CONSIDERATIONS IN AN AMMONIA PIPELINE SYSTEM

Moving ammonia by pipeline has its own particular problems, requiring different operations than those of a natural gas liquids carrier.

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Pipelining is entering a new phase, movement of anhydrous ammonia from the plant into the agricultural areas where it will be consumed.

Many manhours have gone into this development; to produce a safe pipeline system that will provide an economical and dependable means for satisfying an ammonia market. It can be anticipated there will be startup problems. Also we anticipate more changes in ammonia distribution methods which will modify this system as time passes.

The system discussed here is due to be placed in operation on Oct. 15, 1968, about five years from the original concept of the idea. The idea of moving anhydrous ammonia by pipeline originated within our company in 1963, while we were looking for a way to level out the seasonal load factor caused by our propane movements.

MAPCO is a common carrier pipeline system organized and built in 1960 as a natural gas liquids carrier. This system transports ethane-propane mixtures, propane, butanes, and natural gasoline. Propane represents about 70% of the volume transported. As a liquids carrier we are regulated on economic matters by the Interstate Commerce Commission, and on matters of safety by the Department of Transportation.

Research program

Preliminary economic studies for an anhydrous ammonia pipeline system indicated good possibilities. As a result a major research program was undertaken during 1963-1965. The original goal was to determine the technical and economic factors to be considered when batching anhydrous ammonia in the existing natural gas liquids system. The five phases of the program were:

1. A comprehensive literature search covered ammonia manufacturing and marketing, existing transportation and storage systems, and metals technology.
2. Laboratory research to determine the behaviors of various natural gas liquids—ammonia solutions, buffering products, separation and clean up techniques, flow characteristics, and the effects of pressure and temperature under pipeline conditions.
3. Pilot pipeline to verify laboratory results under field conditions.
4. Market research to locate best possible markets and market characteristics.
5. Storage methods.

The conclusions—drawn as a result of this research were:

1. That the farmer gets immediate and worthwhile results by applying nitrogen only. That he wants the nitrogen available at a time and place to fit his own work schedule. That most farmers dislike applying solutions. And finally that anhydrous ammonia application gives the farmer the most nitrogen per unit of cost.
2. The existing state of metals technology caused no serious economic problems when constructing a pipeline for ammonia.
3. The batching of ammonia in the existing system would be a technical success but due to unusual market characteristics result in a financial failure.
4. That the possibility of large underground storage exists but would require more research in the form of a pilot structure.
5. That a pipeline system devoted exclusively to ammonia is the most practical and will result in the greatest overall economic benefits to all parties involved.

Armed with the research data and our own conclusions we set out to promote, design and construct a large scale ammonia pipeline system. This system will be placed in operation on October 15, 1968, just about five years from the original conception of the idea.

Armed with the research data and our own conclusions we set out to promote, design, and construct a large-scale ammonia pipeline system. As shown on the map, it consists of 850 miles of 6 in. and 8 in. pipe extending from Borger, Tex., to points in northwest Iowa. About 720 miles will be finished by October 15; the other 130 miles will be laid in 1969. Initially, delivery terminals are located at Conway, Kans., Greenwood, Nebr. and Whiting, Early, Garner, Ogden and Sanborn, Iowa. An 80,000 ton shipper-owned refrigerated storage is located at Early, Iowa.

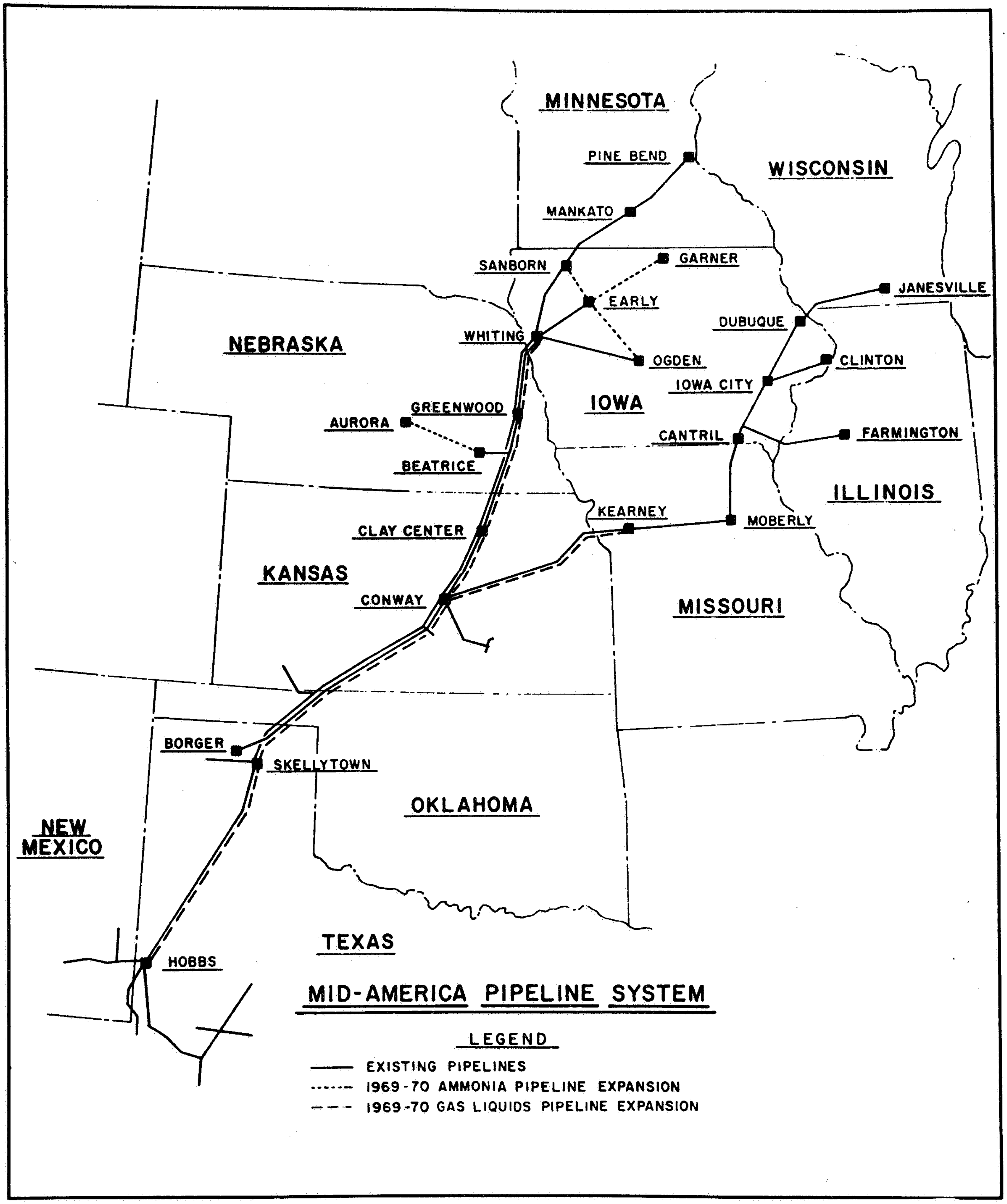
The overall system concept is to move the plant production to delivery terminals and large central storage in the market area, at a uniform daily production rate. Storage at plants will be that required to hold a day's production in case of pipeline trouble.

During the peak demand season the pipeline will move ammonia from the plants and central storage to delivery terminals in both directions. Under present tariff rules a backhaul of 175 miles is permitted.

For example, the present system can pump 1,300 tons/day from production points in the Texas Panhandle to points in Kansas, Nebraska, and Iowa. However, during the peak season we can deliver (from storage and plant) 1,500 tons/day each at Garner, Whiting, Sanborn, and Ogden, Iowa, and 1,000 tons/day each at Greenwood, Nebr., and Conway, Kans., for total peak deliverability of 8,000 tons/day. Additional pumping stations can be added to this system to increase deliverability above these rates.

The system design, construction, and operation has been approved by the ICC and DOT, and also is covered by a patent pending.

The line pipe used is designed to operate at temperatures



in the range of 0 °F-110 °F and at a maximum stress level of 72% of the specified minimum yield of 46,000 lb. This corresponds to a maximum pressure of 1,560 lb./sq. in. gauge for the 8 in. pipe. All line pipe is electric resistance weld, 0.156 in. wall thickness, fully normalized, and having the composition of: carbon 0.25% maximum, mangenese 0.7 to 1%, residual copper 0.15% maximum. To hold the copper within specified limits all scrap used in the steel making process was graded. The complete tube was normalized at a temperature ranging from 1,600°F. to 1,700°F.

Steel used in fittings and valves was held to the same chemistry as the pipe. Valves are installed every 10 miles on the main pipeline. The pipe coating system consists of a primer, 12 mil tar tape, and outer wrap of 80 lb. kraft paper.

Stations consist of centrifugal pumps driven by electric motors. All stations are unattended and remotely controlled from a centralized control center located in Tulsa. Each is equipped with suction and discharge pressure controllers and shutdown devices for low suction pressure, high discharge pressure, high case pressure, high case temperature, low flow conditions,seal failures, bearing failures, and motor winding temperature. Actuating any of the shut down devices cause the suction and discharge valves to close, thus isolating the pump station from the main line.

The central control center is equipped with start, stop functions for each station and a visual and printed record of suction, case, and discharge pressure. Any shutdown condition is indicated at this center and the station locked out until a technician goes by the station.

Pumps are made of case steel, equipped with single mechanical seals and trimmed as follows:

Impellers—cast iron
Impeller wear rings—11-13 chrome hardened to 375-400 Brinnell
Case wear rings—Meehanite hardened to 300-325 Brinnell
Center sleeve—11-13 Chrome with Colmonoy overlay
Center stage piece—11-13 Chrome 375-400 Brinnell
Shaft sleeves—11-13 Chrome 375-400 Brinnell
Throttle sleeve—11-13 Chrome 375-400 Brinnell
Throttle Bushing—Meehanite 300-325 Brinnell
Throat Bushing—Meehanite 300-325 Brinnell

Terminals are driver-attended, and equipped with an automatic data-acquisition system. Each terminal consists of one 263,000 gal. pressure tank and two 500 gal./min. truck loading spots. Deliveries from the pipeline to the terminal are controlled from the central control center. Custody transfer of ammonia is accomplished by the use of positive displacement meters. Meter ticket printout is in pounds.

System construction

Pipeline construction was handled by outside contractors and inspected by company personnel. Pipe was laid with a minimum cover of 36 in. in fields, 48 in. of cover below the bottom of the barrow ditch at roads, railroads, and highways, and 48 in. of cover in water crossings.

Field welding of girth welds was accomplished with the stick electrode method. Three beads were run, the stringer with E6010 rod and the hot pass and cap with E7010 rod. Welds were radiographed 100% on stream, highways, and railroad crossings and 15% on cross-country pipe.

The line was hydrostatically tested with water for 24 hr. to a minimum of 90% and a maximum of 95% of the specified minimum yield. For the 6 in. pipe this is equivalent to 1,950 lb./sq. in. gauge minimum and 2,060 lb./sq./in. gauge maximum; for the 8 in. pipe, 1,490 minimum and 1,570 lb./sq. in. gauge maximum. Following each test the line was displaced with air and then six to eight scrapers, propelled by air, were run to remove any residue.

The ammonia line fill on the first 720 miles will start October 15. Ahead of the ammonia will be a slug of nitrogen to displace the air and any residue moisture.

System operation

The entire system will be operated as a common carrier facility under conditions set out in published tariffs, approved by the Interstate Commerce Commission. Ammonia accepted for transportation must meet the following specifications:

NH_3 by volume	99.5% min.
Dissolved inerts	0.016 max.
Oil	5 ppm max.
Water, form of steam condensate or distilled water	0.2% min. 0.5% max.

Each day the shipper will be furnished a statement showing what quantities have been received and delivered and his inventory balance.

The central control center will monitor and regulate ammonia flow to delivery locations as the demand arises. Lights on the center's board indicate the level of storage at the various delivery points. From this information the center can increase or decrease flow to delivery locations by starting or stopping pumping units.

The center also provides surveillance of the entire system to guard against any possible failures in piping systems, pump stations, or terminals. At each terminal one man will be available during daylight to train drivers and perform routine maintenance. Pipeline maintenance crews and technical crews are located at strategic points along the system.

Discussion

Q. What is the total weight of the ammonia in the pipeline when full.

ROHLEDER: When full we'll have 22,000 tons of ammonia in the line. One reason that we can give you instant deliverability at one point is that the line is full of ammonia all the time. When we put a ton in at one end, it has to come out some place else, right away. So your pipeline transit time is zero, and you're down to the time it takes the truck to get out to the location.

Anon: I'd like to express, a warning. I remember the written history of railroads in United States. When many railroads were built parallel between Chicago and New York, and finally the one was very successful by shipping his cattle on the railroad of his competitor. I would hate to see that happen to ammonia. If we start to make parallel lines of ammonia, regardless of the overall picture in the United States, somebody will fail to compete against the other one who may be just as smart as that cattleman.

So I'd just like to see that this pipline network be some kind of an organized affair and not just one will do it his own way, the other one will run parallel, and then the third one make another parallel, anything like that. I would say that in order to make it really workable for the whole benefit of the whole country, it is always the pipeline should be some kind of coordination like electrical power stations and have finally some kind of interconnections like in electrical power.

So we will not see one day a pipeline rusting because it couldn't compete against another pipeline. Just the general comments that I am taking advantage of this meeting to express because I think I'd like to see this pipeline really a big success right at the beginning.

ROHLEDER: If the LPG business can be used as an example, and I'll grant you that the market for it is a little more stable and a little less seasonal than ammonia, but using the LPG business as a background, when we started in 1960, we were the only pipeline, but now we've got about ten pipelines competing.

So, I don't think you can hold down competition, and from our point of view, I think we're willing to compete. The shipper really benefits by it. I mean, it's hard on us, but the shipper benefits because in the long run he'll get the cheapest transportation and the best service.

Q. You mention the specifications for ammonia that you plan to handle in this pipeline. I have two questions one with particular reference to the water content; how much influence, if any, does the Department of Transportation have on dictating this spec, and secondly, on what basis did you develop the specifications as a whole?

ROHLEDER: Well, the Department of Transportation had quite an influence on this because we hit the Department of Transportation for the approval of this project just about the time the truckers were having all their troubles. So instead of making a big issue out of this, we went along with the Department of Transportation since they required water to be added to the transports anyway, unless you had metallurgically pure ammonia. So the DOT set that deal and we didn't argue very much. As to the development of the specification this was done in conjunction with proposed shippers and some of your industry literature.

Let me explain something to you about tariffs that you may not understand. Pipeline tariffs are published by the carrier and submitted to the Interstate Commerce Commission. You have a certain period of time during which you can object, so if you write a tariff today you can change it tomorrow, as long as nobody objects and the Interstate Commerce Commission accepts them.

Now about specifications. As we learn more about it I'm sure they will be subject to change just like everything else.

Q. Was any heat treatment done on the welds because I gather from your specification this isn't a high tensile steel. The piping was normalized, and I wouldn't expect you would have any need to have any moisture in your ammonia, but you would be doubly guaranteed if you heat treat the welds.

ROHLEDER: We had the pipe completely normalized at the mill. Of course, this takes care of the longitudinal weld seam. We had a big go-around with the DOT about stress relieving girth welds. This would have been real expensive. Because the stress levels in the girth welds are about a third of what they are in the longitudinal seams; together with other reasons developed by our consulting metallurgist, we convinced the Department not to stress relieve girth welds in the field.

However, we made one concession. On piping fabrications with branch connections, made with either weldolets or saddles, we stress relieved these fabrications in the shop. So any fabrication with this branch connection has been stress relieved.

Q. I believe you said that you would have 80,000 tons at Early, Iowa. Is that cryogenic storage?

ROHLEDER: Yes.

Q. Could you tell us the maximum size of a single tank, whether you have diked and whether you have individual dikes around each tank?

ROHLEDER: Well, this is a shipper owned storage. It doesn't belong to the pipeline. It consists of two 40,000 ton tanks, and one refrigeration system capable of taking 375 gallons a minute. And this refrigeration system is designed for a maximum input temperature of 65 degrees. There are dikes around the tanks, and the closest house or habitation is probably half a mile from this location. In the state of Iowa, by the way, we had to stay 300 feet from any house that is occupied with humans.

Q. What are your transportation charges?

ROHLEDER: We have three rates. If you're willing to make a 20 year throughput agreement for 225,000 tons per year, we'll take you all the way from Borger to Garner, Iowa for $8.20 per ton. For this total amount we'll take it in centralized storage and can hold it there for as long as you need to hold it, and then we'll take it back from you and deliver it at this point. In other words, this gives you in-transit privileges. If you're willing to make a five or ten year deal, it goes to $9.02. And if you just want to be an on the spot mover; in other words, you want to put it in today and you might not be there tomorrow, we charge you $9.84 a ton complete.

Q. Does that include the storage cost?

ROHLEDER: It does not include the central storage. In other words you have to furnish the off-season storage.

Q. How much storage do you have, both owned by Mid-America and by your distributor sales people, and how much do you intend to have in the future? The second question is, do you plan to meter this ammonia and bill it as metered, or do you plan to weigh it at the shipping point?

ROHLEDER: Well, first of all, on the shipper-owned storage, at the present time there is this 80,000 tons owned by Hill Chemicals, and then there's another 20,000 tons owned by Cominco-American at Beatrice. This is all shipper-owned storage. What their plans are or what other shippers' plans are down the road, we are not in a position to say because we've been working with some of the people.

Other than these two people. And I really don't know where we go beyond this. It depends on who is the shipper. Now on the metering, we plan to meter it out of the pipeline; we plan to meter it at the truck dock, although it does print out in pounds. We have cleared this with all the state agencies and they have approved this system. First of all, we've got a temperature compensated meter at 60 degrees. Then we take the specific gravity at 60 degrees and through a systm of gearing and so forth we ratio it out to convert to pounds. The other thing is, we also have another head on the meter that does register in gallons if somebody wants to check. So there's a dual head on the meter.

Q. Could you tell me what might be the maximum credible spill of ammonia that you might get if you are unlucky and did get a rupture in a part of your line?

ROHLEDER: Well, let's see. The block valves are ten miles apart, and an eight inch pipe holds about 350 barrels. Now to convert that, it would be 40 tons roughly per mile. So we could get 400 tons out between block valves. I think that would be the maximum, if we get the valves closed immediately. Does that answer your question?

Q. I wondered how promptly you might get a valve closed. Is this something that would be instrumented information in Tulsa or would it be a question of a field patrol or a phone in from somebody who observed the occurrence?

ROHLEDER: On the central dispatch board in Tulsa we have a complete display of the system, and the dispatcher knows what his pressures and flow rates are at all points along the line. If he gets a break like this it immediately shows up and he starts stopping pumping units which might take anywhere from four to five minutes depending on the number of units that we shut down.

And then we have people about every 100 miles along the pipeline and we can get it closed off at those points immediately and then say the average travel time might be 30 minutes or 40 minutes. So within an hour's time we've been able to shut in LPG breaks like that.

Q. You feel you'd be able to get to the line fairly quickly to make a repair with the ammonia that would be around at the time? You'd have people with suits and the like, no doubt, that would be able to get in and make the repairs.

ROHLEDER: Yes. We have pipeline maintenance crews located about every 200 miles along the way, and they are equipped with all of the necessary materials, safety equipment and so forth. First of all we get the line shut in, and to put one of these stopple connections in, takes about eight hours, and then to lay the pipe around that area that is involved might take another couple of hours.

We've guaranteed the shippers that we will be back in service within 16 hours after a break if we have one. The reason we went to the extra pipeline cover is that in the eight years of operating an LPG system 95% of our breaks have been caused by construction equipment hitting the pipeline. In fact, we just had one in Illinois here last week, and it was a coal company building a road across our pipeline. We had relocated the line for them just about eight months ago, and gave them maps and marked it for them, and they still ran into it and the guy on the pusher cat for the pan, got burned critically. He was our first death in eight years on the system.

So we have either been lucky or we've had the necessary precautions, but this is why we think that additional cover on the pipeline is one means of increasing the safety of the ammonia system.

Q. If a terminal receiving your ammonia from the pipeline has a power failure and loses refrigeration, how long is it necessary for him to continue taking the flow of ammonia from the pipeline?

ROHLEDER: We can shut him down immediately, because we have indications—our dispatch board has certain functions that the shipper has given us off his refrigeration equipment. If his equipment goes down for any reason at all, we get a red alarm light. It automatically closes the pipeline valve and the dispatcher starts shutting down pumping units. And we are hoping that the one or two per cent compressibility will keep us out of trouble.

Q. Then the ammonia that's produced is held at the plant during this time?

ROHLEDER: It'll have to be, either that or at the 63,000 gallon tanks at the various terminals.