UDRI
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Aircraft Tire Retread Escalation Process
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Final Report

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Material intended for use by customer and designates.

I. OVERVIEW

This report documents progress on objectives identified in the amended project statement of work (9 August 05), as accomplished since the previous 6-month report on 17 October 05, and prior to termination of the project by mutual agreement as of 18 March 06. In addition, the report summarizes the primary research findings regarding aircraft tire retread escalation processes for the project duration from 11 August 04 through 18 March 06.

II. PROGRESS ON STATEMENT OF WORK OBJECTIVES

The amended project statement of work (9 August 05) identified two primary objectives, which were selected as result of findings from research performed during the first year of the project and suggestions from the FAA.

2.1 Objective: Work with industry to facilitate the documentation of a retread escalation process that would meet the needs of industry and be justifiable to the FAA from a technical and safety perspective. The contractor's input to this process may include, but not necessarily be limited to, compiling data received from industry into publishable form, and assisting in drafting mutually acceptable recommendations for revision of AC 145-4. It should be noted that in accordance with recommendations made to the FAA during year one of the research project, any proposed recommendations for accomplishing tire retread escalation are not expected to alter the general approach for retread facility and process qualification, which is accomplished for both technical and economic purposes by part number or size/ply/speed-rating.

2.1.1 17 October 05 Communication with RMA, identifying the parameters set forth by the FAA for UDRI contributions to revising escalation process documentation, and inviting RMA to meet with the FAA and UDRI to discuss the documentation update process and to define future UDRI involvement.

2.1.2 October 24 ~27 05 SAE Committee Meeting – subcontractor Harry Davis represented the UDRI project team at the meeting and assisted FAA personnel in delivering retread escalation research project status information to the A-5C subcommittee.

2.1.3 18 January 06 FAA/RMA Meeting – the FAA presented a process for industry to contribute to any necessary updates to AC145-4 by developing or updating an industry aircraft tire retread escalation process document for reference in AC145-4 revision. The industry document would incorporate technical changes needed to update quality control and inspection methods, instead of requiring future additional revisions to AC145-4.

2.2 Objective: Perform research concentrating in, but not necessarily limited to, evaluation of microstructure of tires of various types and service histories. The

microscopic structural analysis will be guided in part by interferometric inspection results provided by the retreader with each tire. Supplementary interferometric inspections may also be needed to better isolate the locations for microscopic analysis and to gain additional knowledge about fatigue detection using the inspection equipment as currently implemented in industry.

2.2.1 Examination of Collaborative Arrangement with USAF Landing Gear Test Facility – As follow-up to a contact made during the SAE A-5C meeting, UDRI personnel visited the Landing Gear Test Facility at Wright-Patterson Air Force Base. A mutual arrangement was identified in principle where UDRI personnel would make use of USAF interferometric inspection equipment to carry out its portion of the tire test plan. The tire inspection equipment would be equivalent to that used in the retread industry; and the arrangement would make use of the available government resources to accomplish the tire test plan in the most efficient manner possible.

2.2.2 Examination of Funding Mechanism for Agreement with USAF – CRDA and MIPR mechanisms were evaluated to identify a suitable mechanism for funding measurement of approximately 100 tires at the Landing Gear Test Facility at a cost of approximately $300 to $400 per tire. The project budget for the second year was found adequate to support the tire test expense.

2.2.3 20 December 05 Communication of Research Rationale and Plan to FAA and RMA, furnishing information in preparation for the 18 Jan 06 FAA/RMA meeting. This communication presented the background for the proposed tire test plan requested by the FAA, the basis for testing, knowledge to be gained, and methods to be employed, for consideration by the FAA and RMA in their discussions. Based upon increasing prevalence of industry use of interferometric inspections for evaluating retread tire fitness, together with the relative lack of aircraft incidents attributed to tire fatigue, the FAA and RMA concluded that need for the tire test plan did not have sufficient urgency to proceed with FAA-sponsored tire fatigue research at the present time.

III. SYNOPSIS OF PRIMARY PROJECT FINDINGS

3.1 Detailed discussion of project findings are presented in Six Month Progress Reports UDR-TR-2005-00093 (April 2005) and UDR-TR-2005-00189 (October 2005). These and additional documents containing significant supporting data and communications are included as attachments to this report:

A1. Summary Report and Minutes for SAE A5 Committee Meeting (Oct 04)
A2. Presentation, SAE A5 Committee Meeting (Oct 04)
A3. Communication to RMA (Nov 04)
A4. UDRI / FAA / Sandia Conference Call Minutes (Dec 04)
A5. Review of [previous FAA] Planned Research (Feb 05)
A6. Six-Month Progress Report, UDR-TR-2005-00093 (Apr 05)

A7. RMA Comments (Apr 05)
A8. Update, SAE A5C Committee Meeting (Apr 05)
A9. Summary Report, Aircraft Tire Retread Facility Visits (May 05)
A10. Telephone Discussion with Desser Tire & Rubber (May 05)
A11. Working Outline, Tire Test Plan (May 05)
A12. Communication to RMA (Jun 05)
A13. Communication to RMA and Wilkerson Aircraft Tires (Sep 05)
A14. Six-Month Progress Report, UDR-TR-2005-00189 (Oct 05)
A15. Communication to RMA (Oct 05)
A16. Update, SAE A5 Committee Meeting (Oct 05)
A17. FAA R-level Escalation Research Project [rationale and plan] (Dec 05)

3.2 Summary of Findings Regarding Proposed Updates To AC145-4

3.2.1 Aircraft Tire Retread Inspection Systems

Aircraft tire retreaders employ systems of quality inspections to help assure that escalated tires are worthy of continued use. In general, the prevalent inspections are visual, case pressurization, inner liner integrity, and interferometric.

3.2.2 Inspection Systems in Relation to AC145-4

Two significant comments may be made regarding the relationship between aircraft tire retread inspections and AC145-4. First, inteferometric inspection developed into a routine practice after the issue of AC145-4, and therefore, is not identified as a standard practice within the document. Second, a standard practice that pre-dates interferometric inspection – tread adhesion testing – is included in the document as a requirement for escalating groups of tires. Retreaders have learned that the tread adhesion test is much less useful for determining retread quality than the examination of each tire on its own merit, including interferometric inspection as applicable. Among retreaders surveyed, it was unanimously indicated that the tread adhesion test is no longer valuable for retread escalation, and has been performed nonetheless for purposes of compliance with AC145-4.

3.2.3 Analysis of Tread Adhesion Test

As a destructive test performed on a small sampling of tires, involving only a limited section of the tire, this test cannot indicate fitness of individual tires, which by virtue of the variability in each flight and maintenance cycle are subjected to unique service histories. One part of the test is also non-applicable to radial tires due to their differing construction. In addition to industry input and independent research, data collected and analyzed through previous FAA-sponsored research regarding tread adhesion testing were identified and considered. As a result, it has been suggested that the tread adhesion method not continue as a recommended minimum practice, and that further research to improve or generalize the method, not be undertaken.

3.2.4 Interferometric Inspection Prevalence

All retreaders of high-speed aircraft tires surveyed employ interferometric inspection in their quality control processes. To best manage quality control resources,

most retreaders select specific tires for interferometric inspection based upon part number, performance history, and customer requirements. Typically as a minimum, part numbers in high-stress applications, as well as new part numbers (including radial tires) are selected for inspection; and main gear tires are selected more prevalently than nose gear tires. A subset of tires are interferometrically inspected in the sidewall, based again upon application, performance history, and customer requirements. In general, the quantity of tires inspected interferometrically has increased owing to advancement in economy of this inspection to the overall quality control system.

3.2.5 Interferometric Inspection Results

Interferometric inspection results are reported as “anamolies” on a visual display. Anomalies indicate areas within the tire structure that respond dimensionally to short-term changes in external pressure, including those resulting from internal separations, embedded foreign objects, and gas trapped in the tire during the manufacturing process. Retreaders routinely dissect tires to confirm and expand their knowledge regarding the sensitivity of the inspection process and interpretation of detected anomalies. It is understood that certain types of tire damage may not be detected by interferometric inspection (for example, separations that are vented to the surface), however, such damage is generally presumed to be detected by other key tire quality inspections.

3.2.6 Interferometric Inspection Criteria

Each retreader develops acceptance criteria for number and size of anomalies as well as location within the tire, based upon experience and customer requirements. Inspection equipment may include the option of programming automatic recognition of tires for rejection based upon the retreader’s criteria, which may be defined globally or for each tire part number. Due to the absence of recommendations in AC145-4, and due to the situation-specific nature of tire anomaly criteria needs, retreaders have utilized their FAA-approved retread process specifications to identify their particular method for defining interferometric inspection criteria.

3.2.7 Industry Guidance Regarding Aircraft Tire Retread Process

SAE document ARP-4834 was developed by retreaders in concert with SAE A-5 committee participants in response to an FAA suggestion to generalize aircraft tire retread process guidelines to incorporate radial tire construction types. The document was issued with a modified version of the tread adhesion test, and therefore, predates the ascendance of interferometric inspection as a key means of assuring retread tire quality. As such, the document does not fully reflect the quality control processes presently used by retreaders, as has been acknowledged by retreader representatives. The original version of the document, while constituting an incremental step toward identifying updates in the retread process, would not function as a fully up to date reference for use by the FAA in a revised AC145-4.

3.2.8 Disposition of Proposed Updates to AC145-4

Proposed updates to AC145-4 were identified during the previous FAA-sponsored research project, in a document of recommendations identified as Draft AC145-4A. The document represented a synthesis of the AC145-4 guidelines, research findings, and retreader input. The original proposed version identified the use of interferometric inspection methods as an option that could be performed instead of the tread adhesion test. The tread adhesion test method was generalized to include radial tire use by altering the method and acceptance criteria, based upon statistical analysis. Later, a second version of the document appeared at the FAA with a critical distinction recommending both tread adhesion testing and interferometric inspection. At the time of the initial UDRI/FAA/RMA interchange regarding the present project, the original document was identified by RMA as being acceptable, and it was requested that the Draft AC145-4A be issued by the FAA as an incremental improvement to the retread process guidelines, while the research project proceeded in identifying the longer-term improvements.

The FAA discovered problems with Draft AC145-4A that precluded its issue: the timeline for the original update process had lapsed; the document had not been officially published for public comment; and the second version not deemed acceptable by RMA was the one entered in the document update process. Further, since the document contained a provision for escalation (tread adhesion testing) no longer desired by either the retreaders or the FAA, it was deemed counterproductive by the FAA to re-initiate the effort required for review and approval of the revision. This situation culminated in the conclusion identified at the 18 January 05 FAA/RMA meeting (see 2.1.3 above).

3.3 Summary of Findings Regarding Detection Of Fatigue In Aircraft Tires

3.3.1 Basis for Aircraft Tire Fatigue Detection Research

The FAA's request for tire fatigue research initially stemmed from the recommendations of previous FAA-sponsored research and from the addition of a new guideline in the Draft AC145-4A prescribing the use of a fatigue monitoring program. One retreader presented information to the FAA and UDRI describing such a fatigue monitoring program, based upon the hypothesis that relevant structural damage may exist within a tire that may not be detectable using standard interferometric inspection or other routine quality inspection methods. At the same time, since the present technology for interferometric inspection – shearography – is fairly new to the aircraft tire retread industry, it (in addition to detected anomalies) generates high-fidelity imagery that retreaders have indicated is not yet fully understood. Based upon both of these inputs, UDRI proposed that aircraft tire fatigue research concentrate on further investigating the meaning and discrimination of the interferometric inspection results.

3.3.2 Method for Aircraft Tire Fatigue Detection Research

Various methods were named or considered for the purpose of quantifying aircraft tire fatigue. Two of these examined – chemical and mechanical – were found not feasible for a general study of aircraft tire fatigue. As a composite assembly consisting of many components having various chemical and mechanical properties, which differ greatly by tire part number, the aircraft tire does not lend itself to quantification of fatigue by one-time measurements upon samples derived from real service. Chemical and mechanical methods (and likewise, non-contacting strain measurement methods) would require base-

lining a specific tire or portion of tire, aging via service or laboratory conditioning, then re-measuring for comparison. The results from such an intensive process, while meaningful to that specimen, could not be extrapolated to any other tires with different service histories or designs.

One method of tire fatigue examination – microscopic – was deemed promising, since the method of structural breakdown in a tire is generic, and may be monitored by degrees of separation of the interfaces between cord and rubber within the tire, among other possible visible changes. The plan proposed for aircraft tire fatigue research is therefore to perform shearographic inspection of a significant quantity of tires of various designs and service histories, and then identify particular areas of interest within the tires to evaluate microscopically, examining for relationships, correlations, and other information among the inspection data obtained. Initial FAA and RMA response to the plan was positive. However, the fatigue research plan was not carried to implementation, as result of FAA and RMA conclusions regarding the continued level of necessity for the research project (see 2.2.3 above).