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Project Summary

An Inventory of Used and By-Product Hydrocarbon Streams

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Between September 12, 1978, and September 12, 1979, ETA Engineering, Inc., undertook a study to identify and characterize the major used and by-product gaseous and liquid hydrocarbon streams generated by industry. Since large quantities of these streams are being wasted or improperly disposed of, a subsequent effort was made to estimate their recovery potential. Once identified, an inventory of the streams was developed, and the applicable control and reclamation techniques were reviewed. The magnitude of the various streams was established by applying emission factors to a relevant base variable, such as the quantity of new material sold to industry. The recovery potential estimation was based upon the application of reasonably available control and recycling technology to each source category.

Some of the present disposal methods for used liquid hydrocarbon streams were also reviewed. Several alternative methods of recycling and disposing of such streams were then evaluated in terms of their energy and economic implications. Ultimately, several recommendations were made for those areas where further research might uncover significant potential for used hydrocarbon recovery.

This Project Summary was developed by EPA's Industrial Environmental Research Laboratory, Cincinnati, OH, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

Large quantities of used and by-product hydrocarbon streams are generated by industry each year. The loss of gaseous and liquid hydrocarbon streams through waste or improper disposal results in a loss of energy resources and creates potential hazards to the environment. For example, an estimated 12.5 million metric tons of volatile organic compounds (VOC) are being lost to the atmosphere yearly from various sources with significant recovery potential, including petroleum refineries, gasoline marketing facilities and industrial manufacturing. If the quantities of waste hydrocarbon streams can be minimized or rendered suitable for reuse, tangible benefits will accrue not only to industry in the form of reduced fuel or lubricating costs, for instance, but also to society in the form of a safer environment. And a valuable energy source will have been reclaimed.

Emissions of hydrocarbons are governed by various state and federal regulations. Gaseous hydrocarbon streams are regulated by the Clean Air Act and its 1970 and 1977 amendments. Furthermore, all states are currently proposing regulations to control hydrocarbon emissions as part of their state implementation plans (SIP) to meet the national ambient air quality standards mandated by the Clean Air Act and promulgated by the U.S. EPA. Major federal regulations governing the use, conservation, and disposal of liquid hydrocarbon streams are (1) the Resource Conservation and

Recovery Act, (2) the Energy Policy and Conservation Act, and (3) the Federal Water Pollution Control Act. In addition, several states have passed legislation related to used oil disposal to encourage the recycling of used oils and to avoid unsatisfactory disposal of waste streams. In light of such regulations, industry has been forced to scrutinize the types and volumes of hydrocarbon streams being generated. In particular, companies will be looking to identify the major used and by-product streams with significant potential for recovery and reuse. Furthermore, it has been proposed in the *Federal Register* of December 18, 1978, that used oil be declared a hazardous material. This will give industry added incentive to track the in-plant use and disposal of oils.

Approaches and Procedures

Used gaseous hydrocarbon streams include a variety of source categories, but this study emphasized those source categories with significant emission and/or recovery potential. For example, the storage of petroleum products other than gasoline has been excluded from this study due to their low vapor pressures. Gaseous hydrocarbons were classified and considered as volatile organic compounds (VOC) in order to include some organics in this study—e.g., halogenated organic solvent—that are not truly hydrocarbons according to strict definition. The effects of such organics on the environment and their recovery potential, however, are as significant as those of pure hydrocarbons.

Gaseous hydrocarbons, VOCs, i.e., are emitted from a variety of stationary and mobile sources, with stationary sources accounting for approximately 60 percent of the total emissions. Industrial sources of VOC surveyed in this study include (1) petroleum refining, (2) gasoline marketing facilities, (3) industrial manufacturing, (4) solid waste disposal, and (5) stationary fuel combustion facilities. In addition, solvent evaporation from a variety of solvent coating operations was also surveyed. VOC emissions due to solvent evaporation are the largest single contributor to emissions from stationary sources (degreasing, dry cleaning, graphic arts, for example). Of these stationary sources, surface coating operations are the most significant, accounting for almost 1.8 million metric tons per year. Major industrial surface coating applications include (a) metal coating, (b) paper, film, and foil coating, (c) fabric coating, (d) coating of flat wood products, and (e) wood furniture coating.

For each VOC source category, the following information was derived, source description, emissions characteristics, quantification of hydrocarbon emissions, applicable control technologies, and recovery/capture potential. VOC emission sources with recovery potential were grouped into major source categories based on either process characteristics or the properties of the products whose manufacture resulted in VOC emissions. Hydrocarbon emissions for each major source were then calculated by using emission factors given in related technical literature. To quantify annual source emissions, the emission factors were applied to published statistics on the production or quantities of material handled.

Used oils and used solvents are the major used liquid hydrocarbon streams with significant recovery potential, although basic organic manufacturing industries also generate significant streams of used liquid hydrocarbon. Other liquid hydrocarbon streams offer little recovery protential because of high contamination levels, difficulties of separation, and other technical considerations. Used oils are generated chiefly in the primary metal and metal-working industries and in the transportation/automotive sector. Industrial oils include lube oils, cutting or hydraulic oils, and process oils, for example. Oils generated in the transportation, or automotive, sector include engine oils, hydraulic fluids, and other miscellaneous lubricating oils. Theoretically, almost all of this used oil should be recoverable. The recovery of used oil remains inconsequential, however, because of poor handling and maintenance procedures, inadequate storage and stream segregation, and insufficient knowledge of recycling techniques. For example, most industrial plants have not established a comprehensive oil accounting and reuse program.

The solvents considered in this study are all halogenated hydrocarbons, ketones, and alcohols, which are employed in applications in which they retain their basic chemical identities after use. Only certain solvent usage categories generate waste solvent streams that are potentially recoverable. These categories generally include those industries employing solvents for cleaning metals, clothing or other materials. Degreasing applications utilize solvent vapors to minimize solvent losses and improve operating economy. Solvent reclamation in commercial and industrial applications is presently minimal, largely because of the relatively low cost of any virgin organic solvents. However, more stringent environmental regulations, coupled with the increased cost and uncertain long-term availability of petroleum-based solvents, may make solvent recovery more attractive.

In addition to the used oil and used solvent streams, other major but less significant streams of used liquid hydrocarbons are generated from the manufacture of basic organic chemicals, coal tar and derivatives, organic intermediates, plasticizers, and electrochemical resins. Although on a national basis no quantitative data can be easily developed for the liquid hydrocarbon streams generated from these industries, they are expected to be significant. These streams may offer little potential for recovery as a product, primarily because of high contamination levels, difficulty of separation, and other technical considerations. On the other hand, they do offer a good potential for recovery as fuel.

Findings

Estimates of VOC reduction and recovery potential represent the possible reduction in VOC emissions achievable through the application of control technology. This reduction can be due to the elimination, recovery, or destruction of VOC. Estimates of recovery potential were based on a review of reasonably available control technologies (RACT) for major source categories as discussed in the U.S. EPA's Control Technique Guideline (CTG) documents, which were developed to help states revise their SIPs under the Clean Air Act. The estimation of VOC emissions from the source categories considered existing control practices whenever possible. In the case of a few source categories, no data were available on the existing controls. The emissions in such cases were calculated based on a "no-control" assumption.

Significant quantities of the VOC reduction/recovery potential estimated in this study will perhaps be achieved when state-proposed regulations are finalized and implemented. Such regulations will probably be based on economic and air quality considerations, and so they will not likely call for a uniform application of RACT to all the sources. Therefore, the reduction/recovery achieved through the revised SIPs will be less than estimated.

VOC emissions due to (1) petroleum liquid storage at refineries and (2) transportation of crude oil to refineries were estimated by updating refinery storage emission data in a recent U.S. EPA study and assuming that no vapor recovery equipment was used during the unloading operations. The total achievable VOC recovery potential from the crude oil storage and transfer operations is approximately 417,000 metric tons per year. The major sources of VOC emissions in refinery operations are the cracking units, blowdown systems, vacuum distillation columns, and wastewater systems. The reduction potential for VOC emissions from these sources was estimated to be approximately 570,000 metric tons per year. At present there are no quantitative data available on the reduction potential for refinery fugitive emissions. The control efficiency for the fugitive emissions was assumed to be 50 percent for estimating the total VOC reduction potential. The expected recovery potential for VOC emissions from refinery operations is approximately 475,000 metric tons per year.

Gasoline marketing operations (i.e., bulk terminals, bulk plants, and gasoline dispensing facilities) emit a significant amount of VOC, and most of these are recoverable. CTG documents on these facilities discuss the applicable controls and the recovery potential. Surface coating applications are also a major source of VOC emissions. Out of a total of 1,753,000 metric tons per year emitted, 778,000 tons are due to the use of trade paints and therefore cannot be controlled because of the very nature of the application. (Trade paints are shelf products sold through retail stores.) VOC emissions from industrial surface coating applications total 975,000 metric tons per year, and these can be controlled by various control technologies as discussed in CTG documents. Based on an average control efficiency of 90 percent, the potential reduction in VOC emissions from surface coating applications in 878,000 metric tons per year if all sources are adequately controlled. The recovery potential can vary from nil to a significant proportion of the reduction potential. Process and material changes provide a great potential for the recovery of VOC emissions.

Dry cleaning operations contribute approximately 227,000 metric tons of VOC emissions per year. The overall average control efficiency for a perchloroethylene dry cleaning plant was estimated to be 58 percent. Based on this estimate, the additional reduction/recovery potential is approximately 92,000 metric tons per year. Most VOC emissions from degreasing operations result from such processes as bath evaporation, solvent carryout, and waste solvent evaporation. The application of add-on control systems as recommended in the CTG documents can reduce the VOC emissions by 380,000-470,000 metric tons per year, a range which also represents the recovery potential.

VOC emissions emanating from the use of cutback asphalt can be eliminated by using emulsified asphalt whenever possible. The total emissions from this source category are approximately 470,000 metric tons per year, and about 235 metric tons of these can thus be reduced/recovered. VOC emissions from the use of miscellaneous solvents are difficult to evaluate because of a scarcity of specific data. The printing and publishing industry, however, is one of the major users of miscellaneous solvents, and the achievable reduction in VOC emissions within this industry is approximately 156,000 metric tons per year (based on an average control efficiency of 65 percent).

Again, because of a lack of sufficient information (due to the large number of plants), it was impossible to include all the existing industrial manufacturing operations. The total VOC emissions from major industrial applications are estimated to be 700,000 metric tons per year. There is very little information available on the present extent of VOC emission control in industrial applications, so the emissions were estimated based on the "no control" assumption.

The overall quantities of used oil generated are estimated to be 1.43 billion gallons per year, with the automotive sector accounting for 0.74 billion gallons and the industrial sector accounting for 0.69 billions gallons. Theoretically, almost all of this used oil should be recoverable. Such variables as the type and quantity of oil used, contamination levels, and storage methods affect the amount that can be technically and economically recovered. Therefore, the present recovery of used oils is far below potential recovery. Presently, the major markets for used oil utilization are the industrial fuel market and the road oiling market. Employing used oil for road oiling, however, is a major source of water pollution. And if the EPA's proposed hazardous waste guidelines classifying used oil as a hazardous substance are adopted, used oil will no longer be allowed for road oiling. Thus, the primary reuse of used oil is as industrial fuel. Re-refining can also be an attractive market for used oils from an economic point of view. Re-refining produces fuel (distillate) and lubricating oil base stocks which can be used for motor oils, transmission fluids, gear oils, cutting oils, hydraulic oils, and quench oils.

Quantities of used solvents generated are difficult to estimate, but their recovery potential is very significant. Used solvent streams are generated from those applications where the solvents retain their chemical identities after use. Recovery potential depends on contamination level, application, type of solvent, and reuse potential. At present, only a small percentage of used solvent is recycled; the balance is landfilled, incinerated, evaporated, or dumped. About 45 percent of the solvents used in the degreasing industry are recovered, but for the other industry groups, the percentage of used solvents reclaimed is considerably less than 45 percent. The consumption of some selected virgin solvents in major commercial applications is approximately 4.7 million metric tons per year, an estimate derived by considering halogenated hydrocarbons, ketones, and alcohol-based solvents. The typical reclamation process consists of six operations—initial storage and handling, initial treatment to separate contaminants, distillation, purification, additional storage and handling, and waste disposal. The primary applications in which widespread solvent recovery and reclamation are practiced (the dry cleaning, metal cleaning and degreasing, and surface coating industries) use synthetic, or halogenated, hydrocarbons. The high initial cost of these solvents makes their reclamation economically attractive.

Although other industries generate waste liquid solvent streams, few statistics on a nationwide basis could be developed. Such industries as canning, chemical manufacture, and rubber and plastics manufacture, consider solvent usage data to be proprietary information which, if disclosed, might reveal valuable process information. Little information is available on liquid hydrocarbon streams generated during the manufacture of basic organic chemicals, coal tar and derivatives, organic intermediates, plasticizers, and electrochemical resins. In particular, these offer good potential for reuse as a fuel. (Fuel thus derived differs from petroleum fuel oil in flow characteristics, air-to-fuel ratio, pump and pressure requirements. It also has a lower BTU rating.) These types of hydrocarbon streams are now being burned at an increasing rate in many areas of the country.

Conclusions and Recommendations

Based on the review of hydrocarbon sources, their emissions, control technologies, and recovery potential, several programs are recommended to improve the recovery potential of used hydrocarbon streams and to review the energy implications of some control/recovery processes. These programs are in addition to those already initiated by state and federal agencies to conserve and recover dwindling supplies of nonrenewable energy resources. Until now, for example, very little work has been done to study the lubricating oil use patterns in industrial plants and to develop programs to improve their reuse potential.

It is estimated that approximately 70 percent of all used industrial oils cannot be readily accounted for. Clearly there are both energy-saving and economic reasons for recycling used oil in the industrial plant, particularly if used oil is declared a hazardous material under the Resource Conservation and Recovery Act. Therefore, a key recommendation is the development of an oil conservation program that will extensively audit oil use and disposal practices, analyze the economics of various reuse options, recommend improvements in operation and maintenance practices, and assess the energy implications of the several reuse/disposal methods available. A detailed industry-specific study should be undertaken to audit industrial oil use, to evaluate used oil disposal practices, to suggest better operational and maintenance practices, and to analyze the economics of alternative disposal methods and other uses for used oil. An industry-specific study should include primary data collection at plants. Then, as an outcome of this study, a practical in-plant guide or handbook should be prepared for general dissemination.

To obtain a complete overview of the net energy impacts of controlling and reclaiming used hydrocarbon streams, it is important to estimate the energy demands of RACT by (1) reviewing available data on energy requirements of pollution control equipment, (2) identifying pollution control equipment requirements for various industry categories, (3) analyzing the energy requirements of implementing RACT, and (4) recommending methods for reducing pollution control energy requirements. Hydrocarbon recovery can also be improved through application of a different RACT than is presently required.

As a result of this study, a number of specific recommendations have also been formulated. With respect to liquid hydrocarbon streams, for example, it is recommended that the U.S. EPA develop mechanisms that could enable state agencies to identify sources and analyze the resultant streams, recommend measures to improve stream quality, and analyze the effects of burning these streams as fuel. With respect to used solvent streams, the following areas should be examined in detail:

- Amount(s) available for reclamation
- Disposal practices in light of RCRA
- Modifications in operating and maintenance procedures
- Economics of solvent reclamation

The 1978 Energy Tax Act's definition of *recycling equipment* should be broadened to include used oil and used solvent recycling equipment. This would provide an incentive to increase the recycling of used liquid hydrocarbon streams. (The definition currently relates only to the recycling of solid waste.)

VOC recovery potential from solvent use categories and from industrial manufacturing applications should be reviewed. In particular, the concentrations and compositions of selected organic exhaust streams should be reviewed in conjunction with individual companies or industry associations. The proposed regulations on VOC emission control and the application of RACT will result in energy savings (because of hydrocarbon recovery), but it will also result in additional energy requirements to fabricate, install, and operate add-on pollution control equipment. In some cases, the compliance dates for VOC control regulations should be delayed to allow continued research and development of alternative measures. In the surface coating industry, for instance, the development of low-solvent content surface coatings could provide an inexpensive alternative to costly add-on control devices.

Two additional recommendations address the recovery of fuel from solid organic wastes and the recovery of methane from landfills. The technical and economic feasibility of recovering fuel from solid organic wastes by pyrolysis and the development of pyrolysis facilities within highly industrialized areas merit further investigation. Similarly, a study is recommended to examine the existing methane production, the factors involved in optimizing methane recovery, the energy recovery potential, the socioeconomic impacts, and the hazards of methane recovery.

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The complete report, entitled "An Inventory of Used and By-Product Hydrocarbon Streams," (Order No. PB 82-221 565; Cost: $12.00, subject to change) will be available only from:
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