

FINAL REPORT ON COOPERATIVE AGREEMENT FAA AND FIU

The agreement reached by the FAA Technical Center and FIU provided for testing panels in lieu of the FIU panels at the Technical Center to confirm experimentally the Finite Element Analysis results. A two million dollar curved panel testing equipment and facilities have been made available for just this type of experimentation at the Technical Center and the duplication of test equipment at FIU was deemed too expensive to be practical. The schedule and tentative agenda cited was very late due to construction delays and as a result several months passed by before the testing started. The first test was to use a shakedown panel to ascertain base line measurements for an artificial crack that was placed on the panel. The preparation of the shakedown panel after base line data was obtained was accomplished by FIU personnel with FAA assistance. The panel was taken to Lakewood, NJ for the spraying by Gusmer Corporation personnel. Some Kevlar sheets were placed loosely on the panel and the spray was accomplished with little difficulty. Once the panel was prepared and sprayed it was taken back to the curved panel testing machine to cure. It was anticipated that an additional two to three months would be necessary for the FAA testing people could have the curved panel machine available due to a heavy schedule for the testing machine. Dr. John Bakukas and his crew performed the test and the results were collected in a satisfactory manner. Dr Torres and Dr Wu were present for the entire test. The results were both good and bad. The Kevlar was not stretched in tension and as a result the foam located between the stringers and circumferentials were with many folds precluding the Kevlar to be of any benefit. Nevertheless, the PANTHERSKIN™ performed as the FEA had predicted. the following indicated who is to do the testing and when the testing will be done: Strain Profile and Crack Propagation Testing - The results accomplished by the FAA charted both the strain profile and the crack propagation, with the crack propagation was retarded by a factor of 3 times and the strain profile proved to be very similar to the FEA. FIU was to perform another Finite Element Study (bonded vs riveted) and a complete Material Property Study - FIU has finally molded all the bone shaped samples to complete the material property study but the final testing due to cure time of the foam will not be completed until the end of September. This material study should indicate the length of time that the curing strength should be around 6 months for a complete cure. While all of the samples have been molded they are not scheduled to be completed in the Instron until the end of August. The second FEA with bonded stringers will be underway this summer with a completion date of all data by the end of September. At that time the optimum temperature of formation of the PANTHERSKIN™ and the relative strength to density ration, along with cure time and the methodology of the system to be able to use in the field.

FLORIDA INTERNATIONAL UNIVERSITY

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(1) Finite Element Study

It was mutually agreed that the continuation of FEM studies proceed. Two FEM studies have been involved in the study thus far. The first FEM study was an FIU study accomplished by Dr. Wu to ascertain how to place the strain gauges in the strain tests performed on an aircraft door. This FEM study basically provided distribution of strain across the surface area. It showed that the strain was distributed symmetrically over the surface of the skin and that only one corner needed the instrumentation to measure strain.

That study was completed and the results of the experiment provided us with the preliminary data that have been reported.

The second FEA study is one that we have received from the FAA Hughes Technical Center has been completed. Dr Wu and a graduate student have worked on the study with positive results. To start with, they converted the program to fit the ABAQUS program and found that the design of the program did not allow for bonding of the Panther Skin™ to the Aluminum.

They then succeeded in converting the program to the ABAQUS system and the results were extraordinary. The result of the analysis showed that the Fatigue Life of the aircraft would be extended to 2.5 lifetimes for a two inch thick layer of PANTHERSKIN™ to a 5.1 lifetime for a 3.5 inch thick layer of PANTHERSKIN™. Again it has been mutually agreed upon that another finite element analysis be accomplished, this time with bonded components in lieu of riveted components. This study along with the basic properties of foam for strength versus density, curing times etc. will be done at FIU. This will require two undergraduate students and one graduate student. It has been agreed that FIU would accomplish another FEA for a bonded stringer panel in lieu of rivet attached panels. The schedule for this is for FIU to start as quickly as possible to secure a graduate student to be accomplished as quickly as possible under the new conditions. This will start as soon as the additional funds are available to support the graduate student.

(2) Material Property Study

A more comprehensive study of the strength properties of PANTHERSKIN™ under a variety of circumstances will continue. The original formulator of PANTHERSKIN™ indicates that the strength of PANTHERSKIN™ goes up as the square of the density. An investigation to determine the veracity of this property will continue. Curing time has been observed in past tests. From all the experimental data it appears that six months curing time more than doubles the strength of the poured-in-place foam. A comprehensive study will be done by FIU to confirm not only this but also the curing time of the sprayed foam. The initial indication is that the sprayed foam, underwent a higher temperature during the foaming period, is stronger and its curing time appears to be much quicker than the pour foam due to immediate cross linking rather than a timed cross linking. This study will commence immediately ascertaining all material strengthening parameters. A curing time analysis will be made for every 10 °F added to the spray fluids. It is expected that the increased temperature will strengthen the foam as well as shorten the curing time.

FAA TESTING AT WILLIAM J. HUGHES TECHNICAL CENTER

Atlantic City International Airport, New Jersey
Strain Profile and Crack Propagation Testing

A complete three-dimensional section of fuselage with the above description was tested with the PANTHERSKIN™ and the results were as indicated.

STRAIN REDUCTION: As predicted by the FEA it appears that a strain reduction is evident in the actual test on the curved panel testing machine. The approximate reduction was noted at about 6%. Only one panel was tested and the results would confirm that in this one test an approximate life extension of one life time would be the end result.

CRACK PROPAGATION: The crack propagation rate was found to be retarded by a

factor of 3. Meaning it would take three times longer for the crack to reach critical length than the panel without the PANTHERSKIN™

In addition a burn through test was accomplished on the same panel in the new testing facility to determine the length of time for burn through and according to the FAA information was about 60 seconds short of the desired burn through for the new mandate to be issued. Testing is underway at FIU to extend the time for burn through to meet the new standards. This is being accomplished by a new chemical flame retardant being substituted into the formula for improved burn characteristics.

FAA DEMONSTRATION TEST, VALIDATION CENTER, ALBUQUERQUE, NM

During the Third Joint FAA/DID/NASA Aging Aircraft Conference an opportunity to spray an existing retired aircraft and a defective panel with PANTHERSKIN™. The validators indicated that all flaws could be seen through the foam and that the methodology would be compatible with NDT methods of inspection.