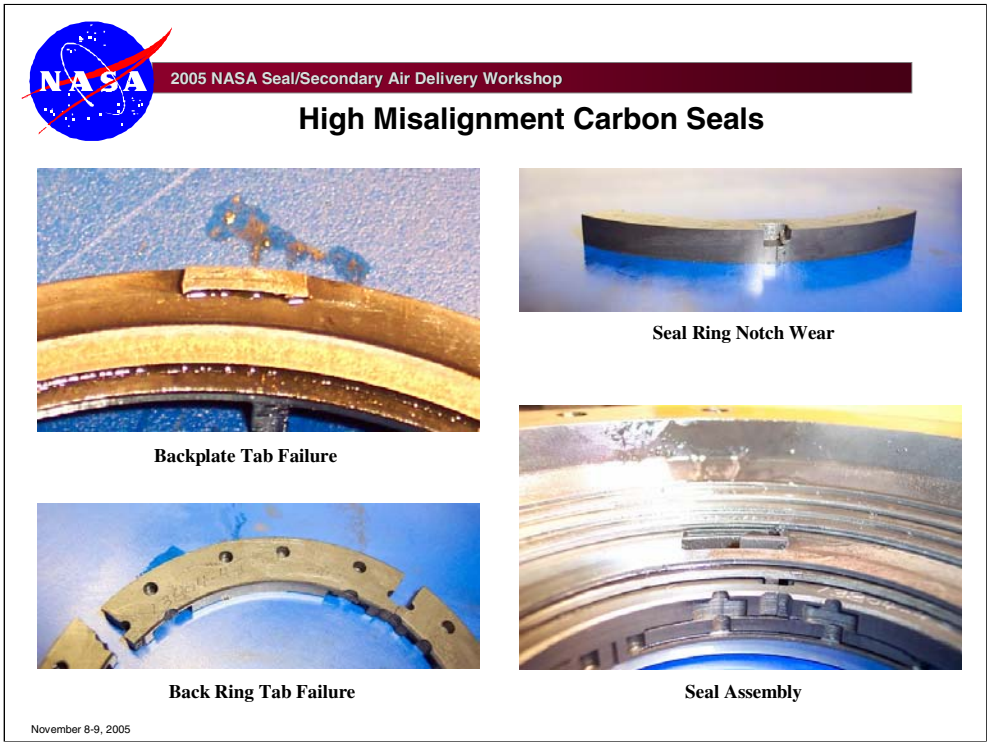
Seal test rig schematics used to impose radial and angular misalignment. Shims are used to impose angular misalignment and pilot rings are used to impose radial misalignment.



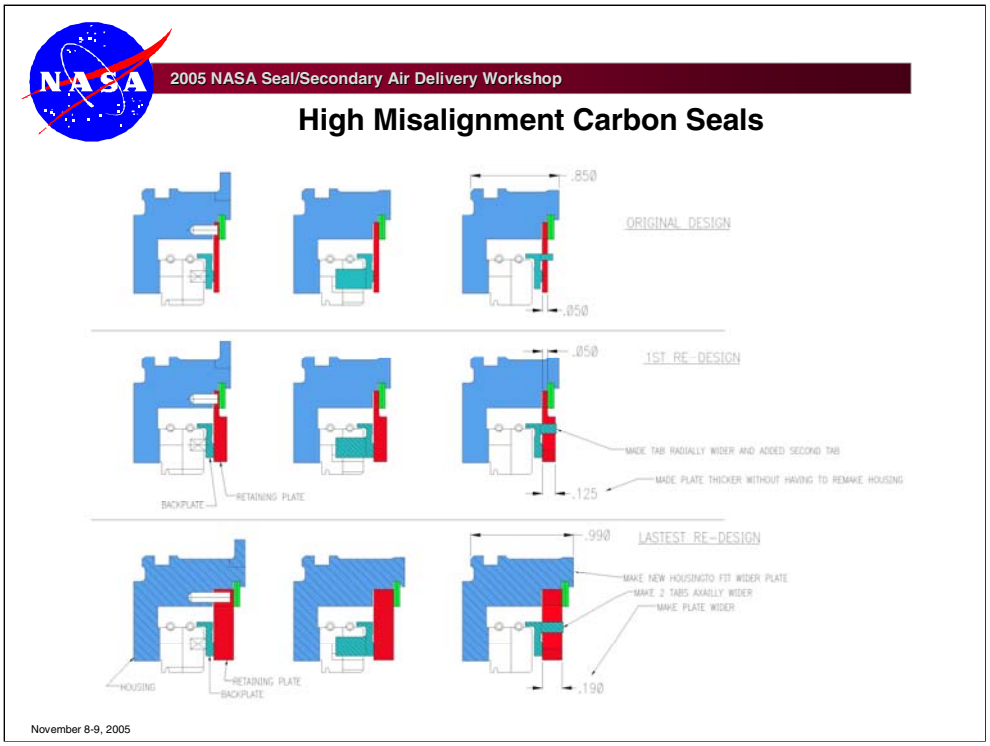
Photos of seal retaining hardware show the wear the occurred during misalignment testing.



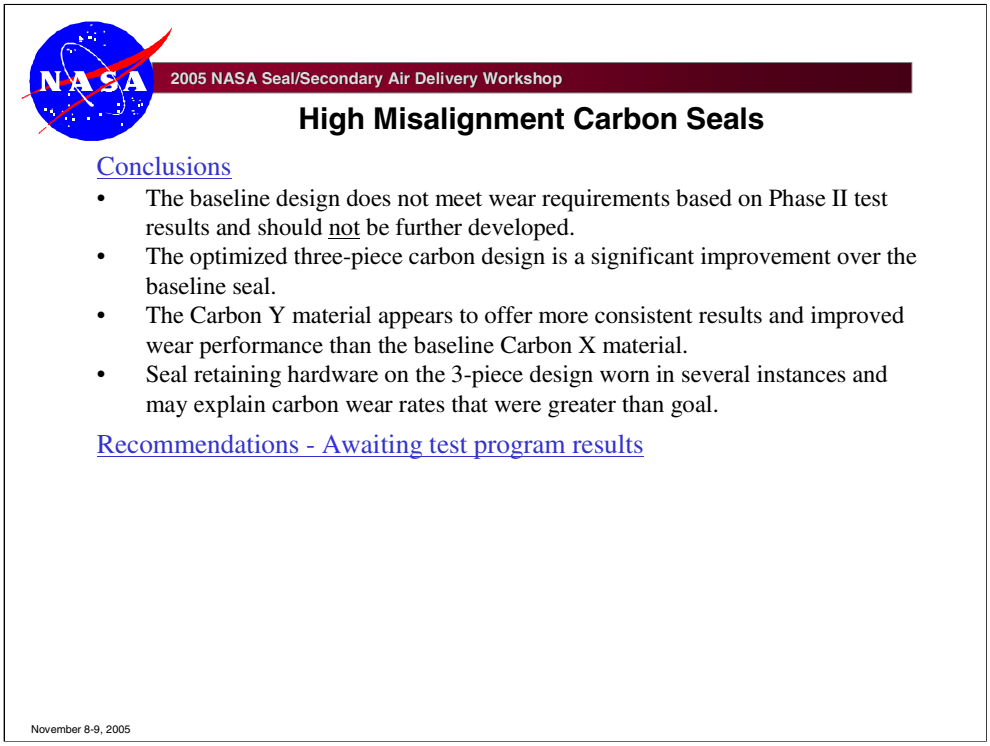
Photos of seal and associated retaining hardware show the wear and stress fracture that occurred during misalignment testing.



Photos of the seal assembly and signs of wear that occurred during misalignment testing.

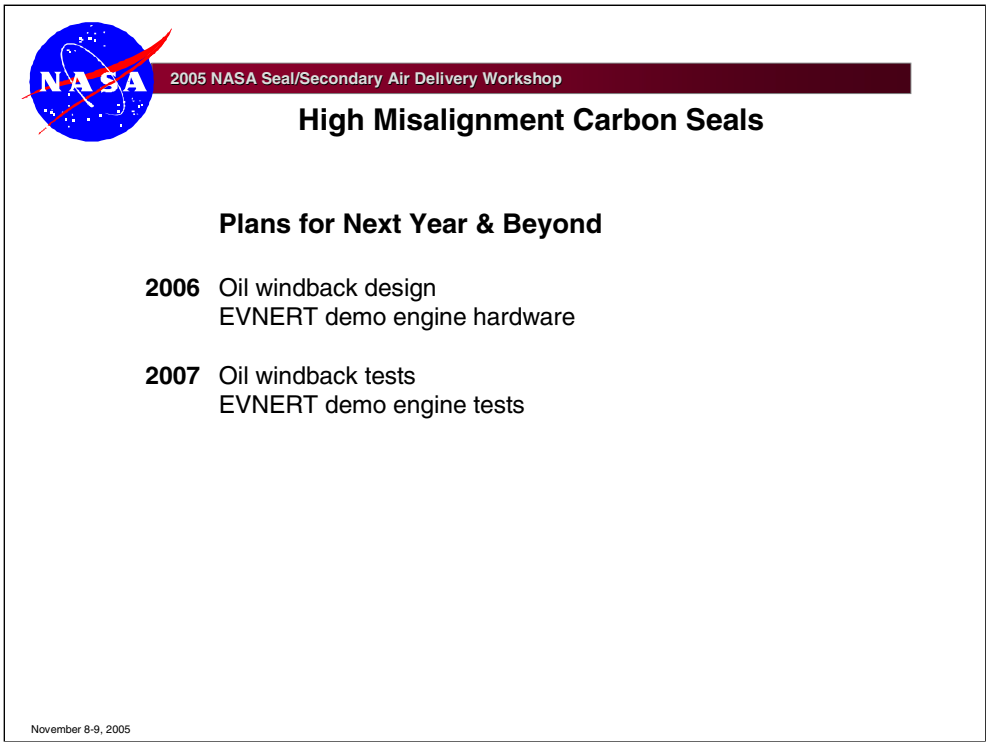


Sections through the test seal illustrate the original design, modifications made during the phase 3 test program and the latest re-design for the current tests phase.



Conclusions identify that baseline seal design should not be further developed. Also the 3-piece design is a significant improvement over the baseline design. Carbon Y material appears to offer improved wear results from that of Carbon X. Further work is needed to improved the seal retaining hardware.

Recommendations are pending the results of the current test phase results.



Plans for continuation include windback design and testing.