

**SENIOR PRINCIPALS**

*President*

Joe R. Fowler, Ph.D., P.E.

*Senior Vice President*

W. Thomas Asbill, P.E.

*Vice Presidents*

Ronald D. Young, Ph.D., P.E.

Clinton A. Haynes

Jack E. Miller, P.E.

J. Randy Long, P.E.

**PRINCIPALS**

James W. Albert, P.E.

Christopher Alexander, Ph.D.

Claudio Allevato, Corp. LIII

Kenneth K. Bhalla, Ph.D.

Mark A. Bennett, P.E.

Richard S. Boswell, P.E.

Helen Chan, C.P.A.

John F. Chappell, P.E.

Kimberly O. Flesner, P.E.

S. Allen Fox, P.E.

David L. Garrett, Ph.D.

Andreas T. Katsounas, P.E.

Terry M. Lechinger

Christopher Matice, Ph.D., P.E.

Charles A. Miller, P.E.

George R. Ross, Ph.D., P.E.

Ramón I. San Pedro, P.E.

Teri Shackelford

Matthew J. Stahl, D.Eng., P.E.

David A. Tekamp, P.E.

Kurt D. Vandervort, Ph.D., P.E.

Kenneth R. Waeber, P.E.

Robert E. Wink, P.E.

Bobby W. Wright, P.E.

**SENIOR ASSOCIATES/  
STAFF CONSULTANTS**

Glenn A. Aucoin, P.E.

Richard C. Biel, P.E.

J. Kirk Brownlee, P.E.

Michael J. Effenberger, P.E.

Greg Garic, P.E.

Robert B. Gordon, Ph.D., P.E.

Lori C. Hasselbring, Ph.D., P.E.

David P. Huey, P.E.

Daniel Krzywicki, P.E., CSP

Kenneth R. Riggs, Ph.D., P.E.

**SENIOR ASSOCIATES**

Rafik Boubenider, Ph.D., P.E.

Roger D. Cordes, Ph.D., P.E.

Donnie W. Curington

Nripendu Dutta, Ph.D., P.E.

Steven A. Garcia

Mark E. Hamilton

Brett A. Hornberg

William A. Miller, P.E.

John M. Moore

Ronald A. Morrison, P.E.

Thomas L. Power, Ph.D., P.E.

Brian S. Royer, P.E.

Mahmod Samman, Ph.D., P.E.

Daniel A. Pitts, P.E.

Lane E. Wilson

Leo Vega

**STAFF CONSULTANTS**

Ray R. Ayers, Ph.D., P.E.

Clinton H. (Clint) Britt, P.E.

Joe W. Frey, P.E.

Michael W. Guillot, Ph.D., P.E.

Steve Hoysan, Ph.D., P.E.

Joe Kintz, P.E.

Paul J. Kovach, P.E.

Ron Scrivner

Jackie E. Smith, P.E.

**ASSOCIATES**

Lyle E. Breaux, P.E.

Douglas E. Drahem

Kenny T. Farrow, Ph.D.

Stuart J. Harbert, Ph.D., P.E.

Scot T. McNeill

David F. Renzi

Chad Searcy, Ph.D.

Obaidullah Syed, P.E.

Kevin Wang, Ph.D., P.E.

**SENIOR ANALYSTS**

Napoleon F. Douglas, Jr.

Lixin Gong, Ph.D.

Yun Han, Ph.D.

Won Kim, Ph.D.

Dilip Maniar, Ph.D.

Bo Yang, Ph.D.

Hong Zhou, Ph.D.

**ANALYSTS**

J. Julian Bedoya

Jonathan Brewer

Rhett L. Dotson

Michael L. Ge

Sachin V. Kholamkar

Karen Lucio

Brent Vyvial

March 9, 2009

PN114315CRA

Mr. Franz Worth, P.E.

**Air Logistics Corporation**

925 North Todd Avenue

Azusa, CA 91702

Phone: 626-633-0294

E-mail: [fworth@airlog.com](mailto:fworth@airlog.com)

**SUBJECT: Review of Air Logistics Test Program Relative to ASME PCC-2 Requirements**

Franz,

Per your request, Stress Engineering Services, Inc. (SES) has reviewed the testing documentation package that you provided and compared the completed tests to the ASME PCC-2 testing requirements. **Table 1** on the attached page was prepared by one of our staff members after reviewing all of the documentation that you provided to us. This documentation included both hard copies, as well as electronic versions of the testing results obtained by numerous third party test labs.

Of the sixteen (16) possible types of tests that are required by ASME PCC-2, your documentation demonstrated that all but two (2) of the listed tests were completed. These included the following:

- Test #9 – Impact performance per Appendix VI of ASME PCC-2 that is required only for composite repair systems used to repair leaking pipes.
- Test #16 – Chemical compatibility that is listed as an optional requirement (ASTM D 543, ASTM C 581, ASTM D 3681, and ISO 10952).

Therefore, of all the mandatory tests that are required for composite repair systems used to provide structural reinforcement (i.e. not the repair of leaking pipes); Air Logistics, Inc. has completed all of the required testing efforts.

It should be noted that SES has made no effort to confirm the validity or accuracy of the reported test results that were provided. Additionally, no attempt has been made to compare test results to the minimum requirements relative to the specified ASME PCC-2 tests.

We have appreciated the opportunity to be of service to you and appreciate the level of detail associated with the provided documentation. Please feel free to contact me if you have any questions or comments related to our review of your test program.

Regards,

*Chris Alexander*

Dr. Chris Alexander

[chris.alexander@stress.com](mailto:chris.alexander@stress.com)

Direct phone: 281-897-6504

Cell phone: 281-450-6642

Attachments: ASME PCC-2 test requirement table

**Table 1 – Summary of Air Logistics Completed Testing Efforts Relative to ASME PCC-2 Requirements**

TEST REQUIREMENTS AND METHOD SUMMARY							
Number	Property	Test Type	Detail Properties	Minimum Values	Testing Performed?	Result	Test Specification
1	Tensile Strength	M	Tensile strength, modulus, Poisson's ratio (for leaking pipes and some design cases); strain to failure in both hoop and axial directions	Strain to failure must be greater than 1%	yes	See data sheets	ISO 527, ASTM D 3039
2	In Plane shear modulus	M for leaking pipes only	Modulus only	None	yes	Avg: 0.781 Msi	ASTM D 5379
3	Per ply thickness	M	Thickness per ply	None	yes	see tensile strength data sheets	None, may be determined from the tensile tests above
4	Hardness	M	Barcol or Shore hardness data	None	yes	see tensile strength data sheets	BS EN 59, ISO 868, ASTM D 2583
5	Coefficient of thermal expansion	M	CTE value	None	yes	see data sheets	ISO 11359-2, ASTM E 831
6	Glass transition Temperature	M or use HDT below	Glass transition temperature $T_g$	None except that this can determine the maximum operating temperature of the composite system	yes	Type 439 Resin: 120 C 71035/73013 Resin: 87 C Sun Glass VE Resin: 105 C	ISO 11359-2, ASTM D 831, ASTM E 1640, ASTM E 6604
7	Heat distortion temperature	M or use $T_g$ Above	Heat distortion temperature HDT	None except that this can determine the maximum operating temperature of the composite system	yes	Aquawrap: >325 F PS Fabric with standard resin: 300 F	ISO 75, ASTM E 2483
8	Adhesion strength	M	Shear strength of composite bond to steel	4NM/m <sup>2</sup> (580 psi)	yes	See data sheets	BS EN 1465, ASTM D 3165
9	Impact performance	Leaking pipes only	Low velocity impact performance	Withstand drop test per appendix VI.	no	none	Appendix VI
10	Energy release rate	Leaking pipes only	Toughness parameter, energy release rate gamma	None	yes	56.6 J/m <sup>2</sup>	Appendix IV
11	Long term lap shear performance	O	Measurement of lap shear strength after 1000 hour heat exposure (may be wet)	30% of lap shear strength determined per item 8 above..	yes	See data sheets including Adhesion Strength data sheets	Appendix II-2
12	Structural strengthening	M	Wrapped pipe with defect must withstand a short-term pressure test	Wrap must not fail	yes	8200 psig, pass 6900 psig, pass	Appendix III
13	Long term strength	O	Determine long -term (creep-rupture) strength of the wrap by either of three methods	None, note that this test qualifies the wrap pursuant to table 5.	yes	See data sheets	Appendix V and ASTM D 2922
14	Cathodic disbondment	O	Cathodic disbondment	None	yes	No delaminating, blistering, or undercutting	ASTM-G 8
15	Electrical Conductivity	O	Dielectric Strength	None	yes	Avg: 180 volts/mil	ISO 14692 ASTM D 149
16	Chemical Compatability	O	Chemical Compatability	None	informal only	none	ASTM D 543 ASTM C 581 ASTM D 3681 ISO 10952