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Project Summary

Granular Activated Carbon Adsorption and Fluid-Bed Reactivation at Manchester, New Hampshire

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This study was designed to evaluate the actual cost and performance of a fluidized-bed, granular activated carbon (GAC) reactivation system, a semiautomatic GAC transport system, and a GAC water treatment system at the Manchester Water Works, Manchester, New Hampshire.

GAC performance was monitored in one of the utility's four 38,000-m^3/day (10-mgd) GAC filters to obtain an initial performance comparison of virgin carbon and reactivated 5-year-old service carbon. This filter was divided at its midpoint and then operated and monitored until a steady-state condition was achieved in both filter media studied. Two additional reactivation runs were conducted on this same GAC, providing performance data over three full reactivation-exhaustion cycles. For a portion of the study, the GAC filter medium was educted through a semiautomatic transport system retrofitted to the existing filters. Operation of this semiautomatic system proved to be unreliable, however, and was subsequently abandoned and replaced by a handheld eductor system. GAC from the three remaining plant filters was also reactivated to obtain additional performance data and to restore the adsorptive capacity of the spent service carbon.

Treatment performances of the virgin and reactivated GAC were evaluated during each cycle by measuring total organic carbon (TOC), trihalomethanes (THM), and trihalomethane formation potential (THMFP). GAC adsorptive capacity was also measured using traditional test parameters including iodine number, molasses decolorizing index, Brunauer-Emmett-Teller (BET), and pore-size distribution analyses.

With the cooperation of three regional water utilities, a short-term program of regional reactivation was also investigated. The actual costs and feasibility of transporting and reactivating GAC from these utilities were determined.

This Project Summary was developed by EPA's Municipal 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

In keeping with the research goals of the Safe Drinking Water Act (Public Law 93-523), the U.S. Environmental Protection Agency (EPA) and the Manchester Water Works (MWW) entered into a cooperative agreement to evaluate the cost and performance of a fluidized-bed, GAC reactivation system plus related facilities at the Manchester Water Treatment Plant. GAC effectiveness was assessed before and after reactivation, and GAC reactivation for other water utilities in New England was calculated on a limited basis. All of the work associated with this project was done under actual operating conditions using full-scale water treatment equipment.

On completion of the water treatment plant in 1974, MWW officials began

investigating alternatives for reactivation or replacement of approximately 432,592 kg (500 tons) of GAC used at the 151,000-m^3/day (40-mgd) water treatment facility. Results of this investigation demonstrated that onsite reactivation was the most cost-effective method of restoring the adsorptive properties of spent GAC for the conditions studied.

Water treatment at Manchester consists of flash mixing followed by flocculation, sedimentation, and series filtration through individual beds of sand and GAC filter media Raw water is obtained from a naturally occurring, highly protected surface supply (Lake Mussabesic), which contains no volatile organics but occasionally has high color plus taste and odor as a result of algae formation

Since the research project spanned a period of nearly 5 years (July 1977 to April 1982), the investigation was divided into three major phases. Phase 1 involved the design, construction, and startup of the fluid-bed reactivation system (see Figure 1), semiautomatic carbon transport system, and laboratory monitoring facilities. One of the four GAC filters in the treatment plant called "the test filter" was half filled with virgin carbon and half with reactivated service carbon to compare GAC filter media. After about 90 days, exhausted GAC (as determined by TOC and THMFP) was removed from the filter, reactivated, and then reintroduced to the filter for another 90-day period of service and performance evaluation.

Phase 2 involved two more cycles of reactivation and repeated evaluation of the test filter. The three other GAC filters in the treatment plant were reactivated a total of five times to determine the operational performance capabilities of the reactivator and to develop reactivation cost data. Losses from both reactivation and transport of GAC were also studied.

After all the objectives of the first two phases were achieved, the third phase was undertaken to study the possibility of using the Manchester treatment facility as a regional reactivation center. The major objective of this program was to establish the economic feasibility of providing a future GAC reactivation service for other water utilities in the New England region. Approximately 18,144 kg (40,000 lb) of GAC from each of three separate utilities was reactivated and subsequently returned to service during 1982.

Significant Findings

The Manchester research project demonstrated that onsite GAC reactivation at a medium-sized water treatment facility is feasible with regard to cost and operation. A fluid-bed reactivation furnace was shown to be a practical addition to a water treatment operation, provided that a properly trained, full-time work force is available to operate and maintain the equipment. During the 10 months from June 1980 to March 1981, more than 1.8 million lb of GAC was reactivated at a total cost of less than 22¢/lb (see Table 1) as compared with a delivered cost of 61.5¢/lb for virgin GAC.

Analytical research showed that without exception, fluidized-bed reactivation of spent GAC is an effective means of restoring its overall adsorptive capacity. The adsorptive performance of GAC reactivated once, twice, or three times equaled and in most cases surpassed the performance levels of virgin carbon.

GAC losses were the largest single cost item in the economic evaluation of onsite carbon reactivation. Consequently, accurate measurement of such losses received considerable attention during the research program. Data gathered at controlled test sites revealed that the average total carbon loss resulting from transportation and reactivation over five reactivation cycles was 11.5% by volume.

Other areas of investigation concerned the physical processes of the fluid-bed reactivator. Off-gas samples were collected to determine compliance with State air emission standards. Results demonstrated that the fluid-bed unit was discharging less than 0.045 kg/hr (0.1 lb/hr) of particulate matter to the atmosphere, compared with an allowable State standard of 0.779 kg/hr (1.73 lb/hr). A stack analysis for volatile organics revealed that only chloroform was detected in the off-gas.

The research project had two distinct periods of operation: the first 14 months, which involved frequent equipment startup problems, and the following 10 months, which were characterized by very successful reactivation operation. The major problem of the first period was a lack of equipment efficiency because of frequent mechanical and electrical difficulties. The operating factor of the reactivation furnace was approximately 30% over this initial period of operation. An expenditure of roughly $100,000 was required to modify the reactivator equipment for successful operation. As a result, the operating factor of the equipment was improved to a level of about 75%.

Use of the carbon transport equipment was eventually abandoned because of incompatibility with existing filter opera-

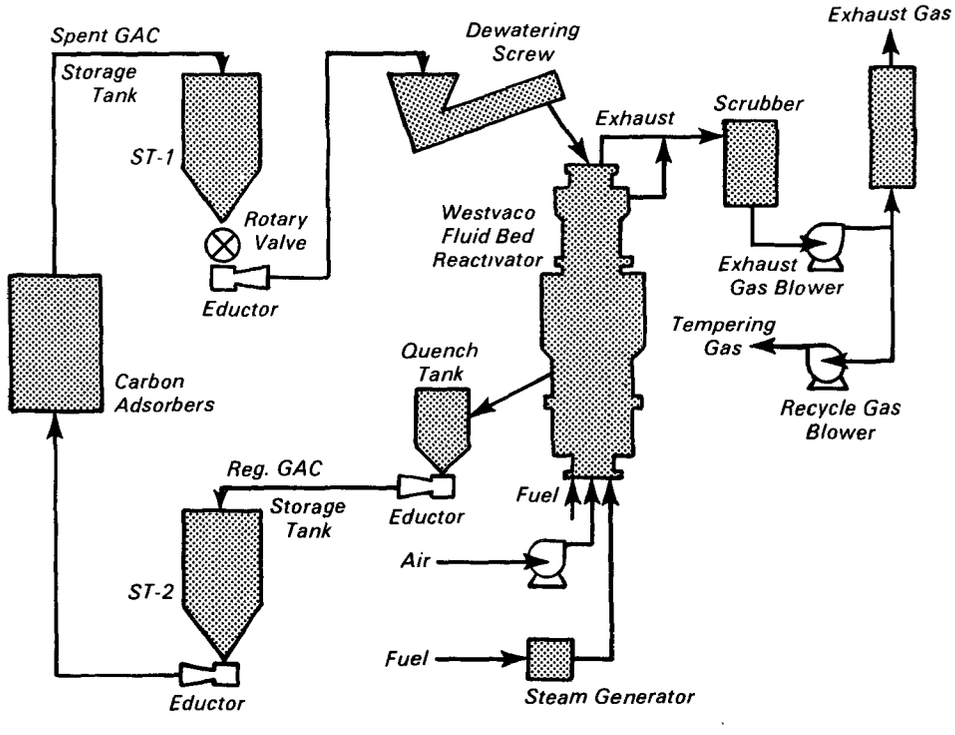

Figure 1. Process flow for GAC reactivation system at Manchester, New Hampshire.

Table 1. *Manchester Water Works Reactivation Costs, June 1980 Through March 1981**

Cost Item	Cost/kg (¢)	Cost/lb (¢)
Makeup carbon	15.59	7 07
Labor for reactivation	4.28	1.94
Labor for transportation	0.62	0.28
Labor for laboratory	0.11	0.05
Labor for administration	2 91	1.32
Parts and service calls	5.87	2.67
Fuel oil	4.92	2.23
Electrical power	1.10	0.50
Water	1.63	0.74
Laboratory supplies and outside analyses	0.11	0.05
Depreciation	4.70	2.13
Overhead	6.08	2.76
TOTAL	47.92	21.74

*Based on reactivation of 842,401 kg (1,857,176 lb) of GAC.

tion, poor reliability, excessive maintenance, and unacceptable removal of filter media. A manually operated hose and eductor system was then substituted and used successfully to transport GAC between the filters and reactivation building.

Because of the success of the research program, the Manchester facility was investigated for use as a regional reactivation center. This final research effort demonstrated that MWW could economically provide a GAC reactivation service for other water utilities in the New England region. The combined average reactivation cost was 49.5¢/lb.

The full report was submitted in fulfillment of Cooperative Agreement No. CR805371 by the Manchester Water Works under the sponsorship of the U.S. Environmental Protection Agency.

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The complete report, entitled "Granular Activated Carbon Adsorption and Fluid-Bed Reactivation at Manchester, New Hampshire," (Order No. PB 84-110 238; Cost: $25.00, subject to change) will be available only from:
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