Failure of an Ammonia Loading Hose

Precautions to maintain the integrity of loading hoses should insure that they are not sharply bent, curved, or twisted etc., while either in storage or in use.

L. V. Caserta
American Oil Co.
Texas City, Tex.

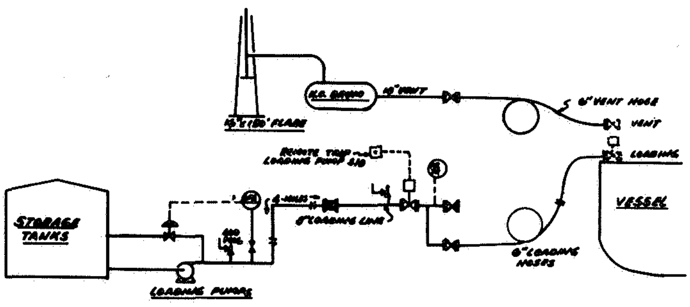

Figure 1. Schematic of the dock loading facilities.

The American Oil Co.'s ammonia complex at Texas City, Tex. consists of two anhydrous ammonia units, three 15,000 ton atmospheric storage tanks, and loading facilities for rail, truck, pipeline, barges, and tankers. The dock area for water transport is about 4 mi. from the storage area, and includes two loading locations, as well as a 150 ft. flare stack installation. An 8 in. low temperature ammonia product line connects the unit area with the docks. The loading arrangement is shown in Figure 1.

The loading pump at the storage area is provided with a low flow sensing device which opens a regulator in the discharge piping and routes the ammonia back to the storage tank. The regulator is sized to pass 10% of the pump's flow, and is intended primarily to prevent the pump from running completely blocked in. At the docks, an air operated valve is provided to permit rapid closure of the pipeline in the event of a hose rupture. The switch for valve closure also automatically shuts down the loading pumps at the ammonia plants via a telephone relay system. A separate switch is provided which will only close the valve. The piping downstream of the motor-operated valve splits into two 6 in. loading spots, each of which is connected to loading hoses. A vent hose is used to connect the vapor space of the vessel to the flare system.

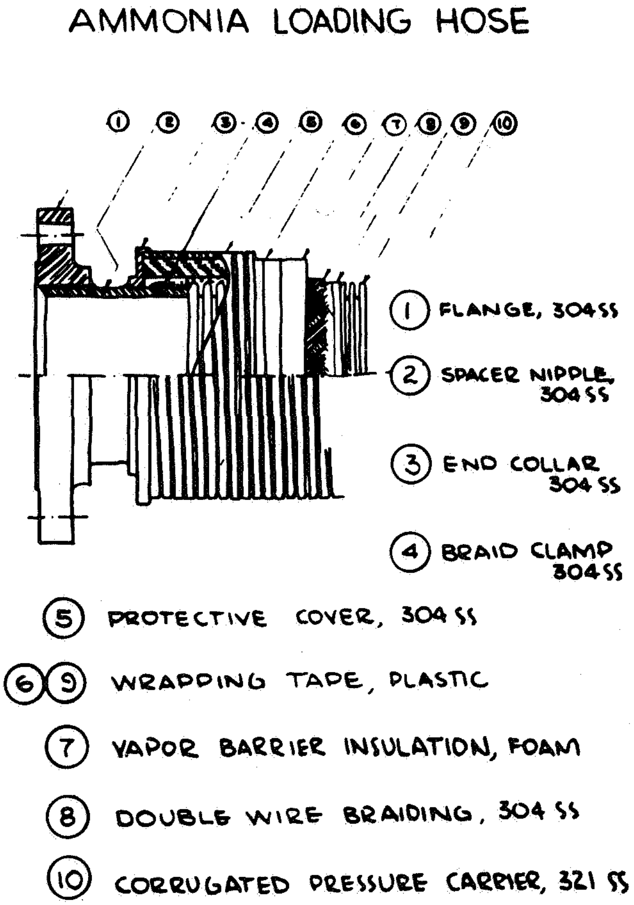

Figure 2. Cross section of the ammonia loading hose.

When the facility was initially constructed in 1964, we employed rubber hoses for loading with a 400 lb./sq. in. maximum working pressure. These were discarded every six months. During 1967, a blister developed in one of the hoses, and we began to encounter some hose deterioration short of the six month life. In 1969 we switched to a stainless hose 6 in. x 25 ft. long, corrugated, having a double wire braiding, plastic tape wrapped, and covered with a vapor barrier insulation contained by a metal hose protective cover, Figure 2. All metallic materials of the hose are stainless type 304, except the carrier hose which is type 321. The hose is tested at 500 lb./sq. in. gauge once a year. The hoses, which have a bursting pressure of 1,000 lb./sq. in. gauge, are considered capable of withstanding pump shutoff pressure, as well as the pressure rise (hammer) associated with a downstream valve manipulation.

Loading hose rupture

On January 26, 1971, after about 22 hr. into the loading of a large vessel on its maiden voyage, a loading hose ruptured, Figure 3. Our dockmen reported hearing a distinct noise emanating from the loading hose area. On investigation, two men were engulfed in a cloud of ammonia vapor. The lead man was splashed about the face and hands with liquid and vapor ammonia, knocked off his feet, and thrown 6-to 8 ft. by the moving inner liner of the ammonia hose. He ran to the end of the pier and jumped into the bay. Once in the water he reported hearing a loud pop and observing a large, white cloud over the entire dock area. The second dockman pushed the emergency stop switch, activated the fire water sprinkler system, and then closed remote ball valves in the loading line. The dock side air motor operated valve functioned; however, the loading pumps did not automatically shut down. They were secured by unit personnel. Prior to loading, the remote shutdowns had been checked and were operable. However, they later failed due to a malfunction in the telephone system. The first dockman received first and second degree burns on the head and arms, and was absent from work for 31 days.

The loading hose failure was apparently initiated when the main liquid loading valve on the ship closed. A blown fuse was found in the ship's fail safe circuitry, and this was reported to have caused the ship's valve to shut quickly. The hose was subjected to a momentary pressure rise exceeding 500 lb./sq. in. gauge (top limit of our recorder), which we speculate resulted in failure of the double stainless steel on the wire braid cover where it is welded to a flanged stub. When the braiding failed, the corrugated metal hose pressure carrier began extruding from the braid, stretching approximately twice its length before complete separation occurred. The fractional additional time permitted the dockman to clear the immediate area. Only a small amount of liquid ammonia leaked onto the dock.

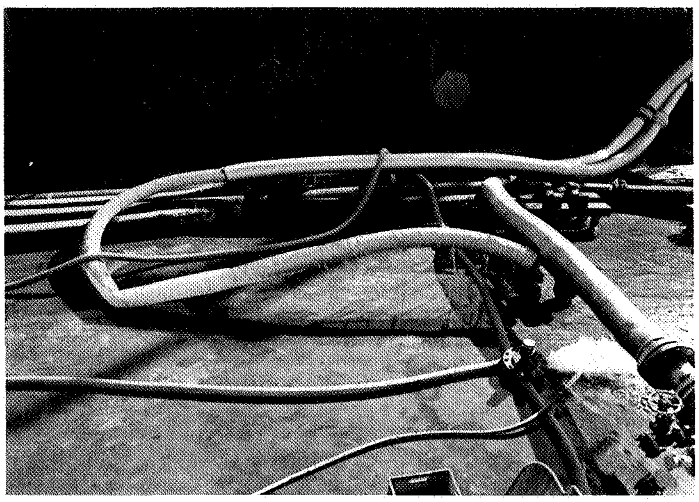

Figure 3. The ruptured ammonia loading hose.

The hose, in service for 24 months, had seen extensive use and handling. Following the accident, the hose was inspected by the manufacturer and by our Research and Development Lab. We concluded that the failure was caused by the pressure rise, and the resultant over expansion of the corrugated hose pressure carrier. The expanded hose exerted a stress above the yield strength of the metal braiding at a point of restraint, i.e., at the weld between the spacer and the hose. Studies on the microstructure at the ruptured area revealed no welding defects. The 321 SS base metal showed no evidence of any significant corrosion. We feel that metal fatigue was a factor in the failure. It should be noted that shut-offs have occurred against our loading hoses in the past without a hose failure.

Following the accident, we asked several companies about their problems with ammonia loading. We found that loading arms, and both rubber and stainless hoses are used, some for extended periods. No significant problems with loading arms or hoses were reported.

Preventive measures

To prevent future problems with our loading facilities, we have taken the following precautions:

1. We will continue to use the stainless hoses. They will be carefully inspected prior to use and tested annually at 1-1/2 times maximum working pressure (375 lb./sq. in. vs. factory test pressure of 500 lb./sq. in. and discarded after 2 yrs.
2. We have imposed the following handling conditions on cargo hose:

a. Do not drag hose over docks or decks. Carry it on dollies, rollers, or move it by derrick.

b. Do not roll hose more than one revolution, unless supported, to prevent the flange from rolling faster than hose, and to prevent twisting the body of the hose.

c. Support the hose every 10 ft. with 6 in. nylon slings and/or saddles.

d. Never lift the hose from the middle with ends hanging down.

e. Limit the curvature to 1 ft. dia. for each inch of hose size. A 6 in. I.D. hose should not be bent to less than 6 ft. I.D.

f. Never support a hose with a single rope sling. Use belt or bridles made of wood, rope, or old hose. Length of supports should be sufficient to maintain curvature given in 2e.

g. Avoid sharp bends at nipples and at manifold connections.

h. Make up the hose line with considerable slack and with the curvature evenly distributed over the full length. Allow for change in tide and draft of ship as it is loaded.

3. Automatic pressure switches will be installed to shut

down the loading pumps and close the motor operated valves on the pierheads, isolating the hoses from the system in case of excessive pressure rise in the line.

4. Surge chambers will be installed to provide additional protection for the hoses from sudden excessive pressure should the vessel automatic valves be closed.

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