INSTALLING HIGH DENSITY POLYETHYLENE (HDPE) LINERS IN EXISTING WATER INJECTION LINES

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ABSTRACT

This paper will discuss the installation of High Density Polyethylene (HDPE) liners in existing cement-lined and bare steel water injection pipelines. Design criteria, economic evaluation, and HDPE liner installation details are included. Also, different types of HDPE liner systems, material properties, and internal corrosion protection will be discussed.

INTRODUCTION

High Density Polyethylene liner systems have been successfully installed in existing 12" cement-lined and 10", 6" and 4" bare steel water injection pipelines as an inner corrosion barrier. Such liners replace deteriorating cement linings and/or costly chemical corrosion abatement programs. HDPE liners were chosen to restore these existing lines because of the potential cost savings over other line replacement; and the HDPE system offers an impervious holiday free barrier for internal corrosion protection. Cost savings up to 77% were realized by installing HDPE liner in the existing pipelines in lieu of their replacement with new cement-lined pipe.

LINER SYSTEMS

To date, the two types of HDPE liner systems available in the United States are the "slip liner" and the "tite liner" systems. The "slip liner" system offers a HDPE liner that is smaller than the steel pipe inside diameter (I.D.), which is pulled into the pipeline using a wireline cable device. The liner then expands and conforms to the inside walls of the pipeline upon the application of internal pressure. A "tite liner" system is similar, except that the outside diameter (O.D.) of the HDPE liner is larger than the steel pipe I.D. This system uses a roll down machine, which compresses the liner while a wireline cable truck maintains tension on the liner as it is pulled into the pipeline. This procedure, in effect, extrudes the liner temporarily reducing its O.D. to permit installation. After the liner is in place, tension is released and the HDPE expands as a result of its "elastic memory" creating a snug fit between the liner and pipe wall without the use of internal pressure.

Table A (See APPENDIX I) lists general material properties of HDPE liner materials. The customized resin is tested in accordance with ASTM 3408. Physical properties of the HDPE liner are tested in accordance with several different ASTM procedures as listed in Table A.

CEMENT-LINED PIPE APPLICATIONS

In our Unit, HDPE liner has been installed in 6600' of 12" X-56 grade carbon steel cement-lined water injection pipe. The liner was installed in continuous lengths of 600', 800', 2400' and 2700'. To our knowledge, these installations were the first successful liner systems installed in cement-lined pipe in the United States.

The installation of HDPE liners in existing cement-lined injection systems is a complex process. The I.D. of the line must be measured accurately before the liner is designed and installed, since each liner is custom manufactured for a specific line I.D. to ensure a trouble free project.

A caliper device similar to the one used for well-logging was pulled through the line to measure various I.D. profiles of the existing cement-lining. The recorded I.D.'s ranged from 10-3/8" to 11-5/8". The caliper log also indicated several areas suspected to be abrupt changes in cross-section, which could cause shear points for the HDPE liner. Such shear points could damage the liner after it is installed. Based on these indications, several samples were removed from the line for inspection and comparison to the log. The results indicated that the sharp profile changes measured by the caliper log were actually relatively smooth transitions and it was determined the liner would not be subjected to shearing. A copy of the caliper log was sent to various liner manufacturers for the custom design of a HDPE liner system. Regardless of the shear aspect, line calipering is recommended due to the possibility of gross I.D. variations in older cement-lined pipelines. This information is also needed to determine whether the application will be within manufacturer's tolerances.

The liner design installed was 10-1/4" O.D. with a 3/4" wall thickness. Each section of liner was fused together in the field to create the desired length. Carbon steel flanges and vent collars (vent and leak detection devices) were installed on each section of pipeline prior to the liner installation. The liner was then installed using wireline and hydrostatically tested before returning the pipeline to operation. Listed in APPENDIX II is a general procedure to install HDPE liner in cement-lined pipelines.

BARE STEEL PIPE APPLICATIONS

Similarly, in our Unit, HDPE liner has been installed in approximately 24,700' of existing 4" schedule 40, 6" schedule 60, and 10" schedule 60 bare carbon steel water injection pipelines. Prior to lining these pipelines, scale and debris had to be removed from the inside of the lines. Cleaning these lines was the most time consuming and difficult part of the project, because of the acidizing, pigging and/or hydroblasting that was required.

The design criteria for this system also must account for all internal surface irregularities. Consideration must be given to localized internal corrosion pits and general wall loss in the bare steel pipe. A representative sample of the existing line should be removed and examined to determine wall loss. Obviously, if new pipe is installed, then the liner design is dramatically simplified, because only mill tolerance needs to be considered.

The installation of a HDPE liner in bare steel pipe is similar to the cement-lined system. The line is taken out of service, dewatered, cleaned, liner installed, tested, and returned to operation. Consideration should be given to hydrostatically testing the pipeline after scale and debris removal. This precaution may prevent a failure in the steel pipe during the hydrostatic test of the liner system, or a future system failure. The HDPE liner does not exhibit sufficient strength to contain high pressures without the support of the steel pipe, therefore, the maximum operating pressure of a liner system is based on the pressure rating of the steel pipe. A general procedure to install HDPE liner in existing bare steel pipelines (procedure is similar for new pipe, except that the extensive cleaning is not required) is listed in APPENDIX II.

COST SAVINGS

Table B of APPENDIX I summarizes cost savings that were realized by restoring rather than replacing existing cement-lined and bare steel water injection pipelines. This table reflects examples of six (6) different installations. As noted in the table, the relative savings increased with the pipeline diameter.

CONCLUSION

After nearly two years of successful service life from HDPE lined systems in the SACROC Unit, it is evident that the use of such corrosion resistant materials in existing systems is a feasible and cost effective alternative to total line replacement. Cost savings ranging from 45%-77% have been realized, dependent on pipe size. Careful attention to the condition of the host system and thorough planning for the installation will enhance project viability.

APPENDIX I

Table A

HDPE Liner Properties

		ASTM TEST PROCEDURE
Resin -	Customized Ultra-High Molecular Weight High Density Polyethylene (UHMWHDPE)	3408
Corrosion Protection -	Provides Holiday-Free System	N/A
Pressure Range -	Up to 4000 psi (Dependent Upon Steel Pipe)	N/A
Temperature Range -	Up to 200°F.	N/A
Modulus of Elasticity -	110,000 psi	D-790
Stress Cracking Resistance -	5000 psi	D-1693
Tensile Yield Strength -	3500 psi	D-638
Density -	.957 gms/CC 7.988 lbs./gal.	D-1505

Table B

HDPE Liner Cost Savings

		New Schedule 80 Cement-Lined Steel Pipe Installation Cost Estimate	HDPE Liner Installation Actual Cost	Realized Savings Dollars	Realized Savings Percent
1.	2618' of 12" Cement-Lined Water Injection Line	$ 196,400	$ 55,400	$141,000	71%
2.	3875' of 12" Cement-Lined Water Injection Line	$ 290,625	$ 83,300	$207,300	71%
3.	2085' of 4" Bare Steel Water Injection Line	$ 32,100	$ 17,800	$14,300	45%
4.	1980' of 6" Bare Steel Water Injection Line	$ 47,500	$ 24,700	$22,800	48%
5.	7282' of 6" Bare Steel Water Injection Line	$ 174,800	$ 79,600	$95,200	54%
6.	11,250' of 10" Bare Steel Water Injection Line	$ 787,500	$ 183,900	$603,600	77%

APPENDIX II

General Procedure to Install HDPE Liners in Cement-Lined Pipe

1. Take the pipeline out of service, dig bell holes and dewater.
2. Blow the wireline cable through pipeline.
3. Pull a caliper tool through the pipeline to measure the line I.D. size.
4. Design the HDPE liner O.D. and wall thickness.
5. Weld carbon steel flanges and vent collars on each end of the pipeline section.
6. Pull or blow sizing/scrapper pigs through pipeline.
7. Butt fuse HDPE liner pipe sections together to the desired length.
8. Butt fuse the HDPE pulling head to liner.
9. Attach the wireline cable to the pulling head and pull HDPE liner into the pipeline.
10. Remove the pulling head and butt fuse HDPE liner flanges (stub ends) to liner.
11. Hydrostatically test liner to desired pressure.
12. Install cement-lined spool piece and bolt the pipeline together.
13. Install vent line, backfill bell holes and put line in service.

General Procedure to Install HDPE Liners in Existing Bare Steel Pipe

1. Take the pipeline out of service, dig bell holes and dewater.
2. Weld carbon steel flanges and vent collars on each end of the pipeline section.
3. Remove scale and debris from inside pipeline by using one or all of the following techniques:
   a. acidizing, and flushing with pigs and fresh water.
   b. hydroblasting, and flushing with pigs and fresh water.
   c. pumping or pulling scrapper pigs with fresh water.
4. Blow or pump the wireline cable through the pipeline (this will also be done prior to scale removal for 3b and 3c).
5. Butt fuse HDPE liner pipe sections together to desired length.
6. Butt fuse HDPE liner pulling head to the liner.
7. Attach the wireline cable to the pulling head and pull HDPE liner into the pipeline.
8. Remove the pulling head and butt fuse HDPE liner flanges (stub ends) to liner.
9. Hydrostatically test liner to desired pressure.
10. Install cement-lined spool piece and bolt the pipeline together.
11. Install vent line, backfill bell holes and put line in service.

Note: Recommend hydrotest (to MAWP only, i.e. - an "integrity" test) of existing steel pipelines after cleaning operation as outlined in item 3.