Trade effluent disposal by long-distance pressure pipeline system

A. N. SHARP

Mr A. N. Sharp

I do not want to discuss this particular project but to consider the disposal by pipeline of trade effluents generally, its potential and its limitations.

65. The subject of pipelines in water pollution control is basic, but I have approached the problem from the point of view of a pipeline engineer, to whom trade effluent and sewage sludge mean no more than any other commodity to be transported by pipeline. Two things must be considered: (a) technical feasibility and economic viability, and (b) the will to carry it out.

66. There is no profit to a manufacturer in getting rid of his effluent, whatever the means. Use of an effluent disposal system, whatever the type, varies indirectly with the cost of using it. Effluent disposal costs money, and the cost should not put national products at a disadvantage.

67. Properly designed, a pressure pipeline can be made virtually automatic. It can be buried and forgotten. However, by its very nature an effluent pipeline does not and cannot compete with a conventional treatment plant. They operate in different spheres. Ultimately I envisage a small number of major outfalls, one based on each important estuary, e.g. the Humber, the Mersey, the Clyde, the Forth, and the Thames. Transmission lines could be laid and extended as necessary to cover the adjacent industrial areas.

68. One thing concerns me. Effluent was not included in the Pipelines Act of 1962, and therefore effluent pipelines are not pipelines under the Act. The ultimate stumbling block is legislation.

Mr L. H. Thompson, Public Health Department, Greater London Council

I would like to congratulate Mr Sharp on presenting a most interesting and informative Paper. The proper and satisfactory disposal of our wastes is rightly receiving more and more attention. It seems that there has for many years been a growing awareness of the advantages of regionalization in the main drainage field. This surely began with West Middlesex in the 1930s. Dilution accompanying the enlargement of drainage districts, has allowed more general acceptance of trade effluent into the sewers.

70. The conditions necessarily imposed on the traders to protect sewers and treatment works sometimes result, however, in large quantities of industrial sludges and toxic wastes remaining as a separate disposal problem for many industrialists. There is no doubt that considerable problems arise, particularly in industrial areas in this respect. The GLC is already responsible for the treatment and disposal of 500 mgd of sewage and the disposal of nearly 3 million ton/year of refuse. Should consideration now be given to the completion of this waste disposal service by providing facilities for dealing with the remainder—the industrial sludges, toxic wastes and materials which cannot be allowed into the sewers for treatment through the normal works? At present the disposal of these various wastes is almost entirely in the

DISCUSSION

hands of private firms, and it may be that satisfactory facilities could be provided by local authorities to augment or replace the rapidly dwindling space available in tips.

71. Whilst there seems little point in setting up a pipeline system for the disposal of trade effluents which are acceptable into sewers and can conveniently be treated in the sewage treatment works, a recent survey estimated that the quantities of trade sludges, toxic wastes, etc. which are not acceptable into the sewers and require disposal in the Greater London area vary between 3000 and 10 000 ton/week.

72. It is difficult to draw a distinct line between domestic sewage, trade effluents, trade sludges and toxic wastes, and refuse. There must therefore be a close liaison between those responsible for disposal of all our wastes, and the question arises as to whether any one section should be in private hands. This question becomes particularly relevant when one includes disposal of sewage sludge in the long distance pressure pipeline system. Although the South Lancashire pipeline may not have been intended to deal with the different types of wastes I have mentioned, it will be interesting to know whether Mr Sharp would have foreseen problems in this respect in his scheme.

73. The disposal of Greater London sewage sludge by pipeline to the North Sea has recently been the subject of a feasibility study carried out by consultants, assisted by the Water Pollution Research Laboratory and the Hydraulics Research Station, on behalf of the GLC. It may be of some interest to mention three points which show a markedly different approach from that of Mr Sharp. While the GLC pipeline scheme was designed primarily to deal with digested sewage sludge, consideration was given to the reception and joint disposal of other wastes, including paper mill wastes. On investigation we were advised that such wastes would be incompatible with the sewage sludge because of the large volume of H_2S which would be generated by their admixture. This sort of difficulty could perhaps be extended to other trade wastes. Secondly, various materials for the pipeline itself were considered. Steel was rejected because of corrosion problems. Cast iron in twin mains was ultimately proposed. Thirdly, apart from duplication of the mains and the built-in facilities for isolating 1–3 mile sections of such a main, emergency storage of about 10–12 days' sludge was considered to be a minimum requirement.

74. It would be interesting to have Mr Sharp's observations on these apparently diverse views.

Mr K. J. Flemons, Sir Frederick Snow and Partners

I would like to be associated with Mr Thompson's congratulations to the Author of this extremely interesting Paper. I am aware of no scheme in Britain of this nature, and I feel that the regional approach will be one of the methods of the future for handling industrial as well as sewage effluents.

76. I have recently been engaged on a very similar exercise for the Greater London scheme referred to by Mr Thompson. In this case the study was made into the disposal of digested sewage sludge from the GLC sewerage area. I feel that our own studies followed his closely, first with the study of the materials to be used, then in the approach to various authorities to find whether the scheme would be acceptable. There was a question of pollution of the sea, although we were luckier than Mr Sharp, as we did not have too many adverse criticisms from the fisheries authority, possibly in this case because it was sewage sludge rather than trade effluents.

77. The pipeline was mainly for the transport of digested sewage sludge but it was also investigated with a view to taking industrial wastes at some future date. As Mr Thompson has mentioned, the sulphates present in these various wastes produced H_2S and for that reason the inclusion of wastes was left very much in the air. Allowance was made in the scheme for other main drainage authorities to participate in future should they wish to do so.

78. In the very early days of this study we worked in conjunction with the British Hydromechanics Research Association to determine the viscosity of digested sewage sludge. It was established by laboratory and field tests that at a moisture content of 97½% by weight, sludge behaved as a Newtonian fluid, but at 95% it exhibited Bingham plastic characteristics.

79. In the Paper there is mention of mixing trade effluent with sewage sludge. Was this possibility examined in depth, and if so, what were the characteristics of this mixture? These could well affect the choice of pump. In our case we felt that the positive displacement type of pump would be the answer to the problem.

80. We also investigated pipe materials. In urban areas the selection of the material was restricted to cast or spun iron, although no final decision has yet been given. On cross-country lines we decided in favour of steel. The Author mentions unlined steel pipes. Was any thought given to using an epoxy resin as an internal lining to combat corrosion and possible abrasion?

81. My last point is the question of failure, and the inbuilt facilities in the system to combat a breakdown. The breaking of a water main is not too dangerous, but that of a sludge or trade effluent line could be very unpleasant. I would like to know what allowance was made in the scheme for this.

Mr H. R. Oakley, J. D. and E. M. Watson

Mr Sharp has asked that the Paper be treated on broad lines, as a discussion of the possibility of trade effluent disposal, without particular reference to its price. I hope I will be forgiven if I see the disadvantages rather than the advantages. The scheme described was particularly suitable to this proposition in that there were a number of sources of similar liquor, extremely strong and difficult to treat, and in a relatively small volume for disposal. Those circumstances do not often arise and if one considers the disposal of trade wastes in the general sense by this means one comes up against two difficulties. One is to do with cost and the other with compatibility.

83. For a pipeline to be economic in these circumstances the concentration of the impurities in the liquor has to be right. If the volume is too big then the pipeline is unlikely to compete with the natural stream channel as a means of conveyance to the sea. Some form of treatment prior to conveyance is likely to be more economic than discharging waste to the sea without treatment. Conversely, if the concentration is too great and the volume is small, then the pipeline is not likely to compete with tankering as a means of conveyance. One has had experience in this connexion with sewage sludge which is not as markedly concentrated a liquor. Nevertheless, on examination it has been found that conveyance by pipeline does not compete very favourably, even for towns close to the sea shore, with conveyance by tanker.

84. It will be interesting to hear the assessments made on behalf of the GLC of these particular alternatives.

85. The other difficulty is that of compatibility, and this arises largely because one can seldom be certain of the composition of the trade effluent likely to be discharged. Mr Sharp mentioned Tees-side and the chemical industry there as a case in point. I was concerned to some extent with that at one time. The intractable wastes which it was desirable to discharge other than to the river proved to be of two kinds. One was extremely acid and the other had a varying composition, containing a good deal of cyanide. It was thought that the mixture would prove somewhat unpalatable.

86. Beyond that there are problems of pipeline design. It is relatively easy to choose a material and lining for liquors of constant composition. It must be extremely difficult to choose a material or lining which would deal adequately with a wide range of liquors.

87. The third difficulty likely to arise is that of risk. Mr Sharp has said very positively that private industry would not like to risk capital on this venture. This implies that it is a bad risk, and I think it would indeed be a bad risk because, if

DISCUSSION

nothing else, industry changes unpredictably. For a local authority to expend a great deal of money on a construction of this nature and take the risk that it will get its money back by a flow of effluent into the pipeline requires an act of faith which most of our politicians, whether of the local or central variety, might find difficult to make. It is a fact of life with industry that the effluent discharges will vary both in quality and quantity and this, I submit, makes the design task virtually impossible.

Mr E. A. Drew, President, The Institution of Public Health Engineers

The Author would have increased the value of his Paper if he had discussed the relative advantages and disadvantages of disposal of trade effluent by pipeline to the sea, as against disposal to the public sewer or by road tanker. Whilst sewerage authorities have, in general, a duty to receive treatable trade effluents, I feel that a case could be made for their responsibility for disposal to be extended to cover any toxic and inhibitory wastes excluded from the sewer. I agree with Mr Oakley that industry is never likely, in the present or future, to require the disposal of the same trade effluent over a long span of years, such as was common in the past.

89. None of the wastes that the Author mentions appear to be toxic or inhibitory to the normal sewage treatment processes. In the light, therefore, of the need to conserve water supplies, particularly by re-use of river water, it would appear to be preferable to deal with treatable trade wastes along with domestic sewage, and pass the purified effluent into the water courses. The problem of improving water courses in areas of heavy industrial development is well known, but I believe that in the foreseeable future there will be considerable improvements, with a river water quality much better than in the past. The cost of producing high quality effluents from sewage works is now known to be reasonable and I feel sure that discharge to the sewer will be the best proposition for treatable trade effluents.

90. Having had experience of disposal by road tanker I would suggest that a pipeline would be more expensive for disposal than road transport. I again agree with Mr Oakley that because of the complexity of all the variables it would be an extremely difficult proposition to design a system for the economic disposal of trade effluent by pipeline.

91. With regard to the Author's question concerning the rateable value of underground pipelines, it would be preferable for the trade effluent pipeline to be considered as a 'sewer', since sewers are not rateable!

92. In conclusion, I wish to congratulate the Author for bringing forward a paper for discussion on a subject which will no doubt produce further investigations, especially in the light of the Greater London Council's feasibility study into a long pipeline down the Thames estuary to the North Sea for disposal of sludge from London and its immediate surrounding neighbourhood.

Mr H. Addison, Consultant

A significant point about the Paper is that although the system in question depends entirely upon pumping plant, the pumps themselves are only mentioned incidentally. Perhaps this is a common omission in papers dealing with pipelines. In a recent article in *The Times* describing pipelines of various sizes for oil, water, gas, air and chalk, the word 'pump' never appeared at all. It was apparently assumed that the fluid ran through the pipeline by itself.

94. I would like to ask, therefore, whether the question of the pumps needed for the trade effluent system has been studied in detail, or whether there is such faith in the pump industry that no one has questioned its ability to provide the right kind of pump for any mixture of fluid and suspended matter? Have any actual tests on the mixtures in question in fact been made?

95. The prospect of segregating trade effluents from river water is attractive to

many engineers. Because in former years this was not practicable, a sewage purification works not far from London met with embarrassing difficulties. A particularly obnoxious trade effluent entered the system higher up, and was not detected for a long time.

Mr A. G. McLellan, Chairman

I would like to comment on the timing of this Paper, which is wholly fortuitous. I refer first to the Lena Jager Committee which is deliberating and will report on sewage disposal in the context of amenity. I refer next to the Central Advisory Water Committee which has been reconstituted to look at the complete hydrological cycle, from the sea back to the sea, in whatever form. In addition, the Prime Minister has recently thought fit to specify as one of the terms of reference of one of his more senior powerhouse Ministers the care of environmental pollution.

97. In this context, and also that of the re-use of rivers which the river authorities and the Water Resources Board are pursuing earnestly and eagerly, I suggest that the Paper may ultimately prove to be more than timely. The project was a brave effort which was frustrated. Mr Sharp puts the chief blame for the frustration on the lack of legislation.

98. The Central Advisory Water Committee is looking at the fundamentals of water, from cradle to grave, from sea back to the sea, through sewers, through trade effluent and wherever it is ultimately disposed of, from whatever sources. I am sorry that Mr Oakley and Mr Drew, two giants in this field, see inherent difficulties in Mr Sharp's system because of the quickly changing nature of trade.

99. There comes prominently to my mind an experiment in the Trent where currently about £500 000 is being spent on an appreciation of whether the Trent can ever be made a major source of water supply. The Trent is that comparative rarity, a very large river flowing from the wetter west to the east. One of the tributaries of the Trent is the Tame and there are industries on the Tame which have noxious effluents. Could it be that part of the answer is to pipe some of this noxious effluent, which may not be treatable economically, to the sea and make the Trent into a river which would be a major source of supply for the drier and thirstier areas of South Humberside?

Written contributions

Mr J. M. Smales, Scott and Furphy, Melbourne

It is interesting to compare the proposals for the Lancashire trade effluent pipeline given in the Paper with a scheme commissioned earlier in 1969 in Australia for trade effluent disposal at Leongatha in SE Victoria.

101. The Lancashire scheme envisaged 29 miles of 22–24 in. dia. steel pipeline, 3 miles of sea outfall and collecting lines to carry 8 mgd of effluent, at an estimated cost approaching £3 million. The Leongatha pipeline comprises a total of 33 miles of 8–12 in. rigid PVC pipe, and was constructed at a total cost, including pumping and storage facilities, of approximately \$1·25 million (Australian) or, say, £575 000 sterling.

102. The scheme was initiated primarily to deal with the discharges from two large milk processing factories and was subsequently extended to include domestic wastes from overloaded sewage treatment plant operated by the local sewerage authority. The factories have previously experienced great difficulty and high annual costs in the disposal of waste, which include large quantities of whey. The magnitude of further extensions to the treatment plant and associated operational complexities were economically unattractive.

103. The outfall pipeline has been designed to carry a peak flow of just over 1 mgd, of which 700 000 gal are milk wastes and the balance is domestic sewage.

104. The discharges from the factories include wastes from cream pasteurization,

DISCUSSION

buttermilk, casein whey, and factory floor spillage and washings. These effluents have low pH and very high solids and BOD values. A typical composite sample of the effluent had the following strength:

	Excluding casein whey, mg/l	Including casein whey, mg/l
Solids, total . . .	4344	—
Solids, suspended . .	740	1000
BOD (5 days) . . .	2300	9300

105. The pipeline system operates at heads of up to 300 ft and consists of about 3 miles of pumping main and 30 miles of gravity line constructed through open country, terminating in a short ocean outfall which discharges below low tide level in the Bass Strait.

106. Mr Sharp comments on the possibility of precipitation and gelling of the mixed effluents and he refers to the use of Hazen and Williams's coefficients of 100 and 150 respectively for steel and plastic pipelines. In the case of the milk wastes, the effluent is subject to seasonal variations and marketing fluctuations in the products manufactured. Over 20 000 gal of casein whey are discharged daily with a total solids strength of 25 000 mg/l and a BOD 5 of 30 000 mg/l. This ferments rapidly, with precipitation of casein and formation of lactic acid. Periods of low velocity are expected, particularly during the earlier stages of the schemes, and the PVC pipeline has been designed using a friction coefficient equivalent to a Hazen and Williams's value of 135.

107. The second butter factory has only just been connected into the system and it is not yet possible to comment on operational and hydraulic conditions.

Mr P. A. Banks, John Taylor and Sons

The Paper, which makes interesting reading, poses more questions than it answers. I would like to suggest that the lack of legislation which is blamed for the demise of the scheme is not a fundamental difficulty. If the Pipelines Act 1962 got on to the statute book, no doubt some amending legislation could have been sponsored by a private member or by the Minister.

109. Many major engineering works have to be preceded by legislation; this is nothing new, and since the scheme is a long-term one the delay involved should not have been crippling. Surely the basic problem is the amount of risk capital involved which is not offset by the prospect of high profits from the operation. Even on Mr Sharp's figures for capital cost, which would seem to be about 50% too low, the average cost per 1000 gal of effluent handled is still high, and there is only a modest return on capital. Furthermore, the operating risk is significant, particularly with only a single pipeline.

110. In § 27, the Author says that enough data were collected to cast doubt on the suitability of uncoated steel pipe. It would be interesting to hear more of these data and to know what solutions would have been proposed.

Mr Sharp

Pollution of the environment is already a focus of public attention: it could well become the major political issue of the decade. My one regret is that it is not possible to deal adequately with so wide and vital a subject as water pollution within the limits of the Paper, nor can the Paper amply demonstrate all the lessons learned in what I

consider an important pioneering venture. The particular project described is unimportant: the fundamental issue is the introduction of a new branch of engineering, pressure pipelining, into a field which until now has been served exclusively by gravity pipelines or sewers. The keen and lively interest evoked in Britain and overseas, however, shows that the Paper has at least achieved its object of pointing the way to a pollution prevention method which could, by the very speed of pipeline construction, give the breathing space necessary to permit other treatment and disposal methods to overtake the march of industry.

112. Many of the questions overlap and I feel that only by answering them collectively can I emphasize the most important.

113. Most, if not all, of the points raised by the first three speakers were clearly foreseen in the development of the project to its final design stage, and the project was indeed based on these points.

114. The primary object of the system was not to separate trade waste from domestic sewage. Had that been the case the rivers could simply have been denuded of water and replaced by large diameter pipelines. I must stress again that the object was to collect and dispose of highly concentrated effluents which the municipal sewage works could not and would not accept and which were being discharged to rivers untreated because of the extremely high capital cost of suitable treatment plant. In the case of the most important of these, black kier liquor, no suitable treatment plant was available in any case for the huge volumes being discharged. The vast majority of dilute trade effluent in the area was even then being discharged to public sewers and treated adequately by conventional sewage treatment works at costs, rechargeable to manufacturers, with which pressure pipeline disposal could not begin to compete. Nor, in similar circumstances, could any custom-built system.

115. The inclusion of trade sludges in the pipeline was an inbuilt factor from the outset of design. The particular sludges encountered were light in character and would have been carried without difficulty in view of the proposed high flowing velocities. The inclusion of sewage sludge was resisted on administrative, not technical grounds, until the system was finally adjudged to be a drain or sewer, and not a pipeline within the meaning of the Pipelines Act, 1962. The subsequent inclusion of sewage sludge in the volumes mentioned raised the total solids content in the system to about 1% and made no practical difference to the hydraulic performance.

116. Much research and investigation was devoted to this aspect of design for the very reasons mentioned by Mr Flemons, and I agree with his conclusions. The change from Newtonian to non-Newtonian characteristics of sewage sludge occurs at about 4% solids: the actual figure varies slightly with circumstances, not least of which is the method of producing the sludge. The viscosity of sludge/effluent mixtures was investigated fairly thoroughly and it was possible to determine reliable constants for fluid flow equations.

117. The Greater London sewage sludge disposal scheme has been approached from the opposite viewpoint, i.e. principally for sludge, with trade effluents a secondary consideration. A similar project in the West Riding of Yorkshire was examined in 1965 with a central sludge burning plant in view, but this faced major difficulties in hydraulic calculation because of the high solids content. I would suggest that the same circumstances could apply in the Greater London scheme without an adequate admixture of trade effluent as a carrier fluid.

118. Too little is known at present of the hydraulic behaviour of sewage sludges for this type of pipelining to be considered seriously on a large scale, and I would stress that this is an important field for scientific research.

119. The dangers inherent in the indiscriminate mixing of trade effluents and sewage sludge were known, and experiments in depth were carried out to determine the risks of gelling, precipitation and H_2S generation, all of which could be fatal to pipeline operation. The investigations showed that only two of the many effluents sampled, both of them acid sulphates from the chemical industry, gave any trouble at

DISCUSSION

all, causing both precipitation and H_2S generation. Removal of these proved what had been suspected, that all the rest were completely miscible and, for practical pipeline purposes, inert. Perhaps the position was favourable in that there were no major inclusions of sulphates and sulphides apart from these: the cotton and paper wastes which formed the bulk of the final effluent were highly alkaline kler liquors and quite trouble-free. One feature worthy of mention is that H_2S generation did not occur at the high pumping pressures proposed for the trunk pipeline even when the acid sulphates were present.

120. The tests proved satisfactorily that the risks from mixing aqueous effluents were more imagined than real. Even so, the tests were on a particular set of effluents and could not serve as a general guide for specific future projects.

121. Choice of materials has aroused much comment. Great surprise has been expressed that unlined steel was chosen for the trunk pipeline, in view of its susceptibility to corrosion and abrasion. I also had reservations at the outset, but tests showed that in the particular case the highly alkaline nature of the final effluent inhibited corrosion, not advanced it. Similarly, the included solids were soft vegetable matter, not hard and gritty, and gave no severe abrasion problem. But again I must stress that this applied to a particular project and could not be applied as a general rule. Further than this, the tests were not of the duration I would have liked, and the final lingering doubts on unlined steel remain.

122. The point has been raised that the characteristics of the final effluent would change markedly over the years as industry changed or developed. This is true of a common carrier line with no restriction on input quality. But in this case the system was to be privately owned and financed, was not subject to the Pipelines Act, and input quality could be restricted. Further, the market survey showed that there would be no marked change in effluent character from the sources served by the pipeline system in the foreseeable future.

123. Epoxy lined steel was investigated but it should be pointed out that at the time this technique was in the embryo stage, particularly for in situ lines, and no successful method of lining welded joints for mill-lined pipe has been developed to date.

124. The comment has been made that the estimated capital costs shown in the Paper are 50% too low. I would reply simply that these costs were calculated not once but several times over the design period by professional pipeline estimators engaged solely on this type of work, and that the results were completely satisfactory.

125. The comment has also been raised that since private industry would not risk capital on this type of venture it would be a bad risk. This is completely missing the point, which is that if private industry is to risk capital on a pipeline scheme, then that same industry must be in complete control of the operation of the system. This would not apply in the case of a regional common carrier scheme. However, if industry is to be attracted to designated areas an existing means of effluent disposal is a prerequisite, as has been proved many times in the past. This is one means of stabilizing the pattern of industry of an area.

126. Finally, legislation is the ultimate stumbling block. In the case described negotiations continued for almost three years, not only with the Ministries of Power, and of Housing and Local Government, but with other bodies such as the CBI, regarding the amendment of the Pipelines Act, 1962, to include effluent pipelines and no satisfaction was received, even though all these bodies were in sympathy with the proposals. The possibility of a Private Member's Bill was explored, but was turned down on the grounds of delay and cost.