October 18, 2018
Email: *mburatto@lifelast.com*

Mr. Mark Buratto
Vice President – R&D/Mfg.
LifeLast
3813 Helios Way, Suite 190
Pflugerville, TX 78660

**SUBJECT: Results of Physical Testing of DuraShield 110/110-61 in Accordance with AWWA C222-18; KTA-Tator, Inc. Project No. 380632-3**

Dear Mr. Buratto:

In accordance with KTA-Tator, Inc. (KTA) Proposal No. PN189178 and subsequent signed Authorization to Proceed (ATP) dated July 2, 2018, KTA has performed various physical tests on coated samples provided by LifeLast in accordance with AWWA C222-18, "Polyurethane Coatings and Linings for Steel Water Pipe and Fittings." This coating was designated as "DuraShield 110/110-61" by LifeLast.

## SAMPLES

The samples listed in Table 1, "Samples" were received from LifeLast on August 10, 2018. It should be noted that at no time did KTA personnel witness the coating application or preparation of the samples.

**Table 1 – Samples**

| KTA ID | Sample Description |
|---|---|
| 380632-FF1 | One free film measuring 12″ x 12″ with coating thickness of 60 mils |
| 380632-FF2 | Five sheets of free film, each sheet measuring 12″ x 12″ |
| 380632-FF3 | |
| 380632-FF4 | |
| 380632-FF5 | |
| 380632-FF6 | |
| 380632-T1 | Three steel panels measuring 4″ x 4″ with a center hole, coated one side |
| 380632-T2 | |
| 380632-T3 | |

Table 1 – Samples, continued

| KTA ID | Sample Description |
|---|---|
| 380632-CD1 | Three coated steel panels (all sides and edges) measuring 4″ x 12″ x 1/4″ |
| 380632-CD2 | |
| 380632-CD3 | |
| 380632-F1 | Six coated steel panels (one side only) measuring 4″ x 6″ x 1/32″ with coating thickness of 20 – 35 mils |
| 380632-F2 | |
| 380632-F3 | |
| 380632-F4 | |
| 380632-F5 | |
| 380632-F6 | |
| 380632-I5 | Seven coated steel panels (one side only) measuring 6″ x 6″ x 1/4″ with maximum coating thickness of 75 mils |
| 380632-I6 | |
| 380632-I7 | |
| 380632-I8 | |
| 380632-I9 | |
| 380632-I10 | |
| 380632-I11 | |
| 380632-TA1 | Two coated steel panels (one side only) measuring 4″ x 6″ x 1/4″ |
| 380632-TA2 | |

## LABORATORY INVESTIGATION

The laboratory investigation consisted of performing various physical tests on the submitted coating material. The following tests were performed: cathodic disbondment, flexibility, impact resistance, abrasion resistance, chemical resistance, dielectric strength, water absorption, hardness, and adhesion to steel. The test descriptions and the results of the testing are provided below.

### Cathodic Disbondment (AWWA C222-18, Section 5.2.1)

Resistance to cathodic disbondment was tested in accordance with ASTM G8-96(10), "Standard Test Methods for Cathodic Disbonding of Pipeline Coatings," Method A, at ambient laboratory conditions (23°C). The panels were inspected for holidays using a high voltage holiday detector. Coating thickness measurements were obtained on five spots on each sample using a PosiTector® 6000 non-destructive electronic coating thickness gage. A ¼″ diameter holiday was drilled into the center of the panels. The panels were suspended in a salt solution consisting of 1% by mass NaCl, $Na_2SO_4$ and $Na_2CO_3$. A -1.5V potential was impressed upon the panels through the use of a magnesium anode.

The samples were removed and evaluated for disbondment after 30 days. Adhesion was assessed at the immersed holiday site and at one non-immersed site by cutting 45° radial cuts in the shape

of an "X" through the coating to the substrate at the sites and manually peeling back the coating with a utility knife blade to determine the extent of coating adhesion loss. A holiday was also drilled in a non-immersed area of each panel and two additional radial cuts were made at the sites. Coating adhesion was assessed in the same manner at the non-immersed site. The amount of coating disbondment was measured from the original holiday to the furthest point of exposed substrate. The radial staining of the exposed substrate is also reported. Disbondment data is provided in Table 2, "Results of Cathodic Disbondment Testing."

**Table 2 – Results of Cathodic Disbondment Testing**

| Sample ID | Average Radial Disbondment – Reference Area (mm) | Average Coating Thickness (mils) | Average Radial Disbondment – Test Area (mm) | Average Radial Staining – Test Area (mm) |
|---|---|---|---|---|
| 380632-CD1 | None | 34.0 | 9 | 7 |
| 380632-CD2 | None | 35.0 | 9 | 6 |
| 380632-CD3 | None | 34.9 | 9 | 6 |

### Flexibility (AWWA C222-18, Section 5.2.2)

Flexibility testing was performed in accordance with ASTM D522/D522M-17, "Standard Test Methods for Mandrel Bend Test of Attached Organic Coatings," Method B. Coating thickness measurements were obtained on five spots on each sample using a DeFelsko PosiTector® 6000 non-destructive electronic coating thickness gage. The coating thickness averages ranged from 21.4 – 26.8 mils thick. Each of the panels was bent 180° over a 3″ mandrel then examined visually for cracking. No cracking was evident on either of the replicates. Additionally, two panels were bent 180° over a 2″ mandrel then examined visually for cracking per the client's request. No cracking was evident on either of the replicates.

### Impact Resistance (AWWA C222-18, Section 5.2.3)

The impact resistance of the coating material was determined in accordance with ASTM G14-04(10)e1, "Standard Test Method for Impact Resistance of Pipeline Coatings (Falling Weight Test)." Seven steel panels each measuring 6″ x 6″ were used for this testing. Coating thickness measurements were obtained on five spots on each sample using a DeFelsko PosiTector® 6000 non-destructive electronic coating thickness gage. The coating thickness averages ranged from 56.7 – 61.3 mils thick. Each panel was secured in the apparatus outlined in the method. The three-pound tup weight was dropped from various heights ranging from 24 – 48″ as outlined in the method. The impacted areas were inspected for cracks or holidays. Following ten successive drops from 48″, no cracks or holidays were observed. The impact strength was calculated by employing height, weight, and frequency of coating failure data. The impact strength was

determined to be >154 inch-pounds, since there was no failure induced. The calculation employed to determine the impact strength is outlined below.

$m = [h_o + d(A/N \pm ½)] \times W$

*Where:*

*m = impact strength (inch-pounds)*

*$h_o$ = minimum height at which the less frequent event occurs (inches)*

*d = increment in height of drop (inches)*

*A = sum of the frequency of occurrence at each height increment times the number of increments above the $h_o$ value for each observation in the N total*

*N = total number of the less frequent event (coating failures or non-failures)*

*W = tup weight (pounds)*

*Note: The (-) sign is used when the mean is based on coating failures; the (+) sign is used when it is based on non-failures.*

## Abrasion Resistance (AWWA C222-18, Section 5.2.4)

Taber abrasion resistance was determined in accordance with ASTM D4060-14, "Standard Test Method for Abrasion Resistance of Organic Coatings by the Taber Abraser." Coating thickness measurements were obtained on five spots on each sample using a DeFelsko PosiTector® 6000 non-destructive electronic coating thickness gage. Duplicate panels measuring 4″ x 4″ were weighed then subjected to 1000 cycles using a 1000 g load and CS-17 abrasion wheels. Post weights were acquired for the samples, and the weight loss (in mg) was recorded. The results of the testing are contained in Table 3, "Results of Taber Abrasion Resistance."

**Table 3 – Results of Taber Abrasion Resistance**

| Sample ID | Weight Loss (mg) | Average Weight Loss (mg) |
|---|---|---|
| 380632-T1 | 73 | 72 |
| 380632-T2 | 70 | |
| 380632-T3 | 73 | |

## Chemical Resistance (AWWA C222-18, Section 5.2.5)

Chemical resistance was assessed in accordance with AWWA C222-18 which references ASTM D543-14, "Standard Practices for Evaluating the Resistance of Plastics to Chemical Reagents." The chemical solutions used for the testing included 10% sulfuric acid, 30% sodium chloride, 30% sodium hydroxide, and No. 2 diesel fuel. The average changes in mass and dimensions of three replicates were calculated after 30 days immersion at ambient temperature. The results of the

testing are provided in Table 4, "Results of Chemical Resistance." Detailed results of the testing are provided in Appendix 1.

**Table 4 – Results of Chemical Resistance**

| Chemical Reagent | Replicate | % Δ Width | % Δ Length | % Δ Weight |
|---|---|---|---|---|
| 10% Sulfuric Acid | CR1 | -0.136 | 0.020 | -0.021 |
| | CR2 | 0.311 | -0.037 | 0.024 |
| | CR3 | -0.130 | 0.077 | 0.062 |
| 30% Sodium Chloride | CR4 | 0.269 | -0.014 | 0.103 |
| | CR5 | 0.690 | -0.041 | 0.039 |
| | CR6 | -0.401 | -0.051 | 0.709 |
| 30% Sodium Hydroxide | CR7 | -0.382 | -0.036 | 0.219 |
| | CR8 | 0.137 | -0.038 | 0.208 |
| | CR9 | -0.214 | -0.022 | 0.251 |
| No. 2 Diesel Fuel | CR10 | -0.432 | 0.034 | 2.839 |
| | CR11 | 0.095 | 0.004 | 5.652 |
| | CR12 | 0.055 | -0.063 | 4.118 |

### Dielectric Strength (AWWA C222-18, Section 5.2.6)

Dielectric strength testing was subcontracted to Advanced Plastic & Materials Testing, Inc. in Ithaca, New York, an A2LA accredited laboratory, Certification No. 626.02. The testing was conducted in accordance with ASTM D149-09(13), "Standard Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies," Method A. The results of the testing can be found in Appendix 2. The average result reported is 884 V/mil.

### Water Absorption (AWWA C222-18, Section 5.2.7)

The water absorption of the free film sample was measured in accordance with Procedure 7.4 (Long Term Immersion) of ASTM D570-98(10)e1, "Standard Test Method for Water Absorption of Plastics." Three bars each measuring 3″ x 1″ were cut from the free film and the thickness of each bar was measured using Mitutoyo Digimatic Calipers. The samples were conditioned in an oven maintained at 50°F for 24 hours. After conditioning, the samples were returned to room temperature and weighed. The samples were then submerged in deionized water maintained at laboratory conditions (approximately 70°F and 50% relative humidity). The samples were removed from the water following 24 hours, one week, and every two weeks thereafter. The samples were wiped dry of any excess water, weighed and immediately replaced in the water. The test duration for long-term immersion is dictated by the performance of the sample. The percent increase in weight was determined using the following equation:

*Increase in weight (%) = (wet weight – conditioned weight)/conditioned weight*100*

The percent increase in weight is reported in Table 5, "Results of Water Absorption Testing" and was graphed as a function of the square root of immersion time. Detailed results of the testing are provided in Appendix 3.

**Table 5 – Results of Water Absorption Testing**

| Replicate | Average Thickness (in) | Increase in Weight (%) Week 7 |
|---|---|---|
| WA1 | 0.0313 | 1.36 |
| WA2 | 0.0316 | 1.30 |
| WA3 | 0.0303 | 1.30 |

### Hardness (AWWA C222-18, Section 5.2.8)

The hardness of the coating was evaluated in accordance with ASTM D2240-15e1, "Standard Test Method for Rubber Property – Durometer Hardness." Coating thickness measurements were obtained from five spots using Mitutoyo Digimatic Calipers. The average coating thickness was 66.7 mils. Using a Shore D durometer, five readings were obtained. The average result was reported. The sample had an average hardness of 74.8.

### Adhesion to Steel (AWWA C222-18, Section 5.2.9)

Tensile adhesion (pull-off strength) was measured in accordance with ASTM D4541-17, "Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers," Annex A4, "Self-Aligning Adhesion Tester Type V." Coating thickness measurements were obtained on five spots on each sample using a DeFelsko® PosiTector 6000 non-destructive electronic coating thickness gage. The testing surfaces electrically abraded until the surface gloss was no longer visible and were wiped clean to remove dust. The pull stubs used were 20 mm in diameter and were lightly abraded with sandpaper prior to being attached to the coating using a two-component epoxy adhesive (3M™ Scotch-Weld™ DP460NS), which was allowed to cure for 24 hours at ambient laboratory conditions (73.5 ± 3.5°F and 50 ± 5% RH). The pull stubs were then detached using a Defelsko® PosiTest® AT. The force (in psi) required to remove each loading fixture was recorded along with the location of break and approximate percentage of each. The location of break is defined as follows:

Adhesive Failure: A split between layers or a split between the substrate and the first layer.

Cohesive Failure: A split within a single layer.

Glue Failure: Coating strength exceeds glue strength.

The results of the testing can be found in Table 6, "Results of Adhesion to Steel."

Table 6 – Results of Adhesion to Steel

| Sample ID | Pull Stub | Pull-Off Strength (psi) | Location of Break | Average Pull-Off Strength (psi) |
|---|---|---|---|---|
| 380632-TA2 | G | 5,316 | 100% cohesive failure within the coating | 5,197 |
| | H | 5,194 | 60% cohesive failure within the coating<br>40% adhesive failure to the substrate | |
| | I | 5,218 | 70% cohesive failure within the coating<br>30% adhesive failure to the substrate | |
| | J | 5,060 | 70% cohesive failure within the coating<br>30% adhesive failure to the substrate | |

## DISCUSSION

The testing was performed in accordance with AWWA C222-08, "Polyurethane Coatings and Linings for Steel Water Pipe and Fittings." The tests performed in accordance with AWWA C222-18 along with the performance criteria described in the specification and the results of the laboratory testing are provided in Table 7, "Summary Results of Testing."

Table 7 – Summary Table of Testing Results

| Test | AWWA C222-08 Requirement | Laboratory Testing Result | Pass/Fail |
|---|---|---|---|
| Cathodic Disbondment | 12 mm radius, maximum | Disbondment – CD1: 9 mm, CD2: 9 mm, CD3: 9 mm<br>Radial Staining – CD1: 7 mm, CD2: 6 mm, CD3: 6 mm | Pass |
| Flexibility | No cracking or delamination | No cracking or delamination | Pass |
| Impact Resistance | 75 in-lbs, minimum | >154 in-lbs | Pass |
| Abrasion Resistance | 100 mg weight loss, maximum | 72 mg | Pass |
| Chemical Resistance | 5% change in mass, length or width, maximum | < 5% change in mass, length or width: 10% sulfuric, 30% NaCl, 30% NaOH, No. 2 diesel fuel | Pass |
| Dielectric Strength | 250 V/mil, minimum | 884 V/mil | Pass |
| Water Absorption | 2%, maximum | 1.3% | Pass |
| Hardness | 65 Shore D, minimum | 74.8 Shore D | Pass |
| Adhesion to Steel | 1,500 psi, minimum | 5,197 psi | Pass |

If you have any questions concerning the testing or this report, please contact me by telephone at 412.788.1300 extension 182, or by email at kstanczyk@kta.com.

Sincerely,

**KTA-TATOR, INC.**

Kaley Stanczyk

Kaley M. Stanczyk
*Project Manager/Chemical Technician*

Appendices:

Appendix 1 – Chemical Resistance Data
Appendix 2 – APM Testing, Inc. Dielectric Strength Report
Appendix 3 – Water Absorption Data

KMS/VDS:pm

# *Appendix 1*

| Sample | Test Solution | Initial Weight | Final Weight | Δ Weight | Initial Width | Final Width | Δ Width | Initial Length | Final Length | Δ Length | % Δ Weight | % Δ Width | % Δ Length |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CR1 | 10% $H_2SO_4$ | 3.795 | 3.794 | -0.001 | 1.476 | 1.474 | -0.002 | 4.922 | 4.923 | 0.001 | -0.021 | -0.136 | 0.020 |
| CR2 | | 3.786 | 3.787 | 0.001 | 1.477 | 1.482 | 0.005 | 4.902 | 4.900 | -0.002 | 0.024 | 0.311 | -0.037 |
| CR3 | | 3.534 | 3.536 | 0.002 | 1.465 | 1.463 | -0.002 | 4.906 | 4.910 | 0.004 | 0.062 | -0.130 | 0.077 |
| CR4 | 30% NaCl | 3.784 | 3.788 | 0.004 | 1.449 | 1.453 | 0.004 | 4.924 | 4.923 | -0.001 | 0.103 | 0.269 | -0.014 |
| CR5 | | 3.856 | 3.858 | 0.002 | 1.463 | 1.473 | 0.010 | 4.927 | 4.925 | -0.002 | 0.039 | 0.690 | -0.041 |
| CR6 | | 3.526 | 3.551 | 0.025 | 1.496 | 1.490 | -0.006 | 4.948 | 4.946 | -0.002 | 0.709 | -0.401 | -0.051 |
| CR7 | 30% NaOH | 3.154 | 3.161 | 0.007 | 1.468 | 1.462 | -0.006 | 5.063 | 5.061 | -0.002 | 0.219 | -0.382 | -0.036 |
| CR8 | | 3.229 | 3.236 | 0.007 | 1.457 | 1.459 | 0.002 | 5.057 | 5.056 | -0.002 | 0.208 | 0.137 | -0.038 |
| CR9 | | 3.269 | 3.277 | 0.008 | 1.446 | 1.443 | -0.003 | 5.068 | 5.067 | -0.001 | 0.251 | -0.214 | -0.022 |
| CR10 | No. 2 Diesel Fuel | 3.339 | 3.434 | 0.095 | 1.483 | 1.476 | -0.006 | 5.031 | 5.033 | 0.002 | 2.839 | -0.432 | 0.034 |
| CR11 | | 3.425 | 3.619 | 0.194 | 1.477 | 1.478 | 0.001 | 5.064 | 5.064 | 0.000 | 5.652 | 0.095 | 0.004 |
| CR12 | | 2.946 | 3.067 | 0.121 | 1.500 | 1.500 | 0.001 | 5.067 | 5.063 | -0.003 | 4.118 | 0.055 | -0.063 |

# *Appendix 2*

# Advanced Plastic & Material Testing, Inc.

42 Dutch Mill Road
Warren Road Business Park
Ithaca, NY 14850
www.apmtesting.com
**PHONE: (607)257-8378 FAX: (607)257-1586**

ACCREDITED
Testing Cert #
326.01 & 326.02

## CERTIFIED TEST REPORT

## APM Report P180578

Prepared for:

Kaley Stanczyk
KTA-Tator, Inc.
115 Technology Drive
Pittsburgh, PA 15275
USA

**P.O. 18PO-405**

Prepared by:
Julia Hoshino
Laboratory Technician

Reviewed by:
Ha Svereika
Lab Manager

September 5, 2018

**Quality System:** APM Testing maintains a quality system in compliance with ISO 17025-2005.

**Procedures:** All tests and services are done in accordance with the APM Quality Manual, revised June 2016. Pratt & Whitney related work is also done in accordance with the PWA Manual F-23.

**Reproduction:** The information in this report represents only the material tested and may not be reproduced except in full without the written permission of APM Testing.

**Retention:** Samples are retained for 90 days minimum and then discarded unless otherwise specified by the client.

**Limited Liability:** APM Testing's liability to the client or any third party is limited to the amount charged for services provided.

**Signatures:** This report is considered an official copy only if signed by the individuals specified on the lines above.

## SUMMARY

All results for the sample are listed below. No specifications were provided for the sample to be evaluated against.

## RECEIVED

One (1) sample for dielectric strength testing:
KTA Job Number 380632 – DuraShield 110/110-61

## DIELECTRIC STRENGTH TEST RESULTS

| | |
|---|---|
| **Test Method:** | ASTM D149-09 (Reapproved 2013), Method A |
| **Test Conditions:** | 23±5°C, 15 to 85% R.H. |
| **Conditioning:** | 40+ hours, 23±2°C, 50±10% R.H. |
| **Preparation:** | As sent by client |
| **Specimen:** | Plaques, 4 x 4 inches |
| **Rate of Rise:** | 2000 volts per second |
| **Electrodes:** | Type 3 (0.25 inch diameter) |
| **Medium:** | Oil |

| Sample | Replicate | Specimen Thickness (inches) | Breakdown Voltage (kV) | Dielectric Strength (V/mil) | Failure Location on Electrode |
|---|---|---|---|---|---|
| **DuraShield 110/110-61** | | | | | |
| | 1 | 0.0255 | 23.5 | 922 | Center |
| | 2 | 0.0226 | 20.0 | 887 | Edge |
| | 3 | 0.0299 | 25.3 | 848 | Edge |
| | 4 | 0.0245 | 23.4 | 955 | Center |
| | 5 | 0.0288 | 23.3 | 809 | Edge |
| | Mean | | | **884** | |
| | Std. Dev. | | | 58 | |
| **Requirement** | | | | | |

# *Appendix 3*

**Job Number:** 380632
**Sample ID:** KTA-1

*Water Absorption of Plastics, Long Term, in Accordance with ASTM D570, "Standard Test Method for Water Absorption of Plastics", Section 7.4, " Long-Term Immersion"*

**Conditioning Time and Temperature**

24 h at 50 ± 3°C

**Conditioned and Immersed Sample Weights and Intermediate Calculations**

| Date and Time | Immersion Time (Hr.) | (Immersion Time) (Hr.) | Replicate 1 | | | Replicate 2 | | | Replicate 3 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Sample Weight (g) | Total Weight Change (mg) | Weight Change Since Last Weighing (mg) | Sample Weight (g) | Total Weight Change (mg) | Weight Change Since Last Weighing (mg) | Sample Weight (g) | Total Weight Change (mg) | Weight Change Since Last Weighing (mg) |
| 8/28/18 9:00 AM | 0.0 | 0.0 | 1.4701 | 0.0 | 0.0 | 1.5345 | 0.0 | 0.0 | 1.4175 | 0.0 | 0.0 |
| 8/29/18 9:00 AM | 24.0 | 4.9 | 1.4776 | 7.5 | 7.5 | 1.5465 | 12.0 | 12.0 | 1.4248 | 7.3 | 7.3 |
| 9/4/18 1:00 PM | 172.0 | 13.1 | 1.4794 | 9.3 | 1.8 | 1.5442 | 9.7 | -2.3 | 1.4268 | 9.3 | 2.0 |
| 9/18/18 8:00 AM | 503.0 | 22.4 | 1.4828 | 12.7 | 3.4 | 1.5480 | 13.5 | 3.8 | 1.4306 | 13.1 | 3.8 |
| 10/2/18 8:00 AM | 839.0 | 29.0 | 1.4874 | 17.3 | 4.6 | 1.5515 | 17.0 | 3.5 | 1.4323 | 14.8 | 1.7 |
| 10/16/18 11:50 AM | 1178.8 | 34.3 | 1.4875 | 17.4 | 0.1 | 1.5518 | 17.3 | 0.3 | 1.4334 | 15.9 | 1.1 |

**Reconditioned Weight and Final Calculation of Water Absorbed**

| Replicate | Reconditioned Weight (g) | Conditioned Weight (g) | Soluble Matter Lost (g) | Soluble Matter Lost (%) | Increase in Weight During Immersion (%) | Percentage of Water Absorbed* |
|---|---|---|---|---|---|---|
| 1 | 1.4675 | 1.4701 | 0.0026 | 0.18 | 1.18 | 1.36 |
| 2 | 1.5318 | 1.5345 | 0.0027 | 0.18 | 1.13 | 1.30 |
| 3 | 1.4150 | 1.4175 | 0.0025 | 0.18 | 1.12 | 1.30 |

*The Percentage of Water Aborbed (%) is equal to the sum of the Soluble Matter Lost (%) and the Increase in Weight During Immersion (%).

**Results****

| | |
|---|---|
| Time of immerson | 7.0 weeks |
| Percentage increase in weight during immersion | 1.14 % |
| Percentage of soluble matter lost during immersion | .18 % |
| Percentage of water absorbed | 1.32 % |

**The percentages in the above table are the average of the corresponding values for the three replicates recorded in the preceding table ("Reconditioned Weight and Final Calculation of Water Aborbed").

| | | | |
|---|---|---|---|
| QC Review: | VDS | Date: | 10/18/2018 |
| Data Transfer Review: | VDS | Date: | 10/18/2018 |