GEORGIA INSTITUTE OF TECHNOLOGY
Engineering Experiment Station

PROJECT INITIATION

Project Title: Vapor Recovery Study
Project No.: A-1534
Project Director: W. H. Burrows
Sponsor: Mr. John S. Pate, Jr.
Effective: April 27, 1973
Estimated to run until: June 30, 1973
Type Agreement: Standard Industrial Research
Amount: $2,000*

REPORTS: As appropriate

CONTACT PERSON: Mr. John S. Pate, Jr.
P.O. Box 933
Cordell, Georgia 31015

*Project initiated for Phase I only

Assigned to Technology Applications Group Division

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GEORGIA INSTITUTE OF TECHNOLOGY
Engineering Experiment Station

PROJECT TERMINATION

Date: January 2, 1975

PROJECT TITLE: Vapor Recovery Study
PROJECT NO: A-1534
PROJECT DIRECTOR: W. H. Burrows
SPONSOR: Mr. John S. Pate, Jr.

TERMINATION EFFECTIVE: 6/30/74

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Miltie J. Jordan
Mr. John S. Pate, Jr.
P. O. Box 993
Cordele, Georgia 31015

Subject: Progress Report, Project A-1534
Vapor Recovery Study

Dear Mr. Pate:

In accordance with the terms of our contract with you, effective April 30, 1973, under subject title and project number, we have conducted a study and analysis of the problem of recovery of gasoline vapors during vehicle tank fillings. The following report summarizes our findings.

1. Patent Search

An extensive search of the patent literature for the past ten years was conducted. It is our belief that any pertinent patents prior to this period would be referenced in this period.

We were provided by the U. S. Patent Office with the class and sub-class numbers most closely allied to this topic; namely, Cl 62-54. However, we started our search by indexing all class-subclass numbers which might be expected to yield information on this or related topics. In the long run, it developed that 62-54 yielded the only patent closely related to your ideas for fuel vapor recovery. A copy of this patent has been forwarded to you. Copies of other patents, and copies of principal claims copied from the Official Digest and surveyed during our search, are available to you and will be forwarded to you at your request.

2. Scientific and Technical Literature

The scientific and technical literature relative to this problem was also surveyed for the same ten year period. From the negative results obtained in this study, we have concluded that there is not at present a feasible method for accomplishing gasoline vapor recovery during vehicle tank fillings.

An article clipped by you from the May-June 1973 PETROLEUM MARKET AND forwarded to us describes various systems now under consideration by major oil companies for use at loading racks. One of these is closely related to the above mentioned patent (Moragne); however, they also include oxidation as a means of elimination of vapor pollution of the atmosphere.
3. The Moragne System

The system described by Moragne in U. S. Patent 3,266,262 takes cognizance of the fact that the vapor space in an unfilled fuel tank is composed of a mixture of fuel vapor and air, the latter having entered the tank as the fuel was used up. (This is a necessary feature of fuel tank performance, for it is the only way in which the pressure inside the tank may be equalized with the outside pressure; unless this occurred, the fuel would cease to flow from the tank to the carburetor, even under the impulse of a fuel pump.) The air contains water vapor, which must be condensed to water and separated from the gasoline, which will also be condensed from its vapor.

In the Moragne system, the delivery hose fits securely into the opening of the tank, thus preventing the escape of vapors around the nozzle, a situation not now found in vehicle fuel tank fillings. As liquid enters the tank it forces this mixture of air and fuel vapor out through a pipe, which is separately connected to the tank. This pipe leads into a header, from which the vapor is piped to the recovery unit. Motion of the air-vapor mixture is assisted not only by the positive pressure of the liquid entering the tank, but by the negative pressure of liquid leaving the storage tank.

The mixture passes through a flash arrestor, then to the first heat exchanger, in which it is cooled to a temperature slightly above the freezing point of water. At this temperature, the water vapor is practically all condensed under conditions which prevent its forming hydrates with the gasoline. Some gasoline vapors also condense in this unit, and the condensed water and gasoline are separated in a gravity unit, from which the gasoline flows into the storage tank. The water is drained off and disposed of.

The remaining vapor mixture then passes through a second heat exchanger operated at a lower temperature, at which the remaining gasoline vapors condense. The resulting liquid also flows into the storage tank. In both exchangers, the stripped air is vented to the atmosphere.

A portion of Moragne's process consists in the use of beds of porous material, preceding the heat exchangers, to increase the efficiency of the vapor-air separation. The function of these beds is not explained.

In considering the elaborate process disclosed by Moragne, it should be borne in mind that this system was developed for recovery of gasoline vapors during massive transfers of bulk fuels, as in loading "tank trucks, tank cars, ship tanks, and the like." From the above cited article, there appears to be some doubt that such a system can be operated profitably, even for massive transfers; however, environmental considerations may, in time, make such systems mandatory. It is certain that such a system could not be considered for the situation involving filling station operation, although certain of its features are basic to almost any recovery system.
4. System Analysis

The amount of gasoline vapor mixed with the air in the air space of a gasoline tank has been estimated from the ratio of the vapor pressure of gasoline to the total atmospheric pressure. The vapor pressure of any liquid increases with increasing temperature; consequently, we have made estimates at 70°, 100° and 130°F. As gasoline is pumped into a vehicle tank, it displaces an equal volume of air containing gasoline vapor. The amount of vapor lost in a tank filling is determined, therefore, by the amount of gas pumped and the temperature of the tank.

Our calculations show that in pumping a 20 gallon tank from empty to full, the quantity of gasoline lost as vapor is as follows:

<table>
<thead>
<tr>
<th>Temperature °F</th>
<th>Gasoline Lost as Displaced Vapor (fluid ounces)</th>
<th>Loss Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>70</td>
<td>2.69</td>
<td>0.105</td>
</tr>
<tr>
<td>100</td>
<td>3.18</td>
<td>0.124</td>
</tr>
<tr>
<td>130</td>
<td>5.34</td>
<td>0.209</td>
</tr>
</tbody>
</table>

This computation takes no account of vaporization at the surface of the incoming stream. Because of the lower temperature of the underground storage tanks and the cooling effect of any evaporation that does occur, it is believed that this additional amount would not exceed a 10 percent increase in the above estimates. Experimentation would be required for confirmation, however.

On the basis of the above estimate, a station pumping 1000 gallons per hour for a 15 hour day would experience a loss of 15.75 gallons of liquid gasoline per day at the pumps.

The same volume of gasoline delivered at the pumps is also received into the storage tanks from the delivery trucks. Except for the lower temperature of the storage tanks, virtually the same quantity of vapor is lost during the delivery of the gas as during its dispensing. We can double the above daily estimate and approximately break even on both the delivery estimate and the ten percent addition to the dispensing estimate (due to vaporization), to get a figure of 31.5 gallons (fluid) of gasoline loss per day.

The quantity of water vapor contained in the air along with the gasoline vapor is determined by the temperature and humidity. At relative humidity 50 percent and temperature 70°F, the quantity of water separated from the above 31.5 gallons of gasoline would be approximate 0.37 gallon, or slightly under three pints. This amount would be insignificant, except for the fact
that it is cumulative. The amount of water that would accumulate in the storage tank would be sufficient to keep the gasoline saturated with moisture, which would degrade its quality in several respects; slower starting, cold weather icing in the carburetor, corrosion, etc.

Obviously, if any appreciable capital outlay is required for a system designed to recover this amount of gasoline over time periods involved, an extended amortization period will be required. In addition, operation costs must be minimized in order to balance against an expected low return on recovery premiums.

5. System Features

It appears that any system which would accomplish recovery of vapors during both operations (delivery from tank truck to storage tank, and pumping into vehicle tanks) would include the following features:

1. Automatic (probably pneumatically operated) seals to seal off the space between pump nozzle and tank opening. A similar feature would be required at the opening of the storage tank.

2. Vapor lines passing through these seals at the nozzles, supplied with check valves to prevent loss when the nozzle is removed from the tank.

3. Header and piping to convey vapors from the vapor lines to the recovery unit.

4. Recovery unit attached to the vents from storage tanks and to the pipe leading from the header, to be fed by both.

The recovery unit might be either of two types; condensation or sorption. The condensation type would be similar to that described in the Moragne patent, except smaller and somewhat simpler. It would require refrigeration to condense the gasoline vapors and associated water vapor, permitting the stripped air to escape to the atmosphere. The condensed water and gasoline would be separated by gravity. The gasoline would be drawn off and returned to storage, probably manually, since there would be no access to storage tanks other than the present service opening.

The sorption type would employ a suitable sorption medium, such as molecular sieve, activated alumina, silica gel or activated charcoal. The unit would contain a sufficient quantity of this material to collect the vapors for a period of two weeks or a month. At the end of each period,
the charge would be removed and replaced by a fresh charge. The filled charges from a group of subscribing stations would then be transferred to a central recovery plant, where the vapors would be expelled by heat and condensed, leaving the charge in reactivated condition for reuse. The condensate would be separated from its water content by gravity, and the gasoline returned to distribution.

Either type of recovery unit would require an input of energy, the amount depending upon many factors which have not been assessed at present; e.g., size of unit, type of materials utilized, transportation factors, type of energy utilized, etc.

6. Conclusions

The preceding analysis indicates that a process for accomplishing the recovery of gasoline vapors during fuel transfer operations at filling stations would require an appreciable capital outlay for equipment and operation, and would yield a comparatively low return on this investment. Justification for development and commercialization of such equipment must, therefore, arise more from ecological than from economic considerations.

In view of this conclusion, we have deferred preparation of a proposal for such development work, until such time as you have had an opportunity to study these results. We are prepared, however, to proceed with additional research and development, if such is appropriate to your objectives, and will prepare a proposal for such additional work at your request.

We shall, of course, be glad to discuss the contents of this report and background material with you at your convenience.

Respectfully submitted,

W. H. Burrows
INDUSTRIAL CHEMISTRY LABORATORY