

THESIS

BY

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PIPE LINE FROM WELLINGTON TO DENVER, COLORADO.

INSTALLATION OF  
PIPE LINE FROM WELLINGTON TO DENVER, COLO.

There is no immediate need for a pipe line from the Wellington field, a few miles north of Fort Collins, to transport crude oil to Denver. This thesis is written on the assumption that the Wellington field has a settled production which can supply 10,000 barrels of crude daily for about ten or fifteen years, and that the oil is needed to supply a refinery at Denver. The object of choosing this topic as a thesis is to become familiar with the actual procedure of the first steps in planning to construct a practical pipe line for crude oil.

ROUTE

Topographic sheets of the U. S. Geological Survey were used in deciding upon the route. The 67 miles between the oil field and Denver is what may be called semi aired and is practically level. The route chosen runs about one mile west of the 105th Meridian and follows a road all the way with the exception of about six miles. It happens that the best route to be chosen is almost the shortest one. The chief obstical in laying of the pipe will be a lake, Fossil Creek Reservoir, 19 miles south of the oil field. The lake is  $\frac{1}{2}$  mile wide and about 60 feet deep where the line will cross it. The right of way should be easily obtained as there are no fields to be cut through.

A high degree of accuracy was obtained by using the U.S.G.S. sheets in plotting the profile and gradient for the 6 inch line along the route as shown on the map.

MOTIVE POWER

This proposed line would be an excellent chance for centrifugal pumps to again show their worth. The Public Service Company is able to furnish electrical power at a small cost for the life of the field because a plant was built near Boulder, Colorado with a capacity to furnish the entire surrounding country at a time in the future. The crude oil will not have to be heated except during extreme cold spells and during such times may be heated electrically at a small cost. Another advantage, the most outstanding, of centrifugal pumps is that they may be installed with a smaller cost than any other type.

CHARACTERISTICS OF OIL FLOW

Crude oil from the Wellington field contains a large amount of paraffin. At temperatures of 50 F. and below the paraffin tends to separate out. Such separation was easily noticed when the viscosities were taken at 53 F. using a Saybolt Universal viscosimeter. The particales of wax hindered the flow and gave inaccurate measurements.

A graph was made (Chart I) using a Saybolt Univ. viscosimeter. Inspection of the curve shows that there is no sudden change of viscosity with rise of temperature above 60 F. Accordingly, 60 F. was chosen in the calculations for the pipe line. At this temperature the paraffin does not seem to collect and the average temperature of the burried line is estimated to be 60 F.

The following data was obtained from a report by the Bureau of Mines on Bartlesville, Oklahoma observations.

Depth	Variation	Total in 15 months
1 ft.	3 or 4 /da.	52 F.
2	(total annual out in two)	40
3		34
4		22
1 ft. Minimm	36 F. Average	60 F.
2		62
3		65
4		66

Continued freezing may make a considerable difference.

Having received no advice from Okla. and Colo. weather bureaus, it was assumed that 5 F. would be the difference between here and Okla. in average temperature.

66 F. Average in one year, 4 ft. deep, in Okla.

61 F. " " " " 4 " " " Colo.

22 F. Variation in 15 months.

61-11-50 F. min. for Colo. at 4 feet.

It is not likely that the minimum temperature would be encountered for any length of time. During such a time the crude oil could be heated electrically to hold its temperature at 60 F. with a small cost.

#### CALCULATIONS

Methods in calculating the pressure, size of pipe, and number of pump stations were found in The Oil and Gas Journal of October 7, 1926; Petroleum Production, by Uren; and Oil Field Engineering of February, 1928. The latter was used because it contained larger curves and more complete charts, giving more accuracy.

Crude Oil 30 Be at 60 F. 0.875 sp. gr. at 60 F.

10,000 bbl./da.

96 Saybolt Universal seconds at 60 F.

6 inch pipe

Referring to Prin. of Pipe Line Construction as Applied to Pan American Pet. Co's Line, by E. H. Wilcox, Oil Field Engineering magazine of February, 1928:

From Table No. 2

$V=3.239$

$d=6/12=0.5$

From Table No. 1

$t=96$  therefore  $6/u=4824$

$dV6Vd6/u=3.239 \times 0.5 \times 4824=7800$

$f=0.0363$  from Chart No. 2

Friction head per mile,  $H_m$   $f \times 162 \times V^2$ , from Chart No. 2.

$H_m=0.0363 \times 162 \times (3.239)^2=61.6$

#### PRES. FOR WELLINGTON STATION:

At 35 Mile Station there is a 200 foot drop below Wellington Station.

$f \text{ loss}=61.6 \times 35=2156$  feet.

Add 30 ft. for tanks.

$30+2156-200=2360$  ft. to be pumped.

Pres.  $\frac{h \times 62.5 \times S}{144}$ , where  $h$ =head in ft.,  $S$ =sp. gr.

Pres.  $\frac{2360 \times 62.5 \times 0.875}{144}$  695 lb./sq.in.

#### PRES. FOR 35 MILE STATION:

Terminal of line is 60 ft. above 35 Mile Station.

$32 \times 61.6$  1970 ft. friction loss.

1970 60 2030 ft. to be pumped.

Pres.  $\frac{2030 \times 62.5 \times 0.875}{144}$  770 lb./sq.in.

The example below illustrates the influence of atmospheric pressure on a pipe line.

Same data as above except 8 inch line is used.

From Table No. 2

$V=1.829$

$d=8/12=0.666$

From Table No. 1

$t=96$  therefore 4824

$dV$   $V \times d \times 1.829 \times 0.666 \times 4824$  5876

$f=0.36$  from Chart No. 2

Friction head per mile,  $H_m$ , for 8" line:

$H_m$   $f \times 122 \times V^2$  from Chart No. 2

$H_m=0.36 \times 122 \times (1.829)^2$  14.7 feet.

In order to maintain rate of 10,000 bbl./da. it is necessary to hold

a back pressure of 112 feet at end of the line.

From 61 mile point to terminal, drop in head is 200 ft. Friction loss for 6 miles  $6 \times 14.7$  88 ft.

190 88 102 ft. back pressure.

Friction loss for 67 miles  $67 \times 14.7$  985 ft.

Difference elev. between pump and terminal 140 ft.

845 102 947 ft. head on pump.

$P \propto h^{62.5} S^8$ , where h head in feet, S sp. gr.

$P \propto 947^{62.5} \times 0.875^8$  410 lbs./sq. in. to be supplied by pump.

#### CONSTRUCTION

17,700 joints of 6 inch, lap welded, bevelled end, 19 to 19.5 lbs. weight pipe are to be distributed along the route.

The ditch digging will be contracted for by someone who will use a machine. All necessary clearing of the way will be done by the crew of the ditching machine. The ditch is to be 4 feet deep.

Because of the level country the pipe can be screwed by machinery. All joints must be welled to secure extra heavy joints.

A protective coating of tar paper and asphalt will be applied to the pipe before it is buried. It is necessary to have the line heavily insulated because the soil is alternately wetted and dried.

The two pump stations are to be identical. Two 10,000 barrel tanks are to be constructed by the 35 Mile Station for storage in case of a breakdown, one of which will be used as a surge tank for the pump, when needed. The buildings are to be made of galvanized iron. Concrete foundation for an electric motor and a centrifugal pump are to be built at both stations. It will not be necessary to build living quarters for the pumpers.

It will be necessary to calculate the amount of current needed to heat one barrel of oil to estimate the number of the electrical heating terminals to be used.

As the lake to be crossed is about 60 feet deep it will be necessary to use a barge to lay the pipe on its bed. A boom will be used on the laying barge to swing the joints of pipe into position and hold them while the pipe is being screwed and welded together. Before laying the line into the lake, heavy river clamps will be put on the line at each joint. A protective coating of tar paper and asphalt will be put on the line before it is lowered into the lake. Extra heavy pipe will be used.