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ABSTRACT

The U.S. Department of Energy (DOE), in DOE Order 5400.5 (1990), directs operators of DOE facilities to apply the Best Available Technology (BAT) to control radiological liquid effluents from these facilities when specific conditions are present. DOE has published interim guidance to assist facility operators in knowing when a BAT analysis is needed and how such an analysis should be performed and documented. The purpose of the guidance is to provide a uniform basis in determining BAT throughout DOE and to assist in evaluating BAT determinations during programmatic audits.

The BAT analysis process involves characterizing the effluent source; identifying and selecting candidate control technologies; evaluating the potential environmental, operational, resource, and economic impacts of the control technologies; developing an evaluation matrix for comparing the technologies; selecting the BAT; and documenting the evaluation process. The BAT analysis process provides a basis for consistent evaluation of liquid effluent releases, yet allows an individual site or facility the flexibility to address site-specific issues or concerns in the most appropriate manner.

INTRODUCTION

The U.S. Department of Energy (DOE) has established primary radiological protection standards for the public and the environment for effluents and emissions from DOE facilities in DOE Order 5400.5, "Radiation Protection of the Public and the Environment" (DOE 1990). This Order also provides for additional controls of radionuclides in liquid wastes and effluents to reduce

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the potential for radiological contamination of natural resources such as land, ground and surface water, and ecosystems. DOE Order 5400.5 recognizes the importance of federal and state environmental protection statutes and regulations, of which the primary statute for controlling liquid effluent releases is the Clean Water Act (Clean Water Act 1977). In implementing the Act, the Environmental Protection Agency (EPA) required the use of "best available technology" (BAT) for National Pollutant Discharge Elimination System (NPDES) permits to control discharges of non-radioactive pollutants to surface waters (40 CFR Part 125).

To provide a level of protection for radionuclides consistent with the Clean Water Act, DOE incorporated BAT into DOE Order 5400.5. One of the provisions in Order 5400.5 calls for the use of BAT as the appropriate level of treatment for liquid wastes containing radioactive material. "Best available technology" is defined by DOE as the preferred technology for treating a particular process liquid waste, selected from among other potential treatment technologies after taking into account social, technical, economic, practical, and other factors. BAT is not in reality a specific level of treatment, but the end result of a selection process that includes considering a number of treatment alternatives. This paper discusses the application of BAT to radioactive liquid wastes in DOE facilities and, in particular, focuses on the BAT selection process for which DOE has recently provided interim guidance to operators of DOE facilities.

APPLYING BAT UNDER DOE ORDER 5400.5

The DOE standards for contaminants in liquid effluent discharges ar driven by the DOE ALARA (as low as reasonably achievable) policy, with the objective of minimizing doses to the public and contamination in the environment to the extent practicable. DOE published general ALARA guidance for radiation exposure in 1988 (Munson et al. 1988) and has more recently produced interim guidance on application of the ALARA process to environmental protection for compliance with DOE Order 5400.5.[b]

The BAT selection process is derived from the ALARA process and may be considered to be a subset thereof. The principal difference between the ALARA process and the BAT selection process is that the ALARA process includes consideration of actual and potential doses to the public or the environment, whereas the BAT selection considers the source term, but not potential exposures to the source.[b] A BAT analysis typically examines the activity concentration of a liquid process stream (source term) before and after a treatment technology is applied, as a basis for selecting the BAT. Implementation of the BAT process is not required where radionuclides are already at a low level; i.e., where the annual average concentration is less than the applicable derived concentration guide (DCG), found in Chapter III of

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(b) "DOE Guidance on the Procedures in Applying the ALARA Process for Compliance With DOE 5400.5," March 8, 1991, attachment to: Raymond F. Pelletier, to Distribution, "Guidance for Implementation of ALARA Requirements for Compliance with DOE 5400 Series Orders: For Interim Use and Comment," DOE memorandum dated March 14, 1991.

DOE Order 5400.5. However, the ALARA provisions are always applicable (DOE 1990).

DOE Order 5400.5 requires the use of BAT for protection of surface waters, ground water, and soil. Discharges to sanitary sewerage systems are also addressed under the BAT selection process. The areas of protection called out in DOE Order 5400.5 and the levels at which the BAT selection process is applied are shown in Table 1. DOE defines the point of compliance to be the undiluted outfall of the waste stream. This is not the site boundary, but the point where the liquid effluent stream enters the environment. The intent is to ensure that dilution with other low-concentration and high-volume streams does not preclude application of the BAT selection process.[c]

TABLE 1. Liquid Waste Stream Radionuclide Levels at Which the BAT Selection Process is Applied

Discharge Destination	Radionuclide Concentration
Surface water	> 1 DCG[1]
Soil column[2] (soil, ground water)	Any active soil column
Sanitary sewerage system	> 5 DCG[1]

[1]Where DCG is the Derived Concentration Guide as listed in DOE Order 5400.5, applied to the monthly average concentration using a sum of fractions method for all radionuclides in the process waste stream.

[2]Use of soil columns (cribs, trenches, ponds, drain fields, etc.) is considered an interim control strategy. Where the period of interim use is indefinite, use of the BAT selection process is required.

DOE also recommends that, as a best management practice, the BAT selection process be applied in several other situations. These situations typically occur only for surface-water discharges:[c]

1) The total annual effective dose equivalent (EDE) to any member of the public exceeds 10 mrem EDE (0.1 mSv), or the annual collective dose exceeds 100 person-rem EDE (1 person-Sv), and the liquid discharge is a major contributor to either of those doses (e.g., 40% of individual or collective doses), or

(c) "Implementation Guidance for DOE 5400.5, Section II.3 (Management and Control of Radioactive Materials in Liquid Discharges and Phaseout of Soil Columns)., attachment to; Raymond F. Pelletier, to Distribution, "Guidance regarding water protection elements of DOE 5400.5", DOE memorandum dated June 17, 1992.

2) The facility's radionuclide discharges have significant potential to cause downstream water treatment facilities to exceed the radionuclide drinking water Maximum Contaminant Levels in 40 CFR Part 141.

An important exemption to the BAT selection process is when tritium is present in liquid waste streams. It is recognized in DOE Order 5400.5 that there is no BAT for control of low concentrations of tritium. However, the Order requires that process alternatives be reviewed to ensure that tritium releases are as low as reasonably achievable.

THE BAT EVALUATION AND SELECTION PROCESS

In its Implementation Manual for Application of Best-Available Technology Processes for Radionuclides in Liquid Effluents (DOE 1992), DOE published interim guidance assisting facility operators to determine when a BAT analysis is needed and how such an analysis should be performed and documented. The purpose of the guidance is to provide a uniform basis for determining BAT for control of radionuclides in liquid waste streams throughout DOE and to assist in evaluating BAT determinations during programmatic audits. The guidance recognizes that the specific content of BAT evaluations will vary greatly because of different site and facility characteristics. Facility operators are provided flexibility in determining what are important factors to consider in selecting the BAT. The review and selection process for determining the BAT may be viewed as a general five-step process, as shown in Figure 1.

Step 1 in the process of evaluating BAT is to characterize the source. A well-characterized radioactive liquid effluent source, including the process that produces the liquid effluent and radioactive constituents, is essential to the BAT evaluation process. This requires familiarity with facility operations and operational parameters, and details of the source characterization are left to the facility operators.

Step 2 is to identify available technologies for controlling the process stream, including the existing control technology currently in place at the facility (i.e., the no-action alternative). These control technology options should be identified and selected for further evaluation based on their appropriateness for controlling the source characterized in step 1. Although the focus of this BAT evalution process is radiological pollutants, the technologies that will be used to handle the nonradiological pollutants in the waste stream, if any, must also be considered in selecting the overall best technology as the BAT for the process. Priority pollutants, which include the 129 toxic substances specified by the EPA, should be treated by BAT before being discharged to surface waters. Figure 2 shows the categories of control technologies to be considered as part of a generic treatment system.

The crux of the BAT selection process starts with step 3 in Figure 1: evaluating the environmental, socioeconomic, operational, and resource impacts of each of the candidate control technologies. The impact evaluation is the most detailed part of the BAT evaluation and selection process, shown in Figure 3.

Each control technology identified in step 2 is initially evaluated to determine if it merits further consideration. A preliminary evaluation is conducted to screen out those candidate technologies that are obviously unacceptable. This preliminary evaluation has two parts: the first compares the projected annual average effluent concentration to the ingested water DCG in Chapter III of DOE Order 5400.5, while the second part evaluates the candidate technology for compliance with all applicable regulations and requirements. If the candidate technology cannot meet either of these two evaluation criteria, the technology is rejected as unacceptable. If the technology meets these criteria, or if not enough information is available for adequate evaluation, it may be considered for detailed evaluation.

The detailed evaluation of candidate technologies has several objectives: to identify important issues for the particular facility and site being evaluated, to gather information on each issue for each candidate technology, and to provide a consistent method of evaluating each candidate technology to determine which is optimal for the site-specific application.

Although managers of each site are responsible for determining the extent of the BAT analyses performed for that site, DOE Order 5400.5 requires that eight specific issues be considered in performing a BAT analysis:

- age of equipment and facilities involved
- the process employed
- engineering aspects of applying various types of control methods
- process changes
- cost of achieving effluent reduction
- non-water-quality environmental impacts (including energy requirements)
- safety considerations
- public policy considerations.

These factors are included in four areas of detailed impact evaluation — environmental, operational, energy and resource, and economic — included in the DOE manual for the implementation of BAT (DOE 1992). In addition, facility operators may add any other issues that are considered important or significant for their particular facility or site. Issues should be selected that will help in evaluating the relative impacts and in discriminating among the various candidate technologies.

For evaluating existing facilities, the existing control technology currently in place at the facility should be used as a baseline and candidate technologies compared with it. The criteria in Table 2, combined with "best professional judgement," should be used to assign "value factors" to each issue category for each candidate technology. Because a candidate technology may be either better or worse than the existing no-action alternative for a specific issue, the no-action alternative is assigned a value (5) in the center of the range (1-10) of value factors.

TABLE 2. General Criteria for Establishing Value Factors for Evaluating Candidate Control Technologies

Value Factor (VF)	Criteria
0	Inferior (i.e., the candidate technology is not appropriate for this issue)
1-2	Substantially deficient, definite negative effect (i.e., the candidate technology is significantly worse for this issue than the existing technology)
3-4	Slightly deficient, slight negative effect (i.e., the candidate technology is somewhat worse for this issue than the existing technology)
5	No change (i.e., the candidate technology does not offer any change from the existing, baseline technology)
6-7	Minimal improvement, slight positive effect (i.e., the candidate technology improves on this issue only slightly)
8-9	Substantial improvement, definite positive effect (i.e., the candidate technology improves on the issue quite well)
10	Excellent improvement, significant positive effect (i.e., the candidate technology improves on the issue extremely well, even if it does not totally resolve the issue)

With adequate justification and documentation, the detailed evaluations may be performed addressing only significant radionuclides. Significant radionuclides are those radionuclides deemed to be significant contributors to dose (e.g., those radionuclides that are estimated to contribute at least 99% of the calculated dose to members of the public). The definition of significant radionuclides is applicable after the candidate technology has been applied; that is, it includes only those radionuclides that remain in liquid effluent discharges after treatment. This allows any minor radionuclides identified in the preliminary DCG comparison to be eliminated from further consideration.

The evaluation process should be as objective as is practicable. The process of BAT analysis requires the use of best professional judgement at each step, so that the analysis can be tailored to fit site-specific conditions. Every effort should be made to be as consistent as possible when making the best professional judgements. In addition, efforts should be made to be consistent in the way best professional judgement is applied to different facilities at the DOE site and at different sites in the DOE system.

Step 4 in the BAT analysis (Figure 1) is to select the BAT. While relying heavily on the best professional judgement of the individuals performing the analysis, the final selection process provides a structured approach that encourages objective evaluation and accountability.

Final BAT selection consists of the four activities shown in Figure 4. The first activity is to assemble all of the technology-related issues, which are defined to include all except economic issues. A determination is made of the relative importance of each of the technology issues, and a weighting factor (WF) is assigned to each issue. Issue weighting factors are assigned on a site-specific basis subject to two constraints: 1) the total of all weighting factors must add up to 100, and 2) issues categorized as environmental impacts must have a weighting factor total of at least 50 (i.e., be weighted at least 50% of the total).

The second activity involves impartially ranking the candidate technologies based on environmental, operational, and energy impacts. The technology-specific value factors (VF) for each issue and issue-specific weighting factors (WF) are used to produce this ranking, in the form of a total weighted value factor (TWVF). This information can be easily assembled in a technology issues matrix to allow comparisons between different candidates on specific issues. The TWVF is calculated as

$$TWVF_{candidate_x} = \sum_{i=1}^{n} VF_i \times WF_i$$

where x is the candidate technology under consideration and n is the total number of issues considered for each candidate. The TWVF provides the ranking of candidate technologies based strictly on the technology-related issues.

The third activity is to organize the information associated with the cost and economic impact of implementing each candidate technology. This is done separately from the technology-related issues. This information is used to assemble an economic figure-of-merit for each candidate, which is used to compare the economic impacts of each candidate. Economic impacts can be evaluated using several different figures-of-merit; however, it is important that the method used be consistent among all of the candidate technologies.

The final activity is to perform a cost-effect analysis by compiling all of the information on technology-related issues (activity 2) and economic feasibility issues (activity 3) into a cost-effect table. The cost-effect ratio of each candidate technology is examined, and the candidate that represents the BAT is selected. The technology-related ranking is the most important consideration in determining the BAT. Economic impact is considered to be a secondary factor in the BAT selection process. Establishing cost in evaluating BAT is for comparative purposes. It may be difficult to establish realistic cost data, because a host of variables associated with each facility affect the cost of controlling liquid effluents.

At this point, any circumstantial limiting factors should be considered, using best professional judgement in evaluating them and weighing the positive effects against limitations. If the candidate with the highest TWVF is not chosen as the BAT, the reasoning and justifications for rejecting it should be explained fully in the documentation.

The final step (step 5) of the BAT analysis process (Figure 1) is documentation. Each step in the BAT evaluation process must be documented. Such documentation ensures that all of the conditions, assumptions, and results of the evaluation are recorded so that the BAT evaluation can be adequately defended if necessary. In all cases, documentation of each step in the BAT analysis should provide sufficient detail for independent review of the scope, methodology, and conclusions. The documentation should indicate how each issue was considered and, if appropriate, should briefly describe the reasons for not performing a detailed analysis. For example, further analysis of impacts on land use may be eliminated if none of the alternatives would alter current land use.

CONCLUSION

A method for fulfilling the requirement for BAT analysis in DOE Order 5400.5 is outlined in a recently published DOE implementation manual (DOE 1992). The method is a structured approach that encourages objective evaluation and accountability while providing the flexibility required to accommodate the very different and specific needs of the various DOE sites and facilities. The method recognizes the strong reliance on the "best professional judgement" of the qualified individuals performing the analysis and provides a framework for incorporating and documenting this input. The guidance provides a uniform basis for determining BAT for control of radionuclides in liquid waste streams throughout the DOE system. The implementation manual is recommended for more specific guidance.

REFERENCES

40 CFR Part 125. 1991. Environmental Protection Agency, "Criteria and Standards for the National Pollutant Discharge Elimination System," U.S. Code of Federal Regulations.

40 CFR Part 141. 1991. Environmental Protection Agency, "National Primary Drinking Water Regulations," U.S. Code of Federal Regulations.

Clean Water Act. 1977. Title 33 U.S.C. 1251 et seq., as amended.

Munson, L. H., W. N. Herrington, D. P. Higby, R. L. Kathren, S. E. Merwin, G. A. Stoetzel, and E. J. Vallario. 1988. Health Physics Manual of Good Practices for Reducing Radiation Exposure to Levels That Are As Low As Reasonably Achievable (ALARA). PNL-6577, Pacific Northwest Laboratory, Richland, Washington.

U.S. Department of Energy (DOE). 1992. Implementation Manual for Application of Best-Available Technology Processes for Radionuclides in Liquid Effluents. Interim Final Report. DOE/EH-263T, U.S. Department of Energy, Washington, D.C.

U.S. Department of Energy (DOE). 1990. "Radiation Protection of the Public and the Environment." DOE Order 5400.5, U.S. Department of Energy, Washington, D.C.

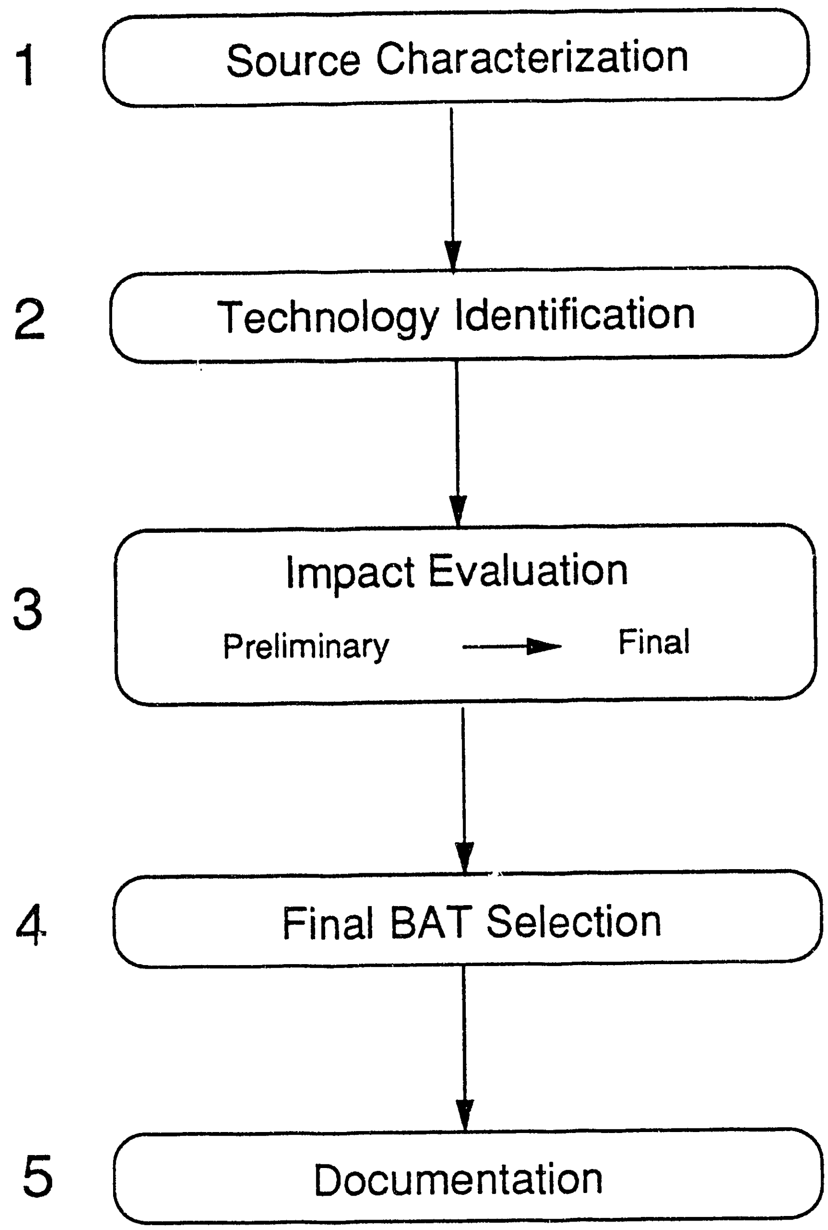

FIGURE 1. Five-Step BAT Evaluation and Selection Process

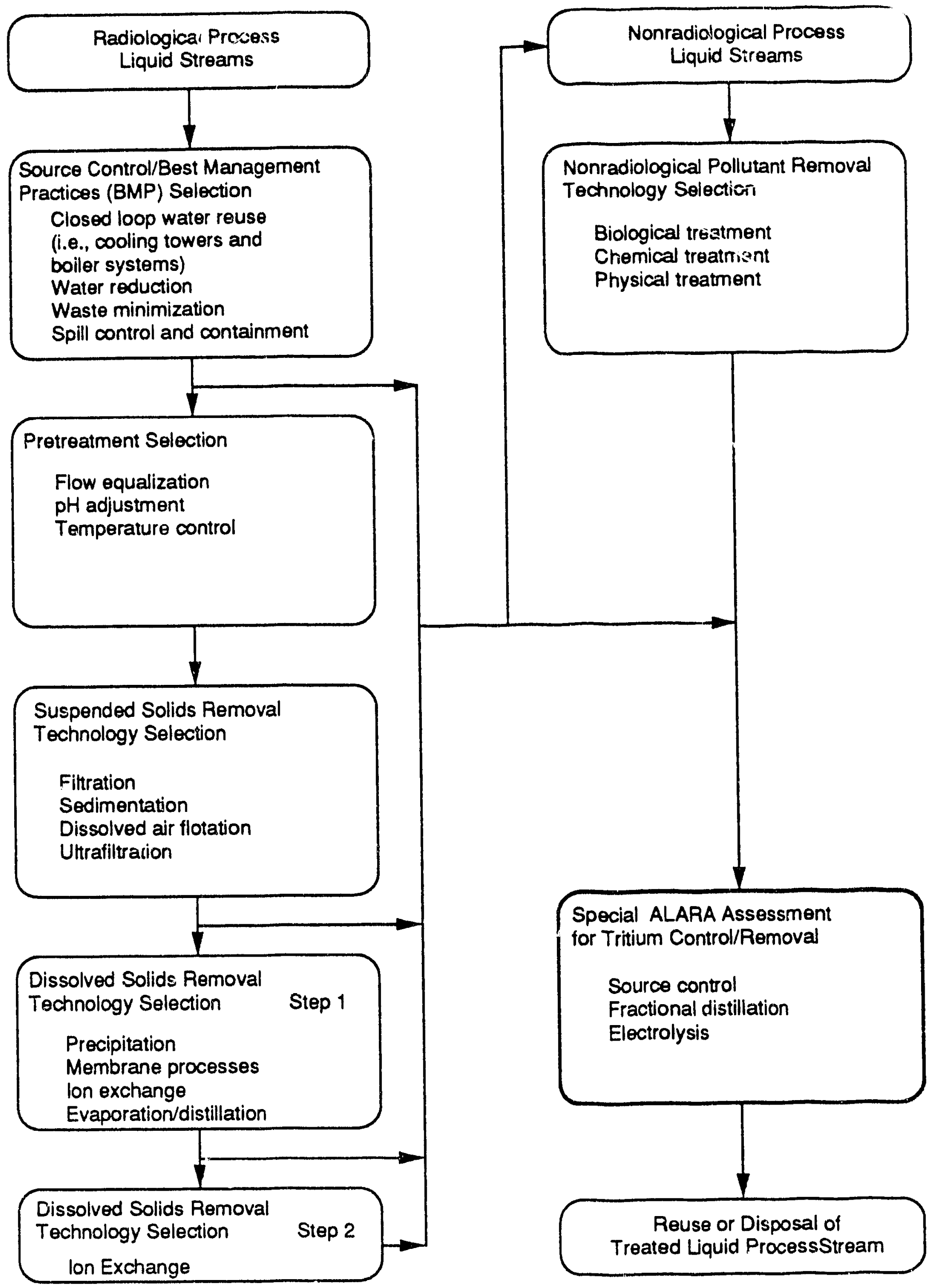

FIGURE 2. A Generic Treatment System for Process Liquid Waste Comprised of Candidate Control Technologies

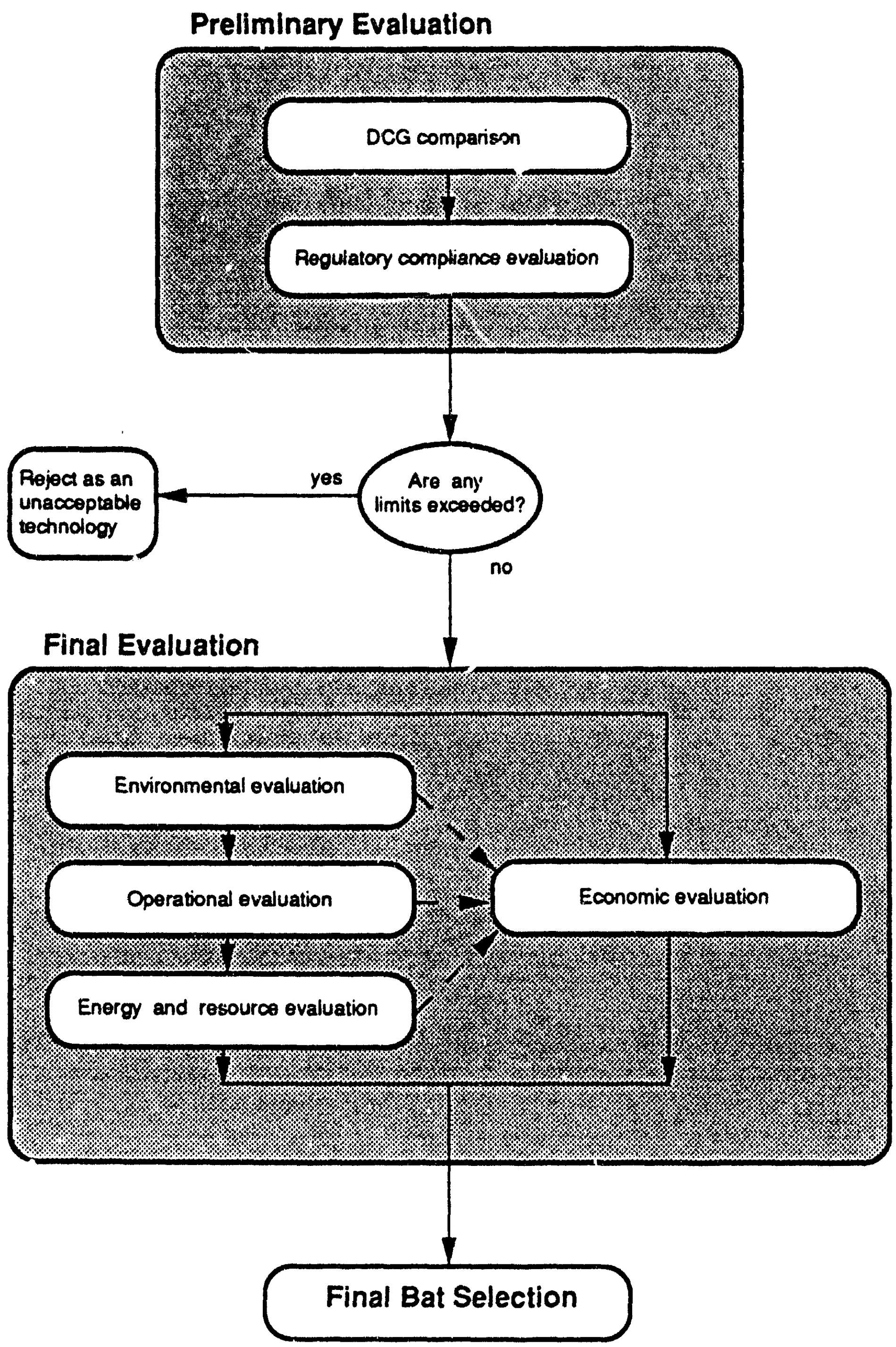

FIGURE 3. The BAT Evaluation Process for Determining the Impacts of Each Candidate Control Technology

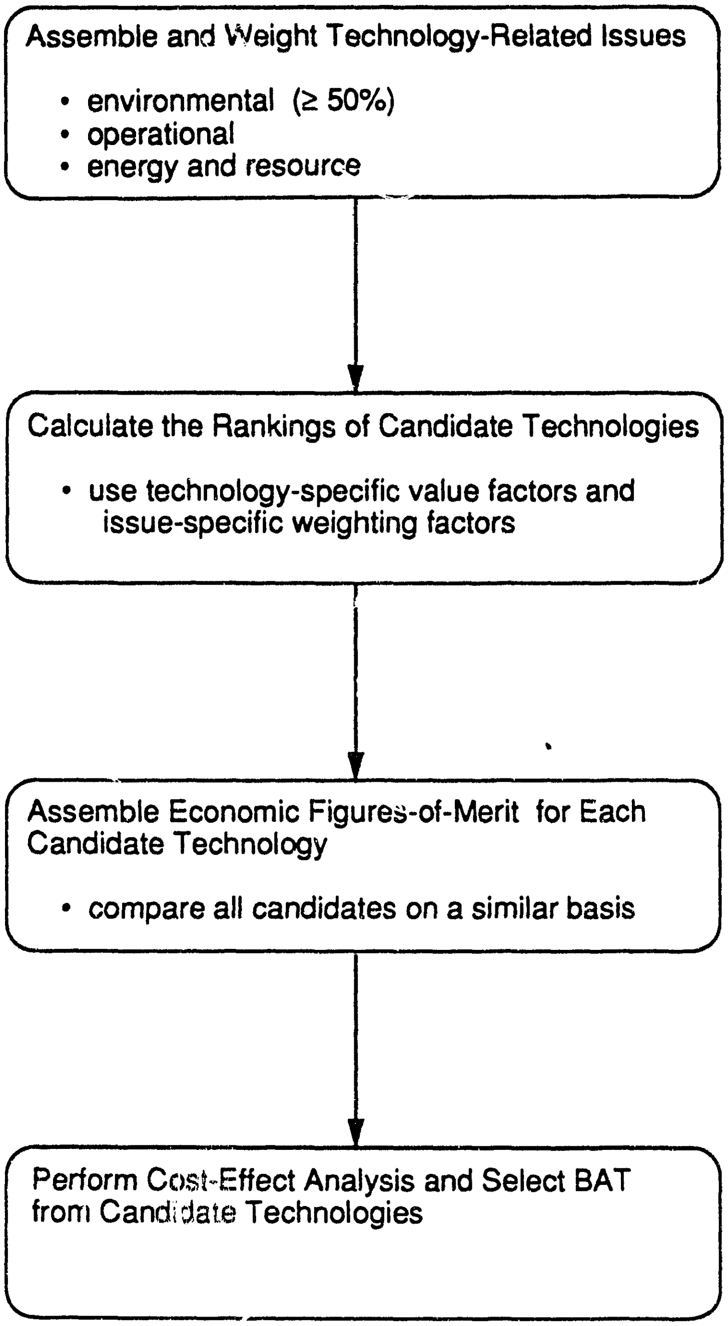

FIGURE 4. The Activities Performed During the Final BAT Selection Process

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