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The Environmental Challenges Facing TAPS

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Before the potential benefits of the recent oil discoveries on the North Slope of Alaska can be realized, the oil must be transported to refining and marketing areas. The Alyeska Pipeline Service Company has the responsibility for the first step in this transportation—to design and construct the Trans Alaska Pipeline System. We will pipe the oil from the discovery areas near Prudhoe Bay to an ice-free, deep-sea tanker loading terminal at Valdez of the South Coast of Alaska. From Valdez the oil will be transported to the West Coast by tankers. This is the most feasible system of a number considered.

The basic facilities of the system consist of a pipeline, the pump stations, a tanker loading terminal, and a communications system to provide the necessary means of operating control. To make possible the construction of these facilities, a haul road must be constructed connecting the present Alaska road system to the Prudhoe area—a distance of some 400 miles.

PIPELINE

The pipeline route generally parallels the Sagavanirktok River across the North Slope, crosses a high pass in the Brooks Range, passes near Wiseman, crosses the Yukon River near Livengood, passes just east of Fairbanks, and closely follows the Richardson Highway to Valdez. (See figure 1)

The line pipe is 48 inches in diameter and is manufactured under strict metallurgical specifications providing the fracture toughness and weldability to satisfy the requirements of the low-temperature Alaska conditions. The line pipe is of 0.462″ and 0.562″ wall thickness and has minimum yield strengths of 60,000; 65,000; and 70,000 psi. The pipe is thoroughly inspected at the mill for both chemical and physical properties and for processing procedures prior to shipment. The construction of the pipeline will be thoroughly inspected and tested prior to its acceptance and operation. (See figure 2)

PUMP STATIONS

Major components of the pump stations will consist of gas turbine prime movers, centrifugal pumps, tankage, power generation equipment, and fuel processing facilities—all enclosed in buildings as required for good operational security. Housing will be provided for both permanent and transient personnel.

Twelve pump stations are required for the maximum design which provides capacity to move 2 million barrels of crude oil per day. The initial construction will not include all pump stations.

TERMINAL

The basic facilities at the tanker loading terminal consist of tanker docks, oil storage tankage, oil loading system, and ballast treating facilities. The tanks will be 250 feet in diamter by 62 feet high, with a capacity of about 510,000 barrels. The docks are sized to handle tankers of up to 250,000 dwt. The ballast treating facilities will be capable of handling total ballast of the largest ships, discharging simultaneously at the dock.

Initial construction will include three docks and 6 million barrels of oil storage. Ultimate facilities are estimated at five docks and from 15 to 20 million barrels of storage. (See figure 3)

COMMUNICATIONS

The communications system as proposed will consist of a highly reliable microwave system, augmented by high frequency radio coverage.

Reliability is stressed due to the need for all operational points to be in data contact, as functions and locations are integrated into a total system control. The entire system will shut down upon loss of communications.

EVIRONMENTAL CHALLENGES

The environment in Alaska is usually described in terms of weather and dimensions—the long winters, extremely low temperatures, winds, ice-fogs, permafrost, the long distances, earthquakes, limitations of transportation and communications. It is a hostile environment! Alaska is also characterized by flora and fauna which are, at the same time, hardy and delicate. Plant and animal life must be hardy to exist under natural conditions. Yet any destruction is not so easily or quickly cured as it would be in areas where plant growth is rapid. Alaska is then described in modern terminology as having a delicate ecology.

There is no doubt that the installation and operation of our proposed facilities in the existing Alaska environment bring many challenges. We will of necessity disturb the environment. Our challenge is to assure that this disturbance will not

Figure 1-Proposed pipeline route from Prudhoe Bay to Valdez, Alaska.

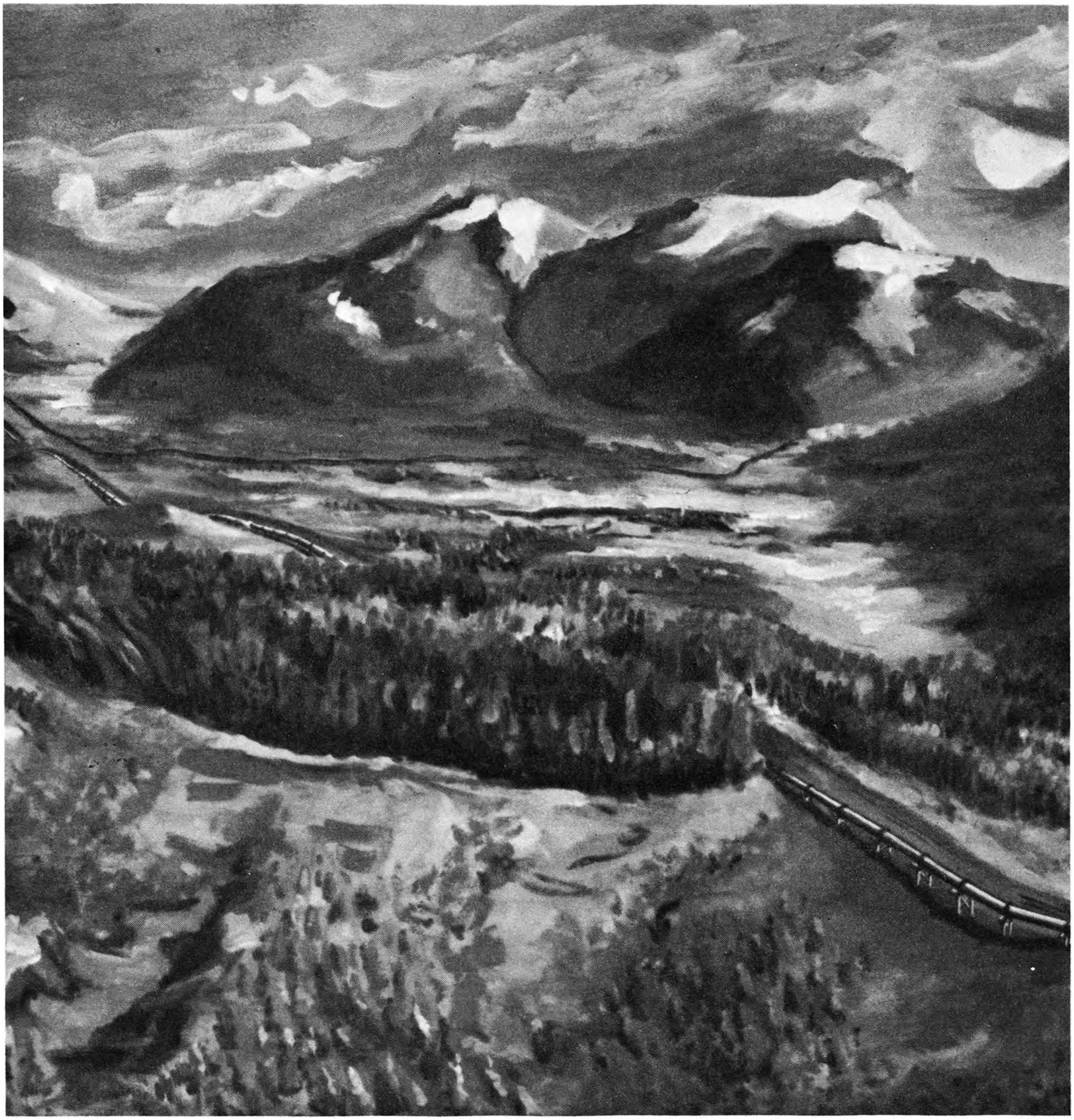

Figure 2-Possible pipeline appearance in mountain valley.

Figure 3-Artist's sketch of proposed tanker loading terminal and oil storage tankage near Valdez, Alaska.

result in permanent damage. The design philosophy has been, from the inception of the project, to design the structures to cause the least disturbance of the environment and to provide the safest structure that can be designed using the most modern technology. The protection of the environment is necessary to assure the safety of the pipeline. Thus the two major criteria are so interrelated that the end requirements are fully compatible.

A very large proportion of the pipeline route is on Federal lands, administered by the Department of the Interior. As a condition to the granting of a permit for construction, the Department of the Interior and the Federal Task Force on Alaskan Oil Development developed stipulations specifically designed to protect the environment. The stipulations cover a wide range of environmental factors including water pollution, thermal pollution, use of pesticides and herbicides, permafrost degradation, sanitation and waste disposal, aesthetics, wildlife protection, fire prevention, restoration and revegetation, and preservation of archaeological findings. Federal personnel have broad powers of approval, inspection, and enforcement. We have agreed to these stipulations which have been publicized as a model for environmental protection. The National Environmental Policy Act is concerned with the same principles.

Another task force was established to review technical data on the effects of the pipeline on the environment and to evaluate the design criteria. More simply stated, it was to define the problems and review solutions developed by our personnel with the aid of private consultants. This group consists of the U. S. Geological Survey and other Federal and State governmental agencies such as the Cold Regions Research and Engineering Lab, Federal Water Quality Administration, Corps of Engineers, Coast Guard.

To implement the requirements of the stipulations and the development of designs, much basic data had to be developed. For example, very little detailed information was known about the types, characteristics and location of the permafrost and soils along the pipeline route or of the population and migratory patterns of certain wildlife. We have counted and charted movements of caribou and other wildlife, have determined species and populations of fish, have recorded marine biological conditions, have excavated many archaeological sites, have determined weather and sea-current data. These are among numerous activities required due to the lack of recorded data normally available in many more developed areas.

Pipeliners believe a pipeline should be buried wherever practical for reasons of aesthetics, noninterference with wildlife migrations, access by humans, reduced exposures to extremes of temperatures, and to the effects of seismicity, protection against forest fires, vandalism, and many other factors.

The determination of where it is practical to bury a pipeline is primarily soils dependent. A buried pipeline transporting warm oil will melt the permafrost at a rate and in a thaw bulb pattern, both of which are predictable. This melting is a problem only where the permafrost is of such character and ice content that it becomes unstable upon thawing.

A logical question, then, is why transport warm oil. Certain benefits are indicated by cooling the oil at below-freezing temperatures to prevent melting. Detailed studies reveal major design and operating problems which render the concept invalid. No cooling method or media is satisfactory when considering the seasonal temperature effects. The rapid cooling results in paraffin dropouts for which no effective, and environmentally protective, disposal method is available. The cooling tends to cause adverse basic changes in physical properties and behavior patterns of the oil. Even if the oil could be cooled satisfactorily, the heat generated by the flow friction would again elevate the temperatures. These factors establish the warm oil condition. However, no heat is intentionally introduced into the system.

As stated previously, the thaw dimensions and thaw rates are predictable. In order to make this determination, a wealth of soils data is required on heat dissipation from the pipe to the soil. The heat dissipation is affected by the type and location of permafrost and soils; the character of the soils before, during and after thaw; the melt rate; migration of melt water; seasonal temperatures; ice-content and location; pipeline insulation; and many other parameters. The heat transfer determinations are made on a computerized mathematical model. The work is very complex and of a pioneering nature. In order to verify the heat transfer model results through ground truth, a heated experimental pipeline section has been constructed in Fairbanks. The section simulates the operating conditions of the line in various soils and permafrost, with emphasis on the critical Fairbanks silt or loess soils. This installation also is being used to determine the types of vegetation which will grow over and adjacent to a heated pipeline so that the revegetation process can be implemented when required.

The melting of the permafrost has a wide range of effects, from negligible to critical, on soils performance. Permafrost has no standard measurement parameter except its temperature condition. Low ice-content permafrost, such as typically exists in the higher, well-drained areas and in the gravel deposits in the benches of selected streams, may be melted and stabilized with minimum harm to the environment. Conversely, permafrost in high ice-content, loess soils, dependent on the local terrain conditions, may present serious problems. Major problems which are caused or magnified by thawing include soil settlement or, specifically, differential soil settlement, slope stability, potential of soil liquefaction, and soil erosion.

Alaska is an area of extensive seismic activity. We have assumed that major earthquakes will occur in the vicinity of the pipeline route. The effects of the earthquake are closely related also to soils characteristics and to terrain. Detailed investigations indicate that earthquake risk areas, in general order of decreasing severity or probability of occurring, are landslides along river bluffs, shallow landslides on slopes, potential for liquefaction of soils, pipeline flexure due to seismic shear waves, and surface breakage due to faulting or tectonic creep.

We have taken the position that the best protection against these soils-associated problems is their avoidance. This avoidance is accomplished through critical selectivity of the route or selectivity of the soils which establish the route. Most potential landslide areas can be avoided by minor rerouting.

The majority of problems are so related to soils that a massive soils investigation program has been under way for about two years. This investigation includes methods such as interpretation of regular black and white, colored, and infrared aerial photography and detailed sampling and analysis of frequent soil borings. Completed or under way are about 3,000 boreholes with numerous other data sources such as previous borings for highway construction and oil exploration. While the borings are effective, the method is penalized by the demands of time and money. In an effort to obtain faster and more complete coverage, several experiments were conducted utilizing terrain-probing radar and seismic methods. Unfortunately, these methods, while promising, have not been developed to the extent that they provide a useful tool for our specific design requirements.

With the detailed soils information, the behavior of the soils under various conditions may be predicted. The allowable limits of the soil behavior may be established by the performance of the pipe, as in the case in differential soil settlement. Thin-wall, high-yield line pipe has the demonstrated ability to conform to the contours of the pipe trench. The limits of this ability are being established on the selected pipe by deflection tests under full operating stresses due to internal pressure and thermal expansion forces.

With all these investigations and tests, we fully recognize that in certain areas the critical soils and conditions may not be avoided. Where the line may not be buried with assurance of environment and pipeline protection, the line will be constructed on elevated structures such as pile-supported bents or gravel pads.

Other areas of interesting challenge and investigation are in performance of the pipe in refrozen soils and revegetation. The cold pipe test near Point Barrow was designed to evaluate the pipe stresses due to ice freezing and cracking and to evaluate the environmental effects of various construction methods. Results indicated that freeze stresses are minimal with respect to the pipe strength and that gravel pads and foamed insulation are effective in controlling permafrost thaw caused by intentional surface disturbance.

Revegetation is important as a natural insulation to prevent or control thawing of the permafrost. Investigations being made include the selection or development of suitable plant species, the effects of fertilizers and growth hormones, and the effects of grazing on both the cold and warm pipeline environments.

These, of course, are only some of the environmental challenges facing us. We recognize and accept the fact that the environment and the pipeline must be protected from damage. We are convinced we have the basic knowledge to accomplish this. Some mistakes will be made; we will correct them. We believe we can proceed with construction, while continuing to learn, for the final test of the design basis is the actual performance in operations. We are proud of the performance of the oil industry in protecting the environment on the North Slope. We represent the same industry with the same intentions and capabilities. We are willing to stand on that record.

A. V. Cardin

A. V. Cardin was born in Mountain Grove, Missouri. He attended Southwest Missouri State College. After two years of teaching in the public schools and four years of Naval Service in World War II, he entered the University of Missouri-Rolla from which he graduated with a B.S. Degree in Civil Engineering in 1948. He was employed by Humble Pipe Line Company and has since worked in various engineering and management positions. He has worked on special projects with other Standard Oil Company (N.J.) affiliates. In 1968, he was assigned as Manager of Engineering for the Trans Alaska Pipeline System, now reorganized as Alyeska Pipeline Service Company.