Cement Lining Of Oil Field Tubular Products

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ABSTRACT

This paper discusses the use of cement linings for internal corrosion protection of steel pipe in oil field water handling systems, including various cement lining materials, means of application and economics.

INTRODUCTION

Corrosion is a very common operating problem encountered in the production of oil and gas, particularly in the Permian Basin. Although corrosion of vessels, tanks and sucker rods is commonplace, perhaps the most expensive problem is protection of oil field pipe. Many methods have been used to minimize operating costs where internal pipe corrosion is a problem. Use is sometimes made of chemical inhibitors, alloys and nonferrous materials. But one means that has gained the most general acceptance as a corrosion preventive is the use of protective coatings and linings which serve as a barrier between the containing pipe and the corrosive material inside that pipe.

One of the more commonly used protective coatings in the petroleum production industry is cement, which finds its most general application in oil field tubular goods. The most extensive application for cement lining involves lines, particularly those in water handling service either disposing of produced water or distributing water for injection. Every oil field water flood and water disposal system requires corrosion control methods of some type. Water handling equipment, including pipe, is usually the most significant expense item in flood or disposal installations. The maintenance or replacement of this equipment may well determine the economic success or failure of a project. Cement linings can help effect economic success. However, use of improperly engineered cement linings can also be a most costly error. Accordingly, it is important to have a knowledge of the mechanics of cement lining and of desired lining characteristics. This presentation will give you an outline and idea of these considerations.

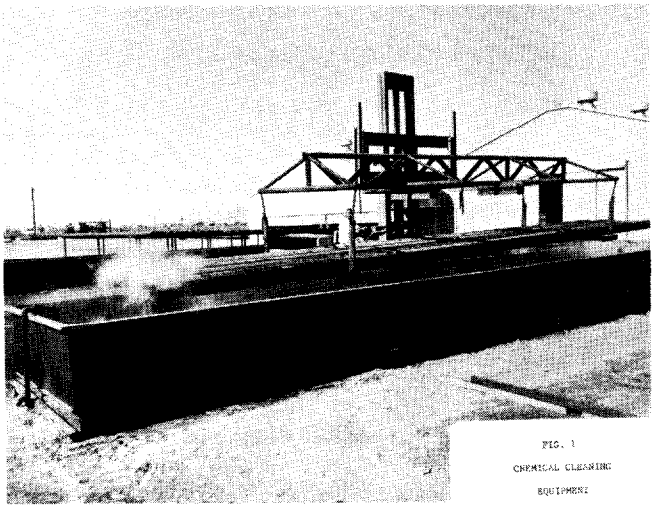

FIG. 1
CHEMICAL CLEANING
EQUIPMENT

MECHANICS OF A CEMENT LINING PROCESS

Surface Preparation

As in any coating or lining process, considerable attention must be given to the preparation of the surface being lined. Paraffin, oil, mill varnishes, mineral scales and rust and loose mill scales should be removed and the surface roughened in some manner in order to aid in producing a bond between the steel surface and the cement lining. If the foreign materials listed above are not removed, they can materially reduce the actual lining thickness applied and will obviously not aid in producing any sort of bond, and likely will contribute to early failure of the lining.

Surface preparation adequate to meet these cleaning and roughening requirements can be accomplished by mechanical cleaning, sand blasting or chemical cleaning.

Excellent chemical cleaning can be accomplished by (1) degreasing in a boiling caustic surfactant, (2) rinsing in water, (3) pickling in inhibited acid and (4) rinsing in alkaline water. Equipment for this is shown in Fig. 1.

The importance of providing a firm foundation to obtain a good product, specifically in this case a well cleaned surface, cannot be overemphasized.

Materials for Cement Lining

At the present time there is no specification (API, ASTM, NACE, etc.) for a cement composition to be used in the lining of oil field tubular goods. However, trial specifications have been adopted for use by some of the major oil companies during the past year. Most of these include or permit a lining composed of a mixture of water, cement, pozzolan, or siliceous material.

Water used to mix the lining slurry should be clean and free of oil, acid, strong alkalies, and vegetable matter. Acceptability of a proposed water can be determined by comparing the strength of cement cubes made with the proposed water with the strength of cubes made with distilled water. Cubes made with the mix water should have a strength greater than 90 per cent of the cubes made with distilled water.

Most cement lining specifications require that the cement be a high temperature, sulfate-resistant type (0.0 per cent tricalcium aluminate), fine ground.

One company adds to their mix a finely ground (90 per cent passing a 200 mesh sieve) silica flour which increases the chemical resistance of the finished lining, see Fig. 2. Additionally, a fine-particle slurry, such as is obtainable with a silica flour additive, will result in a higher lining density and strength and a smoother lining finish, resulting in better performance in the field.

It is obvious, of course, that blending and mixing of the components should be rigidly controlled to obtain the desired end results in the lining.

Application of Cement Lining

Although specific techniques vary considerably with different suppliers of lining, it is generally agreed that centrifugally cast cement linings are the only acceptable

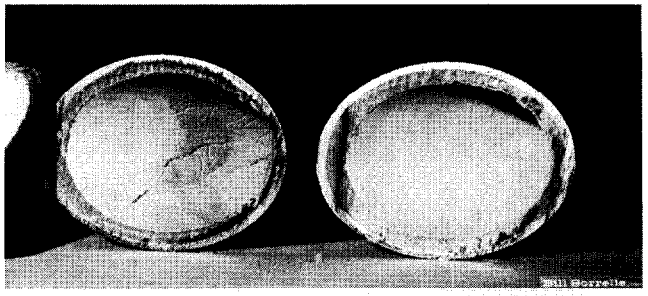

FIG. 2
CROSS-SECTIONED LINERS SHOWING BENEFIT OF SILICA FLOUR TO LINING AFTER 30-MIN. EXPOSURE (STEAM)

types for oil field service.

Briefly, the application process consists of introduction of the mixed slurry into the pipe and rotation of the pipe at high speed to cast the lining material around the interior of the pipe by centrifugal force, Fig. 3.

Uniform distribution of a uniform slurry throughout the length of the pipe prior to the spinning of the pipe is very important, see Fig. 4. Uniformity here helps eliminate variations of lining thickness, density and lamination. The spinning operation must be carefully engineered to provide enough speed for production of a dense lining, but not enough to cause lining lamination or brittleness.

Minimum lining thicknesses recommended as a good balance between cost, adequate strength and adequate corrosion protection are as follows:

PIPE O. D., Inches	LINING THICKNESS, Inches
2-3/8 thru 4-1/2	3/16
5-1/2 thru 6-5/8	1/4
8-5/8 & larger	3/8

Modern techniques of slurry mixing and metering, together with permanent, in-plant spinning equipment, permit production of highly compacted dense linings of the above thicknesses with tolerances of the order of 1/32 inch.

The weakest links in the cement lined piping system generally are the joints. It is critical that the lining at each end of each piece of pipe be square to the long axis of the pipe and be comparable in thickness, density and smoothness to the lining in the body of the joint in order to make a satisfactory connection. Until recently, this has been a major drawback to the use of cement liquid pipe in the oil fields. Centrifugal casting equipment has been advanced to include a method of actually casting a dense lining all the way out to the end of the pipe joint. This method, which utilizes rubber end molds and end lathes, completely eliminates the need for hand finishing ends with relatively porous, noncast cement. Figs. 5 and 6 show this equipment.

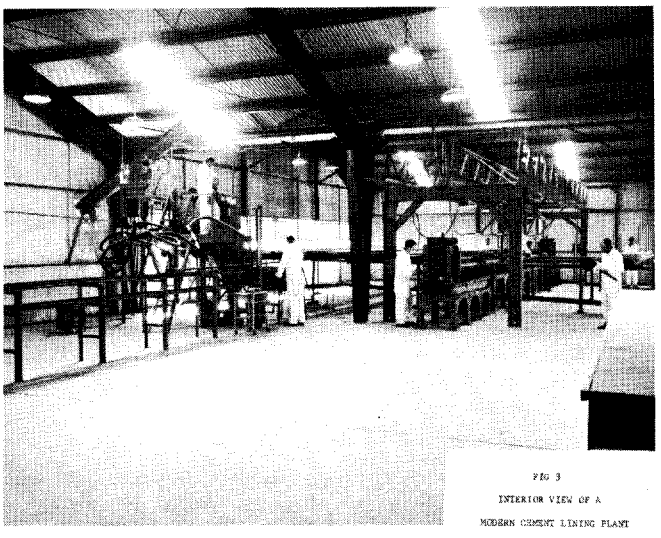

FIG 3
INTERIOR VIEW OF A MODERN CEMENT LINING PLANT

Curing the Cast Lining

Cement lined pipe should be cured with live steam for at least 24 hours after application of the lining and kept moist thereafter until installation in order to prevent weathering damage and cracking. Twenty-four hour steam curing will cure the lining to a three-day strength prior to moving out of the curing room. This three-day strength is the strength level you are familiar with as a minimum before any load is applied to construction foundations. In a cement lining, obtaining this strength level under controlled conditions not only assures a properly cured product and safe handling, but is about the best guard against weathering cracking so damaging to cement linings. Most experienced suppliers and users of cement linings feel that the three-day strength of cement is the minimum that should be obtained prior to handling lined pipe.

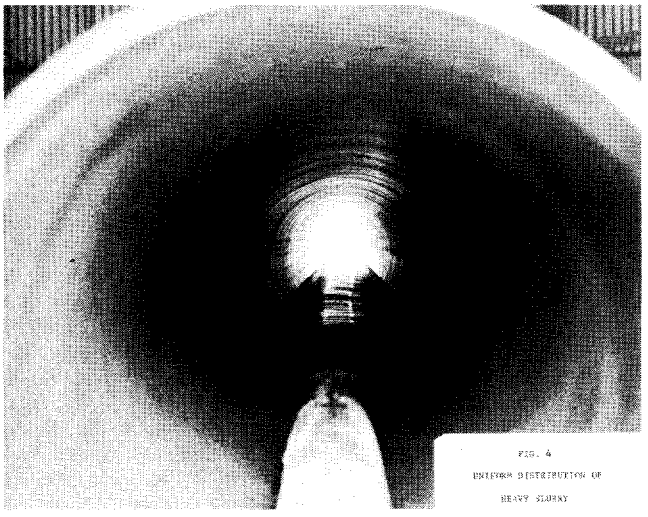

FIG. 4
UNIFORM DISTRIBUTION OF HEAVY SLURRY

INSTALLATION OF CEMENT LINED PIPE

Practically any type of connection — welded, flanged, grooved, or bell and spigot — can be used on cement lined tubular goods. In most general use in the oil fields are the welded and grooved type connections.

Cement lined pipe can be easily welded in the field. The generally accepted method is to use an asbestos gasket between the exposed ends of the lining in the lengths being joined. Improperly cured lining (so-called "green" cement, which contains excess unreacted water) can actually explode off the pipe surface on being exposed to welding heat.

Applicable API welding standards can be used with the following additions:

1. Tack bottoms of length to be welded, place gasket in "V" of joints, close the "V" by movement of pipe to

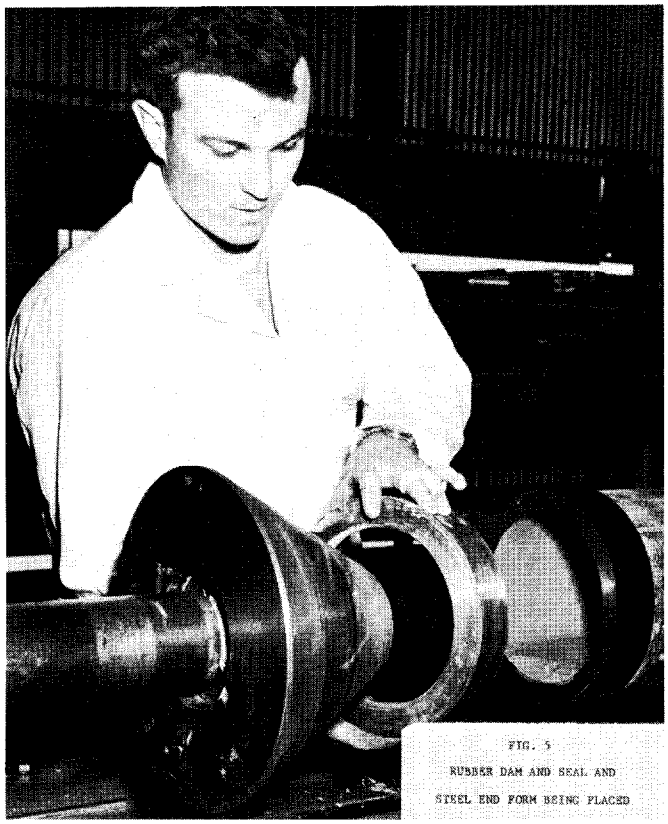

FIG. 5
RUBBER DAM AND SEAL AND
STEEL END FORM BEING PLACED

compress gasket, tack weld top, install lineup clamp and proceed with the weld.

2. Keep welding rod perpendicular to joint at all possible times.
3. Inspect ends of cement lining. Do not use any joints that do not have lining flush with pipe ends or where hand finishing of the end of the lining can be detected.

Field cuts should be kept to a minimum. If it is absolutely necessary to cut lined piped in the field, the following procedures have been used satisfactorily: (1) Cut pipe and lining with a hack saw. (2) Use pipe cutters for approximately 2/3 of the pipe cut, then finish with a saw.

The use of grooved joints, both cut-in for standard weight pipe and rolled-in for thin-wall pipe, is also popular. This can be quite advantageous for temporary or semi-permanent lines where salvage value and salvage ease are important considerations.

Until recently, protecting the exposed metal end of a joint with groove-type connectors has been a serious problem. It has now been met by the coupling manufacturers' invention of gaskets which seal against the exposed ends and prevent contact of the corrosive media with steel at any point in a properly lined system.

In joining screw type lined pipe there will necessarily be exposed thread metal in the made-up joint. Any number of materials have been used for protection in the joint, none of which has been generally accepted as entirely satisfactory. Among the more commonly used materials are cement, cement-varnish mixtures, epoxy resins, and Thiokol.

ADVANTAGES AND DISADVANTAGES OF CEMENT LINING

The major attraction of cement as a protective lining material is the low cost. Its initial cost in most cases is less than plastic coating of any type, particularly for the larger line sizes. Rough pipe and severely corrosion-pitted pipe, that is unsuitable for plastic coating, can be successfully cement lined. Cement lining is the only reliable approach where internal pressures require a welded system or where line sizes are such that other types of connections are unavailable or are not practical.

Cement lining is not, however, without its disadvantages. Among these is a considerable reduction in the usable internal diameter of the tube. For this reason, particularly in the cases of smaller diameter or heavy wall (expensive) pipe, coating makes a more economical package. Although modern cement linings are quite resistant to handling and transportation and installation damage, they require a certain amount of care in handling.

Good linings are acid resistant but not acid proof. For example, acid used to remove a scale buildup may attack a lining. Cement lined pipe cannot be bent appreciably. Permanent deformation of the pipe (yielding) will crack the lining. Finally, extreme care is required in making any type connection during installation to maintain continuity of the lining.

In closing it would be appropriate to point out that the selection of cement lining, coating, or any other protective program for a piping system should be based purely on the specific system being looked at considering such things as system life, allowable pressure drops (usually dependent on highly variable pumping equipment and pumping expense costs), need for acidizing out deposits in the line, etc.

Cement lining is being selected and used in millions of feet of oil field pipe every year. It is a material which will do its job of saving its user money, day after day, year after year, in its proper application. Consider the few but critical aspects of lining discussed in this presentation and this potential economy will be achieved.