RUPTURE OF A 3000 TON

SULPHURIC ACID STORAGE TANK

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PAPER PRESENTED AT THE ANNUAL TECHNICAL MEETING OF THE A.I.C.E.
CENTRAL FLORIDA & PENINSULAR FLORIDA SECTIONS

May 21, 1977

The primary purpose of this presentation is to acquaint other sulfuric acid manufacturers and users with the potential hazards of undetected corrosion in sulfuric acid storage vessels.

On June 16, 1975, a severe side wall rupture occurred in a 3000 ton sulfuric acid storage tank at the Port Maitland, Ontario plant of International Minerals & Chemical Corporation (Canada) Ltd. I will present highlights of the investigation of this failure as well as show photo slides of damage which occurred to tanks and other equipment in the storage tank area. Fortunately, no injury occurred to operating plant personnel.

The storage tank which ruptured was one of three similar tanks. It was constructed of mild steel plate ASTM A-283 grade C plate and was in service for 14 years. The tank was 51 ft. in diameter and 26 ft. high. It was built on a thick concrete foundation. The original side wall plate thickness varied from 1/2 inch in the bottom course to 3/8 inch in the upper course. The floor plate was 1/2 inch thick plate and the roof was of arch construction supported on the side walls. At the time of rupture it contained about 2700 tons of sulfuric acid.

Corrosion Types & Description of Failure

Before we look at details of the tank failure, I would like to review briefly the types of corrosion encountered and inspection methods normally used for sulfuric acid storage equipment. Generally, the most common materials of construction for handling and storage of sulfuric acid are mild steel and cast iron. The rate of corrosion by concentrated sulfuric acid has long been known to be a function of acid strenth, acid temperature and acid velocity. Common corrosion types are:

a) Uniform attack over entire surface area,

b) Pitting corrosion,

c) Erosion - corrosion.

Normally, "uniform attack" corrosion occurs in sulfuric acid storage tanks and a corrosion allowance is added onto the plate thickness during tank design to give an economic tank life. We need to consider, however, that corrosion other than "uniform attack" can occur in storage tanks. The tank rupture I will describe, involved a type of erosion - corrosion pattern which could be called "grooving- corrosion".

The grooving - corrosion pattern occurred on the tank side wall directly in line with the acid fill nozzle. The pattern started about 3 ft. below the tank roof line and extended to within 1 ft. of the tank floor. The grooves in the plate were straight and vertical with a spacing of about 1/8 inch and were cut into the plate about 1/16 inch deep. The pattern was relatively narrow, and extended about 4 ft. around the tank circumference. This area showed general thinning of the platework as well as the grooved pattern.

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The cause of this unusual corrosion pattern was probably a combination of:

a) Acid flowing down the tank side wall due to location of tank fill nozzle about 1 ft. from the sidewall.

b) Acid temperature coming from the plant coolers was about 100°F. Corrosion rate would therefore be higher than if acid were at ambient temperatures (see Fig. 1).

c) Hydrogen bubbles rising along the steel surface on a vertical plate can cause deep grooves to be cut in the surface. This has been demonstrated experimentally.

d) Longer periods of plant operation into this tank as compared to other tanks.

The tank rupture occurred vertically through the steel platework near the center of this grooved pattern, directly in line with the tank fill nozzle (see Fig. 2). The rupture appears to have started about 8 ft. from the tank floor at a horizontal weld seam which had thinned where the vertical corrosion grooves crossed the weld at right angles. The fracture line was straight from top to bottom of the tank wall. When the fracture line reached the "T" weld joints where tank wall plates were attached to floor plates and roof plates, the welds were sheared off around the entire tank floor and roof circumference. With the sudden release of potential energy from acid stored in the tank, the tank walls unrolled to an almost linear position rather than their previous circular position.

This sudden burst of energy caused considerable damage in the storage tank area. An adjacent tank weighing 80 tons was moved about 20 ft. and slammed into a third tank causing side wall damage to both tanks. A smaller tank was moved 75 ft. off the concrete foundation and bumped against railway cars stored on an adjacent siding. Several rail cars loaded with acid were moved off the railway track and the railway was severely damaged. A concrete block pumphouse was levelled at the foundation and debris was scattered about 150 ft. away. A cast iron pipe acid cooler was struck by steel platework and about 75 percent of the pipe was cracked or broken. A 12 inch water main feeding the acid cooler was sheared off and underground piping was broken. The extensive equipment damage resulted in 6 weeks of complete plant shutdown for cleanup and equipment restoration, however, this could have easily been a much longer period.

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Inspection Methods

Normal inspection methods for sulfuric storage tanks are:

a) Plate thickness tests either by sonic test method or test drilling of plates.

b) Internal visual inspection.

The sonic thickness test procedure has the advantage of allowing plate thickness measurements to be taken while the tank is in service. This procedure is used to detect the degree of uniform corrosion. Since only pinpoint thickness tests are taken, a localized erosion - corrosion pattern can be overlooked. Internal visual inspection combined with sonic testing probably gives the most reliable inspection results. Both sonic tests and visual inspections must be carried out by properly skilled people if reliable results are to be ensured.

The tank failure I have described resulted from an unusual, localized corrosion pattern which was not detected during both ultra-sonic and internal visual inspections 10 months prior to the tank rupture. A similar pattern was also missed on inspection of 3 adjacent tanks. In all cases the grooving - corrosion pattern was localized directly below the acid fill nozzle which was positioned about 1 ft. from the tank side wall.

After the tank failure we carried out a very detailed inspection of all storage tanks at the plant using both ultra-sonic and visual inspection methods. Spacing of ultra-sonic test points was reduced to 1 ft. intervals in location below the acid fill nozzle and a very close internal visual inspection was also made in this area. Similar grooving patterns and general thinning was found in all three tanks in the sulfuric acid plant. Tanks in the phosphoric acid plant were also inspected and although the fill nozzles were also located close to the sidewalls, the same grooving corrosion pattern was not found.

Tanks with side manholes showed grooving corrosion in the top-half of the manhole nozzles in some cases of a severe nature. Inspections were also made at another company's plant in the area and a similar grooved pattern was found which necessitated scraping of their tanks. It is notable that this company had made several internal repairs on the tanks but did not notice the grooving - corrosion pattern until they saw the cause of our tank failure and decided to take a second look at their tanks.

During the inspection of one tank which is 16 years old we discovered weld porosity in one area and decided to gouge out the old weld and reweld the area. During this repair we found weld penetration of about 50 percent and decided to radiograph all weld seams. The original tank welding quality found by the radiography tests was so poor that we had to gouge out all original welds and entirely reweld the tank. This tank could easily have ruptured through a weld seam if we had not found this welding quality problem.

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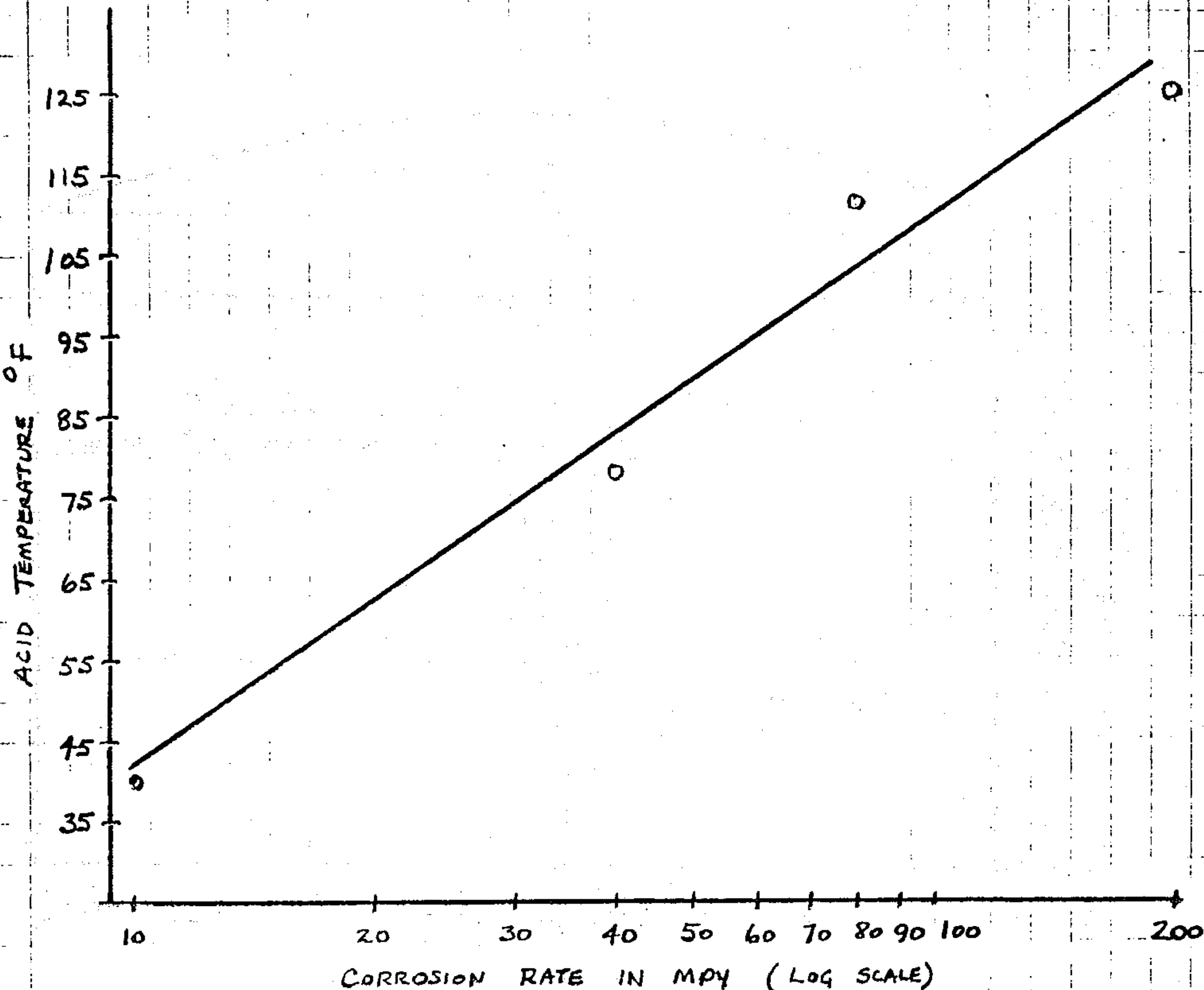
Summary

It should be clear that a thorough inspection and testing program for sulfuric storage vessels is essential. Particular care should be given to tanks which are 15 to 20 years old since welding quality on these tanks may be marginal. Repairs methods should also be reviewed particularly on these older tanks. Cases have been discovered where repairs were made by overlaying plates on the outside shell of a tank by people who were not aware of the serious potential hazards of a tank rupture.

Initial tank design for new construction should also be reviewed to ensure design weaknesses are eliminated such as those caused by side manways and location of tank fill nozzles too close to sidewalls. The API 650 code generally used for tank construction should be amended to take into consideration the special hazards involved in the storage of sulfuric acid.

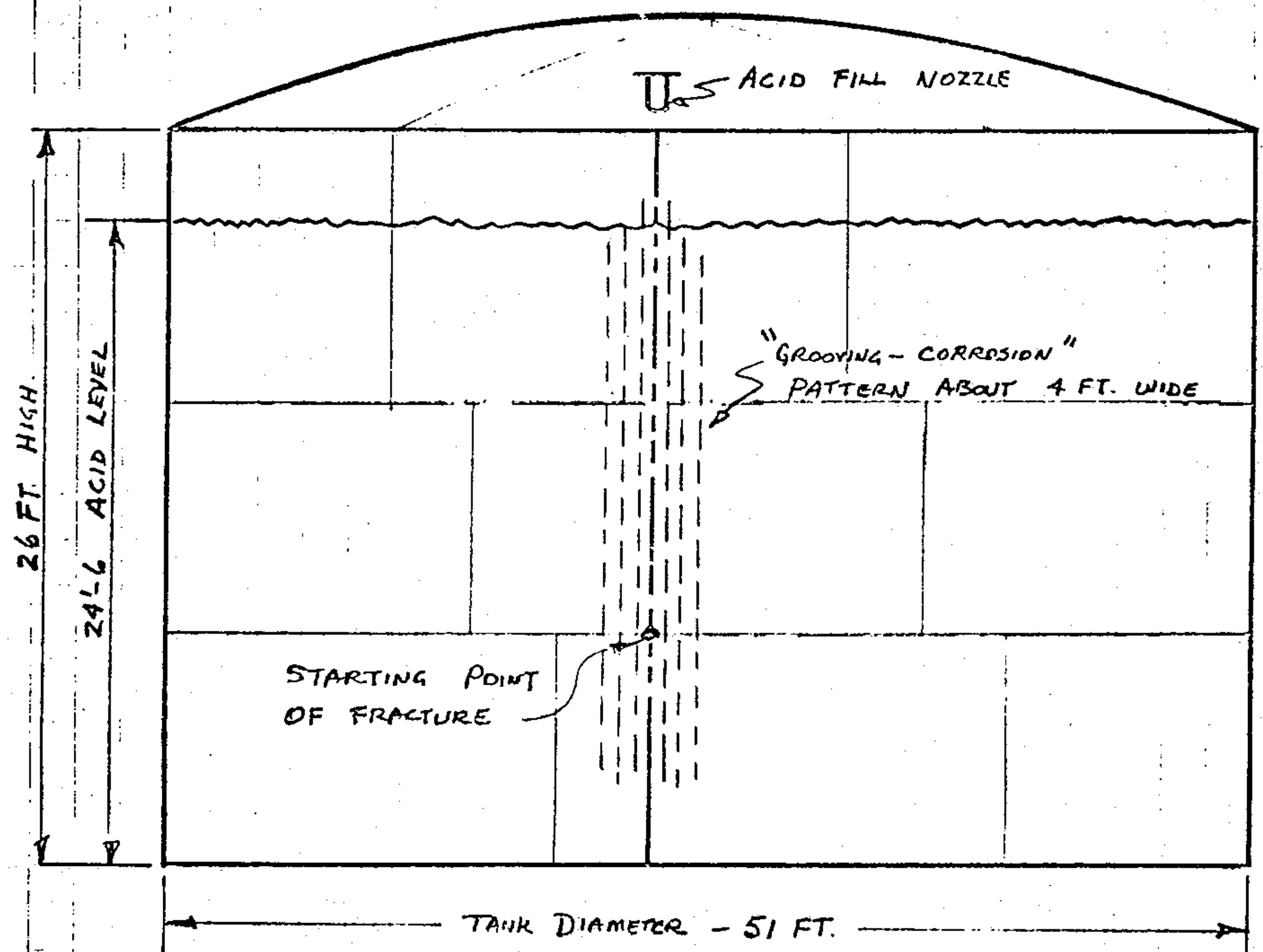
I hope this presentation will improve awareness of plant operation, engineering and construction personnel to the potential hazards of a major tank rupture and cause them to look carefully at test procedures, repair methods, and design and construction of new storage tanks to ensure that only completely reliable tanks are used throughout the industry.

(SHOW PHOTO SLIDES OF TANK RUPTURE & DAMAGE)



TYPICAL – EFFECT OF ACID TEMPERATURE ON THE CORROSION RATE OF CARBON STEEL – 93 % SULFURIC

(FIG. 1)



3000 TON SULFURIC STORAGE TANK

(FIG 2.)