Papers —

Eighth Annual Meeting

"Man & Transportation"

September 6-9, 1967

Montreal, Quebec, Canada

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TRANSPORTATION RESEARCH FORUM

Prospects for Solids Pipelining in Canada Today

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INTRODUCTION:

The first impression of solids or slurry pipelining gained by those who are unfamiliar with the process is one of cautious skepticism. The concept of moving a solid material of any form by means of a lighter liquid in a closed pipe normally seems to them to be at least an unusual approach.

On the other hand, to those of us who have been converted to the principle, these hesitations seem entirely unfounded. The basic laws governing the movement of most solid materials in liquid suspensions through pipelines are well known. They have been described, discussed and refined in minute detail in technical meetings and papers over the past 20 years, so shall not be dealt with there. However, it is pertinent to point out that this paper refers to transporting the materials either in a homogeneous mixture (slurry) or in a heterogeneous mixture where some of the particles move along the bottom of the pipe by saltation.

Apart from this basic question of actually getting the materials through the pipeline, there has arisen a whole host of problems related to the specialized treatment and handling of the materials at either end of the pipeline. Experience from both operating solids pipelines, and from feasibility studies carried out on many others, has shown that these apparently secondary problems often turn out to be the determining factors in the justification or rejection of the schemes.

The object of this paper is therefore to discuss these various facets of solids pipelining, and to present examples of their effects on different projects which have come to our attention over the past year or two.

Dismissal of Transportation Technique and Economics:

In choosing to avoid any detailed discussion of the actual mechanics of transporting the solids through the pipe, it is not my intention to leave the impression that these are definitively known for all materials. Most materials commonly susceptible of pipeline transportation have been extensively studied; these include sand, gravels, coal, gilsonite, most mineral concentrates and potash. Others, such as sulphur present some basic problems still to be overcome, while others again, such as wood chips appear to require only some detailed refinements of the already known relations.

However, at the same time as stating that the laws for most materials are well known, it remains our firm belief that precise laboratory tests should be carried out as a normal design aid in each case. Variations in grain size distribution resulting from the supply process; variations in thixo-

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tropic characteristics as a function of acidity changes during transport; grain size changes due to abrasion in the pipeline, and other factors defy rigorous mathematical treatment. Our experience has shown that the only way to safety encompass these variables is by testing each case individually in the laboratory. This testing has been developed to the point where it consists of a standardized procedure which yields all the necessary data for laying out an optimum installation.

This procedure has been built up on experience by our associate company, Sogreah, which has been intimately involved in the development and design phases of over 30 solids pipelines which have been built in the past 20 years. Close contact with these projects on through the construction and operation phases has provided invaluable information on the detailed problems involved. Added to this is experience gained on numerous other schemes which never got beyond the feasibility or model study stage.

Another major heading which I propose to leave out as a direct, separate factor is economics. As each of us here fully realizes, the only justifiable grounds for any engineering undertaking is that it must be economically viable. Therefore, it is a foregone conclusion that the ultimate factor involved in most of the topics I am going to discuss is in fact economics. However, I choose not to enter into the inextricable complications of each individual cost with all its variable, as these too have been the subject of other papers presented over the past few years.

Secondary Elements Involved In Solids Pipelining:

1. Amount of Material to be Moved:

Pipelining in whatever form it is considered is necessarily a partner of mass consumption of some commodity. If we allow ourselves sufficient latitude, we can say that even the earliest known open aquaducts were a form of pipelining, which points out that the advantages of this mode of transportation have been appreciated for a long time. As our societies have increased in complexity, so have our demands for water increased, and large scale aquaducts and water pipelines have been developed to supply these.

Similarly, the twentieth century has seen the rapid growth of demand for hyrocarbon fuels. Our present day highly mechanized societies roll all but exclusively on petroleum products, and the prime element in getting these products from the oil fields to the markets has been the pipelines. Natural gas is another stable-mate in the hydrocarbon family which moves practically exclusively by pipeline.

Still in the fuel field, but introducing the concept of solids pipeline, is coal. There are now two such lines operating in the world; one in Russia and one in France.

Examination of the throughput figures for these various applications of pipelines brings out one salient feature; they all deal with volumes which run into the millions of tons per year.

Other examples of solids pipelining in the fields of sand and gravel dredging and tailing removal from mineral treatment plants, normally transport their products over much shorter distances. None-the-less, the truly economic cases among these are handling quantities between one half and one million tons per years, and examples of two and three million tons per year are not rare.

Since the investment involved in construction, operating and maintenance of a pipeline is a major one, it follows that vast through-put quantities must be available so that the per unit amortization can be brought down to a competitive value.

2. Available Supply of Transporting Liquid:

The previous discussion showed us that to be economically viable, pipelines must transport large volumes of materials. This in turn infers that for solids transport, large volumes of liquid must be available as well.

In British Columbia, we have seen many ideal smaller projects where a material is located up on a mountain, and where there is a creek nearby with a more than adequate water supply. Only minor works would be required to establish a pump intake to feed a pipeline and take the material down the mountainside to the mill or other transportation below.

On the other hand, many possible schemes exist where water is not nearly so conveniently available. If an insufficient continuous supply is on hand, a dam would have to be built to provide storage for intermittent operation of the pipeline. If no water at all is available, perhaps it would have to be pumped in from somewhere else and recirculated. Questions of a legal nature could be entailed in some cases if the water were moved from one watershed to another.

A peculiarly Canadian problem is that which finds some of our greatest quantities of materials susceptible of pipeline transportation out on the prairies where water normally is in short supply. Strong arguments can be made to the effect that although solids pipelines could use large amounts of water, this is still insignificant when compared with the amounts lost to evaporation or which flow into the Arctic Ocean, None-the-less, an anomaly does appear in such a proposal so it is bound to meet opposition.

Faced with this situation, it is pertinent at this stage to mention the obvious fact that in any solids pipeline schemes of this nature, the transporting medium, usually water, must be considered as a non-revenue waste product. It accounts for approximately half the weight being put through the pipe, hence half the cost of the operation.

Attempts to avoid the costs incurred by transporting a non-revenue medium, at the same time as reducing the cost charged to the solid materials being moved, have been directed at combining solids with oil in the same pipeline. Although seemingly an ideal combination for the solids transporters, this approach has not made much progress in the face of opposition from the petroleum carriers.

3. Material's End Value Not Diminished by Contact with Liquid:

Limiting our argument from this point on to cases where water would be the transporting medium, the ideal situation under this heading would be represented by the various non-oxidizing ores or mineral concentrates, sands, gravels, gilsonite and mill wastes or tailings of no commercial value.

On the other hand, doubt still exists concerning the effects of completely saturated wood-chips; would they rot or discolour in storage piles? Would the digesting process be altered, lengthened, require more heat? Any additional cost introduced in the process would automatically be charged to the pipeline transportation.

It has been proven that finely ground coal still retains its heating value in its use of firing furnaces for thermal power plants. However, in certain cases, some clever economic tightrope walking is necessary to optimize the amount of drying which should be done as opposed to how much penalty on the furnaces' output due to higher humidity coal can be charged to the pipelining. Another case which is less clear cut is the effect that the fine grinding and saturation of the coal would have on its coking qualities for the production of steel.

Of particular interest to the farmers in the west is the transport of their cereal grains to either the east or west coasts. Pipelines have also been looking at these vast volumes which are so attractive to this mode of transport, but so far have drawn a blank against the stringent moisture and health limitations required in the end product.

Many other products which can come under consideration must be evaluated carefully to see that their end values are still acceptable to the economics of the whole system.

4. Material Preparation at Line Entrance:

As mentioned earlier in the paper, our discussion is limited to the two forms of pipelining solids normally referred to as homogeneous or slurry flow, and heterogeneous flow. In the first, all the material is in suspension and remains evenly distributed across the pipe section due to the turbulence of the mixture. In the second case, slightly larger particles are present and form an active deposit on the bottom of the pipe. These particles are drawn along by saltation in the faster moving mixture in the upper portion of the pipe.

In either case, the material required for optimum transport hydraulically must generally be in relatively fine particles. Depending on the case in hand, the largest particles can be considered in the order of 1/16 inch while varying percentages would be required to pass a 200 mesh sieve.

However, when it comes to many other materials which occur in the natural state in larger particle form, crushing becomes necessary. In the case of mineral ores, the question arises of whether or not the whole cost of grinding should be charged to the transportation since the ore would likely have to be ground anyway? This same argument holds for limestone to be used for cement, and coal for thermal electric plants in many instances. In others, pipelining the solids might mean re-locating the grinding plant to have it at the material source rather than at the treatment plant; at the mine portal, in the mine, are men and power available, is there room for it?

Like many parts of our discussion in this paper, the question of pretreatment is fraught with arguments open to various interpretations and rationalization. It is however clear that the preparation costs can be important and must be dealt with in detail for each case on the basis of particle sizes required for the optimum transport operation.

5. Facility with which Material Recovered:

Under this title it is assumed that the transported material is to be recovered in some form or another and rehandled for further use. The ideal case would be represented by sands and gravels or mineral ores and concentrates of larger grain size. These can be recovered from the water mixture very simply by either direct decantation in a pond, by primary cyclone treatment or by screening. Wood chips as well seem to present a straight forward situation where the water could be removed by screening and the chips then distributed by mechanical or pneumatic means.

Where problems can crop up in this subject is whereever the material being transported is very fine. Several stages of cycloning will normally be necessary, and depending on the required degree of humidity reduction, may or may not demand drying as well. With very fine material, attempts to recover it by means of decantation in a pond are often thwarted, as instead of settling out, the fine particles remain in suspension, forming a surface crust underlain by a treacherous sea of mud. In cases where in fact the settling out process does take place, it will generally be relatively slow, and if the project is of the scale mentioned earlier, vast tracts of land would be required for the decantation ponds.

6. Handling of Material at Arrival End:

This heading follows very closely the arguments presented in the preceding paragraph, except that the field of ulterior uses is left entirely open. The ideal case here is represented by projects where the effluent from the pipeline can be discharged into a pond or enclosure where it can seek its own equilibrium, decant and remain undisturbed. Tailings coming from a mineral treatment plant are a good example, as well as sand or gravel for land reclamation or dam construction.

When the materials must be re-handled after pipelining, it is pertinent to compare the case of handling with what it would have been had the material been retained in its original form and shipped by other means of transport. Looking first at say coal or mineral ores or concentrates which had to be ground finely for pipeline transport, whereas had they been transported otherwise, they would likely exist in lump form or at least gravel sizes. For bulldozer, front-end loader removal, or conveyor belt transport, our finer material would be at least as easy to handle, but no doubt a little dirtier for the operators, due to the higher proportion of dust sizes. Once a satisfactory degree of humidity had been obtained in the finer material and it was put into stock-piles, it should retain that degree better; the finer particles on the surface would form a more water tight cover than the larger material, thereby keeping the rain off a greater portion of the reserve. Conversely, in dry weather the surface layer of the finer material would dry out more quickly, making available a dust cover which could be blown about by the wind.

Wood-chips in turn present a special case with a variety of points of view. The physical dimensions of the chips would not be altered, so that conveyor belt or front end loader handling would not be altered. However, since the chips now would be entirely saturated, they weigh nearly 30% more than before pipelining. For ultimate pneumatic transport, this results in a very real additional air demand and power requirement. Similarly, if the chips coming out of the pipeline must be carried by scows, it must be remembered that the scows' capacity would be reduced by the same 30% — the loss of capacity being directly chargeable to the pipeline.

7. Time Available for Studies:

The one thread of continuity that should be noticeable in the preceding series of elements as they were presented is that the variety of problems possible means that each scheme must be examined as a unique case. Solids pipelines are not stock items, and are not likely to be so in the foreseeable future.

However, too often projects appear where time is at such a premium that it is impossible to even consider solids pipelining. Half a day's work in the office can get better than ball-park figures from contractors for roads or railroad construction; rolling stock prices are available from the manufacturers and the union hall will give you all the wages for all the classes of workers involved in other forms of transport. Armed with this, it is possible to arrive at a fairly sound transportation price, and lay down a schedule which will show that in a minimum, and all but perfectly predictable time, the facility will be operational.

But we don't even know yet whether or not the material is amenable to pipelining, and if the question of laboratory testing is raised, it has the same effect on most clients as the starting gun has on a race horse. The answer must be forthcoming forthwith or it is not in the running; even if there are good odds that pipelining might turn out to be cheaper, if it cannot be stated categorically at the outset the discussion is finished.

The plea resulting from this paragraph is that where mass movement of any commodity is proposed, before the project has reached the construction stage, an intelligent evaluation of the solids pipelining possibilities should be carried out.

RECENT PROJECTS CONSIDERED IN WESTERN CANADA

The object of this chapter is to point out in more detail actual cases where we have seen the inner workings of some of the problems described earlier.

1. Copper Ore from the Mine Face to the Mill:

This project is located in the B. C. Interior, and typical of many such mines has its access to the ore body in the form of a horizontal tunnel driven into the mountainside. The proposed operation is to mine 125 tons /- hour of ore; it has a mean specific gravity of 2.9 and grain size in the order of ½ inch to ¾ inch. An unknown quantity of water is available through a vertical shaft from other mining operations higher in the mountain; the head acting on the discharges could vary, and was undefined as well.

The transportation problem which interested us was the removal of the ore from the mine, over 6,000 feet in the tunnel and 1,000 feet outside to the mill; there is a 130 foot vertical drop over this length.

We looked at three different possible schemes based on various assumed water supply conditions.

a. 5 cubic feet per second available under 1400 feet of head; No pumps would be required, the ore would be introduced through a locking system. Our estimated transportation cost was 12¢/ton.

b. 5 c.f.s. available under 100 feet:
A booster pump would be required, power costs and maintenance would be increased. Estimated cost: 17¢/ton.

c. Water supply insufficient, return line required:
The whole system would have to be pump driven, with a double length of pipe. Estimated cost: 35¢/ton.

d. The competitive conventional system being considered is a narrow guage railway at an estimated cost of 50¢/ton. The project has not gone ahead yet as the total extent of the ore body is still uncertain. However, we are hopeful that one of the pipeline schemes will ultimately be chosen.

2. Silica from Tailings Dump to Railway:

Once again, this project is representative of many we see in British Columbia, where the material to be moved is high up on a mountainside and must be brought down into a valley either for treatment or transfer to other transportation means. In many cases, solids pipelining has the hands down advantage of being able to go straight down the slope on a minimum distance track, whereas, either road or rail access would involve tortuous winding about in the bush.

In this case, the practically pure silica was a waste product from an earlier mining operation, and could be used now in the ceramics industry. The proposed operation would work only 6 months of the year at a daily rate of about 600 tons. A one stage screening plant would provide a grain size of 100% minus #10 mesh, and this material would be moved over a horizontal distance of 5 miles, dropping 2,500 feet on the way.

Once again, we examined this from the point of view of availability of a water supply.

a. Assuming a water supply at the source:
A more ideal case for solids pipelining could not be imagined. The headloss resulting in the pipe was almost exactly the same as the topographic slope; only stand-by or booster pumping facilities would be required. Our estimated cost for transporting the material down the hill, dewatering and stocking it ready for loading into rail cars was 12¢/ton.

b. Assuming no water available at source:
Even under these most unfavorable circumstances, pipelining stood up well. We proposed drawing water from the river near the railway in the valley and building a high pressure return line system. Only a small capacity high pressure pump would be required at the bottom to fill the line originally, and to provide water lost in the exit lock system. The pump actually driving the system would be located at the top where it would have to pump only against the headloss. Our estimated cost in this case was 43¢/ton, which still seems like a bargain compared to the estimated truck cost of nearly $5.00!
But there we stand, hat in hand; the rest of the project, involving the enlarged ceramics plant, was judged not economically justified for the time being, so has been shelved indefinitely.

3. Gypsum Pipelining:

The gypsum in this case is a waste precipitate in the production of fertilizer from phosphate rock, and is filtered out of a strong phosphoric acid solution. Its grain size distribution lets 100% pass a 28 mesh sieve and about 80% pass 200 mesh sieve.

The transportation involved must move 1800 tons of gypsum per day over a distance of 6,500 feet, against a vertical rise of 200 feet. Once again the pipeline had several advantages in its favour: a continuous process could be discharged through the pipeline continuously also; rubber lining of the pipeline was among the simplest ways to combat such a highly acidic product, and the grain size distribution lends itself to hydraulic transport.

On the basis of detailed laboratory testing, we suggested two approaches for the scheme:

a. **Dilute Solution:**
The existing launder system evacuates the gypsum from the filters with excess water resulting in a solution containing about 17% gypsum. One scheme was designed using this effluent directly, giving a larger diameter pipeline.

b. **Concentrated Solution:**
The laboratory experiments had shown that the optimum economy of transportation would be obtained by using a concentrated solution containing about 41% gypsum. On this basis then, a smaller diameter pipeline was designed as well.
Later discussions pointed out the distinct likelihood of increasing the fertilizer plant's capacity in the foreseeable future, so a compromise scheme was chosen. The larger pipeline has been specified, to be built and operated with 17% solution to begin with. Then as the fertilizer plant capacity is increased, so will the concentration of gypsum increase until it could ultimately attain its optimum operation for just over double the present output.

4. Silicious Tailings from Concentrator to Back-fill Mine:

This is another project which has not yet made it past the scrutiny of the sharp pencilled economists. However, from the technical point of view, it has only advantages to recommend it.

All the material passes a 42 mesh sieve, and about 50% is minus 200 mesh. The dicharge of 800 tons/day puts it high enough to take advantage of the mass movement principle for the short distance of about 4 miles. The line must rise about 130 feet over its length. The ultimate use is to back-fill the mine tunnels and shafts, so that water transported granular material offers the ideal case for maximum compaction. Drainage would be provided by either the natural slope of the tunnels, or by pumping stations already operating to take care of seepage water.

The economic competition on this scheme is particularly keen. Ore is removed from the mine on an electric narrow gauge railway, and the cars must go back in. Whether they go back in empty or full of tailings, the transport charge remains basically the same, with only the supplementary loading and unloading charges to go against the back-filling. If ultimately the pipeline is chosen, it will be convincing proof of its intrinsic physical advantages as well as marginal economic savings.

5. Woodchips from Sawmill to Pulpmill:

Our discussion under this heading again is typical of several potential pipeline schemes which exist on the West Coast. These essentially consist of transportation distances between 20 and 30 miles, and have annual volumes in the order of 125,000 to 200,000 units.

Following in the steps of the original concept of the pulp and paper industry where the wood traditionally was sent down rivers or streams to the mill, the same general pattern appears today. Mills are normally built at tidewater, and the wood is higher on the hills or mountains. In B. C. any shortage of water is not normally one of our problems, so water should be available to transport chips. There are even two ideal cases where the mills draw their water supplies from the same areas in which the chips are cut. For these, the water used for transporting the chips could be re-used as part of the mill requirements, thereby making the transporting medium a revenue product.

For the several projects we have looked into in the form of preliminary feasibility studies, we have found per unit transportation costs likely in the order of half the present costs by trucking, and about two-thirds the waterborne transport by scows – allowing a 10 year re-imbursement period for the pipeline investment. However, if we must pay off the line in 3 or 5 years, the usual contract period for the other shippers, we are only barely competitive, or at a disadvantage.

Added to this is the fact that in proposing a woodchip pipeline, we must point out that some research is still necessary. To the practical man whose job is to get chips from A to B, the word research is particularly remote – and one to be avoided, so the project is often not pursued beyond that point.

Another item which has been hotly contested in discussions on one of these lines is the question of automation. Who is responsible for re-locating the 100 or 150 men who would be displaced from a trucking system? The unions would have no hestitation in answering this question and perhaps these costs would have to be charged to the pipeline transportation.

6. Woodchips from Sawmill to Pulp-mill:

This particular scheme was one which could not possibly have provided more advantages in favour of a pipeline. The volume of chips to be moved was high, the distance was only 3,000 feet, and water was available at the sawmill under sufficient head to drive the chips through the line. An ejector arrangement could have been developed to introduce the chips so that either none or minimal pumping would be required.

The feasibility study was proceeding very well with dewatering arranged in the simplest possible manner – letting the water run off the piles and drain away by gravity. But here is where the snags began. What would highly saturated wet chips do in a continuously wet pile? Would they rot, or discolour? How much resin and organic material would be in the water as it drained off? Would this organic material, as it decomposed in the sea, create a great enough oxygen depletion to harm fish?

Questions like these could all be answered by research, but the whole construction programme was under way and time allotted for everything but the research. A conveyor system was specified and no doubt will give good service, with speculation the only means of guessing how much more expensive it is than a pipeline.

c. Diatomaceous Earth Pipeline:

This interesting project is being built this year and will transport 10 tons/hour of diatomaceous earth mixed with about 50% clay over a distance of 7½ miles in the B. C. Interior. Like many possible projects, this one places the pipeline in a good position in being able to take a short cut over rough terrain. In fact, the competitive means of transport would have been by truck hauling over 45 miles of mountain road. Water, however, had to be brought to the pipe intake through its own 4,000 foot long pipeline from a river diversion dam. The solids transport will be driven by just one high pressure reciprocating pump.

The solids will be transported in a 10 to 20% mixture of water to which a dispersant has been added to maintain the material in suspension. At the reception end of the line, the solids are removed from the water by centrifuge, then refined to produce chemically pure diatomaceous earth with a moisture content of just 3%.

In many respects, this line refutes the arguments we have been presenting. Its annual discharge is relatively low, and having to bring in a water supply is against us too. On the other hand, the alternative means of transport was so grossly out of scale on costs that these barriers could be overcome. An extensive research programme was carried out, and a specialized scheme taking advantage of the attributes of solids pipelining was laid out.

8. Coal from Fernie to Vancouver, B. C.

The existence or non-existence or possible existence of the requirement to move mass quantities of coal between these two points has used up more printer's ink on the West Coast than any other topic for years. The coal miners in the Eastern Rockies have been doing some excellent negotiating at the international level to create sufficient market for their coal, and on the basis of their progress we carried out a preliminary feasibility study of the project.

As a starting point in the study, we selected similar flow conditions through our pipeline as are presently being used on existing lines. Operation of the 575 mile distance would therefore introduce only the obvious mechanical problems of booster pumping stations and longer stages. Construction of the line would be another story, with large scale problems to be overcome in going through the Selkirk and Cascade Mountain Ranges, two of the most inhospitable areas in the province.

Results of our computations are shown on Figure 1, where the transportation costs shown include preparation of the material (grinding), transportation over the 575 miles, recovering of the coal, dewatering, drying to 8% humidity, and stockpiling ready for loading on ships. The investment for the complete installation was counted as being amortized over 10, 20 or 30 years as shown on the figure.

It is immediately evident that for a pipeline to be competitive, we must be dealing in huge volumes of coal; until we get up into several millions of tons per year there is no hope what-so-ever. By comparison, we must look at the market presently in existence; in 1966, 1,200,000 tons of coal were shipped, and guarantees of the same amount for 1967 and 1968 are in hand. Negotiations are all but concluded for future deliveries of over 3,000,000 tons per year and the optimists can foresee as much as 8,000,000 tons - year as a possible market in Japan.

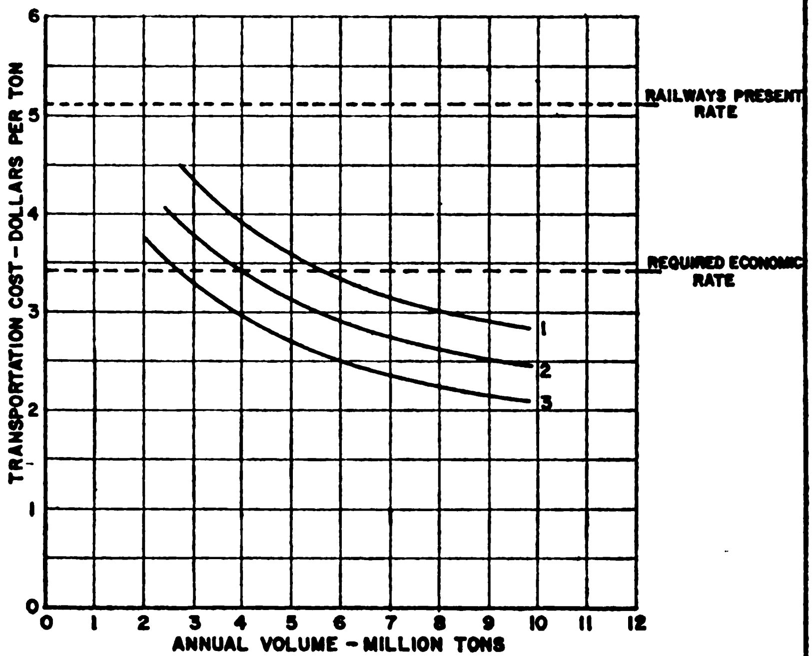
If quantities in the order of this last mentioned figure do materialize, pipelining will be entirely in its element. Detailed studies would then be justified to evaluate the various problems involved in dealing with the finely ground coal as a dust source and to determine its coking characteristics. Or conversely, perhaps it would be worthwhile to carry out this work, detail the pipeline and with firmer figures based on large volume throughput, create the market at the lower price.

REMARKS:

It seems that the great number of variables involved in assessing a solids pipeline have managed to leave us still with an unclear picture of the future. None-the-less, there are several points which show up with enough regularity to at least serve as guide-lines for our thinking.

The first over-all generalization is that solids pipelining appears to be premature for wholesale acceptance in Canada today. Being highly specialized in its functions, it is a process which requires all the characteristics of a well integrated, stable, industrial system. Another characteristic of many of the projects we have seen recently is that they were of marginal economic viability in the first place, and they often give the impression of enquiring about solids pipelines in a last ditch attempt to save the day.

PIPELINE TRANSPORTATION OF COAL
FROM FERNIE TO VANCOUVER, B. C.
ESTIMATED COST PER TON FOR TRANSPORT
DISTANCE - 575 MILES



INVESTMENT
AMORTIZATION PERIODS
1 - 10 YEARS
2 - 20 YEARS
3 - 30 YEARS

FIG. 1

In dealing with short lines, mining perhaps offers the best examples of how economic insecurity works against a pipeline. The mine may have doubtful ore reserves, or the market price for the final product might be subject to variations. The operator therefore always have an eye on the possibility of an untimely shut-down. For his transportation needs then, he is more likely to specify some form of rolling stock which could be used elsewhere in such a case, rather than be left with a pipeline beside a mine which is no longer working.

On the other hand, provided the demand is for a sufficiently long term, it is sometimes possible for shorter lines to be economical for surprisingly small throughput figures. Perhaps the ideal arrangment in this category is when the long term stability is provided by a comprehensive mining – treatment – manufacturing – marketing system, all operated by the same company.

As soon as the discussion falls on long distance pipelines, the requirement of mass movement becomes the decisive factor. As examples of pipelines which are presently working economically look at the 1966 throughput figures of Inter-Provincial Pipeline of 30 million tons and Trans-Mountain Pipeline with a modest 12.8 million tons of crude oil.

By comparison, cereal grains are the only solid prairie produced commodities which rival these figures, and for the time being we do not know how to handle these in a pipeline.

Total shipment through Vancouver last year of just over a million tons of both coal and potash do not yet put us in the right league. Similarly the total Alberta production of sulfur in 1966 attained just over 1.7 million tons, which would still be insufficient, even if it were all directed to the same customer.

Another factor which could ultimately enter into the financial details of long distance pipelining from these interior areas is that the commodities involved are all for export. The long term stability of the market then becomes a function of all those nebulous tentacles of politics and international diplomacy, and the uncertainties in these might well influence shippers to retain more expensive but more flexible transportation. However, a recent development which could reverse this attitude and play right into solids pipelining's hand, was a proposal where the off-shore market interests would invest in the required transportation facilities.

The final element which will be mentioned is the psychological block in the minds of traditionalists who cannot quite bring themselves to accepting the idea of solids pipelining, and in their hestitations seek refuge in that old undergraduate rallying call, "Illigitimis non Carborundum" – don't let them wear you down. It is my desire here today to be part of the wearing down process on these people; to try to convince them that solids pipelining is here to stay, and that it will come into its own as our development moves ahead to satisfy its hungry requirements.