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TEST REPORT PAGE 1 OF 13

FOR: J-M Manufacturing
9 Peach Tree Hill Road
Livingston, NJ 07039
Tel: (973) 535-1633 / Fax: (973) 533-4180
ATTN: Mr. Mai Huynh

LWR NO.: 16438 DATE: Dec. 2, 2005

BACKGROUND: Client submitted several pieces of longitudinally failed 18-inch pipe. The sample was received on 09/31/2005 by customer supplied courier. Visual inspection was performed on 09/31/2005 and no shipping discrepancies were noted.. Sample submitted to determine possible cause of failure. Testing to be performed per signed CRT quotation dated 08/31/2005 and P.O. # 141479. The following additional information is provided:

CRT Order Entry Log Date: 10/12/2005

Sample ID: J-M Mfg. Co., Inc. 18" PVC Blue AWWA C905 DR25 Pipe
1) Bell section, larger piece
   A. Near fracture
   B. Away from fracture
2) Pipe section inserted into bell

TEST PROCEDURES: Failure analysis

Visual and macroscopic examination – per CRT methods
Extrusion quality by acetone immersion – per ASTM D 2152
DSC analysis – per CRT methods
FT-IR analysis – per CRT methods
Impact strength – per ASTM D 256
Tensile properties – per ASTM D 638
Density – per ASTM D 792 (methanol)

TEST RESULTS: Test results are shown in tables 1.1 - 3, attached.

CONCLUSION: The bell and pipe show evidence of excessive insertion force and misalignment. A crack started due to a combination of forces that exceeded the endurance limit of the material. Scars on the inside of the bell show the pipe was inserted with considerable pressure while erosion marks show the angle the pipe was inserted to be as high as 4°. The sample failed in a fatigue mode. The stress was highest at this area where two fractures started at nearly the same time. A shiny surface on the pipe in the area of the failure is due to water erosion polishing.

Specimen Retain Bin: BB (30 day hold only)

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Ken A. Le Jeune
President-CEO / Lab Director

Tom J. Parsons
General Manager

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TABLE 1.1
SAMBLE ID: Area 1A – Near fracture

Visual Examination

The bell was cut in two releasing the inserted pipe. Cuts were made parallel to the longitudinal fracture to facilitate study. See Photos 3 & 6.

The fracture is unmistakably a fatigue type failure with fatigue failure beech marks. A line through the fracture is a ratchet caused by two origins that grew on each side. See Photos 7 – 11.

Misalignment is evident by unparallel lines inside the bell. The angle of the unparallel lines is up to 4°.

The water erosion on the inside of the bell has a matching pattern on the inserted pipe. It is typical of water erosion to leave a shiny surface.

Only two origins were observed. The area was examined for additional cracks on each side of the origins but none were observed. The lack of more cracks shows the stress was localized at this area due primarily to bending.

Extrusion Quality

A section of material was cut near the bell in near the fracture and prepared with 1/8" chamfers machined into the specimen. Several cuts were made in the face of the specimen to facilitate expose of the inner material. The specimen was placed in a beaker with new reagent acetone for a period of 20 minutes. Upon completion, the specimens were examined for any attack including lifting, raising or removing, or both, of any material outside surface, or mid-wall of the specimen. Swelling or softening of the test specimen is not considered attack. Testing was performed in accordance with ASTM D 2152.

Observations	Requirements
There was no lifting, raising, or removing of material on the inside or outside. There was no swelling or softening.	At least 50% attack of the inside, outside, or mid-wall surface or at least 10% attack on more than one surface is indicative of inadequate fusion.

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TABLE 1.2
SAMBLE ID: Area 1A – Near fracture

Thermal Analyses (DSC) Material Analysis

Differential-scanning Calorimetry (DSC) is used to determine transition points of base polymers (in this case PVC). These factors are then calculated to determine the quality of Poly(vinyl Chloride) PVC base resins.

Differential-scanning Calorimetry (DSC) under nitrogen (N_2) was performed in accordance with ASTM D 3418 using a double-scan technique to relieve induced processing stress. Beginning (1st scan) temperature was set at 35°C with a ramp-rate of 12°C/minute until 155°C was achieved. The second scan used the same profiles with exception that the end temperature was set to 260°C.

Determination	Observations
Double-scan Thermal Analysis (DSC) (°C)	
1st T(10%)	65.3
1st T(95%)	85.3
2nd T(10%)	80.1
2nd T(95%)	88.7
Peak melting endotherm	177.0
Anomaly 1	Endothrem at 142.2
Anomaly 2	Exotherm at 177.0

The anomalies at 142.2°C and 177.0°C indicated there may be some trace contaminates in the material. Microscopic FTIR analysis may be able to identify the trace contaminates.

FT-IR Analysis

Fourier Transform Infrared (FT-IR) analysis was performed to determine if the anomalies seen in DSC represent possible contamination. The FTIR spectrum did not show any foreign plastics or other materials.

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TABLE 1.3
SAMBLE ID: Area 1A – Near fracture

Izod Impact strength

Izod impact strength of the finished pipe was determined in accordance with ASTM D 256. Specimens were cut from an area of the bell end of the pipe near the fracture. The results were compared to material requirements for AWWA C905 material 12454 per ASTM D 1784. It must be noted that the material requirements are for specimens made from raw material. The specification does not allow rejection based on specimens taken from finished goods.

Specimen I.D.	Observations
1A-I1	0.66
1A-I2	0.78
1A-I3	0.80
1A-I4	0.72
1A-I5	0.70
Average	0.7 ft-lb/in (Cell 2)
Requirements	Cell 2 minimum

Density

Density was determined in accordance with ASTM D 792 using methanol as the immersion liquid. The values are useful to compare to area away from the fracture to see if there are significant differences.

Specimen I.D.	Observations
1A-D1	1.43
1A-D2	1.43
Average	1.43 g/cm^3

Wall Thickness

Wall thickness of the bell at the point of origin was measured and compared to AWWA C905 requirements

Specimen I.D.	Observations
Fracture origin	0.920
Requirements	0.780 minimum

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TABLE 2.1
SAMBLE ID: Area 1B – Away from fracture

Visual Examination

The fracture surfaces are ductile failure and low cycle fatigue progressions from the initial failure point. No anomalies were observed.

Extrusion Quality

A section of material was cut near the bell opposite the fracture and prepared with 1/8" chamfers machined into the specimen. Several cuts were made in the face of the specimen to facilitate expose of the inner material. The specimen was placed in a beaker with new reagent acetone for a period of 20 minutes. Upon completion, the specimens were examined for any attack including lifting, raising or removing, or both, of any material outside surface, or mid-wall of the specimen. Swelling or softening of the test specimen is not considered attack. Testing was performed in accordance with ASTM D 2152.

Observations	Requirements
There was no lifting, raising, or removing of material on the inside or outside. There was no swelling or softening.	At least 50% attack of the inside, outside, or mid-wall surface or at least 10% attack on more than one surface is indicative of inadequate fusion.

..Complies

Thermal Analyses (DSC) Material Analysis

Differential-scanning Calorimetry (DSC) is used to determine transition points of base polymers (in this case PVC). These factors are then calculated to determine the quality of Poly(vinyl Chloride) PVC base resins.

Differential-scanning Calorimetry (DSC) under nitrogen (N_2) was performed in accordance with ASTM D 3418 using a double-scan technique to relieve induced processing stress. Beginning (1st scan) temperature was set at 35°C with a ramp-rate of 12°C/minute until 155°C was achieved. The second scan used the same profiles with exception that the end temperature was set to 260°C.

Determination	Observations
Double-scan Thermal Analysis (DSC) (°C)	
1st T(10%)	62.0
1st T(95%)	74.2
2nd T(10%)	69.7
2nd T(95%)	88.9
Peak melting endotherm	223.4
Anomalies	None

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TABLE 2.2
SAMBLE ID: Area 1B – Away from fracture

Izod Impact strength

Izod impact strength of the finished pipe was determined in accordance with ASTM D 256. Specimens were cut from an area of the bell end of the pipe opposite the fracture. The results were compared to material requirements for AWWA C905 material 12454 per ASTM D 1784. It must be noted that the material requirements are for specimens made from raw material. The specification does not allow rejection based on specimens taken from finished goods.

Specimen I.D.	Observations
1B-1	0.71
1B-2	0.62
1B-3	0.67
1B-4	0.61
1B-5	0.70
Average	0.7 ft-lb/in (Cell 2)
Requirements	Cell 2 minimum

Tensile Properties

Tensile strength and modulus of elasticity was determined by machining specimens taken from an area near the fracture. Testing was performed in accordance with ASTM D 638 using type I specimens. The results were compared to material requirements for AWWA C905 material 12454 per ASTM D 1784. It must be noted that the material requirements are for specimens made from raw material. The specification does not allow rejection based on specimens taken from finished goods.

Specimen I.D.	Tensile Strength (Psi)	Tensile Modulus (Psi)
1B-T1	6,434	404,100
1B-T2	6,242	411,400
1B-T3	6,246	411,400
1B-T4	6,822	459,700
1B-T5	6,737	396,600
Average	6,349 (Cell 3)	371,140 (Cell 5)
Requirements	Cell 4 minimum	Cell 5 minimum

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TABLE 2.3
SAMBLE ID: Area 1B – Away from fracture

Density

Density was determined in accordance with ASTM D 792 using methanol as the immersion liquid. The values are useful to compare to area away from the fracture to see if there are significant differences.

Specimen I.D.	Observations
1B-D1	1.43
1B-D2	1.43
Average	1.43 g/cm^3

TABLE 3
SAMBLE ID: Pipe section inserted into failed bell

Visual Examination

Scars on the end of the pipe match scars on the bell end that are evidence of significant insertion force. The force can not be quantified by the scars.

The water erosion on the outside of the end of the pipe matches the pattern on the inside of the bell area.

Extrusion Quality

A section of material was cut near the bell in near the fracture and prepared with 1/8" chamfers machined into the specimen. Several cuts were made in the face of the specimen to facilitate expose of the inner material. The specimen was placed in a beaker with new reagent acetone for a period of 20 minutes. Upon completion, the specimens were examined for any attack including lifting, raising or removing, or both, of any material outside surface, or mid-wall of the specimen. Swelling or softening of the test specimen is not considered attack. Testing was performed in accordance with ASTM D 2152.

Observations	Requirements
There was no lifting, raising, or removing of material on the inside or outside. There was no swelling or softening.	At least 50% attack of the inside, outside, or mid-wall surface or at least 10% attack on more than one surface is indicative of inadequate fusion.

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PHOTOS

Photo 1: Bell section and inserted section as received

Photo 2: Section broken from bell piece shown above

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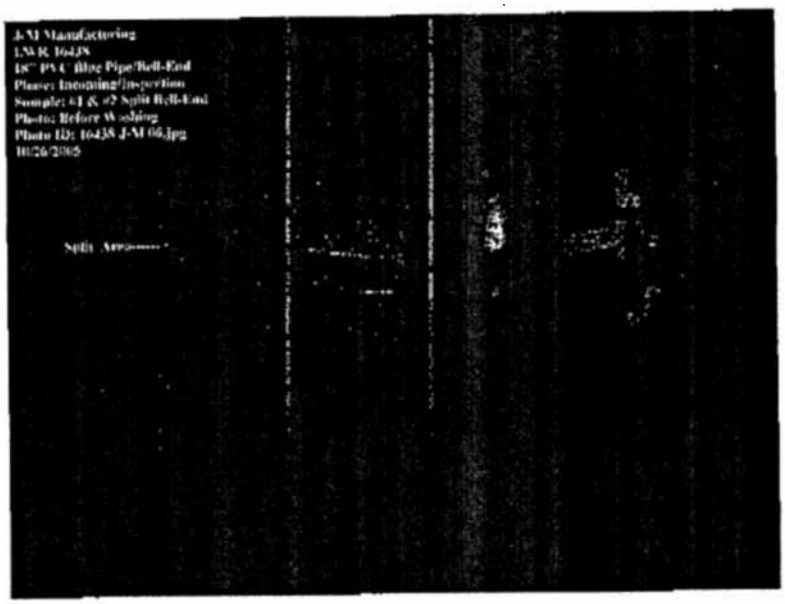

Photo 3: Photo of area at origin of fracture, as received

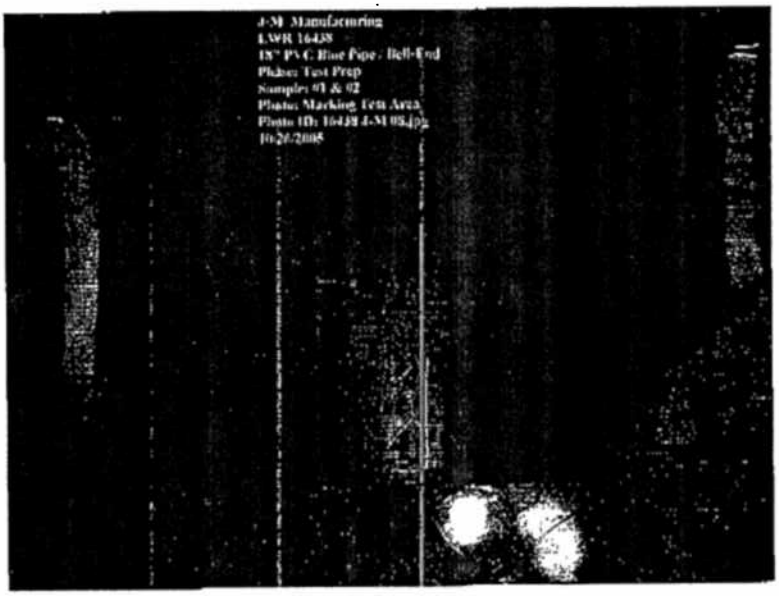

Photo 4: Location tensile and impact specimens taken from bell end of the pipe

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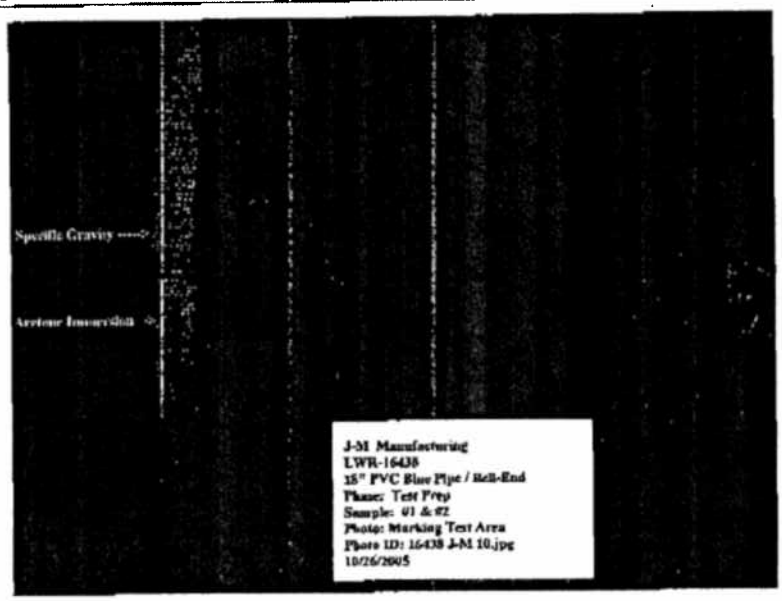

Photo 5: Location of acetone immersion and specific gravity specimens on bell end

Photo 6: The fracture origin was cut from the pipe and DSC sample taken nearby.

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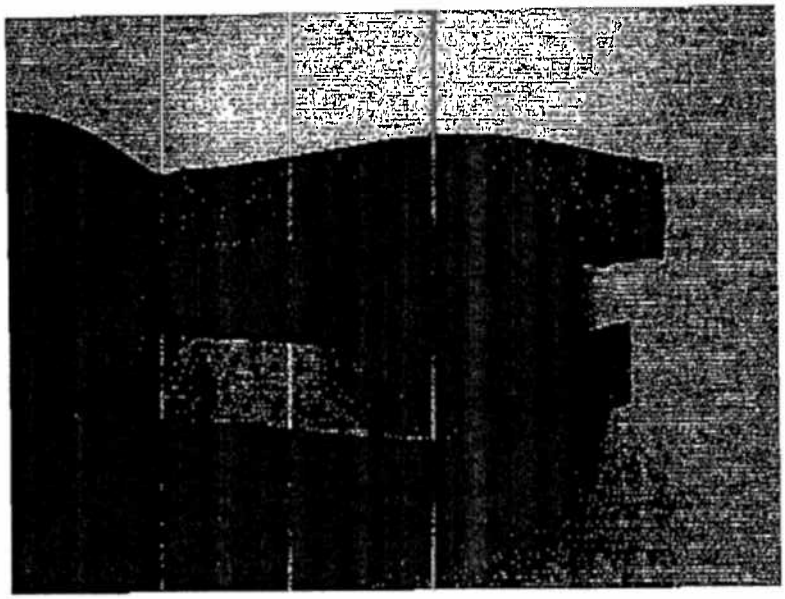

Photo 7: Both sides of the initial fracture

Photo 8: Inside view, origin of fracture is at tear shown near center of photo

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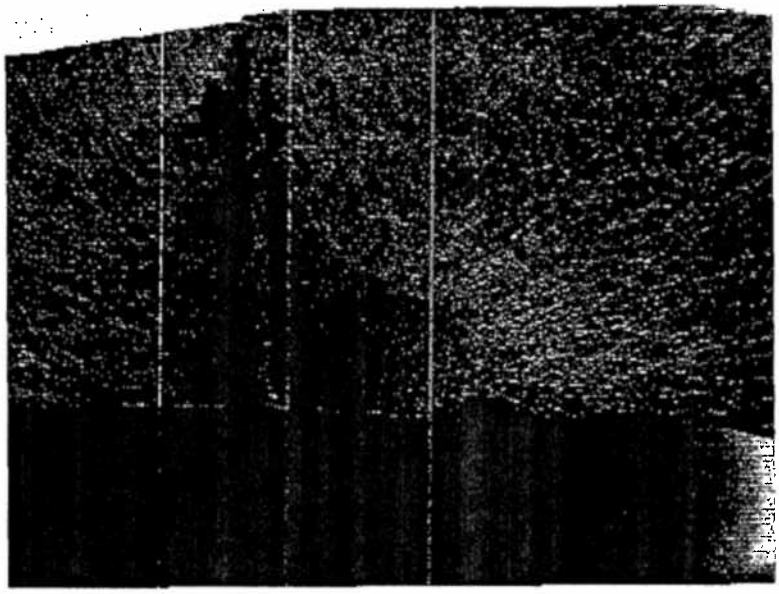

Photo 9: Striations typical of a fatigue fracture, inside surface facing down

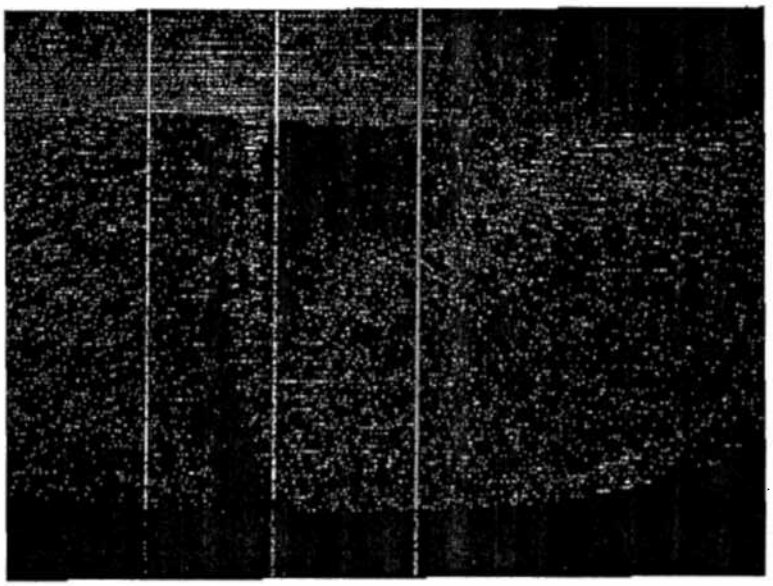

Photo 10: Opposite side of fracture, inside surface facing up

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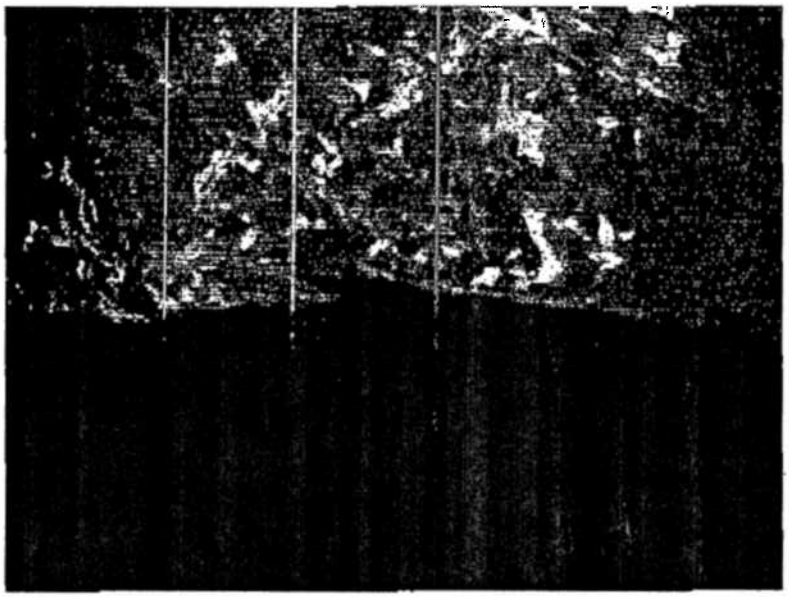

Photo 11: Unusual shiny are inside pipe may be erosion.