THE CLEAN ENVIRONMENT COMMISSION

Preliminary Report

on

CONTAMINATION OF UNDERGROUND WATER SOURCES BY REFINED PETROLEUM PRODUCTS

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Summary and Conclusions

General

1. Contamination of underground water supplies by refined petroleum products has been reported in as many as 32 Manitoba communities and in recent years the incidence of this form of pollution appears to be increasing. Compared with other provinces the problem in Manitoba appears to be worse.

2. In some instances a fire hazard was caused by the accumulation of gasoline fumes in basements; in most cases however, the complaints have been that domestic water supplies have been rendered unfit for use.

3. No evidence has been presented concerning the long term effect of consuming water containing traces of petroleum products on human health. The direct hazard to health arising from the consumption of contaminated water appears to be small because water becomes unpalatable when it contains product in minute quantities. By the same token, a small spill may contaminate vast quantities of groundwater.

4. Adequate clean-up of a contaminated aquifer is virtually impossible and the natural removal of petroleum products by dispersion and break-down is extremely slow. The ill-effects are therefore likely to persist for many decades in any location.

5. Provided that the contamination is not severe, the use of activated carbon filters may make the water supply fit for human consumption. This remedy, however, gives only partial relief, it seriously reduces the rate of flow and is costly since the filters require frequent replacement.

6. Sources of groundwater contamination with petroleum products are:
   (a) leaking underground storage tanks;
   (b) accidental spills during storage, handling and transport;
   (c) indiscriminate dumping of waste oil.

Each of these will be discussed briefly below.

Leaking Underground Storage Tanks

7. Sensitivity mapping can be used to delineate in the province certain areas that are more susceptible than others to groundwater contamination by leaking storage tanks by virtue of;
   (a) corrosive soil conditions;
   (b) permeability of the strata in which the tanks are located;
   (c) the use of relatively shallow or unconfined aquifers for domestic water supplies.

The designation of susceptible areas should be undertaken forthwith; it should form the basis for determining priorities in dealing with the problem; it should be flexible enough to be adjusted as new evidence and information is obtained.

8. Especially in the more corrosive soils in the province, underground fuel tanks may be expected to start leaking within a few years from the date of installation, unless they are provided with a high grade coating and with cathodic protection.

9. The Underwriters' Laboratories of Canada has only in recent years included the requirement of cathodic protection in its standard for underground fuel tanks, which has been adopted voluntarily by the industry. In view of the absence of provincial or municipal legislation concerning the protection of underground storage tanks, and in view of the susceptibility of protective coatings against damamge, it must be expected that practically all tanks in the province are inadequate in the light of modern requirements. The occurrence of leaks is therefore only a matter of time.

10. Leaks may be detected at a fairly early stage by careful inventory control. Such inventory control should be made mandatory and a condition for continued operation; that is to say: inspectors should be empowered to prevent the use of underground storage tanks unless meaningful inventory control is practiced. However, inventory control is not sufficient in itself for two reasons:

(a) the stage at which leakage is detected is very much dependent on the alertness of the operator;

(b) the amount that may escape before even an alert operator will detect leakage, is far more than what can be considered acceptable from the point of view of protecting the quality of underground water supplies.

11. A hydrostatic test is needed to determine whether or not a tank is leaking. At present such a test is time consuming and costly; therefore, it may be impractical at the present time to check all existing underground tanks by means of the hydrostatic test frequently enough to ensure timely removal of all leaking tanks. It is possible, however, to make a start with the checking of all existing tanks in areas designated as susceptible to this kind of contamination.

12. As a first step, it would seem advisable to require that all existing tanks be registered with full particulars concerning size, wall thickness, type of coating used, year of installation, record of inspection, etc.

13. On the basis of experience gained in areas designated as susceptible, a time limit should be set, in the near future,so that tanks that have been in the ground for this length of time or more in susceptible areas, must be exhumed or taken out of service. This time limit should aim at reducing the incidence of leakage and at a gradual replacement of all sub-standard tanks with new tanks that are adequately protected.

14. In areas not designated as susceptible, inventory control should be regarded as the first line of defense for existing tanks. Hydrostatic testing should be required when there is a suspicion of leakage. A limit should also be set for these tanks, presumably longer than in the susceptible areas, with the provision that use of the tank beyond the limit may be authorized by the inspector if the operator can demonstrate to the inspector's satisfaction that the tank is still in satisfactory condition and that measures taken to detect leakage will provide a high degree of protection of the environment.

15. Legislation is needed that requires all new tanks to be manufactured and protected in accordance with the Underwriters' Laboratories of Canada Standard ULC-S603.1-1973, concerning steel underground tanks for combustible liquids. In addition, such legislation should require the installation of a capped vapour detection well in the granular backfill of the tank.

16. The legislation should also specify the proper installation practice, including adequate testing of new tanks and piping. Installation and testing should be allowed only in the presence of a government appointed inspector.

17. Surveillance over new tanks should be based on inventory control, regular inspection of the anodes used in cathodic protection and vapour detection.

Accidental Spills

18. Spills during handling and transfer of product can only be prevented if proper operating procedures are carefully worked out in advance and rigidly adhered to. The responsible department and the industry should cooperate in the establishment of rules and guidelines concerning the handling of product.

19. The responsible department and the industry should also cooperate in the establishment of an approved training program for all personnel which may be handling product. The legislation should provide that no one will be allowed to handle product without a valid certificate as proof of having received approved training.

20. Carelessness and disregard of established rules should be cause for suspension of certification.

21. Legislation should provide that all spills of product be reported forthwith. In addition, each operator should provide a contingency plan for each operation involving the handling of product. Such plans should be subject to the approval of a government appointed inspector; they should be a prerequisite for continuing operation.

Indiscriminate Dumping of Waste Oil

22. Dumping of waste oil should be prohibited; the enforcement of the prohibition should receive priority attention in susceptible areas.

23. Industry and government should together solve the problems of collecting, storing and reclaiming used lubricating oil. If there are insufficient economic incentives for the recycling of waste oil then the government should provide such incentives by means of taxation and subsidies.

Contamination of Underground Water Sources

by Refined Petroleum Products

Chapter 1

Introduction

Pollution of groundwater by refined petroleum products is not a new problem in Manitoba. Several cases, some attributed to spills and others to leaking tanks, have been investigated in the last twenty to thirty years by provincial public health inspectors. In recent years, however, the number of reported cases appears to have increased considerably.

In some instances a fire hazard was created by gasoline fumes accumulating in the basement of dwellings; this occurred in Flin Flon, where some houses had to be evacuated. In most cases, however, complaints were about domestic water supplies that had become unfit for use.

The increased frequency of the problem made an investigation desirable, especially because this particular form of environmental contamination has several disturbing features. Firstly, drinking water becomes unpalatable when it contains petroleum product in extremely low concentrations, so that relatively small spills may contaminate very large volumes of groundwater. Secondly, contaminated aquifers cannot be cleaned up adequately by any known technique and natural dispersion or break-down is so slow that the water supply may remain unusable for many decades. Thirdly, the source of the pollution can seldom be pinpointed with sufficient certainty to determine legal responsibility. And, fourthly, in Manitoba there is presently no legislation which is aimed at preventing this contamination by regulating the handling of product or by settling design standards for underground tanks.

The Clean Environment Commission therefore concluded that it was desirable that the problem be investigated in its entirity on a province-wide basis and decided to hold a series of public hearings that would form the focal point of the investigation.

Two types of public hearings were envisioned. The first would concentrate on the overall problem; to it the Commission invited spokesmen of the industry, personnel from various levels of government within and from outside the province, and the general public. All were asked to assist the Commission in obtaining a clear understanding of the problem and to suggest ways and means of coping with it. The first public hearing of this type was held in Winnipeg on November 18 and 19, 1974. Additional hearings may be held at a later date if needed.

Public hearings of the second type would focus on local experience to ensure that specific local concerns and conditions were not overlooked. One hearing of this type has been held in Bird's Hill on March 17, 1975. Other hearings may be held in other locations where groundwater contamination has occurred.

In addition, the Commission wrote to many agencies in Canada and the United States for information and informed opinion on the subject. In this way the Commission collected an extensive documentation of the many aspects of the problem.

In the early stages of the investigation it became clear that the Commission would wind up its work by making specific recommendations to the government concerning legislation pertaining to the handling of product and the manufacture and installation of underground storage tanks. Since the Commission is not a technical body, it seemed desirable to invite the comments of the industry and of government agencies with experience and expertise in the matter, on any specific issue prior to making a definite recommendation to the government. For this reason, the Commission decided to issue a preliminary report with tentative conclusions at this time. The Commission invites comments on this report and the conclusions which may assist the Commission in formulating its recommendations.

The investigation is limited to refined petroleum products such as gasoline, jet fuel, domestic and industrial heating oil, diesel fuel, lubricating oil and solvents. The Commission is aware of the environmental hazards associated with the production and transportation of crude oil, but considers this outside the scope of this study.

Chapter 2

Description of the Problem

Nature of the Contamination

Various environmental hazards may arise from petroleum products that are spilled on or leaked into the ground. Combustible vapours may collect in sewers or basements and create a fire hazard. Or, the effect may be a film on surface waters that is toxic to certain forms of plant and animal life and interferes with recreational use. Petroleum products may contaminate a domestic groundwater supply and make the water undrinkable. The product may contaminate the soil itself by coating the particles with an oil film which is difficult to dislodge and which over long periods releases soluble contaminants that are carried by percolating rain water to aquifers that may supply domestic wells.

The seriousness of the contamination depends on the mobility of the product in the soil and on the solubility of its components. There are large differences in this respect, both in product and in soil conditions. This explains, at least in part, why some spills have caused complaints and others not.

Concerning solubility, the heavier fractions have less, the lighter ones have more soluble components. From the point of view of groundwater contamination the distinction is probably of minor importance since minute quantities of dissolved product will make water unfit for human consumption.

The mobility of the petroleum products in the soil depends on several factors. One is the viscosity of the oil; heavy oils do not readily penetrate the soil while lighter fractions, in particular gasoline, move through soil more easily than water does.

The mobility also depends on the quantity that is released. Since oil leaves a coating on the soil particles as it traverses successive layers, the amount that travels on is gradually reduced until movement virtually stops. Large spills travel therefore farther than small spills. Mobility depends most of all on the permeability of the soil. The product may move readily through sand and gravel layers while clay may prove an effective barrier. Some bedrock, in particular sandstone and lime stone, is extensively fissured and cracked; this may allow oil to travel fast.

It should be noted that the more permeable sand and gravel layers, as well as fissured bedrock strata, form the aquifers that are suitable sources of groundwater for domestic wells. The relative permeability of the upper strata in which contamination can take place is therefore an important factor in the vulnerability of a locality with respect to contamination of its groundwater supplies.

The oil spill itself need not reach the groundwater table in order to contaminate it. The groundwater body is constantly replenished by rain and melting snow which percolates through the soil. While passing through contaminated layers the water will pick up soluble components and carry them along.

If the spill is large enough to reach the groundwater table, then the oil is forced to spread laterally; it cannot penetrate the groundwater body since oil is lighter than water. Assisted by the movement of the groundwater the oil then spreads out in the form of a thin pancake. Soluble components will dissolve in the water and vapours will be released which may collect in sewers or basements.

<u>Hazards Caused by the Contamination</u>

A spill or leakage of combustible liquids entails an immediate danger of fire and explosion. Several instances in which fire hazards were created have been reported in the province.

At one location in Manitoba a number of families had to be relocated by order of the Medical Officer of Health because a gasoline contamination of the groundwater had resulted in a continuing accumulation of fumes in their basements.

Fortunately, gasoline vapours can readily be detected by smell at concentrations much below the level that creates any explosion hazard. In the vast majority of cases explosions can thus be prevented by monitoring. However, the hazardous condition may last for a long time during which a building may remain unfit for occupancy.

Little is known about the factors that cause gasoline vapours to accumulate in any particular location; concern has been expressed about the formation of a so-called frost shield in the ground in the winter; this could cause vapours to travel laterally to points where their presence could be dangerous.

Most complaints about the underground contamination with petroleum products arise from the pollution of domestic wells. The human taste is very sensitive to the substance and a concentration between 0.005 and 0.5 pounds in 100,000 gallons of water, depending on the individual, will be described as a bad taste.

The hazard to health arising from the consumption of contaminated water is reported to be low because people find the water undrinkable at levels of contamination far below those that would be harmful. It should be mentioned, however, that no evidence has been presented to the Commission regarding long term health hazards associated with the consumption of trace amounts nor on the occurrence of allergic reactions. The overall effect on human health therefore remains an open question.

Sources of Contamination

The source of groundwater contamination by petroleum products can be either a spill or a leaking tank. Since not all spills are reported it is often difficult to tell what did cause a particular contamination.

Chemical analysis can be employed to distinguish type and brand of product. This is not always successful because the soil tends to change the chemical constituents of the product. Moreover, even if type and brand were established, the proximity of service stations handling the same line of products and the possibility of an unreported spill makes it virtually impossible in most cases to pinpoint the source with certainty. The approximate amount of product involved is also difficult to determine afterwards. It requires an extensive drilling program and even then the results are likely to be uncertain since soil samples differ considerably in their tendency to asborb oil.

The catastrophic types of spill caused by a pipe line rupture, by highway or railway accidents involving the transport of oil and the shipwreck of tankers, are outside the scope of this report. Three main sources will be dealt with: the spillage during transfer of product from one container to another; the indiscriminate dumping of waste oil; and, finally, leakage from underground storage tanks and their piping system.

By far the most frequent cause of spillage during transfer of product is human error. This may be in the form of inattention, failure to check the capacity of tanks to hold the estimated amount, opening the wrong valve, failure to make the required connections, etcetera.

The dumping of waste crankcase oil in a convenient ditch has been a common practice in the past and is likely to continue as a source of groundwater pollution unless the re-use of waste oil is ensured by government intervention in the form of regulations and incentives aimed at providing suitable collection, storage and recylcing facilities. At the hearings the point was made that quarries and gravel pits are especially vulnerable to infiltration by spilled oil; it was also pointed out that the operations of quarrying and excavating or processing gravel requires heavy machinery which requires frequent oil changes.

Leakage of underground storage tanks is a major source of contamination. The bulk of the tanks presently in use in the province do not have cathodic protection nor the best protective coating. The average life of such tanks has been estimated to be 12 to 15 years at the most. In corrosive soils, such as do occur in many locations in the province, the life is likely only a fraction of the average. Leaks can thus be expected to occur regularly.

Leaks may develop gradually and may remain unnoticed for a long time until the losses became economically significant for the operator. By that time sufficient gasoline may have leaked out to contaminate a vast aquifer. Statistics collected in Ontario over a four year period show that leaking storage tanks and fuel lines were responsible for about two thirds of the pollution problems reported. The size of product loss in known cases was reported to vary from 150 to 11,000 gallons; sixty percent of these cases involved gasoline as opposed to diesel oil. About one third of the reported cases was caused by spills or miscellaneous and unknown causes.

Local Incidence of the Problem

Contamination of groundwater supplies by petroleum products has been reported in all Canadian provinces, in the U.S.A. and in Europe. The available documentation suggests that it occurs wherever petroleum products are used on a large scale. However, there are significant differences in incidence of reported contamination. Of the Canadian provinces Manitoba appears to have the worst problem.

To date contamination has been reported in 36 separate communities in the province. The source is not always known; it has been suggested that some instances have resulted from careless handling of gasoline by a property owner in the vicinity of his well. Accidental spills and careless dumping of waste oil may account for several other reported cases. There are indications, however, that a substantial number of problems in the province has been caused by leaking underground storage tanks.

Certain areas in the province appear to be more prone than others to this problem. The reason lies probably in two factors: the corrosiveness of the soil, which varies from place to place and which determines to a large degree the life of the tanks, and the permeability of the upper geological formations, which determines the vulnerability of the underlying aquifers.

Underground storage tanks for gasoline are found in every hamlet and along all major highways; in addition, there are countless underground heating oil tanks.

Many of these tanks have been in the ground for a long time, some have been abandoned and may still be partly filled. Leaking underground storage tanks are therefore a common occurrence; in the more corrosive soils one may expect the leaks to occur with greater frequency than in the less corrosive soils. However, when tanks are located in clay strata and the nearby domestic wells obtain their water from confined aquifers at great depth, then leakage may not cause an immediate problem until it shows up in the records of the operator. If, on the other hand, the tank is located in permeable strata that are connected with aquifers, then the first sign of trouble may be the pollution of a domestic well. One may therefore suspect that the reported cases of pollution due to leaking tanks form only the visible tip of the iceberg.

Remedial Action After Contamination has Occurred.

Large surface spills, if discovered in time, can be recovered in part. The highly technical problem of maximum recovery, while of obvious importance to the problems at hand, will not be discussed here since it has recieved considerable attention from the side of the governments as well as from the side of the industry. The question posed here is about remedial action aimed at solving the problem of the householder whose basement fills up with fumes and whose well yields water that smells and tastes like gasoline.

There appears to be general agreement that clean-up of contaminated aquifers is not possible. With large spills some of the oil may be recovered but enough will remain in the soil either as mobile oil or as a film on soil particles to contaminate well water and to cause fire hazards in basements for many years.

There are natural processes capable of removing the contaminants; these are bacteriological break-down and dispersion. Both are extremely slow, if operative at all. In the aerated zone of the soil, bacteria will break petroleum down under favourable conditions; at greater depth, petroleum persists indefinitely. The flow of groundwater will eventually remove the oil but even in the most productive aquifers groundwater velocity is measured in inches per day. One may conclude, therefore, that contamination at any location will persist for decades. Experience bears this out. A small spill which occurred in one Manitoba community five or six years ago still contaminates nearby domestic wells. Other examples outside the province have been quoted of contamination which still persists after 20 and 70 years.

This does not mean that the concentration of petroleum product in the well water will remain constant. The groundwater level is subject to change. When the water table is high after a wet period the water may pick up hydrocarbons from the oil film on soil particles, at other times the supply of dissolved hydrocarbons may be less. The level of contamination may thus vary with time.

Moreover, the contamination may in time spread to wells that previously were free from it. This process may take years because of the slowness of groundwater movement.

It has been suggested that in selected cases the direction of the flow of groundwater can be changed by intensive pumping from wells drilled specifically for this purpose. In this manner it might be possible to divert the flow of contaminants away from domestic wells. This procedure is likely too costly and too uncertain.

Relief for the householder whose well is contaminated can be provided by activated carbon filters. Such filters may have to be replaced frequently. Sometimes a new well can be installed. In cases of extensive contamination it may be best to provide a municipal water system. In this connection it should be mentioned that in municipal water systems hydrocarbons can be removed by aeration.

It appears that the best way of dealing with the problem lies in prevention since all remedial action appears to be costly and uncertain, if effective at all.

Chapter 3

Current Regulatory Control

Current Legislation

Only two Canadian provinces, Alberta and Ontario, have legislation that can be used to enforce safe handling practice of petroleum products and the proper construction and installation of underground storage tanks. In Alberta the applicable legislation is contained in the "Service Stations and Garage Regulations" made pursuant to the Fire Prevention Act. In Ontario the applicable legislation is contained in the Gasoline Handling Code, which is a regulation under the Gasoline Handling Act.

The Alberta regulation is rather minimal. In the matter of handling gasoline, it makes both the tanktruck operator and the service station operator responsible for taking all due precautions before a cargo is discharged. The regulation furthermore prescribes that the tanktruck operator must remain within 20 feet from the truck and that he must maintain constant supervision during the entire discharge operation. The truck operator must ensure that none of the gasoline overflows the tank into which it is discharged. In the matter of protecting underground tanks against corrosion, the regulation specifies merely a coat of red lead paint followed by one coat of asphalt paint or coal tar paint, to the satisfaction of the inspector.

The Ontario regulation is more specific and more stringent. It requires the truck operator to gauge the tank in which he is to discharge the gasoline to ensure that it will hold the volume he intends to unload. The operator is not allowed to remain in his vehicle while unloading, but must remain in close proximity of the discharge control. Similarily during loading, he must maintain a position that will permit him to shut off the flow of product instantly. In the event of spillage he is obliged to take immediate corrective action and to notify the nearest inspector forthwith.

With regard to the protection of underground storage tanks against corrosion, the regulation requires that all tanks installed after May 1st, 1974, be in accordance with the standard for steel underground tanks ULC-S603.1-1973, prepared by the Underwriters' Laboratories of Canada. This standard requires among other things that the tank be provided with cathodic protection, which not only prolongs its life but also gives an indication how much protection against corrosion is still available.

Manitoba has no legislation which specifically deals with these matters. Municipal governments may have adopted in their bylaws the requirement of compliance with the National Fire Code of Canada. The present Code is wholly inadequate in this respect. The newly proposed second edition of the Fire Code is out for public comment only. It may be able to fill in some of the gaps, provided of course that it is encorporated in provincial or municipal legislation.

The Clean Environment Act forbids the contamination of soil or groundwater in excess of prescribed limits. But since no limits have been prescribed, it is no offence to have a leaking tank or to cause a spill. The Act may be used to require a person responsible for a spill or leak to clean up at his expense; this, however, is hardly a practical way of dealing with the overall problem. A regulation dealing with the handling and underground storage of petroleum products is clearly needed. In view of the grave environmental consequences of spills and leaks it would seem that the Clean Environment Act would be the logical base for such a regulation.

Industrial Guidelines

The absence of pertinent legislation in Manitoba should not lead to the conclusion that current practice in this province is likely much different from the practice in Alberta and Ontario. It is in the economic interest of the petroleum industry to avoid leakage and spills. The industry has therefore voluntarily adopted the most recent standards for the design and installation of its underground tanks, namely the aforementioned standard of the Underwiters' Laboratories.

While this appears to be the policy of the major companies, there are others, commonly referred to as independents, who may or may not follow the same policy. Moreover, company policy cannot replace enforceable legislation and adequate supervision. It should furthermore be mentioned that the Underwriters' Laboratories standard is primarily concerned with the design and manufacture of the tanks. While some rules concerning the installation have been formulated, installation, maintenance and leak detection is not within the normal purview of the organization. Finally, the most pressing problem does not concern the new tanks but the multitude of existing tanks that have been manufactured and installed before the present standard had been developed.

The industry has developed its own policy concerning the safe handling of product, the prevention of spills and the control over and detection of leakage. This is extremely important and must remain the first line of defense. Nevertheless, it is apparent that enforceable legislation is needed to bring all aspects of handling and storage of petroleum products to uniformly high standards in the entire province.

Chapter 4

Suggested Preventive Measures

Manufacture and Installation of Underground Storage Tanks

The incidence of leakage can be reduced by the use of tanks that last longer. The latest Underwriters' Laboratories Standard requires cathodic protection in addition to the use of protective taping or coating of high quality. Cathodic protection inhibits the electro-chemical process whereby the metal of the sacrificial anode goes in solution as ions and is subsequently precipitated as rust. It does this by setting up an electrical current between anodes that are buried in the adjacent soil and the tanks, which becomes the cathode. The resulting electric potential opposes the movement of the iron ions so that rusting is prevented. Cathodic protection has the advantage that areas inadequately protected by the coating or the taping are still protected until the anodes are consumed. The anodes can be inspected regularly and their condition is an indication of the degree of protection still available. It would seem that, particularly in the corrosive soils of Manitoba, cathodic protection is a necessity.

Cathodic protection does not prevent leakage from other causes such as faulty manufacture, leaking connections, rupture of piping because of soil settlement. These can only be controlled by proper installation, inspection and testing requirements.

Neither does cathodic protection prevent corrosion on the inside of the tank. This kind of corrosion is generally considered to be a lesser concern than the corrosion originating on the outside. Nevertheless, if the outside is protected by high-grade coatings and cathodic protection, then the useful life of the tank may well be determined by inside corrosion. The Underwriters' Laboratories of Canada is presently investigating coatings for inside protection. It was reported that in Switzerland inside coatings are mandatory.

Insufficient data have been presented to the Commission to suggest what inside coating might be effective. It appears, however, that this problem involves fewer variables than the protection of the outside so that pertinent research should lead rapidly to an effective solution. This research should be proceeded without delay.

It has been suggested that tanks for underground storage be made to comply with the Pressure Vessel Code. This Code requires rigid control of the manufacture and installation as well as periodic inspection with pressures considerably in excess of the operating pressure. The Pressure Vessel Code, however, has been drafted with a different purpose in mind, namely the prevention of damage and injury resulting from a violent rupture of the pressure vessel. While some of its requirements may be applicable, it would seem that those requirements be incorporated in a code that is designed to fit the conditions encountered with the low-pressure underground tanks.

It was also suggested that underground tanks be provided with double walls; leakage of the inner tank would then be detected before the product had a chance of getting into the ground. Thin walled tanks, however, derive much of their stability from the support they receive from the surrounding soil. Without this support, the design is quite complex. The resulting tank would be not only expensive but more prone to structural failure. Moreover, there is a good possibility that the outer shell would corrode long before the inner one.

The evidence presented suggests that legislation will be needed to ensure the adequacy of tank manufacture, corrosion protection and installation. With regard to the first two points the latest Underwriters' Laboratories Standard appears to be adequate except for the protection of the inside. Inside protection should be provided but it is presently not possible to suggest in what form. With regard to the installation of the tank and the lines, it appears that the requirements of the Ontario Gasoline Handling Code could be followed. Two additional requirements would seem worthwhile: one, that all installations as well as all testing following assembly be done in the presence of an appointed government inspector: and, two, that locations must be approved and recorded.

Detection of Leaking Tanks

Prolonging the useful life of underground storage tanks is an important step, but in itself it merely postpones the inevitable time when leakage will set in. Since relatively small amounts of products may have a disastrous effect on an aquifer, it is imperative that measures be taken that will ensure early detection of all leaks.

At present there are two methods of leak detection: inventory control and hydrostatic testing. Testing with air is used after assembly to ensure that all connections are tight, but this is not considered to be a reliable method once the tank is backfilled.

Hydrostatic testing is normally performed only if there is a definite suspicion of leakage. The test takes 24 hours and is reported to cost between $300 and $400 per test. It is possible that for large scale routine testing both time and cost can be reduced, nevertheless, the procedure is too cumbersome for early leak detection.

Inventory control may detect losses soon after they start to occur; for this reason inventory control is very important and should be made mandatory for all operators. It must be realized, however, that it takes an alert and consciencious operator to detect relatively small losses at an early stage since several factors have a bearing on the reconciliation of storage with delivery and sales. The volume of gasoline changes with temperature which requires corrections to be applied to delivery and storage; in addition, there are inaccuracies and human errors. It has been estimated that proper inventory control will detect losses of 10 to 25 gallons per day. This means that one must anticipate that often several hundred gallons of gasoline may escape before corrective action is taken. This is unacceptable from an environmental point of view.

The Commission has received a suggestion that an air sampling well be installed in the backfill between the tank and the excavated sides. Such a well would consist of a capped 2-inch diameter P.V.C. pipe, with slotted part at the lower end extending above the maximum groundwater level. Any gasoline fumes diffuse readily through the soil and could be detected in the well either by smell or by testing with an explosimeter. It has been claimed that this device would be very sensitive so that even small leaks would be detected almost instantaneously. In fact, one criticism of the device is that it is too sensitive; a minor surface spill would also result in gasoline fumes in the well.

Although this is a disadvantage, it must be considered that spills on the surface in the immediate vicinity of tanks can be prevented with proper equipment and reasonable care. In the absence of any other reliable device or suggested method, the air sampling well would seem an important improvement and well worth the modest cost. To avoid disputes over the significance of gasoline fumes in the well, legislation should make the presence of such fumes sufficient grounds for the requirement that a hydrostatic test be performed and that a tank be taken out of operation until its adequacy has been demonstrated by the operator. The air sampling well could be installed in the vicinity of many existing tanks as well.

Control over Existing Tanks

The main problem is not so much in the control of manufacture and installation of new tanks as in the large number of existing tanks. The information collected to date suggests that new tanks can be installed to standards that will ensure a high degree of protection of underground water supplies, if proper manufacture and installation practice is coupled to measures leading to early leak detection. Existing tanks, on the other hand, have as a rule no cathodic protection and frequently an inadequate coating. Many may be leaking now, others will undoubtedly start leaking in the near future. In perhaps the majority of cases the migration of gasoline through the soil is slow and if there are no domestic wells in the vicinity then it may be a long time before a problem is manifest, if one develops at all. In may other cases, however, existing substandard tanks form a serious threat to underground water supplies.

In view of the fact that all existing tanks with perhaps a few exceptions, are substandard in the light of modern requirements, a maximum term should be established for all tanks not provided with cathodic protection. After being in the ground for that length of time, the tanks should be exhumed or emptied and sealed. Exceptions to this rule should only be allowed in non-sensitive areas if the owner of the tanks can satisfy the authority responsible for the inspection that the tank is in good condition and that the measures taken to prevent and detect leakage preclude all danger of ground water contamination.

A comprehensive program of testing and inspection should aim not only at leakage detection but also at the gradual elimination of all sub-standard tanks. This is undoubtedly a time consuming undertaking; however, it cannot be avoided and while underway it will have the added advantage of impressing upon the operators the importance of preventing leakage while giving the inspectors an opportunity for a check on proper operating procedures.