



Workshop Report

Improving Test Methods and Performance Models for Containerboard and Converted Packaging

June 25-26, 2019
Forest Products Laboratory
Madison, WI

The Alliance for Pulp & Paper Technology Innovation or **APPTI**, a non-profit organization, exists to identify high priority, pre-competitive technology challenges for the pulp and paper industry and to promote research and development projects to address them. Member companies believe that certain common challenges too large for individual companies to tackle alone can be best addressed through cooperation among producers, suppliers, universities and government agencies.

Priority focus areas are improving packaging testing, next-generation chemical pulping, energy-efficient black liquor concentration, reuse of process waters, energy-efficient papermaking – delivering a drier web to the paper dryers – and cellulosic nanomaterials.

The APPTI Packaging Testing Team focuses on the development of more accurate physical test methods and models related to containerboard and converted packaging. This will enable reduction in manufacturing costs, limit customer product loss and facilitate the development of higher performing packaging.

The problem to be solved is that physical test methods used to control containerboard quality often show large variations in results. Short span compression (SCT) (or STFI), ring crush (RCT) and Concora (CMT) are common tests for quality control but all lack precision. This is problematic since SCT or RCT are also used in prediction of combined board properties such as ECT (edge crush test) which is used in prediction of finished box performance BCT (box crush test).

Customers in North America often receive boxes on ECT specification and/or BCT performance. However, ECT is not always a good predictor of actual box performance in the field leading to damaged consumer goods. The easiest solution to solving packaging complaints is to over engineer by adding basis weight to the package to cover the deficiencies in paperboard production or converting to the finished box. This practice is wasteful and costly for producers but often employed as an easy solution to address consumer complaints about packaging problems. A better understanding is needed of all of the factors that impact field performance including more accurate and precise physical tests, a greater understanding of the impact of environmental factors on box performance, and more comprehensive predictive models.

The team's specific aims are:

- To better understand and catalog the strengths and weaknesses of the various physical test methods currently in use
- To improve existing test methods or to develop new ones based on developments in measurement technology and data analysis and other means
- To improve performance models to better predict field performance

In order to develop a foundation to address these aims, the team held a workshop June 25-26 in Madison, Wisconsin. The purpose of the workshop was to bring together board and packaging producers, testing

equipment suppliers, and scientists to discuss some of the common problems with today’s board and packaging test methods, define research gaps, and provide the foundation for work to improve testing and performance.

This workshop exploring R&D needed in corrugated packaging began with a section intended to frame the critical issues with various experts presenting a summary of

accepted and potential test methods and models for containerboard and converted package performance. This was followed by small group discussions of state-of-the-art methods and needed improvements in testing and performance prediction. Finally breakout sessions were held in order to define and prioritize research needs.

The workshop agenda is shown below and on the next page.

June 25, 2019: Assessment and Improvements Needed		
TIME	TOPIC	SPEAKER/ MODERATOR
12:00-1:00	Registration – Room 500 Lobby Forest Products Laboratory · One Gifford Pinchot Drive · Madison, WI	
1:00 – 1:15	Welcome & Introduction	<i>David Turpin Alan Rudie Alex Beam</i>
1:15 - 5:45	Session I: State-of-the-art in testing and technology gaps	<i>Saad Hussain</i>
1:15-2:15	<i>Comprehensive Literature Review</i>	<i>John Considine</i>
2:30-3:30	<i>Box lifetime and its relationship to strength parameters</i>	<i>Doug Coffin</i>
3:40-4:15	<i>Overview of corrugated testing issues, effects of moisture and testing methods</i>	<i>Roman Popil</i>
4:20-5:05	<i>Modelling strength variations and their impacts</i>	<i>Mikael Nygård</i>
5:10-5:45	<i>Measuring structural formation and paper strength variation</i>	<i>Syed Saad Javaid</i>
5:45 - 6:00	Wrap-up Summary of Day One; charge for Day Two	<i>Saad Hussain Alex Beam</i>
6:30 - 9:00	Offsite Dinner - The Best Western Inn Towner 6:30-7:00 Reception 7:00-9:00 Dinner	

June 26, 2019: Research Gaps / Potential Solution Pathways		
TIME	TOPIC	SPEAKER/ MODERATOR
8:00 – 8:15	Recap day one activities and plan for day 2	<i>Alex Beam</i>
8:15 – 9:30	Session II: Challenges and Knowledge Gaps for Containerboard and box testing Arrive at a vetted list of challenges and knowledge gaps that define the technical “problems to be solved”	<i>Breakout groups</i> <ul style="list-style-type: none"> • Paper • Box
9:30 – 10:00	Group Report for Session II	
10:00 – 11:00	Session III: Identify solution pathways Participants identify and prioritize R&D pathways that address the challenges and knowledge gaps determined in Session II and will prioritize the needs	<i>Breakout groups</i> <ul style="list-style-type: none"> • Paper • Box
11:00 – 11:45	Group Report for Session III Review the R&D pathways identified and select those to push forward. Develop the final list for further exploration and refinement.	<i>All Participants</i>
11:45 – 12:00	Wrap-up, Next Steps	<i>Saad Hussain Alex Beam</i>
12:00	Depart - Box Lunches available	

Literature Survey

The APPTI Packaging Testing Team sponsored a systematic analysis of current test methods and models (literature review) to identify strengths and concerns related to field performance of corrugated containers. The report provided by John M. Considine, Nathan J. Bechle, and James J. Bridwell supplied the literature review of test methods and scientific articles to meet that request.

The workshop began with an overview of the report. The authors believe that the combined board industry has a preoccupation with strength and failure. Although this focus was natural—due to limitations of testing, evaluation and modeling— the inability to go beyond this aspect of material behavior has hampered

new developments and a better understanding of the mechanical response of containers in practice. More simply stated, we know that compressive failure is one of many failure modes. Relying only on strength, without recognizing the failure mode, provides only a value (strength), but not insight to the mechanism(s) needed to increase that value and/or optimize the use of material.

The review provided information to support this opinion and also furnished the material showing how some researchers have already begun understanding failure in cellulosic materials. Finally, the authors suggested a path deviating from a reliance on strength to a mechanistic understanding of failure. Container strength/performance is still the ultimate goal, but a strategic plan,

based on recent work, can provide an informed series of research goals, readily achievable with current technology. The final product of these research goals is a comprehensive model of combined board behavior incorporating quasi-static, viscoelastic-plastic (e.g., creep, vibration), and hygroelastic-plastic (e.g., mechano-sorptive) behavior.

The workshop presentations can be obtained by any attendee in pdf format by contacting APPTI.

Workshop Summary

The workshop was attended by 24 people including 11 from APPTI companies, plus RISE, ABB, SCION, PCA, and prominent experts/consultants. The full list of attendees is given at the end of the report.

The priority action items from the workshop include the following:

- Develop a comprehensive model to predict box behavior - especially failure - under quasi-static testing, in varying RH environments, in dynamic load conditions, and in multiple loading conditions.
- Elucidate the role of formation in test accuracy and a test's applicability to box performance. Use this knowledge to evaluate existing test procedures or modify/invent test procedures to be used in a box model.
- Identify and determine the viscoelastic and hygroelastic properties that are required to support that box model

A Request for Proposal will be developed to reflect these needs.

Participant List		
Name	Title	Company
Ted Altman	Consultant	Blue Ridge Paper Consulting
Dwight Anderson	Manager, Innovative Technology Development	International Paper
Alexander Beam	R&D Engineer	Domtar Paper
Nathan Bechle	Computer & Electronics Engineer	USDA Forest Products Laboratory
Andy Bethea	Product Engineering Manager, Containerboard	International Paper
James Bridwell	General Engineer	USDA Forest Products Laboratory
Mark Chmielewski	Account Engineer	ABB
Douglas Coffin	Professor	Miami University
John Considine	Materials Research Engineer	USDA Forest Products Laboratory
Greg Fike	Director R&D	Georgia-Pacific
Benjamin Frank	Senior Manager, Technical Operations and Resources	Packaging Corporation of America
Thomas Furst	Global Product Manager- Paper Laboratory Testing	ABB Lorentzen & Wettre
Charles Habeger	Consultant	
Saad Hussain	Lead Packaging Scientist	International Paper
Syed Saad Javaid	Graduate Student	Georgia Institute of Technology
Steven Johnson	Director of Product Testing & Technical Services	WestRock
Gustav Marin	PhD-student	RISE - Research Institutes of Sweden
Bill McDonnell	Director R&D/Innovation	WestRock
Babak Mirzaei	Sr R&D Scientist	WestRock
Mikael Nygårds	Research Director	Research Institute of Sweden
Seongkyung Park	Analytical chemist	University of Maine
Roman Popil	Senior Resarch Scientist	RBI/Georgia Tech
Mats Stuxberg	Technical Lead Engineer	ABB Lorentzen & Wettre
David Turpin	Executive Director	APPTI
Kelly Wade	Scientist	Scion
Marty Wakefield	L&W/KPM Product Sales	ABB
Jack Westney	Product Development Manager	Georgia-Pacific
Haixuan Zou	Research Engineer	University of Maine