

Aluminized Pipe Evaluation

FL/DOT/SMO 15-572

FDOT Office State Materials Office

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Date of Publication 01-2015 Several recent aluminized pipe failures in the State of Florida prompted the Department to take a closer look at the quality of the pipe being produced today. Sections of pipe were sampled from all plants currently producing aluminized steel pipe for Department projects. These samples were sent to the State Materials Office, Corrosion Laboratory to perform an evaluation on the condition of the aluminum coating after fabrication. A total of nine pipe samples were acquired. See Table 1 for a list and description of these pipe samples.

Each pipe was visually inspected for damage and then coupons were taken in order to perform metallographic analysis at locations of interest. The visual inspection showed multiple locations of obvious damage to the aluminized coating. Table 2 provides a summary of the number of observed damages for each pipe sample. Coupons were obtained from areas with visible damage, as well as from lock joints, corrugations, and flat areas. A total of 56 locations were analyzed.

The metallographic analyses showed that there was no apparent coating damage induced by the manufacturing process in any of the pipe samples. The only damage to the aluminized coating that was observed appeared to be the result of handling after fabrication. This damage was primarily in the form of scrapes and gouges. It is unclear if the damage was caused during the sampling process or if it was the result of normal transport and storage of the pipe itself. The samples appeared to have been cut from the full length of pipe using either a cutting torch, reciprocating type saw, or possibly an abrasive cutting wheel. Most of the damage seen can easily be accounted for if the pipe was rotated in place as the sample was cut from the pipe.

During the analysis of the lock joint on pipe sample 7, a crack was found in the lock joint fold. See Figure 81. This crack is most likely the result of excessive force applied during the crimping process. Two additional locations along the lock joint of the pipe sample were evaluated and the metallographic analysis showed evidence of the crack at these locations as well. See Figures 82 and 83.

All photo documentation is provided below with observations.

Pipe sample 1 is seen in Figures 1 through 13; Pipe sample 2 is seen in Figures 14 through 23; Pipe sample 3 is seen in Figures 24 through 34; Pipe sample 4 is seen in Figures 35 through 49; Pipe sample 5 is seen in Figures 50 through 59; Pipe sample 6 is seen in Figures 60 through 70; Pipe sample 7 is seen in Figures 71 through 83; Pipe sample 8 is seen in Figures 84 through 95; Pipe sample 9 is seen in Figures 96 through 113

There are two main conclusions from this evaluation. The pipe being produced today is of good quality and the importance of proper handling of the pipe after fabrication is evident. Each location where the aluminized coating suffers damage is a prime location for a premature corrosion failure of the pipe to occur depending on the service environment the pipe is placed in.

Table 1 Pipe sample inventory showing the producer, plant location, pipe diameter, coil manufacurer, coil date, roll date, and corrugation design.

Sample #	Lab #	Plant #	Dia.	Coil Manufacturer	Coil Date	Roll Date	Corrugation Design
1	2014-08-036	1	24"	Severstal	"unknown"	"unknown"	Round
2	2014-08-037	4	36"	AK Steel	"unknown"	"unknown"	Round
3	2014-09-008	4	36"	AK Steel	2/2014	"unknown"	Square
4	2014-09-009	4	36"	Severstal	5/2014	"unknown"	Square
5	2014-09-010	2	24"	AK Steel	3/2014	"unknown"	Round
6	2014-09-017	5	18"	"unknown"	5/2012	1/2014	Round
7	2014-09-018	3	24"	AK Steel	8/2014	9/16/2014	Round
8	2014-09-046	2	24"	AK Steel	"unknown"	"unknown"	Round
9	2014-10-002	2	24"	AK Steel	10/2013	12/2013	Square

Table 2 Summary of visual damage to the pipe samples.

Sample #	Pipe Sample Length (inches)	# of Damaged* Locations	Approximate # of Damaged* Locations per Linear Foot
1	19	11	7
2	17	5	4
3	18	0	0
4	12	0	0
5	12	4	4
6	13	2	2
7	14	1	1
8	12	2	2
9	16	2	2

* Note: 1 Not all areas that appeared to have damage to the aluminum coating went down to the steel substrate.



Figure 1. Pipe #2014-08-036 – 24" section of pipe. Eleven areas had visible damage, samples were removed for metallographic analysis

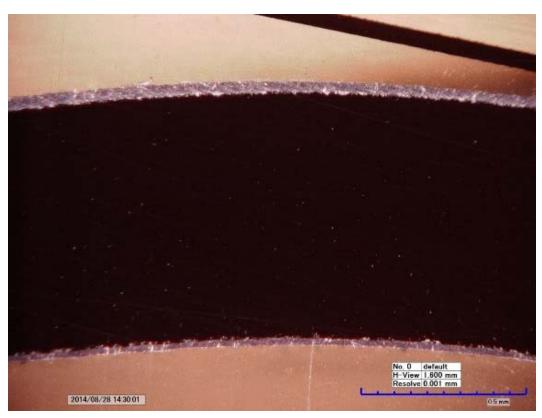


Figure 2. Pipe #2014-08-036 – Cross section of a control sample. There is no visible damage to the Aluminum layer. 70x

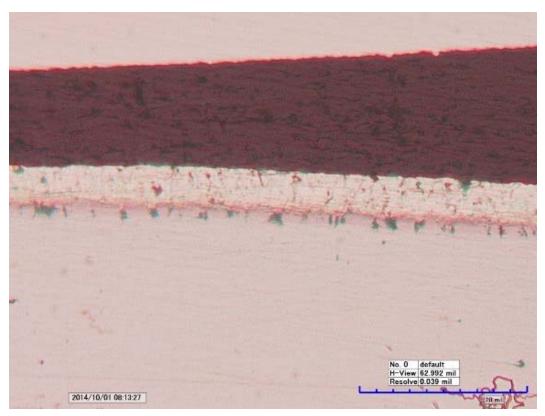


Figure 3. Pipe #2014-08-036 – Cross section of a control sample. When examined under further magnification, there is no visible damage to the Aluminum layer. 350x



Figure 4. Pipe #2014-08-036 – Close up of a deep scratch on the corrugation. Visible damage to the aluminum coating is seen.

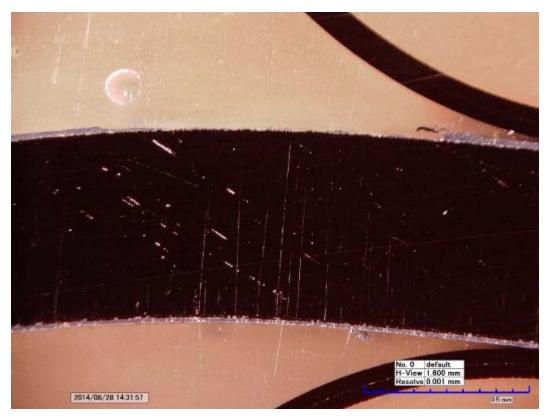


Figure 5. Pipe #2014-08-036 – Cross section of a scratched area showing visible damage to the aluminum layer. 70x

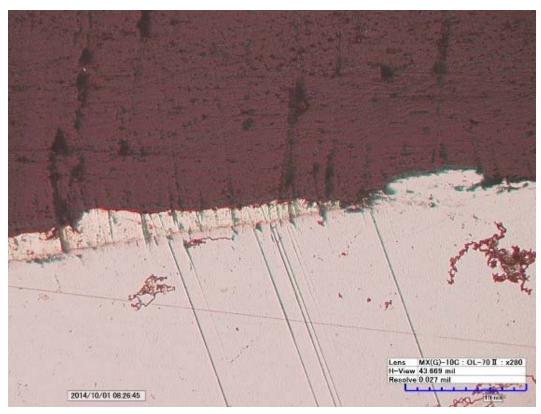


Figure 6. Pipe #2014-08-036 – Cross section of a scratched area. When examined under further magnification, there is visible damage to the inner metallic layer. 280x



Figure 7. Pipe #2014-08-036 – Close up of gouges in the pipe. This shows visible damage.

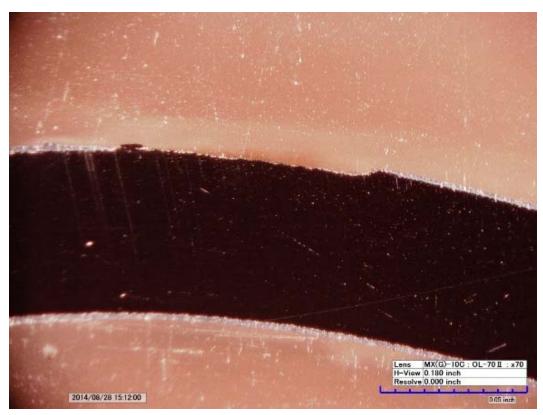


Figure 8. Pipe #2014-08-036 – Cross section of the gouged area showing visible damage to the aluminum layer. 70x

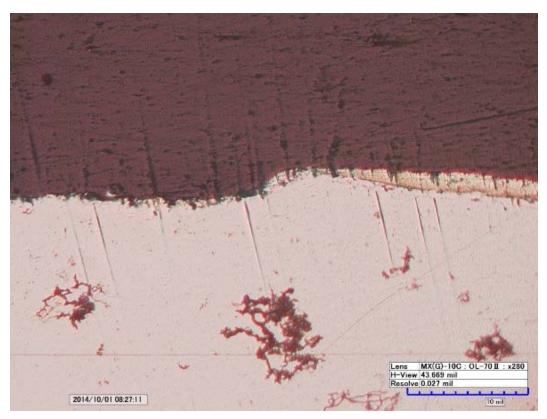


Figure 9. Pipe #2014-08-036 – Cross section of the gouges area. When examined under further magnification, there is visible damage to the inner metallic layer as well. 280x



Figure 10. Pipe #2014-08-036 – Close up of the lock seam. There was no visible damage.



Figure 11. Pipe #2014-08-036 – Low magnification of the lock seam. There was no visible damage to the exterior, but there was damage in the folds to the aluminum layer. This type of damage is common, but poses little concern.



Figure 12. Pipe #2014-08-036 – The lock joint was examined under further magnification after additional polishing was performed. A clear separation of the aluminum layer is seen. 70x

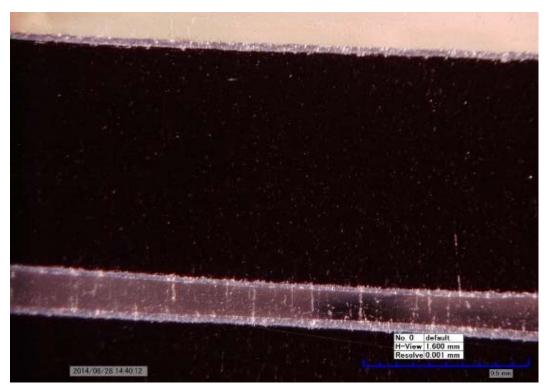


Figure 13. Pipe #2014-08-036 – The lock joint shows no visible damage to the aluminized layer in the center portion of the joint. 70x



Figure 14. Pipe #2014-08-037 – 36" section of pipe. Five areas had visible damage, and samples were removed for metallographic analysis.



Figure 15. Pipe #2014-08-037 – Close up of a control sample. This shows no visible damage.

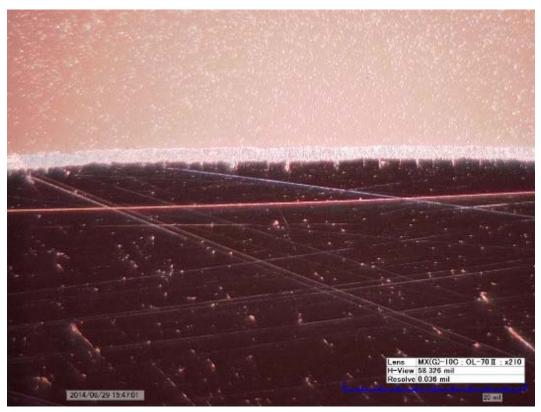


Figure 16. Pipe #2014-08-037 – Cross section of the control sample showing no visible damage to the aluminized layer. 210x



Figure 17. Pipe #2014-08-037 – Close up of a rolling mark showing visible markings on the exterior.

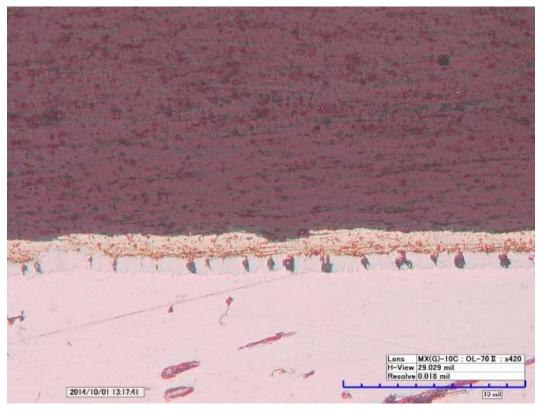


Figure 18. Pipe #2014-08-037 – Cross section of the rolling mark area shows minimal damage to the aluminized layer. 420x



Figure 19. Pipe #2014-08-037 – Close up of a gouge in the pipe. This shows apparent damage to the aluminum coating.



Figure 20. Pipe #2014-08-037 – Cross section of the gouged pipe showing visible damage to the intermetallic layer. 70x



Figure 21. Pipe #2014-08-037 – Close up of the lock seam. There was no visible damage.

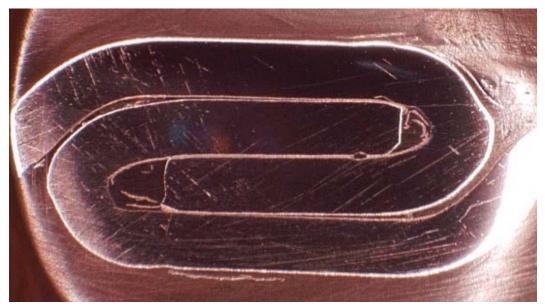


Figure 22. Pipe #2014-08-037 – Low magnification of the lock seam. There was no visible damage to the exterior, but there was damage in the folds to the aluminum layer. This type of damage is common, but poses little concern. 10x



Figure 23. Pipe #2014-08-037 – Cross section of the lock joint. A clear separation of the aluminum layer is seen. 70x



Figure 24. Pipe #2014-09-008 – 36" section of pipe. No visible damage to the aluminum coating. Multiple rolling marks on the corrugations.

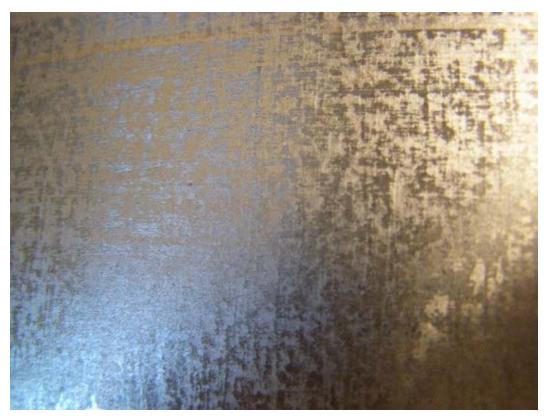


Figure 25. Pipe #2014-09-008 – Close up of the control sample shows no visible damage to the aluminum layer.



Figure 26. Pipe #2014-09-008 – Cross section of the control sample showing no visible damage to the aluminum layer; 420x



Figure 27. Pipe #2014-09-008 – Close up of rolling marks showing visible markings on the pipe surface.



Figure 28. Pipe #2014-09-008 – Cross section of rolling mark area showing no visible damage to the aluminum layer. 140x

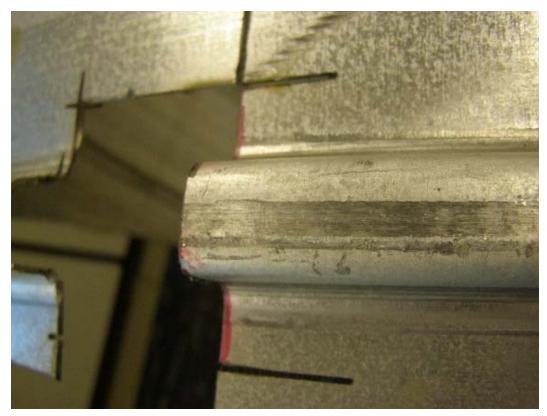


Figure 29. Pipe #2014-09-008 – Close up of rolling marks on top of the corrugation showing visible markings on the pipe.



Figure 30. Pipe #2014-09-008 – Low magnification cross section of the rolling marks.

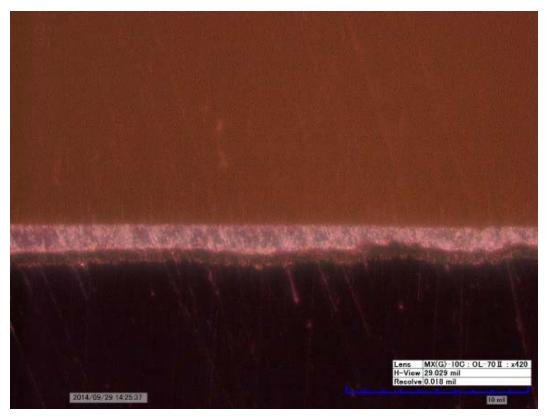


Figure 31. Pipe #2014-09-008 –Further magnification of the rolling marks on the corrugation show no visible damage to the aluminum layer; 420x

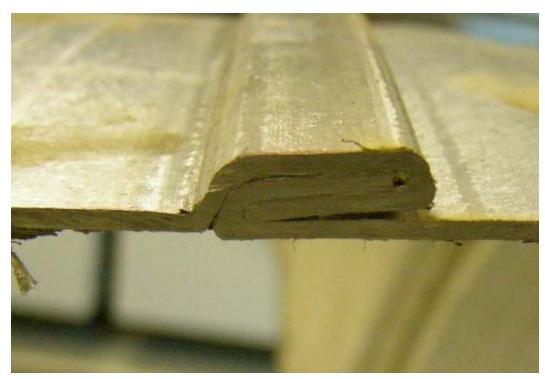


Figure 32. Pipe #2014-09-008 - Close up of the lock joint.



Figure 33. Pipe #2014-09-008 – Cross section of the lock joint. As previously noted the aluminum layer has some damage in the bend region. 70x

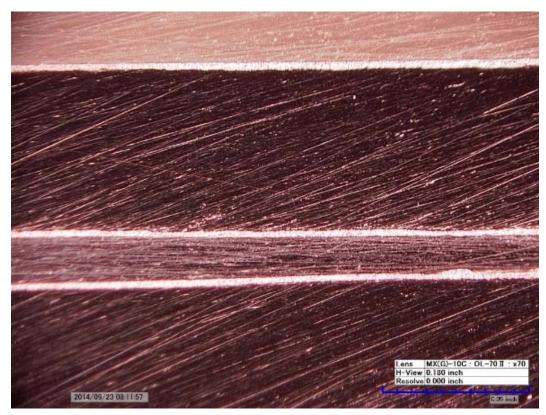


Figure 34. Pipe #2014-09-008 – The center of the lock joint shows no visible damage to the aluminum layer. 70x



Figure 35. Pipe #2014-09-009 – 36" section of pipe. No visible damage to the aluminum coating. Multiple rolling marks on the corrugations.



Figure 36. Pipe #2014-09-009 – Close up of the control sample showing no visible damage to the aluminum layer.

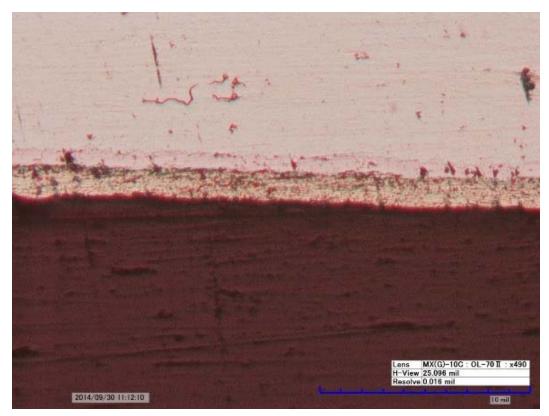


Figure 37. Pipe #2014-09-009 – Cross section of control sample showing no damage to the aluminum layer. 490x



Figure 38. Pipe #2014-09-009 – Close up of rolling marks on top of the corrugation showing visible markings on the pipe.



Figure 39. Pipe #2014-09-009 – Low magnification cross section of the rolling marks.

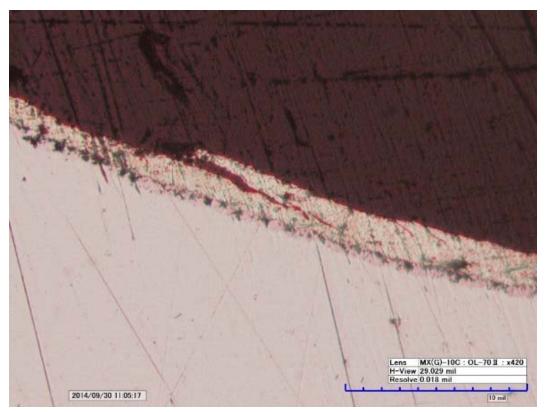


Figure 40. Pipe #2014-09-009 –Further magnification of the corrugation shows minor damage to the aluminum layer. 420x

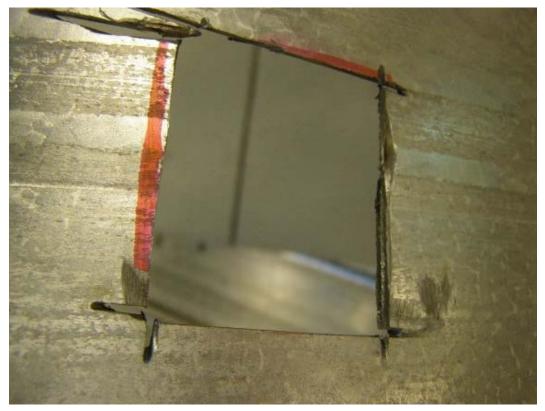


Figure 41. Pipe #2014-09-009 – Close up of rolling marks showing visible markings on the pipe surface.



Figure 42. Pipe #2014-09-009 – Cross section of rolling mark area showing no visible damage to the aluminum layer. 70x



Figure 43. Pipe #2014-09-009 – Cross section of rolling mark area under further magnification showing no visible damage to the aluminum layer; 420x



Figure 44. Pipe #2014-09-009 – Close up of scraping on the corrugation showing possible damage to the aluminum layer.



Figure 45. Pipe #2014-09-009 – Low magnification cross section of the corrugation at locations of scrapes.

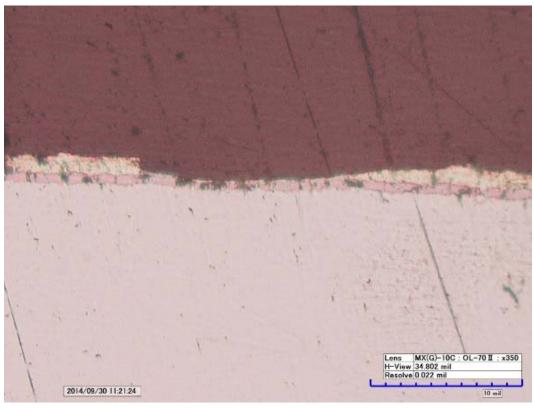


Figure 46. Pipe #2014-09-009 – Further magnification of the corrugation shows the scrapes damaged the aluminum layer. 350x

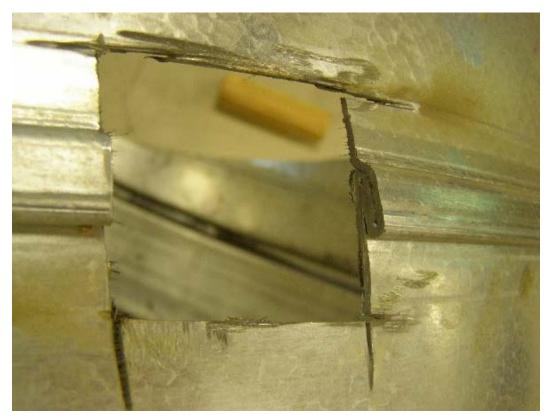


Figure 47. Pipe #2014-09-009 - Close up of the lock joint.

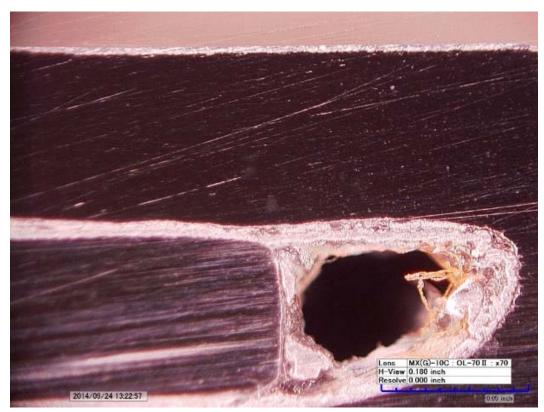


Figure 48. Pipe #2014-09-009 – Cross section of the lock joint. As previously noted the aluminum layer has some damage in the bend region. 70x

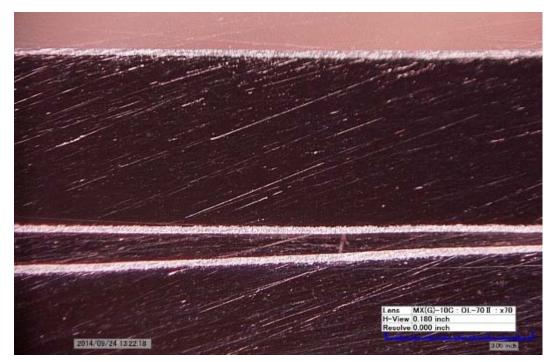


Figure 49. Pipe #2014-09-009 – The center of the lock joint shows no visible damage to the aluminum layer. 70x



Figure 50. Pipe #2014-09-010 - 24" section of pipe. Four areas had visible damage, and samples were removed for metallographic analysis.

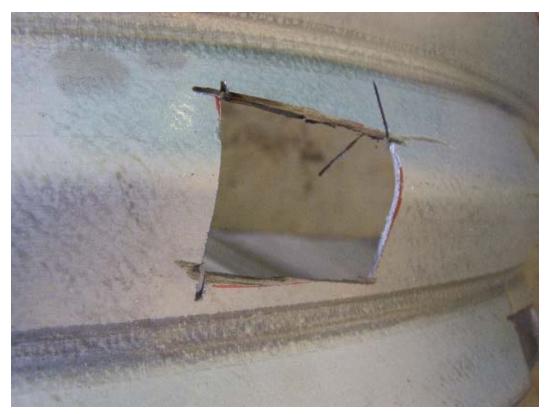


Figure 51. Pipe #2014-09-010 – Close up of the control sample showing no visible damage to the aluminum layer.

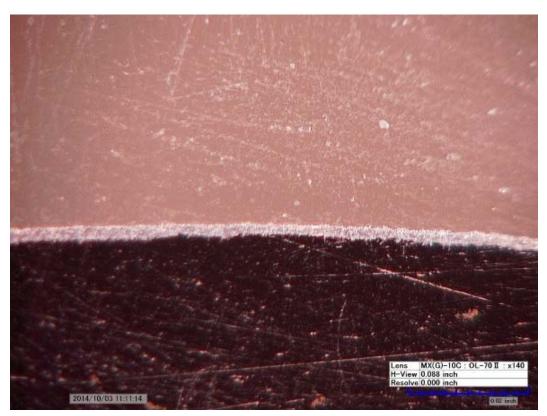


Figure 52. Pipe #2014-09-010 – Cross section of the control sample showing no visible damage to the aluminum layer. 140x

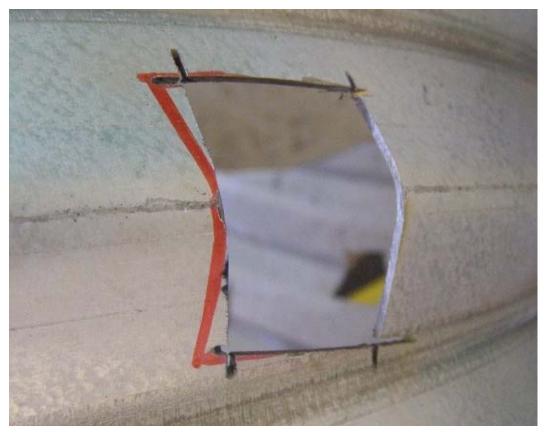


Figure 53. Pipe #2014-09-010 – Close up of rolling marks on top of the corrugation showing visible markings on the pipe.

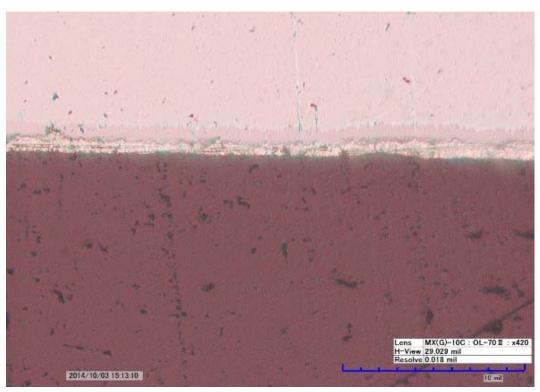


Figure 54. Pipe #2014-09-010 – Cross section of the rolling mark area shows no damage to the aluminized layer. 420x



Figure 55. Pipe #2014-09-010 – Close up of a gouge in the pipe. This shows apparent damage to the aluminum coating.

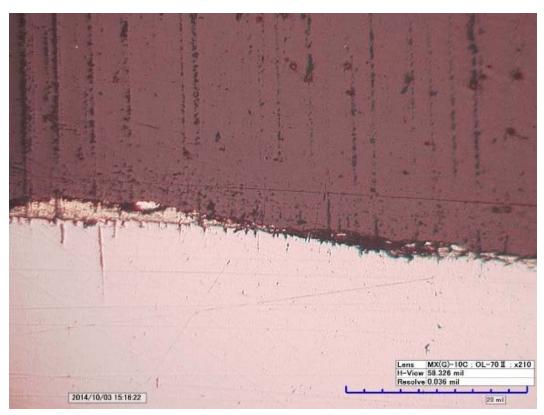


Figure 56. Pipe #2014-09-010 – Cross section of the gouge in the pipe showing damage to the inner metallic layer and possible the steel substrate. 210x



Figure 57. #2014-09-010 – Close up of the lock joint.

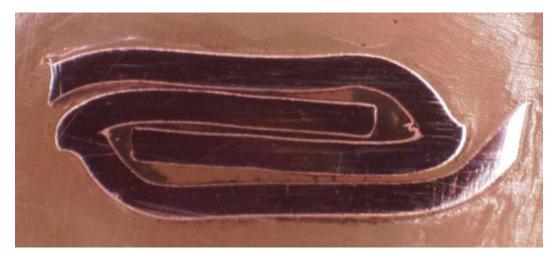


Figure 58. #2014-09-010 – Low magnification of the lock joint. There was no visible damage to the exterior, but there was damage in the folds to the aluminum layer. This type of damage is common, but poses little concern. 10x

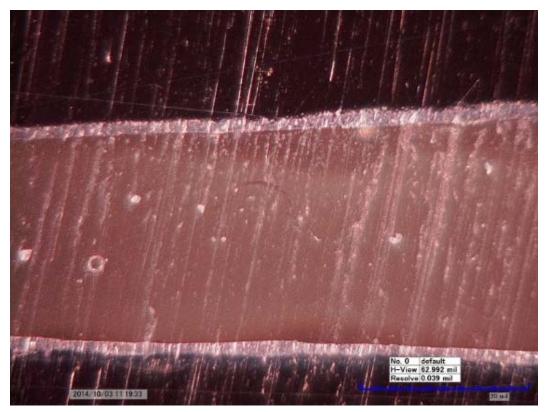


Figure 59. #2014-09-010 - The center of the lock joint shows no visible damage to the aluminum layer. 280x



Figure 60. #2014-09-017 – 24" section of pipe. Two areas had visible damage, and samples were removed for metallographic analysis

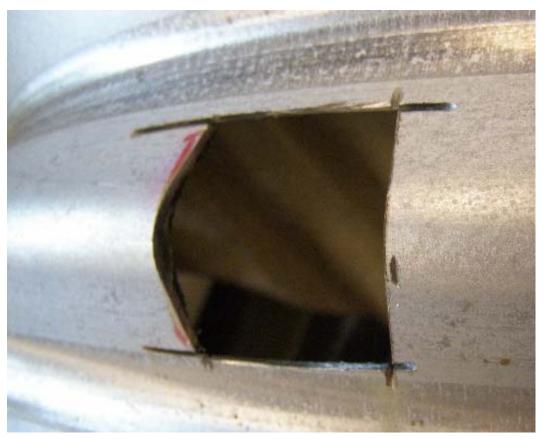


Figure 61. #2014-09-017 – Close up of the control sample showing no visible damage to the aluminum layer.

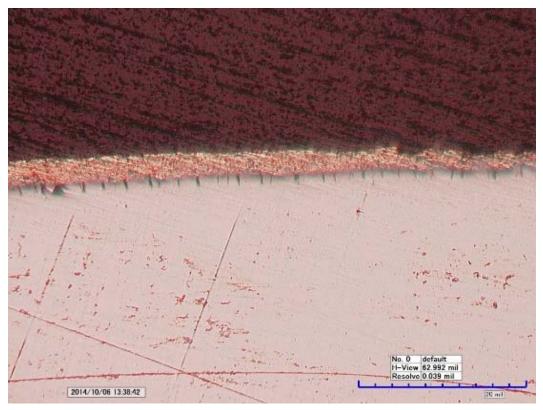


Figure 62. #2014-09-017 – Cross section of the control sample showing no visible damage to the aluminum layer. 350x



Figure 63. #2014-09-017 – Close up of rolling marks on top of the corrugation showing visible markings on the pipe.

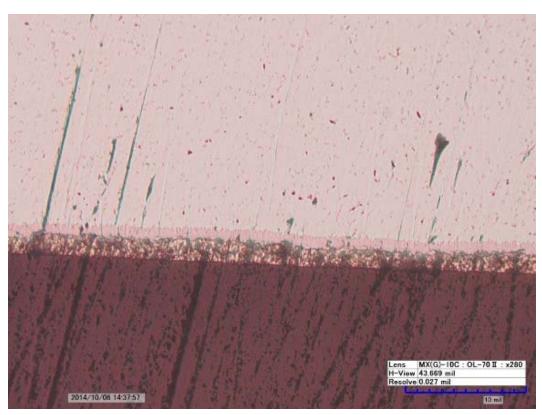


Figure 64. #2014-09-017 – Cross section of the rolling mark area shows no damage to the aluminized layer. 280x

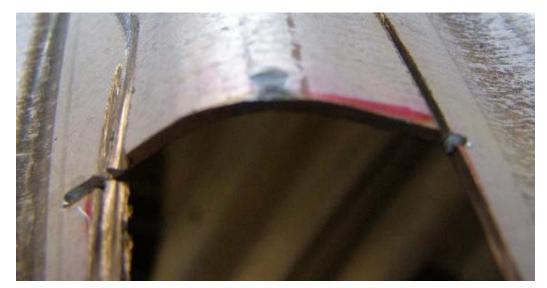


Figure 65. #2014-09-017 – Close up of a gouge in the pipe. This shows apparent damage to the aluminum coating



Figure 66. #2014-09-017 – Cross section of the gouge in the pipe showing damage to the aluminum layer, inner metallic layer and the steel substrate; 140x

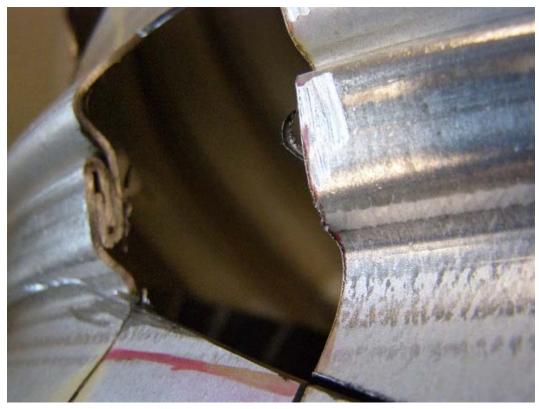


Figure 67. #2014-09-017 - Close up of the lock joint.



Figure 68. #2014-09-017 – Low magnification of the lock joint. There is apparent damage to the aluminum layer on the exterior, as well as the common damage in the folds to the aluminum layer. 20x



Figure 69. #2014-09-017 – The center of the lock joint shows no visible damage to the aluminum layer. 70x



Figure 70. #2014-09-017 – Cross section of the lock joint showing damage on the top surface to the aluminum layer, inner metallic layer and the steel substrate. 140x



Figure 71. #2014-09-018 – 36" section of pipe. One area had visible damage, and samples were removed for metallographic analysis

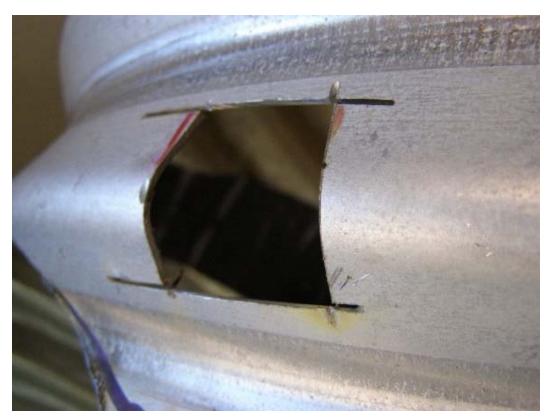


Figure 72. #2014-09-018 – Close up of the control sample showing no visible damage to the aluminum layer.

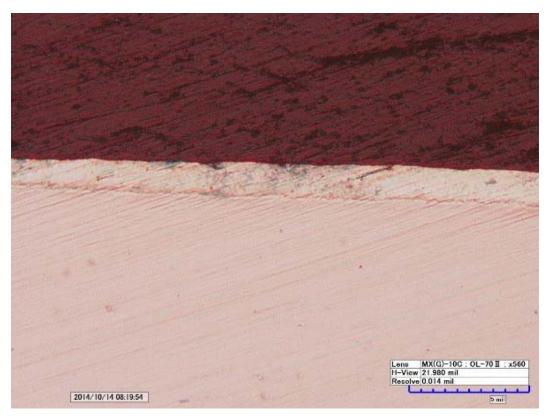


Figure 73. #2014-09-018 – Cross section of the control sample showing no visible damage to the aluminum layer. 560x



Figure 74. #2014-09-018 – Close up of rolling marks on top of the corrugation showing visible markings on the pipe.



Figure 75. #2014-09-018 – Cross section of the rolling mark area shows no damage to the aluminized layer. 210x



Figure 76. #2014-09-018 – Close up of a gouge or cut in the pipe.

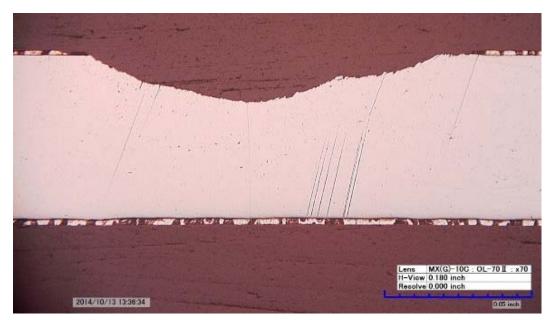


Figure 77. #2014-09-018 – Cross section of the gouged area showing visible damage to the steel substrate. 70x



Figure 78. #2014-09-018 – Close up of the Lock Joint.



Figure 79. #2014-09-018 – Low magnification of the Lock Joint.

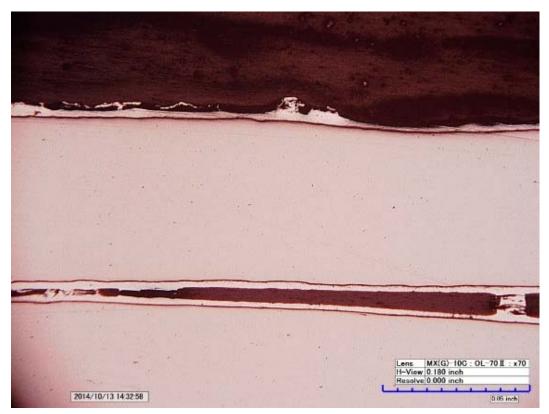


Figure 80. #2014-09-018 - The center of the lock joint shows no visible damage to the aluminum layer. 70x



Figure 81. #2014-09-018 – The right fold in the lock seam shows a visible crack in the steel substrate. 70x

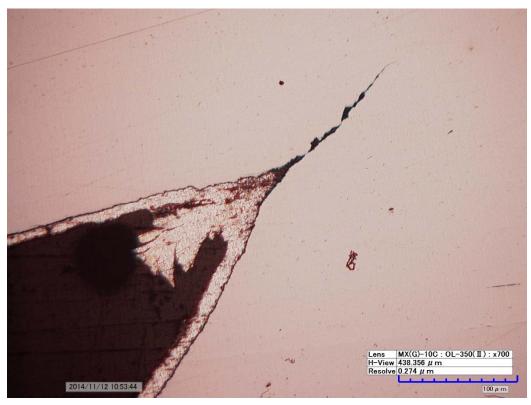


Figure 82. #2014-09-018 – Another lock joint location was examined and shows a visible crack in the steel substrate. 700x

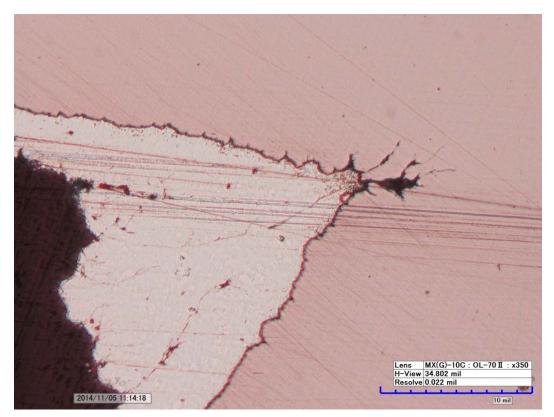


Figure 83. #2014-09-018 – A third lock seam location was examined and again showed a visible crack in the steel substrate. 350x



Figure 84. #2014-09-046 – 24" section of pipe. Two areas had visible damage, and samples were removed for metallographic analysis.



Figure 85. #2014-09-046 – Close up of a control sample. This shows no visible damage.

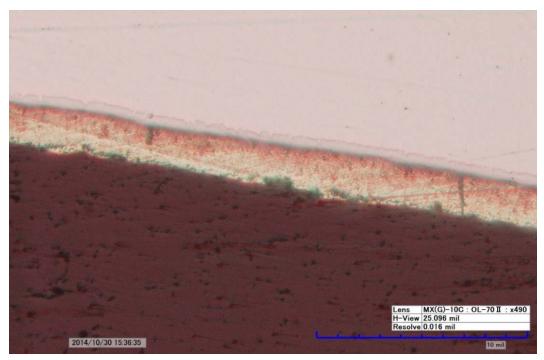


Figure 86. #2014-09-046 – Cross section of the control sample showing no visible damage to the aluminum layer. 490x



Figure 87. #2014-09-046 – Close up of rolling marks on top of the corrugation showing visible markings on the pipe.

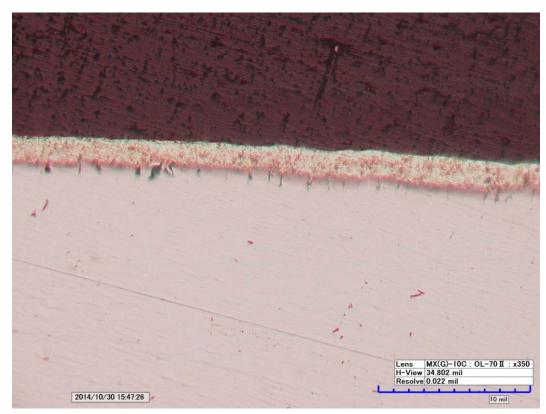


Figure 88. #2014-09-046 – Cross section of the rolling mark area shows no damage to the aluminized layer. 350x



Figure 89. #2014-09-046 – Close up of scrape marks on the corrugation.

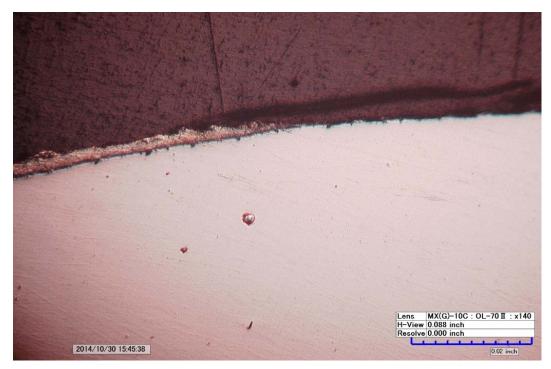


Figure 90. #2014-09-046 – Cross section of the scraped area showing visible damage to the aluminum coating as well as the intermetallic layer. 140x

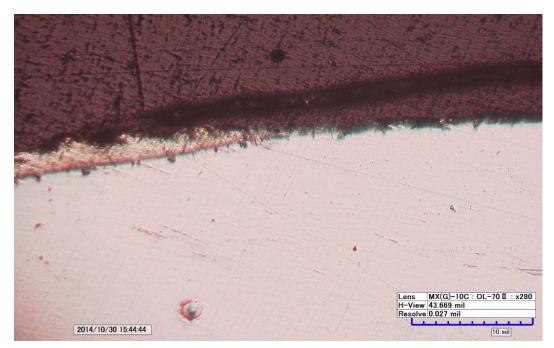


Figure 91. #2014-09-046 - Under further magnification the exterior shows minor damage to the steel substrate. 280x



Figure 92. #2014-09-046 - Close up of the lock seam.

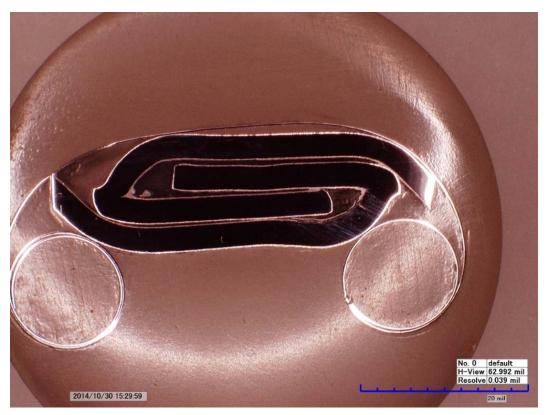


Figure 93. #2014-09-046 – Low magnification cross section of the lock seam showing no visible damage to the aluminum layer. 10x

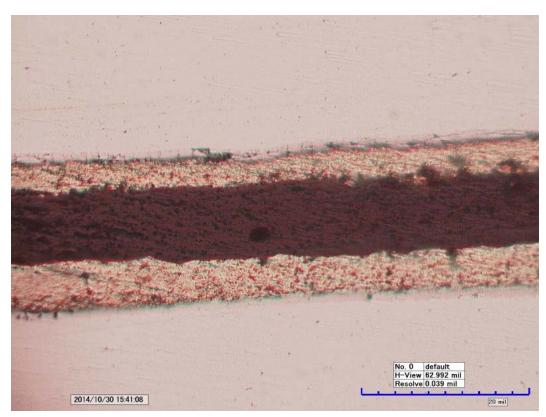


Figure 94. #2014-09-046 – The center of the lock joint shows no visible damage to the aluminum layer.~140x



Figure 95. #2014-09-046 - Cross section of the lock joint showing no visible damage to the aluminum or inner metallic layer. 280x



Figure 96. #2014-10-02 – 24" section of pipe. Two areas had apparent coating damage. Samples were removed for metallographic analysis

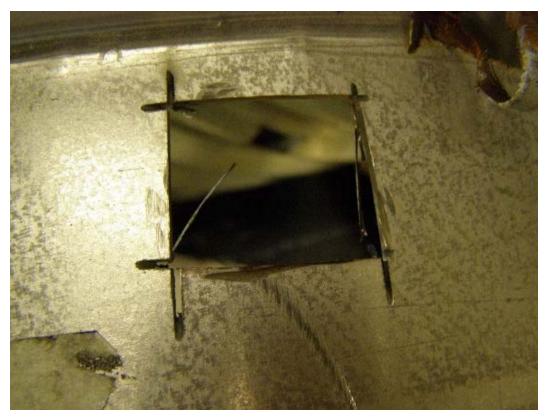


Figure 97. #2014-10-02 – Close up of the control sample showing no visible damage to the aluminum layer.

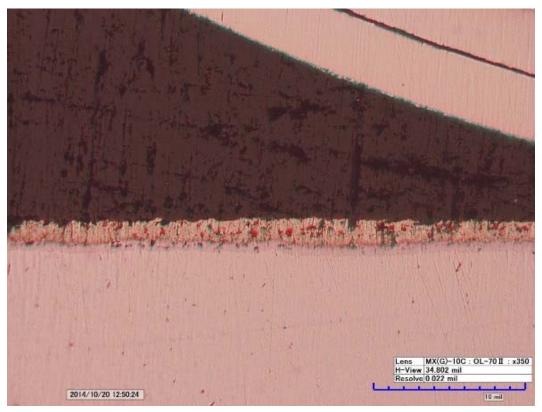


Figure 98. #2014-10-02 – Cross section of the control sample showing no visible damage to the aluminum layer. 350x

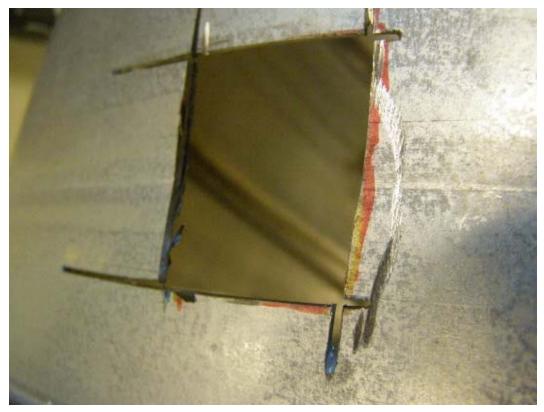


Figure 99. #2014-10-02 – Close up of rolling marks showing visible markings on the pipe surface.

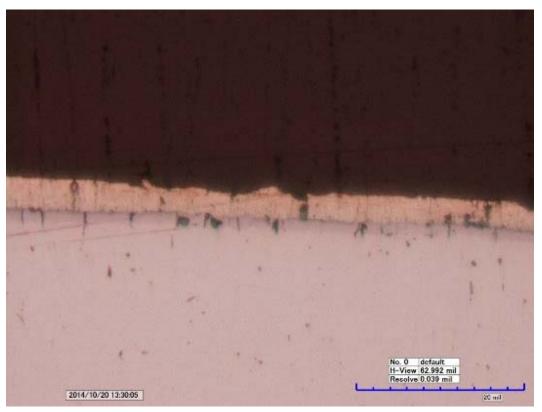


Figure 100. #2014-10-02 – Cross section of rolling mark area showing no visible damage to the aluminum layer. 350x



Figure 101. #2014-10-02 – Close up of rolling marks on top of the corrugation showing visible markings on the pipe.

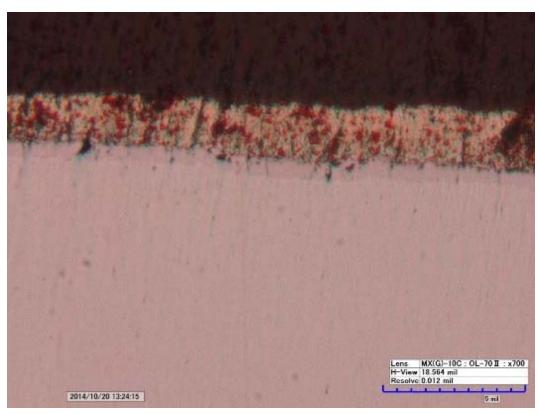


Figure 102. #2014-10-02 – Cross section of the rolling mark area shows no damage to the aluminized layer. 700x



Figure 103. #2014-10-02 – Close up of scuff or scrape marks on the corrugation.



Figure 104. #2014-10-02 – Low magnification cross section of the corrugation at locations of scrapes.



Figure 105. #2014-10-02 – Cross section of the scraped area showing visible damage to the aluminum layer as well as the inner metallic layer. 70x



Figure 106. #2014-10-02 – Close up of scuff or scrape marks on the corrugation.

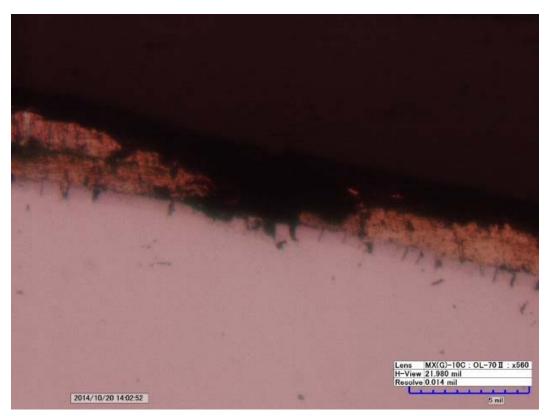


Figure 107. #2014-10-02 – Cross section of the scraped area showing visible damage to the aluminum layer as well as the inner metallic layer. 560x



Figure 108. #2014-10-02 – Close up of the inside corrugation showing visible rust staining.



Figure 109. #2014-10-02 – Low magnification cross section of the corrugation with visible rust staining.

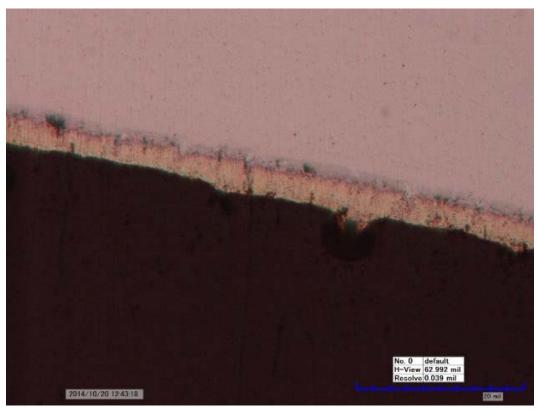


Figure 110. #2014-10-02 – Cross section of the corrugation with visible rust staining showing no visible damage to the aluminum layer. 210x

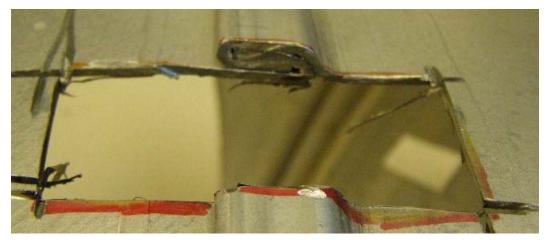


Figure 111. #2014-10-02 - Close up of the lock joint.



Figure 112. #2014-10-02 – Low magnification cross section of the lock joint showing no visible damage to the aluminum layer.

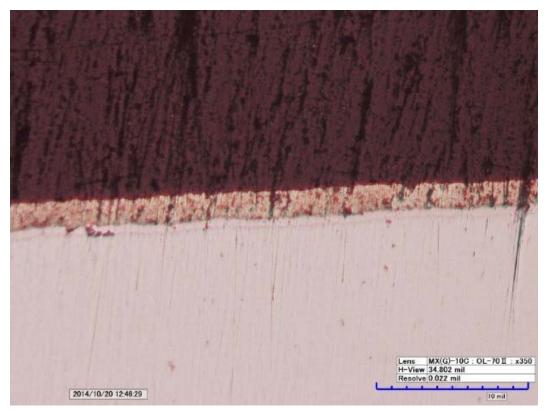


Figure 113. #2014-10-02 – The lock joint shows no visible damage to the aluminum layer. 350x