

Developing Ammonium Nitrate-Fuel Oil Blasting at International Salt Company

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ABSTRACT

A brief history of the development of Ammonium Nitrate-Fuel Oil blasting in the underground Rock Salt Mines of the International Salt Company. Beginning with the hand loading of 2 1/4 inch diameter drill holes in 1958, progress will be reviewed up to and including the present practice of pneumatically loading 1 5/8 inch diameter by 13 foot deep drill holes. Emphasis will be on actual operating difficulties and problems encountered with resulting solutions and operating techniques developed. Current practice in all International's mines will be discussed along with ideas, if not daydreams, covering the future.

The International Salt Company operates mines at Detroit, Michigan; Retsof, New York; Avery Island, Louisiana, and Cleveland, Ohio. At all of these operations, except for Cleveland which is still in the development stage, Ammonium Nitrate-Fuel Oil (AN-FO) mixtures are being successfully used as the primary blasting agent. Following is a brief history of the development of this blasting agent at International Salt Company:

In mid 1958, our Detroit Mine became interested in the application of AN-FO mixtures as a blasting agent, utilizing 2 1/4 inch diameter drill holes, which at that time was considered very small. Representatives from Detroit made several trips to underground AN-FO operations in Ohio, since at that time, Ohio was one of the few states in this area which approved the use of AN-FO in underground operations. These visitations were most instructive and soon after this Detroit began experimenting with AN-FO by hand filling kraft-paper tamping bags and then placing the bags in the drill holes as with dynamite. Results were encouraging, but time and labor were excessive.

Detroit next contacted the Atlas Powder Company and working with a group of their technical people, headed by Mr. John Jeffries, they experimented with the pneumatic placement of AN-FO using the Atlas Jet Loader. Results were most favorable both as to salt breakage and quantities of Carbon Monoxide and Oxides of Nitrogen produced. At this same time, extensive tests were run to try and obtain static voltage readings as the AN-FO was blown into the drill holes. No show of static voltage could be detected and it appears that any static voltage on the ammonium nitrate prills goes to ground through the salt body as the prills are blown into the drill holes. It was also determined that for best blasting results, the primer containing an electric millisecond delay blasting cap should be placed in the back of the drill hole. After a careful review of procedures, it was decided to place the operation on a production basis. This was in October, 1958.

A short time later it was discovered that the AN-FO in the top row of blast holes, produced an excessive shock which apparently weakened a sand seam about one foot above the mine roof. After a week or more, this weakened seam allowed the one foot slab or scale of roof salt to sag and eventually fall. Obviously this condition was hazardous and, therefore, some different means had to be developed for shooting the top row of holes. The technique which was developed consists

of using long polyethylene tubing 1 1/4 inch in diameter by 0.005 inch thick, filled with AN-FO. These tubes are cut in 4 foot lengths and filled by special equipment. Both ends of the tube are closed by stapling. In loading the top row, the primer is first placed in the hole, followed by the filled tube. The collar end of the tube is then punctured to provide expansion for light tamping. No stemming is used. This procedure provides an air space between the 1 1/4 inch diameter tube and the 2 1/4 inch hole which tends to cushion the shock upon detonation. The scale problem has been completely solved by using this procedure. At first there was some concern that the air space in the drill hole might give trouble in the form of incomplete detonation or misfired holes, but there has been no trouble of this nature to date.

In the actual present production system, 6 per cent diesel fuel oil is metered into 50 pound polyethylene bags of prilled ammonium nitrate which are allowed to stand a minimum of 24 hours. The present 2 man loading rig consists of a fully insulated platform, which holds the Jet Loader, mounted on the front of a large rubber-tired fork lift truck complete with compressor. From this movable platform, approximately 350 pounds of AN-FO is placed in fifty-seven 2 1/4 inch diameter by 11 to 13 foot drill holes which are primed with 1 1/4 inch by 8 inch sticks of 65 per cent semi-gelatin dynamite. Rooms have been previously undercut to a depth of 10 feet and the blast in each room yields approximately 900 tons of broken salt. It is interesting to note that Detroit Mine has the longest known history of continual operation with AN-FO blasting agents in the world.

We at Retsof mine had been alerted to the favorable results of AN-FO blasting at Detroit and after visiting Detroit to observe its use on a production basis, we returned to Retsof to try our luck.

The mine face at Retsof is 65 feet wide by 9 1/2 feet high, being undercut a depth of 10 feet. As we began to prepare for initial experimental work we found that we had three major problems confronting us. The first was the size of the hole. At Retsof, due to our relatively low average room height of 9 1/2 feet we had been blasting with sixty-four 1 5/8 inch diameter by 12 to 13 feet deep drill holes. Due to the good fragmentation obtained with this pattern along with our desire not to begin experimental work by modifying drilling equipment, we decided to try and adapt AN-FO blasting to our standard 1 5/8 inch diameter drill hole. Up to this time, 2 1/4 inch diameter drill hole. Up to this time, 2 1/4 inch diameter drill holes appeared to be the smallest practical size for satisfactory AN-FO blasting, thus we had the problem of reducing the diameter by roughly 28 per cent and still keep the shot going. Experimental work with AN-FO filled kraft paper tamping bags looked very encouraging although the small diameter drill holes had to be pre-cleaned by blowing salt cuttings to allow the kraft paper tamping bags to travel to the rear of the hole.

We were quite fortunate at this time to find that the Spencer Chemical Company had just completed some experimental work in pneumatic loading 1 5/8 inch diameter drill holes with the then relatively new Spencer Powder Monkey. Working with a Spencer group, headed by Mr. C. M. Cooley, we began pneumatic loading under controlled conditions.

Results were impressive! We were very pleased with fragmentation and further experimenting showed that the number of holes in the face could be reduced nearly 20 per cent and still produce satisfactory breakage. This reduction of course yielded further economies in caps, primer and drilling time. Recently, we have again revised this drilling pattern to better fit the fragmentation requirements of our newer mine loading equipment. This newest pattern has 59 holes and yields approximately 425 tons per face.

We were also pleased with the resulting toxic fumes produced, with carbon monoxide actually showing lower percentage concentration than some dynamites used for comparison testing. We were somewhat disturbed though with the variations in oxides of nitrogen produced. Some shots were excellent while others were not. We soon found that by blowing all salt cuttings from the drill holes prior to loading with AN-FO, the oxides of nitrogen produced stayed well below our self-imposed limit of 5 p. p. m. Evidently what had been happening was that salt cuttings were being picked up by the prills during placement or pushed ahead of the primer during priming, thus forming a salt barrier within the column of AN-FO.

The second problem concerned the method of priming. The State of New York has a policy that no explosives or blasting agent can be blown over electric blasting cap leg wires. Thus we were limited to collar priming of all holes. This actually has caused us very little trouble in that we stem all holes with one kraft-paper tamping bag filled with salt cuttings and results are excellent. Of course it should be remembered that we have never tried priming any other way. Consequently, we have no basis for a comparison. We can say, though, that we can see no great disadvantage to collar priming and in fact we even save money through lower costs for shorter cap leg wires.

The third problem was the actual selling of AN-FO blasting to the New York State Bureau of Tunnels & Quarries. Since we were the first underground operation in New York State to request permission to use AN-FO underground, the State was most interested in our progress. During all of the experimental work, we worked directly with both the New York State Bureau of Tunnels & Quarries and personnel of the U. S. Bureau of Mines. These agencies proved most helpful especially in the areas of air sampling and analysis. Thus at the time of the final decision, we found ourselves selling the State a method of blasting in which they themselves had actively participated towards its perfection. Needless to say this was a most satisfactory situation and we were accordingly granted approval.

At Retsof, all of our face operations are incentive jobs and management felt that the AN-FO operation should also be this type of system. Our present AN-FO blasting manpower consists of 2 men and 3 men crews depending upon blasting requirements for the day. A three man crew consists of two AN-FO loaders with a third man priming. In a two man crew, there is no man priming with the two men both loading and priming the holes. Each crew has a Willy's CJ5 Jeep with a 60 c.f.m. air compressor and a homemade semi-trailer which carries the Powder Monkey, a day's supply of prills in poly bags, along with all necessary tools and equipment. This unit is a highly mobil, flexible, and independent rig which has proven very satisfactory. We have three of these rigs along with a spare Jeep-compressor unit. A three man crew loads 8 rooms per shift and a two man crew loads 5 rooms per shift.

Ammonium Nitrate prills and 6 per cent by weight No. 2 fuel oil are mechanically mixed and allowed to stand in 50 pound polyethylene bags at least 24 hours before using. Tamping bags for stemming are prepared by undercutter helpers and left in rooms for future loading. All blasting is done at the end of the last shift and the section foreman then tests the rooms the following day for toxic fumes with a Drager Gas Detector.

The Avery Island Mine began experimenting with AN-FO mixtures in 1959, roughly the same time as Retsof. For some reason, Avery could not obtain satisfactory results with kraft-paper tamping bags filled with AN-FO. However, with the knowledge of the successful application of pneumatic placement at the Detroit Mine, Avery purchased a Spencer Powder Monkey which gave very satisfactory results.

At Avery, the entries are driven in two benches. The first advance (or lower) bench, 34 feet high, 10 feet deep and 100 feet wide, is undercut and then drilled with a self-propelled cat-mounted multiple drill rig. The second bench, 52 feet high, 14 feet deep and 100 feet wide, is drilled with a telescoping mast rig. This benching practice produces a face 86 feet high and 100 feet wide, which when shot, yields approximately 6,600 tons of salt. In the interest of efficiency, the benches are shot at the same time whenever possible. Obviously this cannot always be done since the low roof advance is 10 feet and the high roof advance is 14 feet.

The drilling, loading and shooting crew consists of three men. One man handles the pneumatic placement machine and charges this machine at ground level, and two men are located on the elevating platform of the drill rig to handle the loading hose and to prime the holes with dynamite. One of the men on the rig places the primer in the back of the hole; the second man handles the plastic hose for blowing the AN-FO into the holes. Pressures used vary between 25 and 40 psi, depending on the height of the drill hole being loaded. While one man is placing prills in the drill hole, the second man is placing the primer in the next hole. When all holes have been loaded, the cap leg wires are connected and the room is ready to be shot.

AN-FO blasting in underground mining operations is here to stay. The economics that can be effected through its use in the rock salt industry, make it mandatory that it be used by a producer if he hopes to remain competitive.

As to the future, the author sees no real limitation to this method of blasting. As confidence in this blasting method grows, newer and more radical applications will be attempted and better testing, development and engineering facilities will be made available for further advancement in the field. Most recently AN-FO has been introduced into the gypsum, copper and iron ore operations.

We at Retsof have been "brain-storming" the idea of placing AN-FO in drill holes via the new hollow drill steel recently made available with the introduction of through steel dust collection. With such a system, the AN-FO would be pneumatically placed in the hole by the drill operator as the drill steel is retracted.