The storage of petroleum products in permafrost areas

Pihlainen, J. A.

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PREPARED BY J.A. Pihlainen CHECKED BY APPROVED BY R.F.L.

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SUBJECT The Storage of Petroleum Products in Permafrost Areas

The storage of petroleum products in permafrost areas may be divided into two broad considerations: safety and the limitations imposed by the existence of permafrost. Safety considerations, although not especially peculiar to permafrost areas, are of such vital importance in the north that some general notes are thought to be in order. The notes on the limitations imposed by permafrost are by no means complete but do record the present experience and practice of the Imperial Oil Limited Refinery at Norman Wells, N.W.T.

SAFETY

The storage of petroleum products creates a potential hazard and this fact must be fully understood right at the planning stage. Accordingly the storage site must be away from populated areas and general activity. The ignition of fumes and spillage should be prevented. The construction of fire walls (earth fill) around individual tanks, designed to contain the full contents of the tank in case of a rupture, is recommended. If several types of petroleum products are being stored, then it is advisable to alternate tanks of highly inflammable products with tanks of less inflammable products. The storage area should be inaccessible to unauthorized personnel and the "no smoking" law rigidly enforced.

DESIGN CONSIDERATIONS

Type of Petroleum Product

In extremely cold temperatures, some petroleum products become so viscous that they will not flow. The temperature at which a liquid will not flow is known as the "pour point" temperature.

The pour point of gasolines is so low that their pouring qualities are unaffected by air temperatures. Diesel fuels, depending on their composition, have pour points in the range of normal arctic and sub-arctic air temperatures and some heat must be supplied to any exposed storage container. Medium diesel fuels have a pour point of -30°F (±10°F) while heavy diesel fuels may be as high as +5°F (±10°F). Bunker fuel (or the reduced crude with or without a blend of diesel or gasoline) may have a pour point as high as 15°F, again depending on the composition.

The Storage Container

Many factors are involved in choosing the optimum size of container. The location, type of petroleum product to be stored, the quantity and demand, and the flexibility of storage units are some factors which should be considered for every general installation.

Standard welded or bolted tanks are in use in the arctic and as far as it is known, no special type of container has been developed for the north. Generally, welded steel tanks appear to give better service than bolted tanks. The chief criticism of bolted tanks is that after some years, the bolts must be re-tightened and in some cases, the gaskets must be replaced. However, this should not reflect in any way on bolted tanks for temporary measures as they are speedily erected and require only semi skilled labour. Welding bolted tanks which have been in service cannot be carried out unless the tanks are thoroughly cleaned.

Buried vs. Surface Tanks

At the present time, the placing of fuel storage tanks underground in permafrost areas is not thought to be economically feasible. The large expense of excavating frozen ground, difficulty of keeping the tanks free of seepage and ice and the high maintenance cost of buried installations are some of the main reasons.

Should over-cover be required to resist the effects of various types of bombs then it would appear that the only recourse would be to build the tanks at the toe of a slope, enclose the tanks with sheeting and fill over with as much material as is needed to provide effective over-cover.

The varying quality of perennially frozen ground and its delicate equilibrium between freezing and thawing, prohibit its use alone or with any integral fabric as a fuel storage container. The use of small (say 200 gallon) plastic or plastic treated fabric tanks buried at some depth in permafrost does not appear to be economically feasible at the present time. The costs and problems of excavation, pumping and moisture condensation would have to be economically solved before this type of storage is contemplated.

Foundations

Before some of the limitations imposed by permafrost on the design of fuel storage tanks are considered, a brief review of some pertinent properties of permafrost is in order.

Permafrost is not a new material but merely the frozen near equivalent of other materials found in more temperate climates. It may be organic, clay, silt, sand, gravel, or even bedrock but because it remains frozen perennially, it is known as "permafrost". The main difficulty to any foundation resting on permafrost is that any change in the natural cover (such as clearing, grading or erecting a heated tank) starts a thawing of the frozen soil. If the permafrost is bedrock or any material which has adequate bearing strength when thawed, then the thawing of the soil usually has no harmful effects. If, on the other hand, the soil is compressible when thawed, differential settlements can be expected. For organic materials such as the familiar frozen peat, settlements measured in feet are common.

In the north, frost action is quite severe and very frequently failures due to this phenomenon are erroneously attributed to permafrost. Structural damage due to frost action is seasonal and contributes progressively to the failure while settling due to the thawing of permafrost is continuous. These destructive features can act independently but more often they contribute co-operatively to the failure of a structure. In the design of foundations, both must be considered.

Frost action forces are first felt during the early winter as the soil begins to freeze, sucks up water from below like a blotter, and gradually builds up ice lenses which heave the ground or any foundations not securely anchored. Then in the spring, this soil with an excess of water melts and produces a ground with reduced bearing strength. As a result, the ground which has heaved, then begins to settle. In many cases, the settlement does not equal the heave and with the passing of more cycles of heaving and thawing, fails the structure.

Choosing a type of foundation in a permafrost area depends on knowing or estimating some of the properties of the perennially frozen ground and checking the frost action susceptibility of the soil.

If the permafrost in an area is not thick in depth and is close to the melting point (30-32°F) then it is quite probable that once thawed, it will not reform again. In such a case, a recommended procedure is to destroy the perennially frozen condition and to design the foundations for the thawed properties of the soil. This is usually accomplished by clearing and grading the site some years in advance of construction. Frequently steam thawing is used to shorten the waiting period.

If the proposed location is in an area where permafrost is present everywhere and to a great depth then the destruction of the frozen state of the material becomes practically impossible. Every effort should then be made to preserve the perennially frozen condition of the soil and to utilize the supporting power of the frozen soil. The present practice is to fill the proposed site with a moss and brush covering and to provide a graded working surface of gravel. This fill is then allowed to consolidate before construction.

In both types of permafrost areas, the frost action of the layer of soil subjected to seasonal thawing and freezing must not be overlooked. Adequate drainage appears to be the first remedy to combat frost action. Removing the frost susceptible soil and replacing with gravel is recommended if the costs are reasonable. The use of admixtures to reduce frost action is not extensive, due probably to the scarcity of information on the subject.

These general construction practices illustrate the importance of site selection in permafrost areas. Much expense and grief can be avoided by locating structures on bedrock or gravel and by building on "muskeg" only if no other sites are available. For heated tanks on "muskeg" (organic material) organic and gravel pad foundations are not satisfactory. The use of piles should be considered.

Connecting Lines, Pumps and Heating of Tanks

Connecting lines should be on the surface for easy access in the event of breaks. Heavy fuels should be steam traced so that they will flow in cold weather. Pumps are normally connected at the bottoms of tanks, with bleeders to drain off any water which may have accumulated in the tank.

For the storage of heavy diesel and bunker fuels, the tanks should be steam heated at various levels throughout the depth of the tank. The heating units at the various tank levels should have independent controls and draw offs, to keep heating to a minimum.

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