

Improved Affordability for Composite Structures

Interim Report for the PDMT Panel Meeting

NSRP ASE Project No. 2007-373

September 25, 2007

Improved Affordability for Composite Structures - Outline

- Background
- Project Overview and Objectives
- Small Scale Panel Production
- Small Scale Panel Assembly
- Lessons Learned

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Improved Affordability for Composite Structures

Background

Large Composite Structures Utilizing Flat Panels



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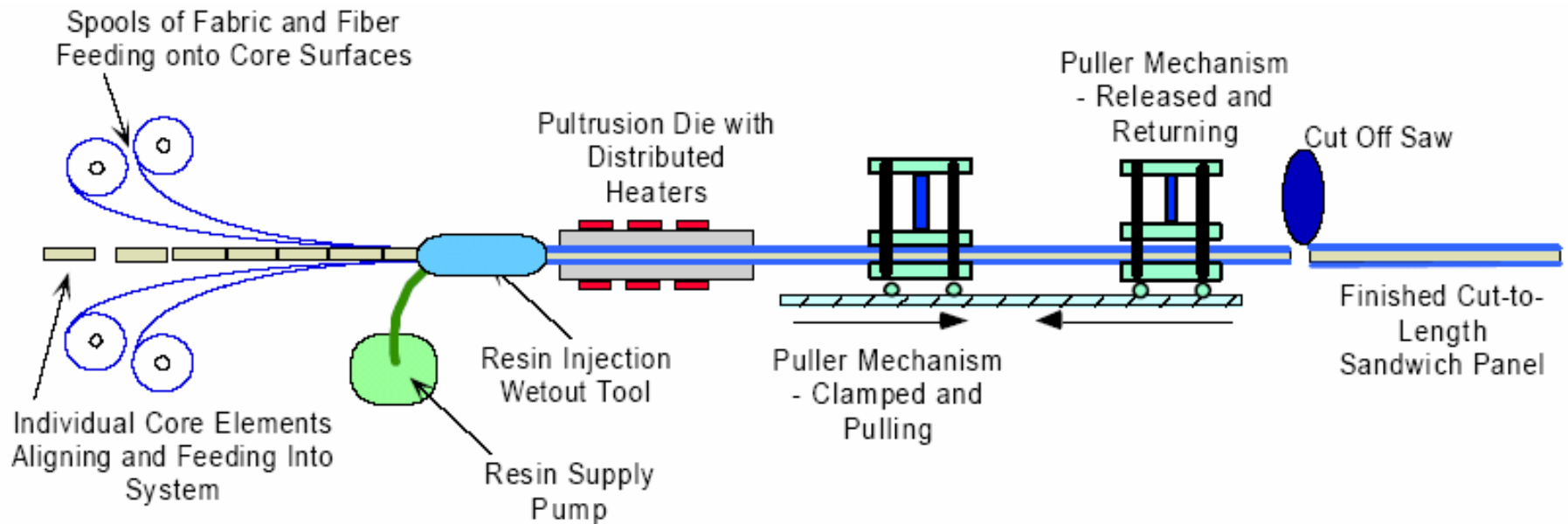
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Pultrusion Technology for Flat Panels

- Low cost pultrusion technology has demonstrated panels and joints equal to VARTM process.



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10 Foot Wide Pultrusion Machine at KaZaK Composites Inc.



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Pultruded Sandwich Panels Produced with ONR Funding



Photo courtesy of Bedford Reinforced Plastics Inc. in Bedford, Pennsylvania.



Photo courtesy of Bedford Reinforced Plastics Inc. in Bedford, Pennsylvania.

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Pultruded Sandwich Panels Shown to be Equal to VARTM Produced Panels



Panel testing performed by West Virginia University
Constructed Facilities Center – FRP Center of Excellence.



Panel testing performed by West Virginia University
Constructed Facilities Center – FRP Center of Excellence.

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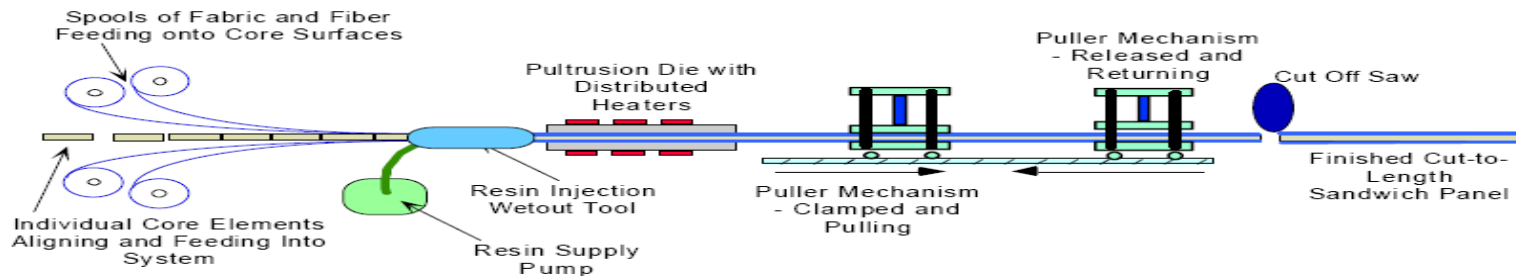
Improved Affordability for Composite Structures

Project Overview & Objectives

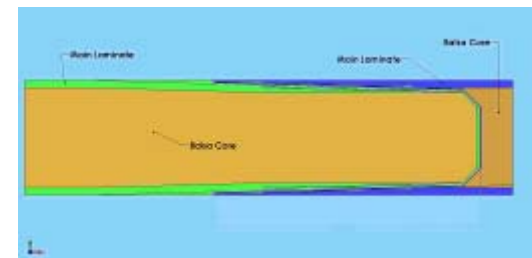
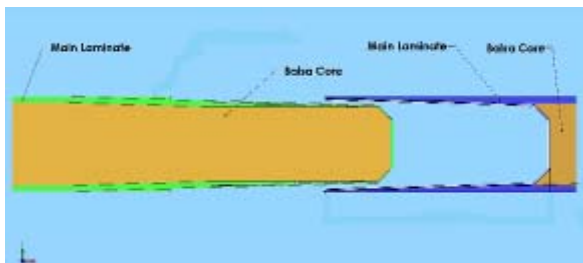
Pultrusion

A Continuous Process for the Rapid Manufacturing of Flat Composite Sandwich Panels

Pultrusion Technology



Integrated Joint Feature



Panel Fabrication



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Pultrusion

A Continuous Process for the Rapid Manufacturing of Flat Composite Sandwich Panels

Project Objective

Make composites more cost competitive with traditional shipbuilding materials.

Specific Technical Goals

- 1. Develop methods for joining pultruded panels.**
- 2. Demonstrate labor savings.**
- 3. Demonstrate equivalent strength.**

Project Phases

- 1. Small scale assembly**
- 2. Production scale assembly**
- 3. Testing and integration**

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Pultrusion

A Continuous Process for the Rapid Manufacturing of Flat Composite Sandwich Panels

Project Metrics

1. Panel production – goal is 60% of VARTM labor hours.
2. Bonded joint strength – goal is 100% of VARTM panel.

Funding Plan and ROI

Funding request is \$1,976,494 with cost share of \$988,247
Project ROI is >100% with 10 year NPV of ~ \$15MM

Project Team

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Project Team

- **Northrop Grumman Ship Systems**
 - Ron Wood – Program Manager
 - Dick Hodges – Principle Investigator
 - David Loving – Composites Engineer
 - Harold Brashears – Scientist
 - Mark Losset – Project Manager
- **KaZaK Composites**
 - Jerry Fanucci – President & CEO
 - Mike McAleenan – Composites Engineer
- **Naval Surface Warfare Center Carderock Division**
 - Michael McDonald – Mechanical Engineer

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Improved Affordability – Project Tasks

■ Phase I

- Task 1-1 Construct Small Scale Assembly Fixture
- Task 1-2 Assemble Small Panels

■ Phase II

- Task 2-1 Pultrude 10' Wide Panels (KaZaK)
- Task 2-2 Construct Production Scale Assembly Fixture
- Task 2-3 Assemble Production Scale Panels
- Task 2-4 Construct VARTM Test Panel

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Improved Affordability – Project Tasks

- **Phase III**
 - Task 3-1 Prepare Panel Specimens for Testing
 - Task 3-2 Conduct Panel Scale Test Program (NSWC)
 - Task 3-3 Project Analysis and Integration

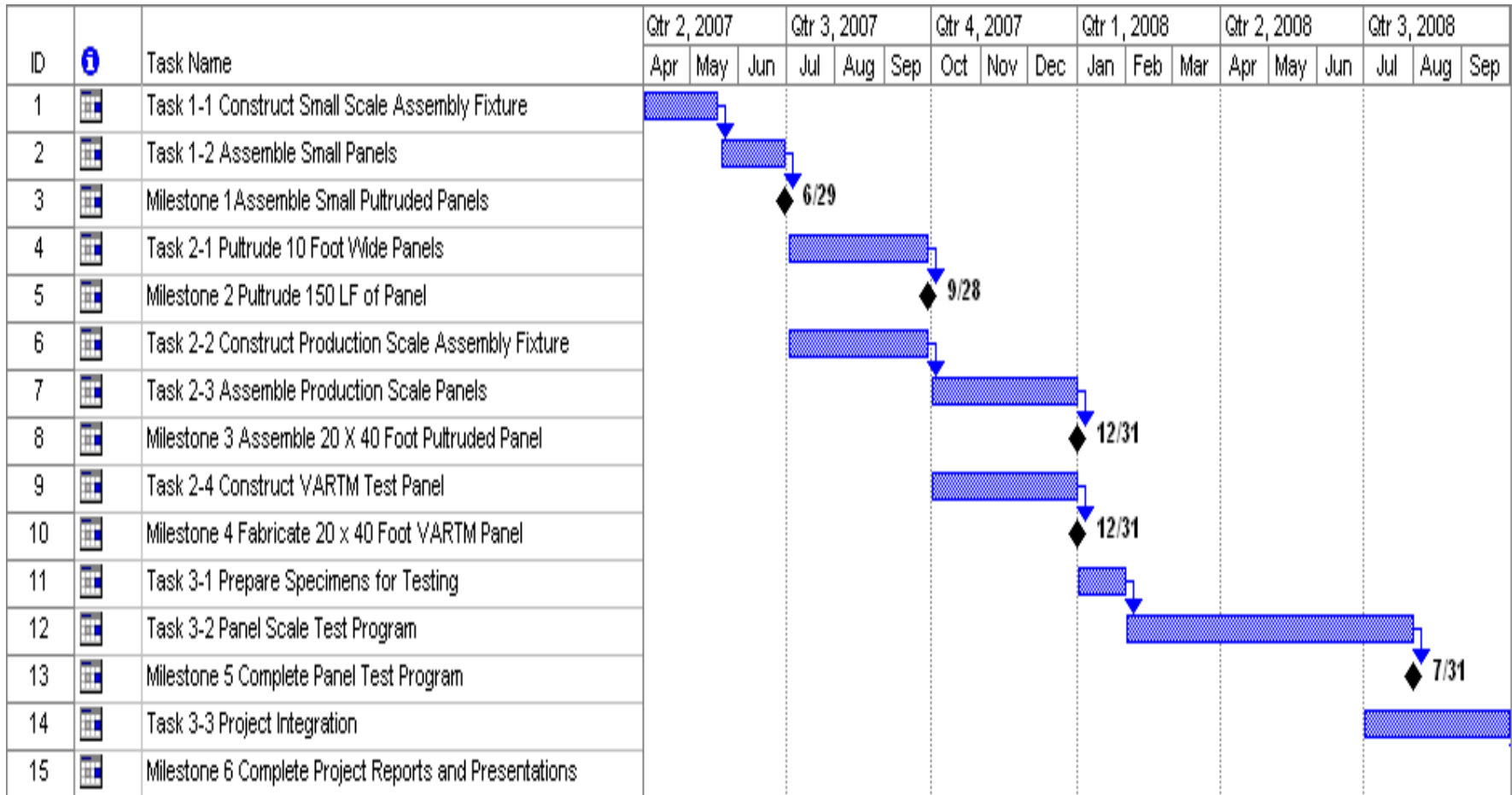
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Schedule of Milestones



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Tasks and Metrics

PHASE	TASK	METRIC	STATUS
Phase 0	Initial Administrative TASK		
Task 0-1	Kick off meeting	Kick-off meeting completed and project turned on.	Finished March 1
Task 0-2	Management Plan	Management Plan submitted to ATI by March 30.	Submitted March 30
Task 0-3	Tech. Transfer Plan	Tech Transfer Plan is submitted to ATI by March 30.	Submitted March 30
Phase 1	Small Scale Assembly		
Task 1-1	Construct Small Scale Assembly Fixture	Construction of small scale assembly fixtures completed.	Completed April 30
Task 1-2	Assemble Small Panels	Demonstrate assembly of small panels.	Complete July 31
Phase 2	Production Scale Assembly		
Task 2-1	Pultrude 10 foot wide panels	Pultrusion of large 10 foot wide panels completed.	
Task 2-2	Construct Production Scale Assembly Fixture	Construction of large scale assembly fixtures completed.	
Task 2-3	Assemble Production Scale Panels	Demonstrate assembly of production scale panels	
Phase 3	Testing and Integration		
Task 3-1	Prepare Panels for Testing	Complete preparation of panels for testing	
Task 3-2	Panel Scale Test Program	Testing of panels complete	
Task 3-3	Project Integration	Submit Final Report	

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Improved Affordability for Composite Structures

Small Scale Panel Production

Small Panel Pultrusion



KaZaK Composites pultruding 10' wide composite panels at its new manufacturing plant in Hudson, NH. These pultruded panels are intended for NGSS small panel assembly trials.



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Small Panels Ready for Shipping to NGSS

KaZaK Composites is continually refining process development to ensure high quality pultruded panels 10' wide with integrated joint edge details.

Systematically varying pultrusion process parameters provides greater understanding of the effects of inter-dependent parameters and therefore improves pultruded panel quality to maximize laminate properties.

Major process parameters include:

- Fabric selection
- Fabric alignment
- Resin injection
- Processing speed
- Optimizing material volume versus die volume
- Die pressure
- Laminate stacking sequence
- Die temperature



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Small Scale Panel Assembly

Small Assembly Apparatus



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Small Assembly Apparatus



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Panel Joint Surface after Sand Blasting



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Panel Joint Surface Wipedown



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Mixing Plexus MA560



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Plexus Application in Progress



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Plexus Application Complete



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"High Tech" Panel Joining Tool



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Assembled Panel Joint



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Apply Pressure with Vacuum



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Applying Vacuum Plates



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Vacuum Plates Top and Bottom



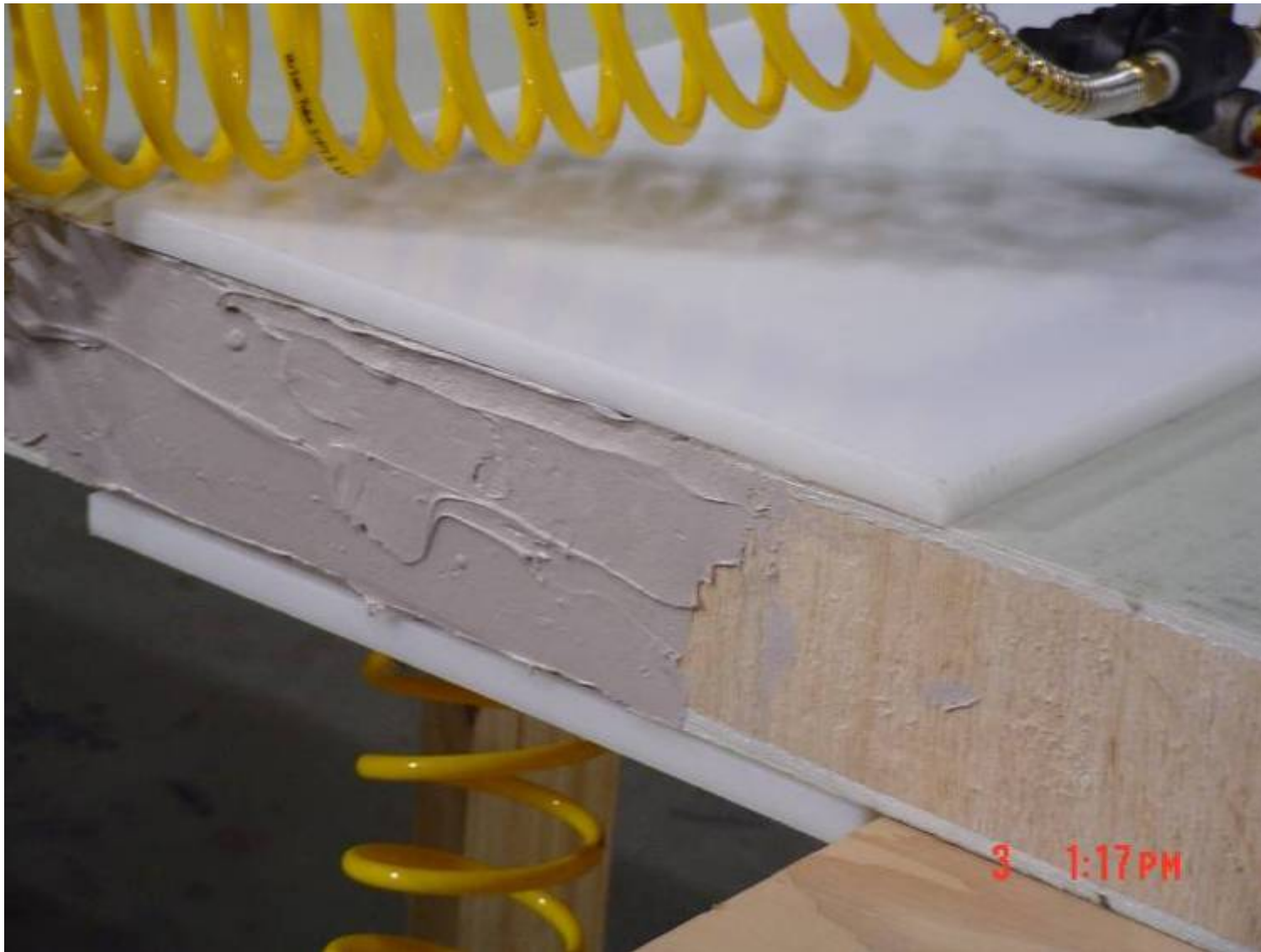
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Close-up of Vacuum Plates



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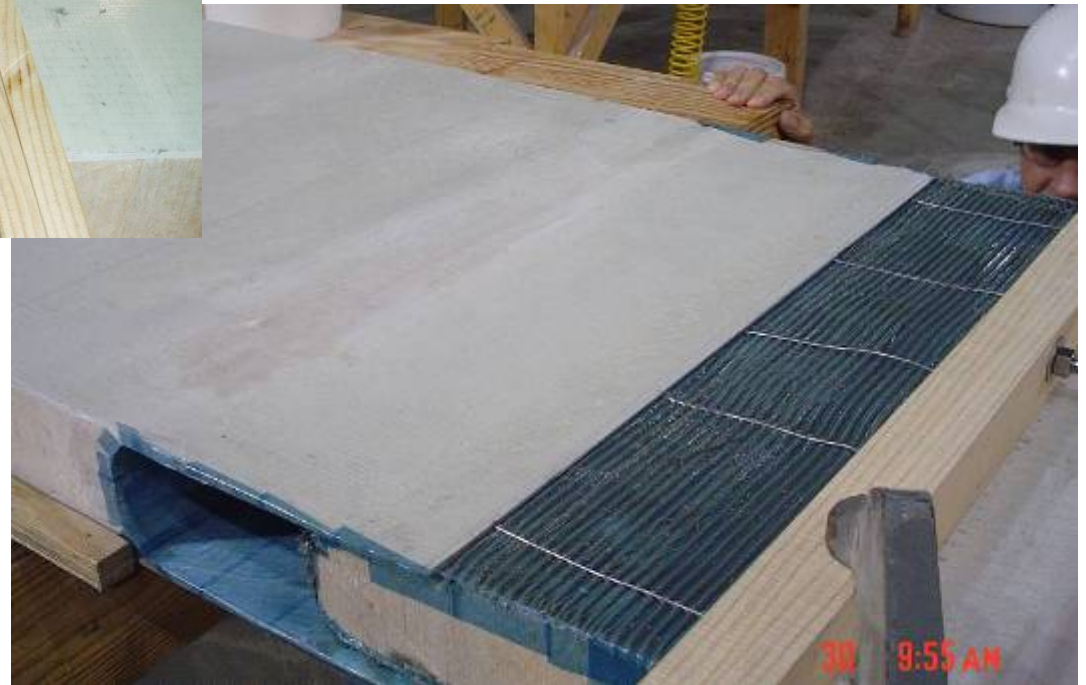
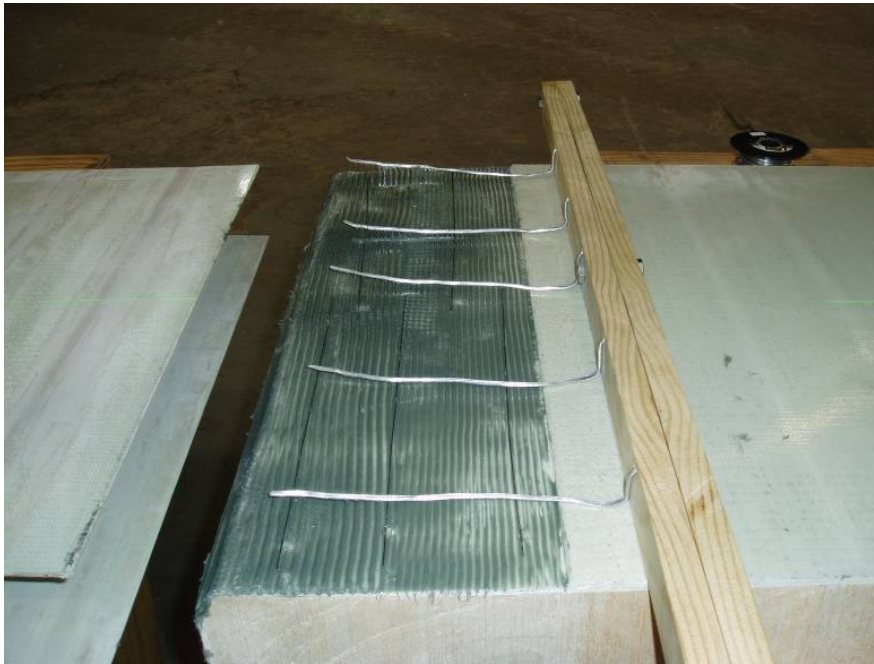
Underside of Vacuum Plates Showing Gasket



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Spreader Wires



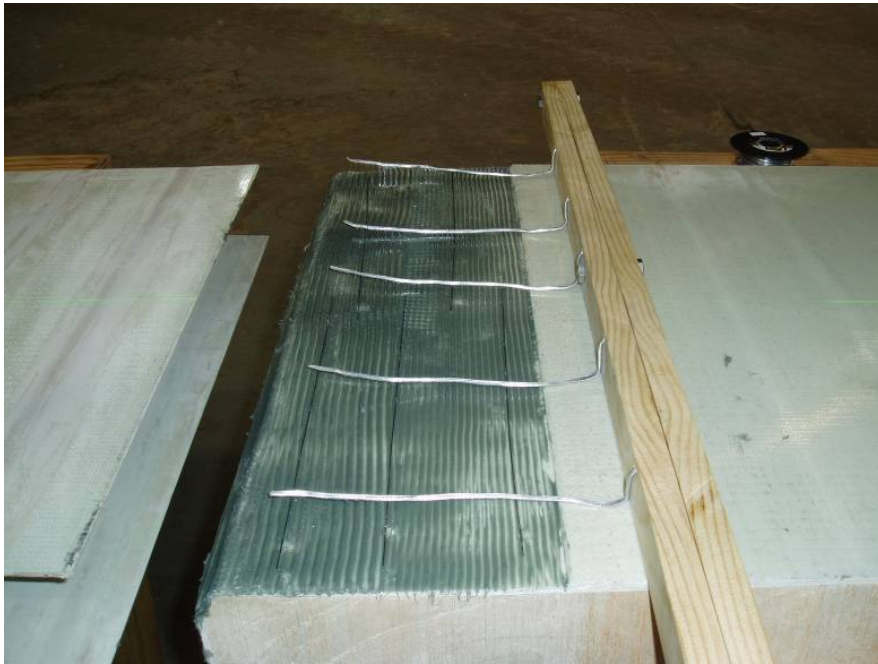
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Spacer Wires



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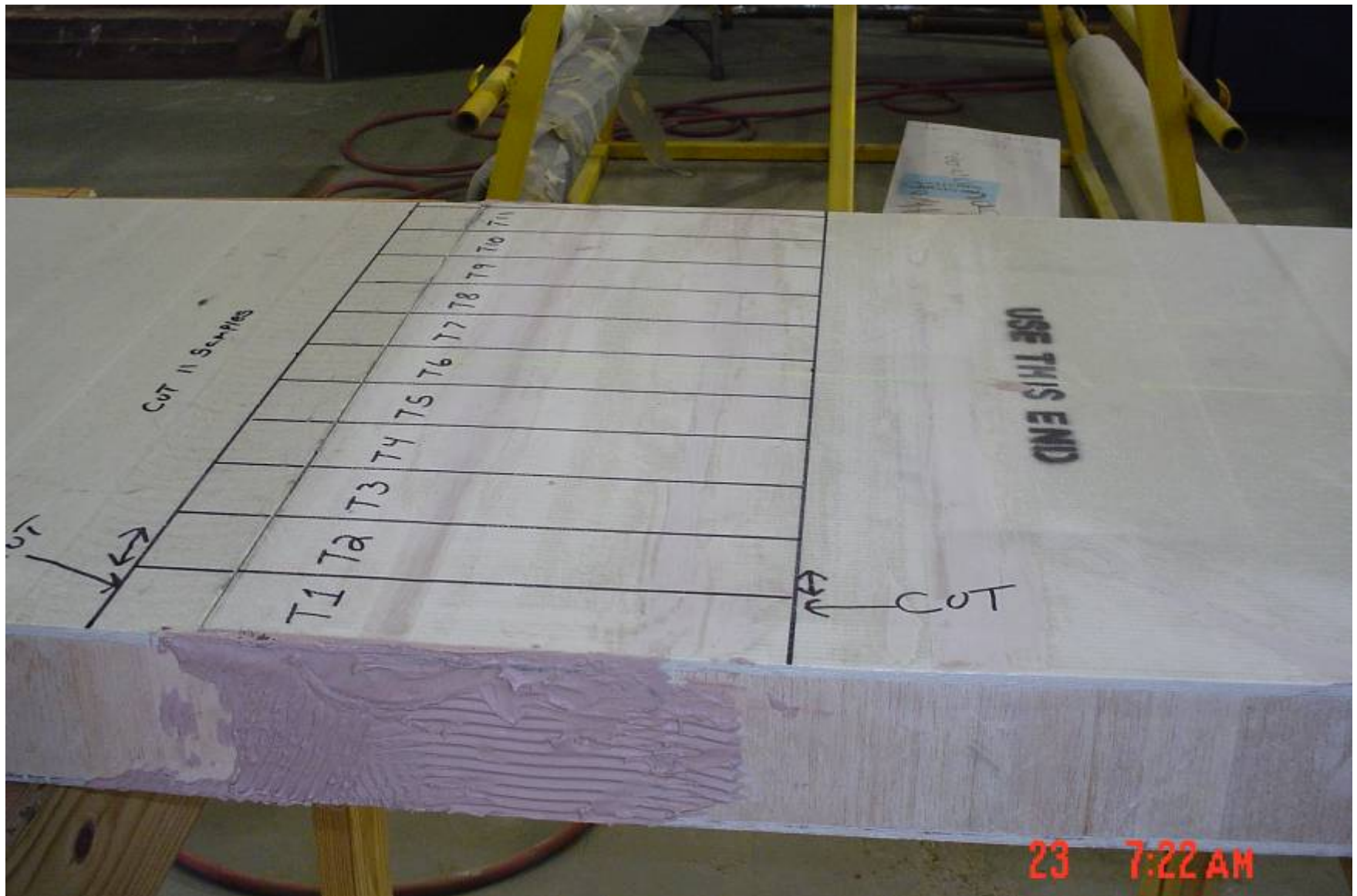
Spreader Wires Lifting Upper Flap During Assembly



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Cured Joint Marked for Sectioning



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Joint Sawed into Two Inch Wide Specimens



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Good Overall Bondline



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Good Bondline at Top



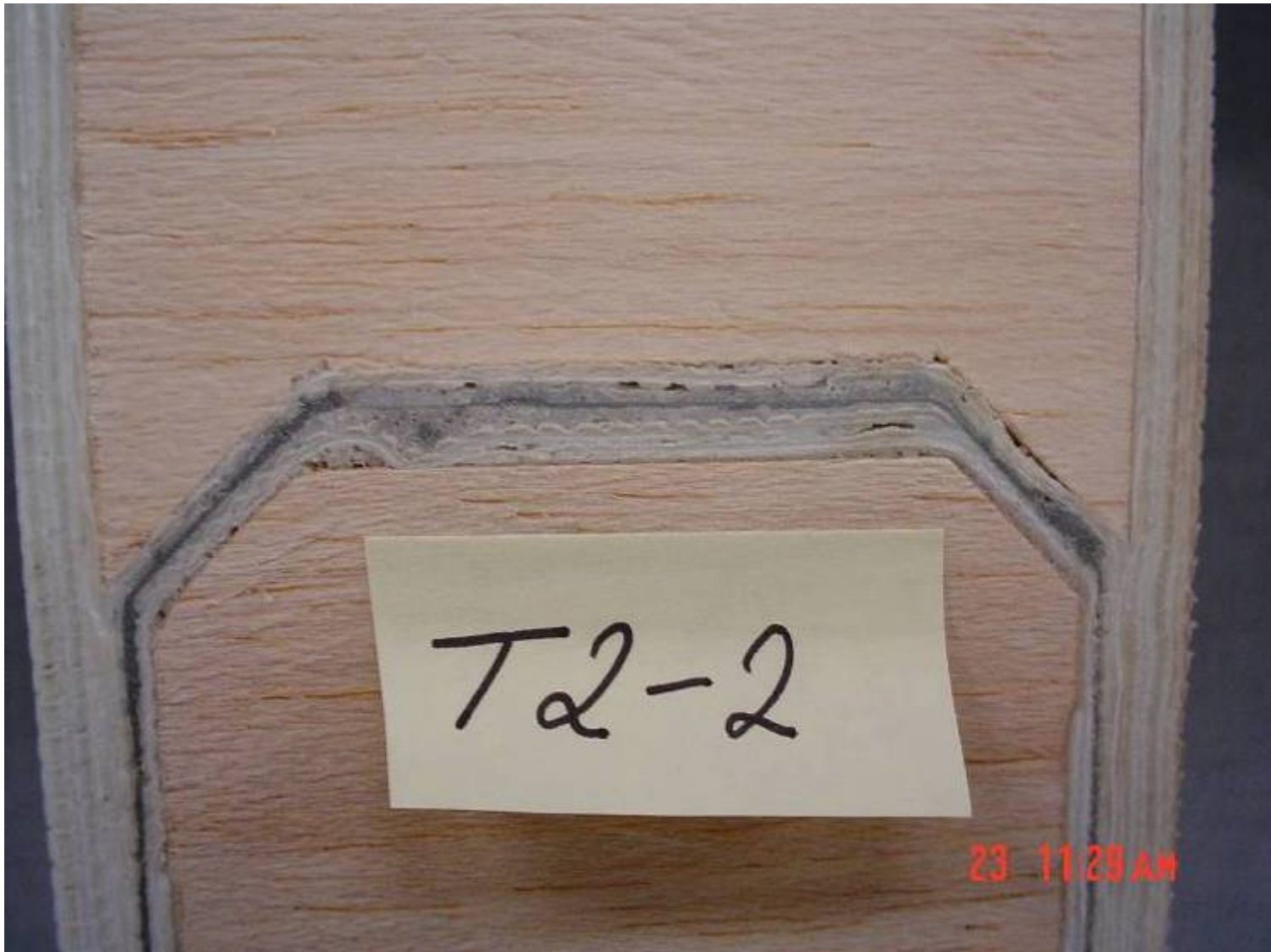
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Proper Bonding



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Voids in Bondline at Top



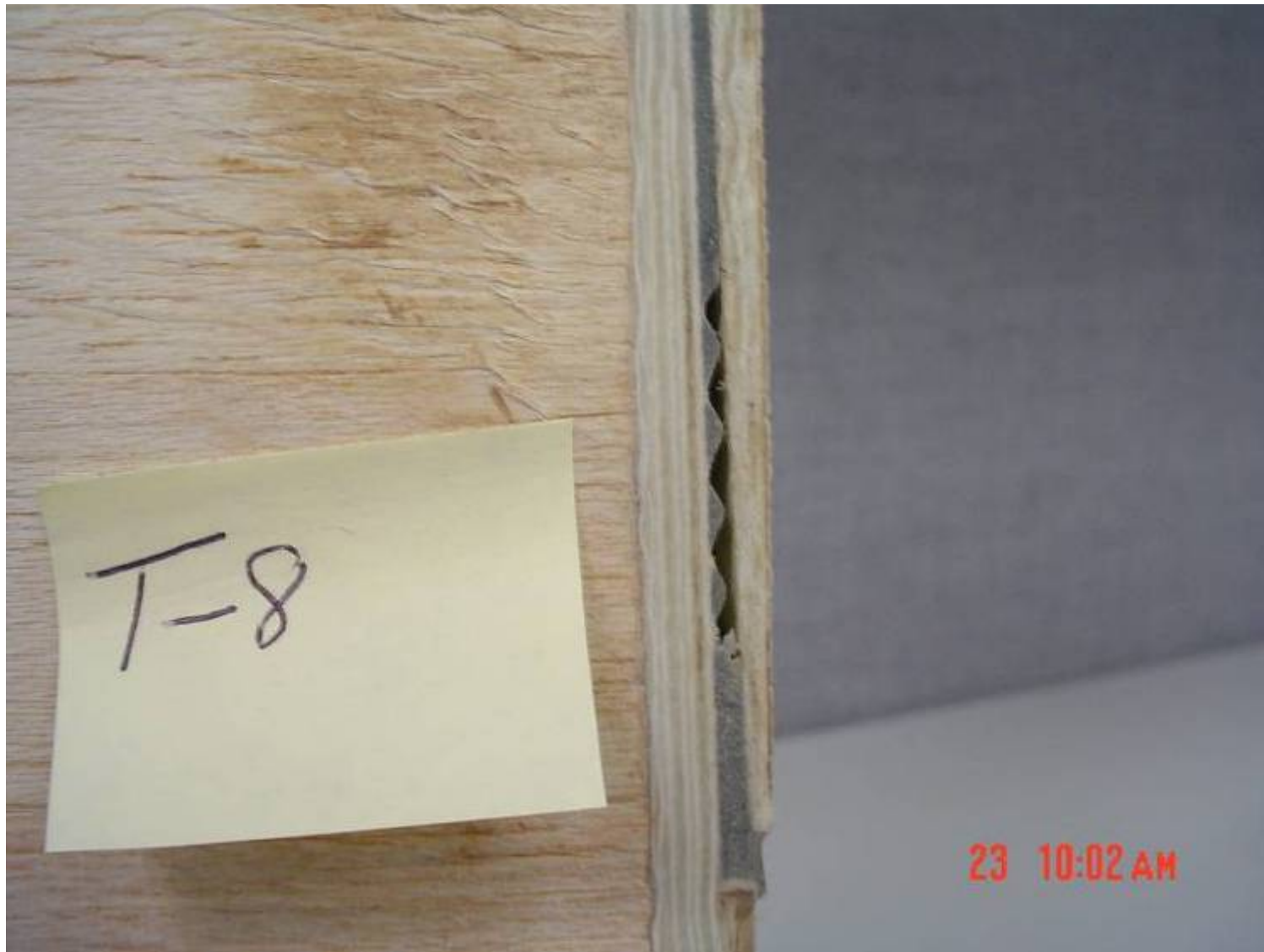
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Voids in Bondline on Flap



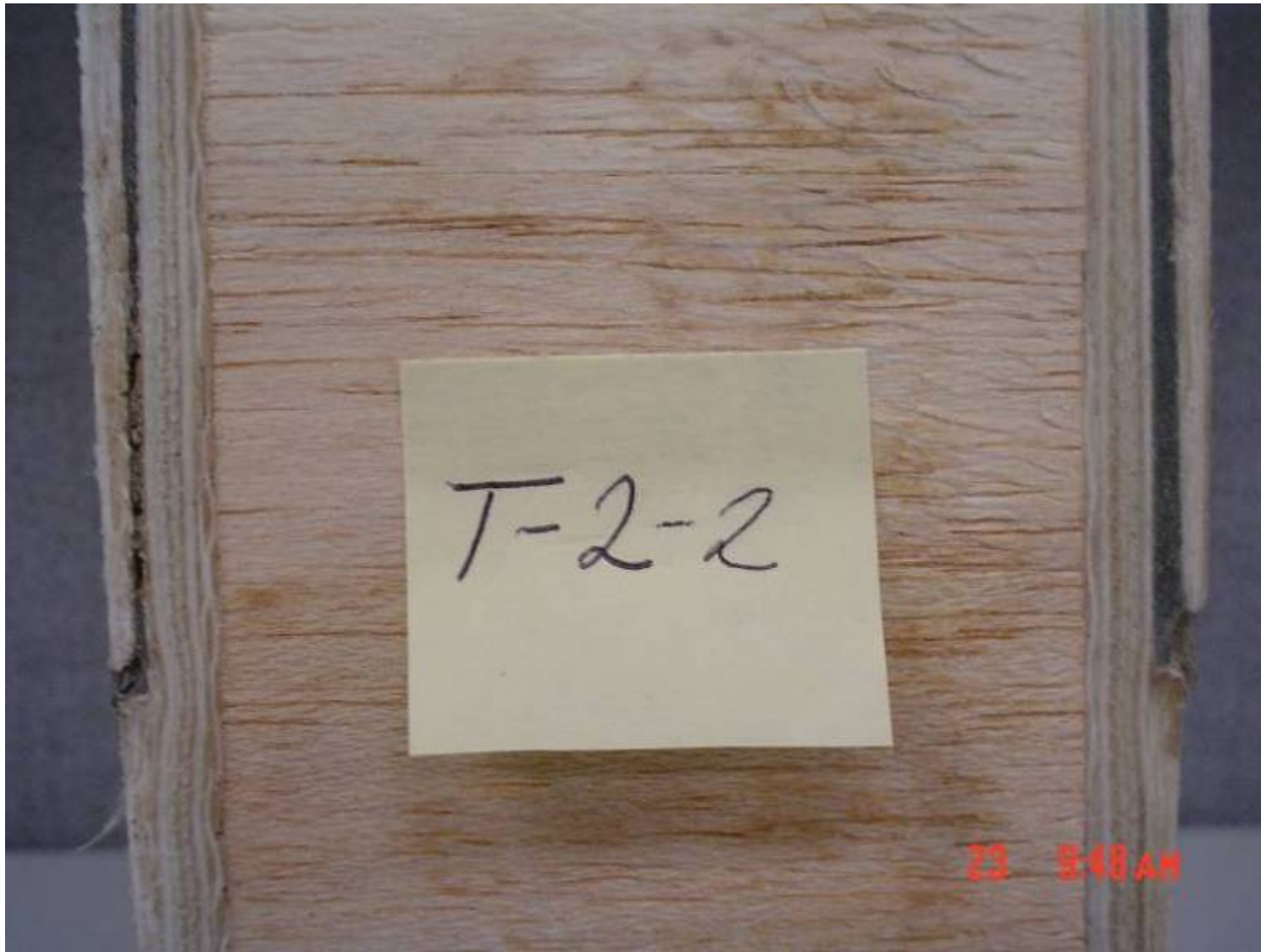
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Uneven Bondlines



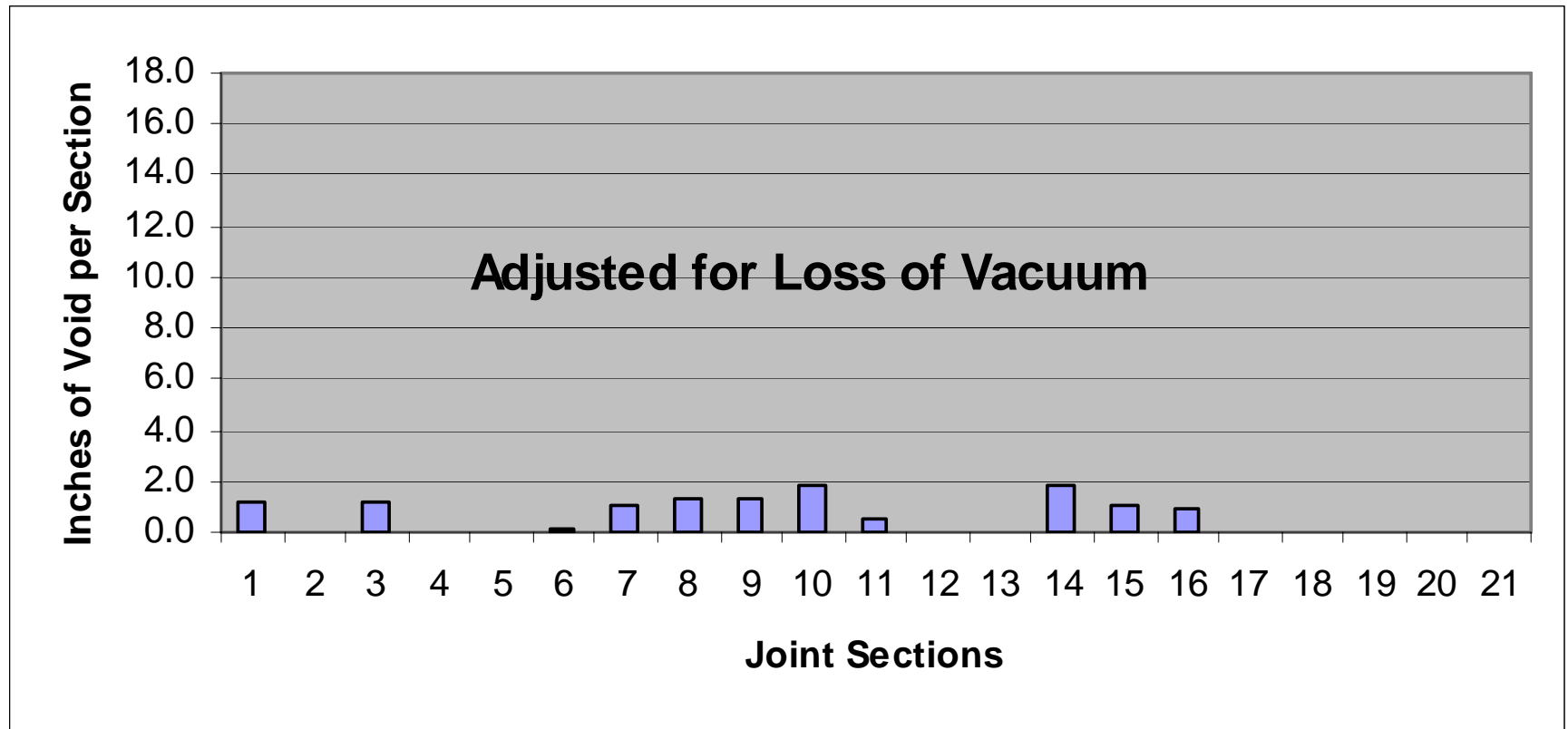
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NORTHROP GRUMMAN

Analysis of Voids in Bondline



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Summary

- **Task 1-1 Construct Small-scale Assembly Fixture**
 - Finished
- **Task 2-1 Assemble Small Panels**
 - Finished

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Results of Small Scale Assembly

- **Assembly easily accomplished in composites fabrication environment.**
- **Bond line was within target at 0.30 to .060 inch.**
- **Adhesive voids averaged less than 7% of bond line.**
- **Vacuum plates produced smooth joint surface.**

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Lessons Learned in Small Scale Assembly

- **Short wires work as well as longer wires for joint spacing and have less tendency to bunch up.**
- **Wire joint flap spreaders are needed and do not create permanent voids in adhesive.**
- **Back-up equipment is needed for adhesive mixing and for vacuum.**

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Phase II - Next Steps

- **Fabrication of Production Scale Assembly Fixture**
- **Pultrusion of 20 foot long panels**
- **Assembly of 20 by 40 foot panel for testing**
- **Fabrication of a VARTM panel for comparison testing**

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