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**AIR PLENUM (DUCT SEALING) REHABILITATION AT FORD'S ROUGE VISITOR CENTER  
By CIPP methods described in ASTM F 1216 & ASTM F 1743**

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This paper addresses the rehabilitation of four (4) 20" diameter air plenum lines (Figure #1) constructed beneath the Ford (BP-432) Visitor Center Theatre in Dearborn Michigan. Prior to rehabilitation the spiral wound PVC air plenum duct material was allowing ground water to pass into the system (Figure #6), which then created the potential for mildew and mold propagation. The system defect was identified by Walbridge Aldinger, the General Contractor and Q/C Engineers at Ford's Heritage Sustainability Project 7-7130. Unfortunately with the opening date deadline looming; seats, carpeting, and other major decorative appointments (Figure #3) had been or were in the process of being installed along side this integral air system which was part of the theatre experience itself. The challenge became to identify a non destructive, trenchless means of repairing the leaks to the system in the available tight quarters of access which were available, without tolerating any demolition of the theatre complex, seating, stage or other constructed effects.

This paper shall document the installation of an epoxy impregnated CIPP in low pressure air duct rehabilitation. Special considerations included the forced air application, broad swing temperature fluctuations, the need for exacting inverted tube dimensional limits , a short timeline for project completion, and selection of a people friendly "non styrenated " epoxy resin system.

Due to cost and handling efficiency considerations the types of materials presently being utilized in air plenum construction are extremely installation intensive. They are not typically over designed to allow for the rigors of backfill in an open trench environment. Additionally, care must be taken to insure the air pressure ratings are preserved; perhaps by testing after installation and prior to being placed in service. Ground water infiltration (Figures #6 & #10) was on the verge of rendering this installation obsolete had it gone undetected by the Q/C constituent onsite.

The contract was negotiated and signed with the expressed firm understanding that only a precious few weeks existed before the scheduled Grand opening of this Theatre and centerpiece of the soon to be inaugurated Visitor Center at The Dearborn facility.

The air system delivered bursts of air into the vicinity of the viewing area (Figures #8 & #9) to help facilitate the narrative being conveyed in each performance. Therefore a “people friendly” non styrenated resin system needed to be identified and utilized. The selection of epoxy for this application seemed obvious. The desirable physical and chemical properties which had direct impact on the success of this installation included:

0% VOC’s, High Adhesion Strength, Zero Shrinkage, A Stable and dependable Pot Life, and a resin viscosity which was totally applicable to CIPP tube impregnation.

We implemented a UL Listed Neopoxy suitable for drinking water system components. The system used was 100% solids, solvent free with zero VOC’s. Additionally the material exhibited zero shrinkage with exceptionally high adhesion properties; exceeding 2500psi with steel, or “concrete to failure” per ASTM D 4060. A wire brush was remotely operated within the PVC lines prior to installation as an effective surface preparation. Initial set time (Pot life) at 75 degrees Fahrenheit is less than two hours so we cooled the hardener to 60 degrees, while maintaining the resin at between 70 and 75, prior to wet out, to insure maximum workability (optimum viscosity for wet out) of the system. Cure time was approximately 50 minutes.

System pressure was designed to accommodate 5 psi working, 10psi test. Temperatures anticipated during service were in the 40 degree to 120 degree fahrenheit range.

Dimensional challenges included negotiating access ports which were only 14” in diameter.

There were several system bends (Figures #4 & #5) which needed to be negotiated, while primary accesses for the main runs were through supply and return ducts at the front of the theatre. The bends were as severe as 60 degrees; however, several of the bends were simultaneous therefore challenging the CIP inversion process resulting in some fining. As a general rule, bends in the same direction may or may not cause a fin to propagate; however, directional changes are more likely to produce this anomaly. In any event the resultant fins were judged not to be performance inhibiting.

Cleaning included a mildew retardant rinse followed by foam swabbing. Televising was by both push cam, as well as, robotic methods so that all rehabilitation limits could be documented.

Tubes were fabricated at Lanzo Lining Service’s Roseville Michigan facility, and shipped at approximately 40 degrees Fahrenheit.

Installation was performed by methods described in ASTM F 1216 and ASTM F 1743. A glass reinforced Novapipe polyester tube was selected which demonstrated superior invertability and dimensional control. Specifically, the delivery and return line primary runs were direct inverted, while the cross runs were installed using pull and invert technology. After lateral reinstatement, trowel able epoxy was hand applied at all liner outlets and junctions.

Third party testing was performed on coupons taken from the 20” diameter 7.5mm plenum rehabilitation. Flexural Modulus exceeded 540,000psi, while the Flexural strength achieved was 7,000 psi. Neat resin properties of the epoxy system utilized were as follows:

Specific Gravity	1.2-1.5 G/ml
Weight per gallon	10.5 – 11.5 Pounds
Viscosity (Brookfield LV)	5,000 – 6,000 cps
Hardness (Shore D)	>80
Hardness (Barcol)	>25
Vertical Wet-out-Test	>40mm

The project was complete within one (1) week. Job cost was precisely the amount contracted for with the deadline being met.

A Subcontractors performance evaluation was conducted by Walbridge Aldinger on 10/13/03 as part of the Ford Heritage Sustainability Job 7-7130, system analysis.

The Project Manager was Fred Tingberg, while the Project Superintendent was Ali Feiz.

Overall team comments regarding Lanzo Lining Services simply stated "Dependable, Team Players, skilled at the services they provide".

The report included the comment: "Extremely refreshing to have a subcontractor work as efficiently as Lanzo did on this project. They understood the problem, knew their installation process required .... And completed the work with little assistance from the construction manager.



Figure #1 Pre Video of Air plenum cross run



Figure #2 Post Video of Air Plenum cross run



Figure #3 Gallery exhaust vents within the theatre

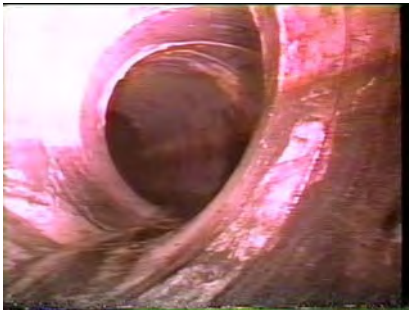


Figure #4 Pre Video of direction change

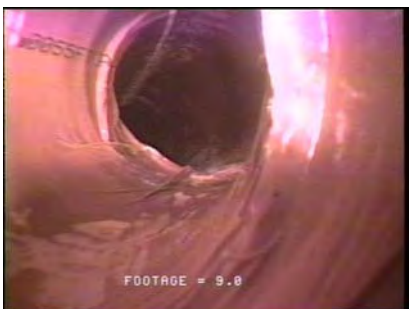


Figure #5 Post Video of direction change



Figure #6 Pre Video of plenum junction



Figure #7 Sewer log header document



Figure #8 Gallery piping side view



Figure #9 Gallery piping exhaust close-ups



Figure #10 Internal mildew manifestation