Water Tank Inspection Report

For

Town of New Hartford WPCA

Of the

175K Welded GST
New Hartford, CT

May 18, 2010

Extech, LLC

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New Hartford, CT

INTRODUCTION

On May 18 & June 4, 2010 EXTECH representatives, Scott Leighton and Matt Budney performed corrosion and coating assessment of the exterior and interior of a steel water tank for the Town of New Hartford WPCA. The inspection was conducted to establish the current condition of the tank coatings, substrate steel, and sediment depth.

- **Tank# 2 175K-Welded Standpipe**

The tank was inspected in accordance with the latest version of AWWA D101-53-86R standard for water tank inspections, the new AWWA M42 Tank Manual and CTDPH Tank Requirements.

The tank interior was inspected while full and in operation with the TankRover remotely operated vehicle (TR). The TankRover is the only piece of equipment like it in the United States and was developed by Extech. By using the TankRover the tank was inspected with no special preparation, no additional disinfection, no confined space entry and no downtime.

The TankRover was prepared for the inspection by disinfecting in accordance with AWWA C652-02, by spray application of a 200-ppm chlorine solution prior to insertion of each tank.

The exterior portion of the tank was inspected by walking the roof, shell portions that were accessible from the ground and vertical ladder, and portions that could be inspected from the tank base. The objectives of the assessment were to:

1. Perform field inspections and tests to assess the structural and coating integrity of the tank
2. Review the safety compliance of tank ladders and access.
3. Determine if any interior coating damage was done during cellular antenna installation.
4. Formulate a report to document the assessment findings.
5. Provide recommendations for rehabilitation.

EXECUTIVE SUMMARY

The condition and recommendations for each tank are briefly summarized in this section. For detailed information regarding detailed tank conditions and the specific recommendations please refer to the designated section for each tank.

The exterior coating systems on both the roof and shell are in good condition despite moderate chalking. Mildew has stained the lower three shell rings.

The interior coating is in good condition except for the first horizontal shell weld above the floor. Numerous corrosion cells were found on this weld with small pitting. It appears that the weld was never stripe coated during the coating application process.

The tank floor has only a light accumulation of sediment with trace amounts around the perimeter. The floor coating is in very good condition.

The tank does not require maintenance at this time. There are several suggested items in the Recommendations section of this report.

The tank should be inspected in the spring of 2015 according to AWWA D-101-53-86R recommendations and current industry practice.

OBSERVATIONS

Interior and exterior photographs provided in the report were developed from a digital camera and were captured in digital format from the interior videotape. The interior images are as clear as our printing technology will allow. The interior videosnaps in the report provide a reference for our comments. Keep in mind that the videotape provides the greatest detail and should be viewed as part of the report. Each Videosnap (VS) is marked with the time stamp from the videotape. This allows the reader to easily view the original footage for each feature.

Narration on the videotape is done in the field and some of the comments may be different than the written report. The written report is the official document and contains the formal opinion of Extech.

A Posi-Tector 6000 was used to gather dry film thickness measurements on the exterior roof and shell surfaces.

Tank#2 175K Welded Standpipe

The tank was constructed in 2002 and is a welded steel structure with four shell rings. The tank dimensions are approximately 33 feet tall and 30 feet in diameter. The tank capacity is approximately 175,000 gallons.

Information was unavailable about prior maintenance or rehabilitation. Due to the relatively new tank construction it is reasonable to conclude that no prior maintenance has been performed.

Interior

The interior of the tank was accessed through one of the two 24-inch square roof hatches. The hatch used to access the tank was not locked at the time of the inspection. The hatch is equipped with a 9-inch sanitary curb and a 2-inch hatch lip.

The water level during the inspection was consistently 1-foot below the overflow.

Roof (ceiling)

The domed roof is a self-supporting structure with exterior lap welded steel plates. The roof has numerous seam corrosion areas on all welds located around the central dollar plate and radial welds see VS# 3. The knuckle welds also have prolific seam corrosion and rust staining see VS# 2. No metal loss was found on the roof welds or components. The steel plates are in good condition with intact coating and only minimal surface corrosion see DP# 21&22.

Shell

The shell coating was in very good condition except for the first horizontal weld above the floor. Numerous corrosion cells were found throughout entire circumference of this weld with some pitting see VS# 6-8. It appears that all other welds on the tank interior were stripe coated prior to the coating application see VS# 5. Only one other area of minor corrosion was found on the upper portions of the tank see VS# 4. The shell to floor seam was in very good condition see VS# 9.

Minor edge corrosion was found on the shell manway neck see VS# 11. No problems were found with the sealing surface.

Floor

The floor had only minimal sediment layer with some rust particles built up around the perimeter due to the corrosion on the first shell weld see VS# 9. No corrosion cells were found on the shell plates.

The tank has one combined inlet-outlet pipe see VS# 10. The pipe is equipped with a sediment ring that is in good condition.

Ladders

The tank is not equipped with an interior ladder.

Exterior

Roof

The exterior roof coating is in good condition with moderate chalking. The majority of the roof is intact and continuing to protect the underlying substrate see DP# 17&18.

The dry film thickness readings showed an adequate coating thickness that ranged from a low of 10.60 mils to a high of 35.60 mils with an average of 15.23 mils.

Adhesion test results were performed on the roof and according to ASTM D3359-02 method ‘B’. A 4B rating was achieved between the topcoat and the primer and the primer to the substrate see DP# 19. The results show a properly performing coating system.

Vent

The tank is equipped with one dome capped, centrally located vent see DP# 15. The vent has a 16-inch collar diameter and a 22-inch vent cap to roof distance. The vent is equipped with an exterior coarse screen and interior fine mesh bug screen, which are in good condition, see DP# 16. New bolts were installed in the vent flange as part of the inspection.

Ladders and Railings

The tank has a 16-inch wide ladder with a 12-inch rung-to-rung spacing, a 7-inch toe clearance. The ladder base is 10-feet from grade but the ladder guard covers up to the 16-ft level. The ladder has an anti-climb shield and rail climb but no safety cage see DP# 2.

The roof is equipped with a railing system with a 42-inch tall top rail, a 21-inch mid-rail and a 4-inch toe kick see DP# 14.

Shell

The shell coating is in good condition with light chalking and moderate mildew staining. The mildew staining is darkest on the first shell course but is prolific on all four shell rings see DP# 11. Overall the majority of the shell coating is intact and protecting the underlying substrate.

The coating thickness measured from a minimum of 8.20 mils to a maximum of 27.30 mils. The average paint thickness was 14.07 mils.

Overflow

The overflow pipe measures 12-inches in diameter and extends from a top shell penetration to just above grade. The outlet discharges adjacent to the tank into a catch basin and is equipped with a fine mesh screen see DP# 2-4.

Foundation

The exposed foundation top and side faces are in good face with no major cracking or spalling locations. The grouting between the chime plate and the foundation top has started the shrink and pull away in isolated locations, see DP# 9. Vegetation overgrowth was found around the tank base.

The tank is secured to the foundation with (10) anchor bolts and ½-inch chairs. Light surface corrosion was found on the anchor nuts, bolts and chairs see DP# 5-7.

RECOMMENDATIONS

Tank# 2 175K Welded Standpipe

The tank is in good overall condition however some upgrades and repairs should be performed to maintain trouble free service.

The exterior coating is in good condition but will need power washing to remove the mildew staining and sprayed with a bio-barrier material to resist future mildew growth.

The interior coating is in very good condition except for the first shell course. It appears that the metal loss is minimal and the coating should be adequate until the next inspection cycle.

The grouting between the chime plate and foundation is starting to separate from the chime in small spots but does not require repair at this time. The vegetation growing out of the foundation should be removed.

The floor surface has only minimal sediment accumulation and will not require cleaning at least until the next inspection cycle.

The tank should be inspected in the spring of 2015 in accordance with AWWA D-101-53-86R recommendations and current industry practice.

Estimated Costs:

Power wash and apply bio-barrier to exterior shell $ 1800

NACE Certified Coating Inspector #00050

GLOSSARY OF TERMS

Cathodic Protection - The use of a sacrificial metal or energized substance to polarize the structures surface and prevent corrosion.

Chalking - The degradation of a paint system when exposed to ultra-violet light which creates a loose residue on the surface.

Corrosion Cell - a concentrated localized site of accelerated corrosion that creates pitting.

Dry Film Thickness - Total thickness of a paint film when complete cured.

Finial Vent - The central roof vent on top of a water tank.

Holiday - a hole in a protective coating that may be invisible to the unaided eye that extends to the substrate.

Lead Abatement - The removal and a lead bearing paint system.

Lead Encapsulation - The covering over of a lead based paint by applying a compatible topcoat.

Osmotic Blister- Raised coating area created by build up of fluid under the coating. Fluid moves through coating in response to water/solvent concentrations between coating and tank water.

ROV- Remotely operated vehicle, underwater inspection device “TankRover”

Silt - Material that accumulates in the bottom of a water tank originating from treatment by products and distribution system debris.

Tubercle- Domed shaped build up of corrosion products over an active corrosion site. Promotes metal loss through pitting due to differential oxygen concentrations.

Ultrasonic Measurement - The use of high frequency sound waves passed through a material to measure the time required to return. The time required to pass through the material is correlated to the speed of sound in the substrate to yield an actual thickness at a specific location.

Appendix A

Photographs

Tank# 2
175K
Welded Steel Standpipe

001.JPG
04/15/2010
Overall view of tank.

002.JPG
04/15/2010
Exterior shell ladder equipped with rail climb and anti-climb.

003.JPG
04/15/2010
Overflow outlet equipped with flapper valve

004.JPG
04/15/2010
Fine screening on overflow outlet.

005.JPG
04/15/2010
Spot corrosion area on anchor chair.

006.JPG
04/15/2010
Closeup of spot corrosion area on anchor chair.

007.JPG
04/15/2010
Surface corrosion on anchor nut and bolt.

008.JPG
04/15/2010
36-inch round shell access hatch (1 of 2)

009.JPG
04/15/2010
Slight grout separation area under chime plate.

010.JPG
04/15/2010
Vegetation growing near foundation.

011.JPG
04/15/2010
Moderate mildew staining on tank base.

012.JPG
06/03/2009
24-inch roof hatch.

013.JPG
06/03/2009
42-inch roof railing equipped with mid-rail and toe kick.

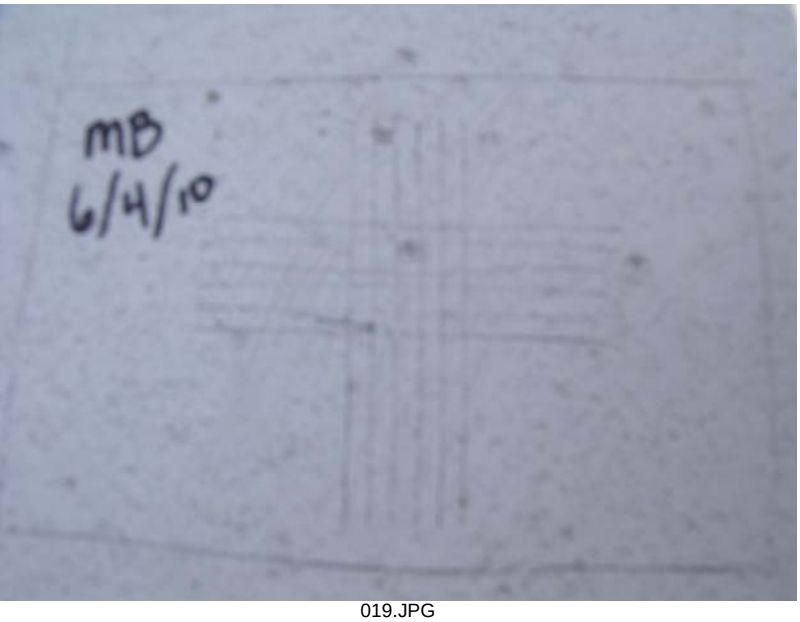
014.JPG
06/03/2009
Roof safety railing and center roof vent

015.JPG
06/03/2009

016.JPG
06/03/2009
Coarse rscreen outside with fine mesh under cap. All bolts replaced at time of inspection.

017.JPG
06/03/2009
Left hand view of exterior roof from shell ladder

018.JPG
06/03/2009



019.JPG
06/03/2009
Cross cut adhesion test taken on the exterior roof

020.JPG
06/03/2009
Interior dollar plate with edge corrosion

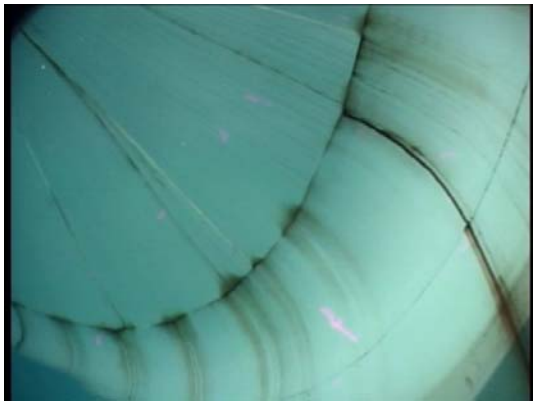
021.JPG
06/03/2009
Edge corrosion on roof plate seams

022.JPG
06/03/2009
Right hand view of interior roof from roof hatch

023.JPG
06/03/2009
Interior overflow pipe

Town of New Hartford WPCA **175K Welded Tank**

VS # 1: Overflow elbow (Time: 00:52)

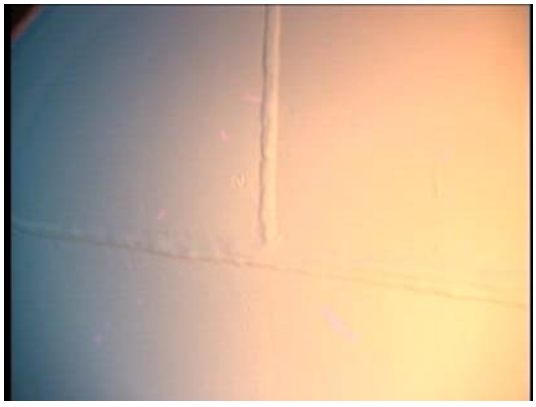


VS # 2: Seam corrosion and rust staining on knuckle welds (Time: 01:35)

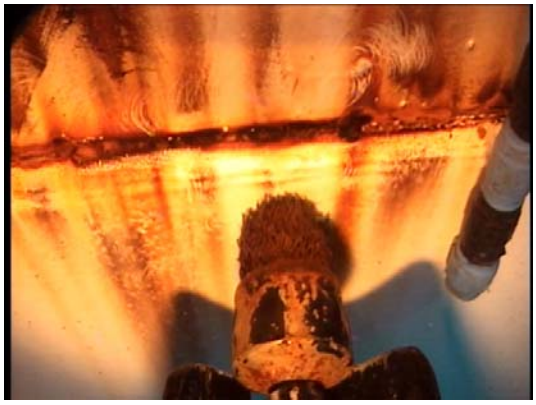
VS # 3: Center dollar plate with seam corrosion (Time: 03:20)

Town of New Hartford WPCA **175K Welded Tank**

VS # 4: Minor area of seam corrosion on horizontal weld (Time: 09:53)

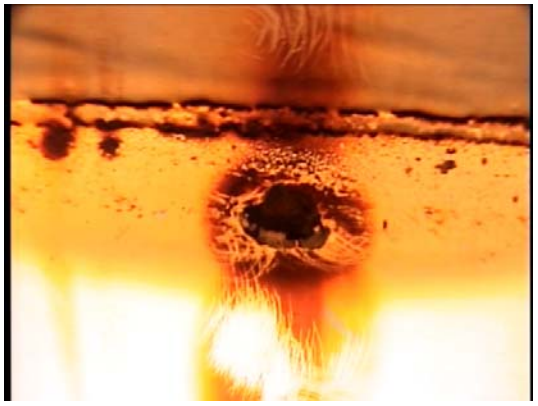


VS # 5: Typical good shell coating condition (Time: 12:06)

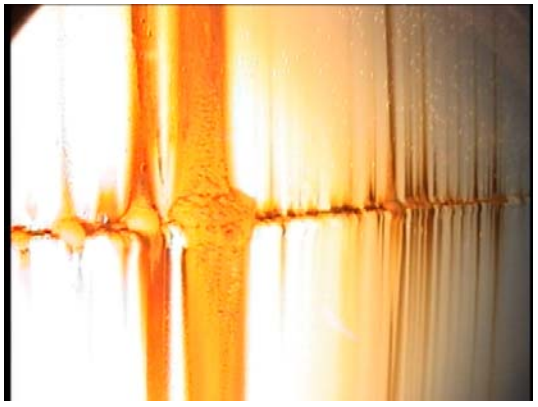


VS # 6: Corrosion area on lower horizontal weld after wire brushing (Time: 14:40)

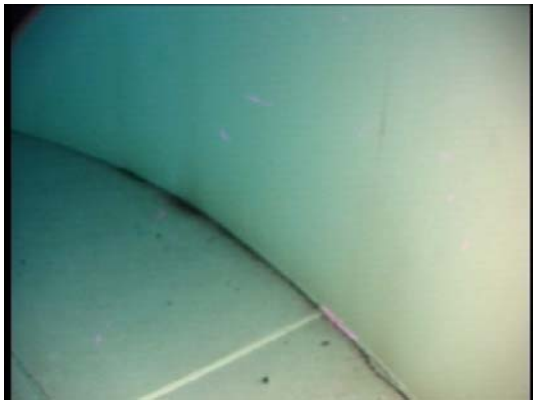
Town of New Hartford WPCA **175K Welded Tank**



VS # 7: Small pit below horizontal weld seam (Time: 17:23)

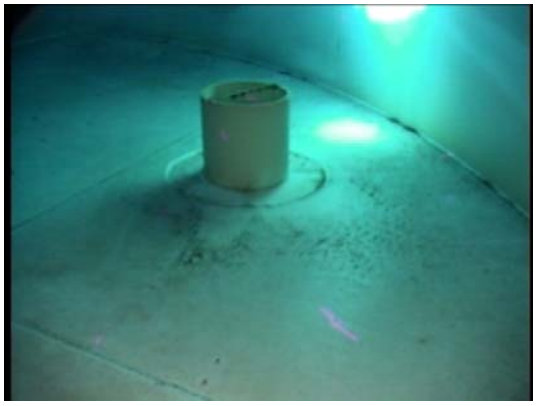


VS # 8: Numerous corrosion cells on horizontal weld seam (Time: 18:55)



VS # 9: Floor to shell seam in good condition (Time: 22:10)

Town of New Hartford WPCA **175K Welded Tank**



VS # 10: Inlet/Outlet pipe with sediment ring (Time: 23:30)

VS # 11: Minor edge corrosion on neck of shell man way (Time: 23:45)

Appendix B

Dry Film Thickness Reading

TOWN OF NEW HARTFORD
TANK #2
ROOF D.F.T.

Readings - B1 **6/4/2010 3:35:56 PM**

Reading	Time & Date	Coat 1 (mil)
1	9:57:25 AM 6/3/2010	14.4
2	9:57:27 AM 6/3/2010	15.9
3	9:57:28 AM 6/3/2010	15.5
4	9:57:31 AM 6/3/2010	13.4
5	9:57:33 AM 6/3/2010	35.6
6	9:57:35 AM 6/3/2010	18.8
7	9:57:38 AM 6/3/2010	18.1
8	9:57:40 AM 6/3/2010	16.4
9	9:57:41 AM 6/3/2010	12.0
10	9:57:43 AM 6/3/2010	12.8
11	9:57:45 AM 6/3/2010	13.8
12	9:57:47 AM 6/3/2010	12.8
13	9:57:49 AM 6/3/2010	13.9
14	9:57:51 AM 6/3/2010	14.4
15	9:57:52 AM 6/3/2010	13.3
16	9:57:54 AM 6/3/2010	16.8
17	9:57:56 AM 6/3/2010	15.7
18	9:58:00 AM 6/3/2010	16.8
19	9:58:02 AM 6/3/2010	22.8
20	9:58:04 AM 6/3/2010	11.8
21	9:58:07 AM 6/3/2010	14.5
22	9:58:09 AM 6/3/2010	13.5
23	9:58:10 AM 6/3/2010	20.2
24	9:58:13 AM 6/3/2010	14.9
25	9:58:15 AM 6/3/2010	15.7
26	9:58:17 AM 6/3/2010	16.8
27	9:58:31 AM 6/3/2010	13.0
28	9:58:33 AM 6/3/2010	16.1
29	9:58:35 AM 6/3/2010	11.9
30	9:58:37 AM 6/3/2010	13.4
31	9:58:38 AM 6/3/2010	15.2
32	9:58:40 AM 6/3/2010	14.2
33	9:58:42 AM 6/3/2010	12.7
34	9:58:44 AM 6/3/2010	12.2
35	9:58:46 AM 6/3/2010	14.2
36	9:58:47 AM 6/3/2010	10.8
37	9:58:49 AM 6/3/2010	13.1
38	9:58:51 AM 6/3/2010	12.5
39	9:58:53 AM 6/3/2010	14.7
40	9:58:55 AM 6/3/2010	13.3
41	9:58:57 AM 6/3/2010	18.5
42	9:58:59 AM 6/3/2010	10.6
43	9:59:01 AM 6/3/2010	11.8
44	9:59:08 AM 6/3/2010	12.4
45	9:59:12 AM 6/3/2010	24.2

Summary - B1 **6/4/2010 3:35:56 PM**

Reading	Time & Date	Coat 1 (mil)
Max		35.60
Min		10.60
Mean		15.23
StdDev.		4.22

TOWN OF NEW HARTFORD
TANK #2
SHELL D.F.T.

Readings - B2 **5/18/2010 3:25:31 PM**

Reading	Time & Date	Coat 1 (mil)
1	12:01:34 PM 5/17/2010	14.2
2	12:01:36 PM 5/17/2010	13.4
3	12:01:37 PM 5/17/2010	13.6
4	12:01:41 PM 5/17/2010	14.7
5	12:01:43 PM 5/17/2010	13.7
6	12:01:45 PM 5/17/2010	13.2
7	12:01:50 PM 5/17/2010	9.0
8	12:01:51 PM 5/17/2010	12.3
9	12:01:54 PM 5/17/2010	15.2
10	12:01:58 PM 5/17/2010	9.3
11	12:02:00 PM 5/17/2010	9.3
12	12:02:01 PM 5/17/2010	11.0
13	12:02:05 PM 5/17/2010	27.3
14	12:02:07 PM 5/17/2010	8.2
15	12:02:09 PM 5/17/2010	12.1
16	12:02:14 PM 5/17/2010	13.2
17	12:02:16 PM 5/17/2010	12.4
18	12:02:18 PM 5/17/2010	14.3
19	12:02:21 PM 5/17/2010	13.4
20	12:02:23 PM 5/17/2010	14.9
21	12:02:25 PM 5/17/2010	13.9
22	12:02:30 PM 5/17/2010	14.7
23	12:02:32 PM 5/17/2010	16.2
24	12:02:34 PM 5/17/2010	12.1
25	12:02:37 PM 5/17/2010	17.9
26	12:02:39 PM 5/17/2010	18.1
27	12:02:41 PM 5/17/2010	17.0
28	12:02:45 PM 5/17/2010	14.0
29	12:02:47 PM 5/17/2010	11.2
30	12:02:49 PM 5/17/2010	12.9
31	12:02:53 PM 5/17/2010	12.2
32	12:02:54 PM 5/17/2010	11.8
33	12:02:57 PM 5/17/2010	11.2
34	12:03:00 PM 5/17/2010	13.9
35	12:03:01 PM 5/17/2010	13.8
36	12:03:03 PM 5/17/2010	15.6
37	12:03:06 PM 5/17/2010	16.2
38	12:03:08 PM 5/17/2010	18.8
39	12:03:10 PM 5/17/2010	13.7
40	12:03:13 PM 5/17/2010	12.6
41	12:03:15 PM 5/17/2010	14.6
42	12:03:18 PM 5/17/2010	14.8
43	12:03:22 PM 5/17/2010	14.5
44	12:03:24 PM 5/17/2010	17.6
45	12:03:26 PM 5/17/2010	19.3

Summary - B2 **5/18/2010 3:25:31 PM**

Reading	Time & Date	Coat 1 (mil)
Max		27.30
Min		8.20
Mean		14.07
StdDev.		3.21

Appendix C

Adhesion Test Method 3359

Designation: D 3359 – 02

Standard Test Methods for Measuring Adhesion by Tape Test[1]

This standard is issued under the fixed designation D 3359; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope

1.1 These test methods cover procedures for assessing the adhesion of coating films to metallic substrates by applying and removing pressure-sensitive tape over cuts made in the film.

1.2 Test Method A is primarily intended for use at job sites while Test Method B is more suitable for use in the laboratory. Also, Test Method B is not considered suitable for films thicker than 5 mils (125μm).

NOTE 1—Subject to agreement between the purchaser and the seller, Test Method B can be used for thicker films if wider spaced cuts are employed.

1.3 These test methods are used to establish whether the adhesion of a coating to a substrate is at a generally adequate level. They do not distinguish between higher levels of adhesion for which more sophisticated methods of measurement are required.

NOTE 2—It should be recognized that differences in adherability of the coating surface can affect the results obtained with coatings having the same inherent adhesion.

1.4 In multicoat systems adhesion failure may occur between coats so that the adhesion of the coating system to the substrate is not determined.

1.5 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

1.6 *This standard does not purport to address the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

D 609 Practice for Preparation of Cold-Rolled Steel Panels for Testing Paint, Varnish, Conversion Coatings, and Related Coating Products[2]

D 823 Practices for Producing Films of Uniform Thickness of Paint, Varnish, and Related Products on Test Panels[2]

D 1000 Test Method For Pressure-Sensitive Adhesive-Coated Tapes Used for Electrical and Electronic Applications[3]

D 1730 Practices for Preparation of Aluminum and Aluminum-Alloy Surfaces for Painting[4]

D 2092 Guide for Preparation of Zinc-Coated (Galvanized) Steel Surfaces for Painting[5]

D 2370 Test Method for Tensile Properties of Organic Coatings[2]

D 3330 Test Method for Peel Adhesion of Pressure-Sensitive Tape [6]

D 3924 Specification for Standard Environment for Conditioning and Testing Paint, Varnish, Lacquer, and Related Materials[2]

D 4060 Test Method for Abrasion Resistance of Organic Coatings by the Taber Abraser[2]

3. Summary of Test Methods

3.1 *Test Method A*—An X-cut is made through the film to the substrate, pressure-sensitive tape is applied over the cut and then removed, and adhesion is assessed qualitatively on the 0 to 5 scale.

3.2 *Test Method B*—A lattice pattern with either six or eleven cuts in each direction is made in the film to the substrate, pressure-sensitive tape is applied over the lattice and then removed, and adhesion is evaluated by comparison with descriptions and illustrations.

4. Significance and Use

4.1 If a coating is to fulfill its function of protecting or decorating a substrate, it must adhere to it for the expected service life. Because the substrate and its surface preparation (or lack of it) have a drastic effect on the adhesion of coatings, a method to evaluate adhesion of a coating to different substrates or surface treatments, or of different coatings to the

[1] These test methods are under the jurisdiction of ASTM Committee D01 on Paint and Related Coatings, Materials, and Applications and are the direct responsibility of Subcommittee D01.23 on Physical Properties of Applied Paint Films.

Current edition approved Aug. 10, 2002. Published October 2002. Originally published as D 3359 – 74. Last previous edition D 3359 – 97.

[2] *Annual Book of ASTM Standards*, Vol 06.01.

[3] *Annual Book of ASTM Standards*, Vol 10.01.

[4] *Annual Book of ASTM Standards*, Vol 02.05.

[5] *Annual Book of ASTM Standards*, Vol 06.02.

[6] *Annual Book of ASTM Standards*, Vol 15.09.

same substrate and treatment, is of considerable usefulness in the industry.

4.2 The limitations of all adhesion methods and the specific limitation of this test method to lower levels of adhesion (see 1.3) should be recognized before using it. The intra- and inter-laboratory precision of this test method is similar to other widely-accepted tests for coated substrates (for example, Test Method D 2370 and Test Method D 4060), but this is partly the result of it being insensitive to all but large differences in adhesion. The limited scale of 0 to 5 was selected deliberately to avoid a false impression of being sensitive.

TEST METHOD A—X-CUT TAPE TEST

5. Apparatus and Materials

5.1 *Cutting Tool*—Sharp razor blade, scalpel, knife or other cutting devices. It is of particular importance that the cutting edges be in good condition.

5.2 *Cutting Guide*—Steel or other hard metal straightedge to ensure straight cuts.

5.3 *Tape*—25-mm (1.0-in.) wide semitransparent pressure-sensitive tape[7] with an adhesion strength agreed upon by the supplier and the user is needed. Because of the variability in adhesion strength from batch-to-batch and with time, it is essential that tape from the same batch be used when tests are to be run in different laboratories. If this is not possible the test method should be used only for ranking a series of test coatings.

5.4 *Rubber Eraser*, on the end of a pencil.

5.5 *Illumination*—A light source is helpful in determining whether the cuts have been made through the film to the substrate.

6. Test Specimens

6.1 When this test method is used in the field, the specimen is the coated structure or article on which the adhesion is to be evaluated.

6.2 For laboratory use apply the materials to be tested to panels of the composition and surface conditions on which it is desired to determine the adhesion.

NOTE 3—Applicable test panel description and surface preparation methods are given in Practice D 609 and Practices D 1730 and D 2092.

NOTE 4—Coatings should be applied in accordance with Practice D 823, or as agreed upon between the purchaser and the seller.

NOTE 5—If desired or specified, the coated test panels may be subjected to a preliminary exposure such as water immersion, salt spray, or high humidity before conducting the tape test. The conditions and time of exposure will be governed by ultimate coating use or shall be agreed upon between the purchaser and seller.

7. Procedure

7.1 Select an area free of blemishes and minor surface imperfections. For tests in the field, ensure that the surface is clean and dry. Extremes in temperature or relative humidity may affect the adhesion of the tape or the coating.

7.1.1 For specimens which have been immersed: After immersion, clean and wipe the surface with an appropriate solvent which will not harm the integrity of the coating. Then dry or prepare the surface, or both, as agreed upon between the purchaser and the seller.

7.2 Make two cuts in the film each about 40 mm (1.5 in.) long that intersect near their middle with a smaller angle of between 30 and 45°. When making the incisions, use the straightedge and cut through the coating to the substrate in one steady motion.

7.3 Inspect the incisions for reflection of light from the metal substrate to establish that the coating film has been penetrated. If the substrate has not been reached make another X in a different location. Do not attempt to deepen a previous cut as this may affect adhesion along the incision.

7.4 Remove two complete laps of the pressure-sensitive tape from the roll and discard. Remove an additional length at a steady (that is, not jerked) rate and cut a piece about 75 mm (3 in.) long.

7.5 Place the center of the tape at the intersection of the cuts with the tape running in the same direction as the smaller angles. Smooth the tape into place by finger in the area of the incisions and then rub firmly with the eraser on the end of a pencil. The color under the transparent tape is a useful indication of when good contact has been made.

7.6 Within 90 ± 30 s of application, remove the tape by seizing the free end and pulling it off rapidly (not jerked) back upon itself at as close to an angle of 180° as possible.

7.7 Inspect the X-cut area for removal of coating from the substrate or previous coating and rate the adhesion in accordance with the following scale:

5A	No peeling or removal,
4A	Trace peeling or removal along incisions or at their intersection,
3A	Jagged removal along incisions up to 1.6 mm (1/16 in.) on either side,
2A	Jagged removal along most of incisions up to 3.2 mm (1/8 in.) on either side,
1A	Removal from most of the area of the X under the tape, and
0A	Removal beyond the area of the X.

7.8 Repeat the test in two other locations on each test panel. For large structures make sufficient tests to ensure that the adhesion evaluation is representative of the whole surface.

7.9 After making several cuts examine the cutting edge and, if necessary, remove any flat spots or wire-edge by abrading lightly on a fine oil stone before using again. Discard cutting tools that develop nicks or other defects that tear the film.

8. Report

8.1 Report the number of tests, their mean and range, and for coating systems, where the failure occurred that is, between first coat and substrate, between first and second coat, etc.

8.2 For field tests report the structure or article tested, the location and the environmental conditions at the time of testing.

8.3 For test panels report the substrate employed, the type of coating, the method of cure, and the environmental conditions at the time of testing.

8.4 If the adhesion strength of the tape has been determined in accordance with Test Methods D 1000 or D 3330, report the

[7] Permacel 99, manufactured by Permacel, New Brunswick, NJ 08903, and available from various Permacel tape distributors, is reported to be suitable for this purpose. The manufacturer of this tape and the manufacturer of the tape used in the interlaboratory study (see RR: D01-1008), have advised this subcommittee that the properties of these tapes were changed. Users of it should, therefore, check whether current material gives comparable results to previous supplied material.

results with the adhesion rating(s). If the adhesion strength of the tape has not been determined, report the specific tape used and its manufacturer.

8.5 If the test is performed after immersion, report immersion conditions and method of sample preparation.

9. Precision and Bias [8]

9.1 In an interlaboratory study of this test method in which operators in six laboratories made one adhesion measurement on three panels each of three coatings covering a wide range of adhesion, the within-laboratories standard deviation was found to be 0.33 and the between-laboratories 0.44. Based on these standard deviations, the following criteria should be used for judging the acceptability of results at the 95 % confidence level:

9.1.1 *Repeatability*—Provided adhesion is uniform over a large surface, results obtained by the same operator should be considered suspect if they differ by more than 1 rating unit for two measurements.

9.1.2 *Reproducibility*—Two results, each the mean of triplicates, obtained by different operators should be considered suspect if they differ by more than 1.5 rating units.

9.2 Bias cannot be established for these test methods.

TEST METHOD B—CROSS-CUT TAPE TEST

10. Apparatus and Materials

10.1 *Cutting Tool*[9]—Sharp razor blade, scalpel, knife or other cutting device having a cutting edge angle between 15 and 30° that will make either a single cut or several cuts at once. It is of particular importance that the cutting edge or edges be in good condition.

10.2 *Cutting Guide*—If cuts are made manually (as opposed to a mechanical apparatus) a steel or other hard metal straightedge or template to ensure straight cuts.

10.3 *Rule*—Tempered steel rule graduated in 0.5 mm for measuring individual cuts.

10.4 *Tape*, as described in 5.3.

10.5 *Rubber Eraser*, on the end of a pencil.

10.6 *Illumination*, as described in 5.5.

10.7 *Magnifying Glass*—An illuminated magnifier to be used while making individual cuts and examining the test area.

11. Test Specimens

11.1 Test specimens shall be as described in Section 6. It should be noted, however, that multitip cutters[10] provide good results only on test areas sufficiently plane that all cutting edges contact the substrate to the same degree. Check for flatness with a straight edge such as that of the tempered steel rule (10.3).

12. Procedure

12.1 Where required or when agreed upon, subject the specimens to a preliminary test before conducting the tape test (see Note 3). After drying or testing the coating, conduct the tape test at room temperature as defined in Specification D 3924, unless D 3924 standard temperature is required or agreed.

12.1.1 For specimens which have been immersed: After immersion, clean and wipe the surface with an appropriate solvent which will not harm the integrity of the coating. Then dry or prepare the surface, or both, as agreed upon between the purchaser and the seller.

12.2 Select an area free of blemishes and minor surface imperfections, place on a firm base, and under the illuminated magnifier, make parallel cuts as follows:

12.2.1 For coatings having a dry film thickness up to and including 2.0 mils (50 μm) space the cuts 1 mm apart and make eleven cuts unless otherwise agreed upon.

12.2.2 For coatings having a dry film thickness between 2.0 mils (50 μm) and 5 mils (125 μm), space the cuts 2 mm apart and make six cuts. For films thicker than 5 mils use Test Method A.[11]

12.2.3 Make all cuts about 20 mm (¾ in.) long. Cut through the film to the substrate in one steady motion using just sufficient pressure on the cutting tool to have the cutting edge reach the substrate. When making successive single cuts with the aid of a guide, place the guide on the uncut area.

12.3 After making the required cuts brush the film lightly with a soft brush or tissue to remove any detached flakes or ribbons of coatings.

12.4 Examine the cutting edge and, if necessary, remove any flat spots or wire-edge by abrading lightly on a fine oil stone. Make the additional number of cuts at 90° to and centered on the original cuts.

12.5 Brush the area as before and inspect the incisions for reflection of light from the substrate. If the metal has not been reached make another grid in a different location.

12.6 Remove two complete laps of tape and discard. Remove an additional length at a steady (that is, not jerked) rate and cut a piece about 75 mm (3 in.) long.

12.7 Place the center of the tape over the grid and in the area of the grid smooth into place by a finger. To ensure good contact with the film rub the tape firmly with the eraser on the end of a pencil. The color under the tape is a useful indication of when good contact has been made.

12.8 Within 90 ± 30 s of application, remove the tape by seizing the free end and rapidly (not jerked) back upon itself at as close to an angle of 180° as possible.

12.9 Inspect the grid area for removal of coating from the substrate or from a previous coating using the illuminated magnifier. Rate the adhesion in accordance with the following scale illustrated in Fig. 1:

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[8] Supporting data are available from ASTM International Headquarters. Request RR: D01–1008.

[9] Multiblade cutters are available from a few sources that specialize in testing equipment for the paint industry. One supplier that has assisted in the refinement of these methods is given in footnote 10.

[10] The sole source of supply of the multitip cutter for coated pipe surfaces known to the committee at this time is Paul N. Gardner Co., 316 NE First St., Pompano Beach, FL 33060. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,[1] which you may attend.

[11] Test Method B has been used successfully by some people on coatings greater than 5 mils (0.13 mm) by spacing the cuts 5 mm apart. However, the precision values given in 14.1 do not apply as they are based on coatings less than 5 mm (0.13 mm) in thickness.

5B The edges of the cuts are completely smooth; none of the squares of the lattice is detached.
4B Small flakes of the coating are detached at intersections; less than 5 % of the area is affected.
3B Small flakes of the coating are detached along edges and at intersections of cuts. The area affected is 5 to 15 % of the lattice.
2B The coating has flaked along the edges and on parts of the squares. The area affected is 15 to 35 % of the lattice.
1B The coating has flaked along the edges of cuts in large ribbons and whole squares have detached. The area affected is 35 to 65 % of the lattice.
0B Flaking and detachment worse than Grade 1.

12.10 Repeat the test in two other locations on each test panel.

13. Report

13.1 Report the number of tests, their mean and range, and for coating systems, where the failure occurred, that is, between first coat and substrate, between first and second coat, etc.

13.2 Report the substrate employed, the type of coating and the method of cure.

13.3 If the adhesion strength has been determined in accordance with Test Methods D 1000 or D 3330, report the results with the adhesion rating(s). If the adhesion strength of the tape has not been determined, report the specific tape used and its manufacturer.

13.4 If the test is performed after immersion, report immersion conditions and method of sample preparation.

14. Precision and Bias [8]

14.1 On the basis of two interlaboratory tests of this test method in one of which operators in six laboratories made one adhesion measurement on three panels each of three coatings covering a wide range of adhesion and in the other operators in six laboratories made three measurements on two panels each of four different coatings applied over two other coatings, the pooled standard deviations for within- and between-laboratories were found to be 0.37 and 0.7. Based on these standard deviations, the following criteria should be used for judging the acceptability of results at the 95 % confidence level:

14.1.1 *Repeatability*—Provided adhesion is uniform over a large surface, results obtained by the same operator should be considered suspect if they differ by more than one rating unit for two measurements.

CLASSIFICATION OF ADHESION TEST RESULTS

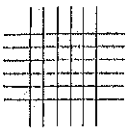
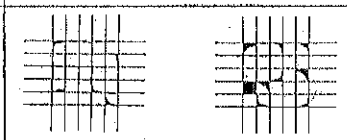
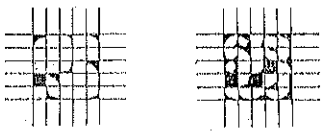
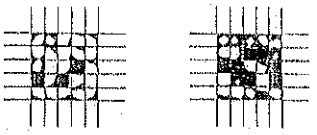
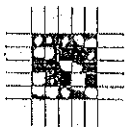
CLASSIFICATION	PERCENT AREA REMOVED	SURFACE OF CROSS-CUT AREA FROM WHICH FLAKING HAS OCCURRED FOR SIX PARALLEL CUTS AND ADHESION RANGE BY PERCENT
5B	0% None	
4B	Less than 5%	
3B	5 - 15%	
2B	15 - 35%	
1B	35 - 65%	
0B	Greater than 65%	

FIG. 1 Classification of Adhesion Test Results

14.1.2 *Reproducibility*—Two results, each the mean of duplicates or triplicates, obtained by different operators should be considered suspect if they differ by more than two rating units.

14.2 Bias cannot be established for these test methods.

15. Keywords

15.1 adhesion; crosscut adhesion test method; tape; tape adhesion test method; X-cut adhesion test method