PARAMETRIC STUDIES OF THE IMPACT OF CONVENTIONAL DISPOSAL OF WASTES BELOW REGULATORY CONCERN (BRC) USING THE IMPACTS COMPUTER CODE WITH THE EPRI IMPACTS-PLUS INTERFACE

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ABSTRACT

Disposal of low-level radioactive waste is becoming an important issue for utility waste managers. The NRC has addressed this issue through a recent Policy Statement on Below Regulatory Concern (BRC) wastes. This policy statement encouraged the use of the IMPACTS-BRC computer code to analyze the impacts of low-level waste disposal. The NRC has requested petitioners to use this code when submitting petitions for rulemaking involving BRC waste streams. To facilitate use of the IMPACTS code, the Electric Power Research Institute has developed a user-friendly interface to the program. The interface, IMPACTS-PLUS, was used to perform a parametric analysis of the controlling variables for the program. This paper presents the methodology and results of the analysis.

INTRODUCTION

The NRC Staff implementation of NRC's policy on procedures for considering rulemaking petitions for conventional disposal of very low-level wastes deemed below regulatory concern (BRC) refers to the computer code IMPACTS as the methodology that will be used to evaluate radiological impacts associated with such petitions. This code, developed for NRC, was originally written for batch operation on a large computer. The FORTRAN code is now available to run on the IBM XT and compatible microcomputers and NRC has issued a "User's Guide" (1), the code remains batch oriented and difficult for the user who is not a computer professional.

To make this program more useful to the engineer or radwaste manager, the Electric Power Research Institute (EPRI) has developed an interactive, user-friendly, interface for the IMPACTS code. The interface program, called IMPACTS-PLUS, allows the user to enter data, run the IMPACTS program, and print the results in a variety of formats.

EPRI has utilized IMPACTS-PLUS to study the sensitivitiy of the IMPACTS program to its various input parameters. This paper will briefly describe the IMPACTS code and discuss the input and output interfaces of IMPACTS-PLUS and their interactive features. The important results of the parametric studies will then be presented including the controlling parameters for the following three groups of input data:

- Waste stream physical and radiological characteristics
- Disposal method operational parameters
- Disposal site environmental characteristics

The paper will conclude with a discussion of the overall usefulness of IMPACTS-PLUS in helping nuclear power plants effectively manage the low-level waste generated at their sites.

THE IMPACTS CODE

The IMPACTS computer program was developed for the NRC in 1984. It is presented to the public in NUREG/CR-3585, "De Minimis Waste Impacts Analysis Methodology" (2). The program calculates various doses that could be realized from the disposal of very low-level radioactive waste streams. The program takes into consideration the physical and radiological properties of the waste stream and the characteristics of the proposed disposal site and method of disposal when calculating doses. The doses to nine individual organs and the whole body via five exposure pathways are calculated. IMPACTS also calculates doses from exposure to the waste stream through various groundwater exposure pathways at times ranging from 20 to 20,000 years after disposal.

The NRC has recently reissued the IMPACTS code under a new title. The new program, IMPACTS-BRC, is not actually a new computer code, but is simply a modification of the original IMPACTS. Some of the assumptions used in the new program are conservative for several exposure scenarios. The IMPACTS-PLUS interface is designed to be compatible with either code, and the results obtained from each should be similar. A study is currently underway to determine the differences between two codes, and the conclusions of this study should be available in the near future.

THE IMPACTS-PLUS INTERFACE

The IMPACTS-PLUS interface is a program which must be used in conjunction with the IMPACTS code.

The IMPACTS code is not altered by the interface, and it can still be run without the interface. IMPACTS-PLUS, on the other hand, is useless without the IMPACTS program.

The interface steps the user through the data entry/editing process necessary to make a successful IMPACTS run. It also enables the user to save files, delete files, generate reports, and run the IMPACTS program. Other features of the interface include help screens and note taking capabilities. IMPACTS-PLUS can be used in two modes, a "Quick" mode and an "Update" mode. The "Quick" mode allows the user to rapidly page through the input screens, editing only certain pre-selected parameters. The user must have previously specified (while in the "Update" mode) which parameters will be skipped over and which will be viewed in the 'Quick" mode. The "Update" mode permits the user to view the current value as well as the pre-set designation for each parameter. The user may change any or all input values while in the "Update" mode. The option selected will depend on the variability of the input for a series of cases.

The IMPACTS-PLUS interface was developed by the Electric Power Research Institute (EPRI) to promote use of the IMPACTS code as a tool for evaluating the alternative disposal of very low-level radioactive wastes. The NRC has announced that it will use the IMPACTS-BRC code to evaluate all petitions for rulemaking related to disposal of low-level wastes. NRC licensees have employed the program in the past when preparing their applications for approval to dispose of waste by alternative means. IMPACTS-PLUS is therefore a useful tool for utilities seeking to find alternatives to NRC-licensed low-level waste disposal.

PARAMETRIC ANALYSIS

In order to determine the controlling parameters of the IMPACTS code, the program was run many times, varying only one parameter at a time. The results of these "sensitivity runs" were then compared to the results obtained from the "base case" calculation to identify significant variations in impacts. The base case calculation was performed using very generalized data. The waste was assumed to be disposed of in a sanitary landfill located in an area typical of the rural southeastern U.S. The waste stream, disposal site, and disposal method data used in the base case are generic and are taken from Ref. 2.

The base case output was then compared to the sensitivity run results. The differences in impacts were recorded on an matrix of the IMPACTS input variables and the various exposure scenario categories evaluated by the program. The matrix (Fig. 1) was then used to determine which parameters controlled the program.

Parameter / Scenario	Accessibility	Activity Concentration	. . .
Transportation		♦	
Intruder	♦	♦	
Exposed Waste	♦	♦	
Incineration and Operational	♦	♦	
Leachate Accumulation	♦	♦	
Ground-water:			
Intruder-well	♦	♦	
Population-well	♦	♦	
Population-surface water	♦	♦	

*Note: This figure is representative of the type of matrix used in the analysis. Over sixty parameters were studied using this format. Only the controlling parameters are discussed in this paper.

Fig. 1 Matrix of Input Parameters and Exposure Scenarios Categories

The parameters evaluated in this study are divided into three categories:

- Waste stream physical and radiological characteristics
- Disposal method operational parameters
- Disposal site environmental data

The conclusions of the parametric analysis are organized according to the above categories. In each category, a controlling parameter is defined as one for which the effects of the sensitivity runs can be seen in four or more of the exposure scenario categories. The following sections of the paper summarize the results of the parametric study.

Waste Stream Physical and Radiological Characteristics

The user must quantify certain physical and radiological parameters related to the waste stream being analyzed. These variables include:

- Annual volume/mass/density of the waste stream
- Packaging of the waste
- Accessibility of the waste material
- Dispersibility of the waste material

Other waste properties to be input to the program include the radiological characteristics of the waste. The user must specify the solubility of each element considered by the program and its concentration (by nuclide) in the waste stream. The program then uses this physical data about the waste stream to calculate the impacts of disposal using data stored in the IMPACTS code on the radiological properties of each nuclide.

Controlling parameters in this category include the annual waste volume and the activity concentrations present in the waste stream. The product of these factors is the true controlling parameter, the total activity disposed of per year. The total activity of the waste directly affects all exposure scenarios. Another parameter in this category which has a noticeable effect on the impacts is the accessibility of the waste form. Wastes which are more stable (i.e. activiated metals) are less accessible and therefore contribute less dose via all exposure scenarios but transportation. Packaging of the waste material (i.e., unpackaged vs. packaged in drums or boxes) also has some effect on the disposal impacts. Use of metal or other containers to package the waste increases the doses due to the transportation scenarios, while it has no effect on the remaining five exposure scenarios.

The solubilities of the radionuclides in the waste material have a small effect on the impacts of disposal. All scenarios but transportation are affected by altering nuclide solubilities. In general, lower solubility classifications result in lower lung doses. However, doses to all other organs as well as the whole body increase slightly with low solubility classification.

Disposal Method Operational Parameters

The disposal method operational parameters studied relate to some aspect of the waste disposal methodology. The primary variables examined include the five types of land burial disposal sites evaluated by IMPACTS. These are:

- On-site disposal
- Sanitary landfill disposal
- Open dump disposal
- Hazardous waste facility (Type I) disposal
- Hazardous waste facility (Type II) disposal

Other methods evaluated include the pre-disposal incineration of the waste prior to burial at one of the above sites. The operational aspects associated with each of the disposal methods were also examined. Table I summarizes the parameters evaluated as disposal method operational characteristics.

A comparison of the impacts of the disposal of the base case waste stream at each of the generic disposal sites leads to the following broad conclusions:

- Sanitary landfill disposal results in the most conservative overall impacts
- Disposal at a hazardous waste facility significantly reduces population doses, but doubles the impacts in the transportation scenarios, and increases disposal site worker dose thirty times
- Disposal at an open dump results in much higher doses via all exposure scenarios except transportation, which remains the same
- The methodology used in the current version of IMPACTS for on-site disposal does not calculate doses for the transportation or operational scenarios. In general, doses for on-site disposal are slightly higher compared to those for the base case. Controlling parameters for on-site disposal are the calculated values for site selection population disposal facility operations and the atmospheric dispersion factor.

The specific controlling parameters for disposal method operations include the following:

- Pre-closure control period
- Post-closure control period
- The number of disposal facilities
- The total annual volume disposed at the site of interest

Other factors which have some effect on the doses are the emplacement and disposal efficiencies, and the various incineration parameters.

The variation in impacts resulting from incineration and disposal of the ash versus disposal of the materials without incineration are not insignificant. Incinerating the waste and burying the ash results in higher doses for three of the exposure scenario groups while lower doses were observed for the remaining five scenario groups, including the groundwater scenarios.

Disposal Site Environmental Data

The disposal site environmental parameters characterize the environment of the disposal site. Many variables relating to the climatological, hydrological, and geological features of the disposal site are required input to IMPACTS. The generic values assigned to these parameters by the program as a result of the selection of a regional location were modified by a power of ten in each direction. The resulting output leads to the conclusion that, while modifying a single variable had little or no effect, changing blocks of related data (such as waste-to-air transfer factors) produced noticeable effects. Further observations show marked differences in the

TABLE I
Disposal Method Operational
Parameters

OPERATIONAL FACTORS
• Pre-closure control period • Post-closure control period • Annual volume for disposal • Disposal operations atmospheric dispersion factor • Disposal operations exposure duration factor • Operation waste-to-air transfer factors • Daily exposed areas • Cover mixing efficiency • Emplacement efficiency • Surface disposal efficiency • Erosion delay time
INCINERATION FACTORS
• Number of incinerators • Combustible content • Annual volume incinerated • Incineration atmospheric dispersion factor • Incineration exposure duration factor • Incineration waste-to-air transfer factor • Density of waste for transportation and incineration
TRANSPORTATION FACTORS
• Number of waste shipments • Percent of very low-level waste in truck load • Populatipn density around transportation route • Distance dependent dose factor • Transportation distance • Transportation velocity

impacts from disposal in one region of the country compared to another. As expected, modification of air-related parameters had the greatest effect on the airborne exposure scenarios. Likewise, changing the water-related parameters resulted in changes in the water-borne exposure scenarios. Overall, no individual controlling parameter was observed in the site environmental data category. The parameters evaluated in this category are listed in Table II.

Other relationships explored in this category include the differences resulting from disposal in the various generic regions described in NUREG/CR-3585. The generic regional sites characterize the local environment typical of the northeastern, southeastern, and southwestern United States.

The base case evaluated sanitary landfill burial in the rural southeast. Sanitary landfill burial in the rural northeast produced the following results:

- Slightly increased doses in the transportation, exposed waste, and incineration and operational scenarios
- Lower doses in the intruder, leachate accumulation, and groundwater scenarios

Comparing the base case to sanitary landfill burial in the rural southeast led to these conclusions:

- Higher doses for intruder and exposed waste scenarios
- Lower doses for transportation, incineration and operational, leachate accumulation, and groundwater scenarios

A comparison of rural versus urban disposal resulted in similar variations in impacts for all disposal methods studied. Disposal of the waste stream in a rural environment decreased doses for three of the eight disposal scenarios. Doses decreased in the exposed waste, incineration and operational, and leachate accumulation scenarios.

TABLE II
Disposal Site Environmental Data

WATERBORNE PARAMETERS
• Infiltration percolation • Contact time fraction • Incremental waste travel time • Water travel time (Intruder well, population well, surface water) • Incremental peclet number • Peclet number (Intruder well, population well, surface water) • Dilution factor (Intruder well, population well, surface water • Retardation Index
SITE SELECTION PARAMETERS
• Site selection factor (construction) • Site selection factor (intruder-agriculture) • Site seleciton population disposal facility operations • Population site selection factor (erosion) • Site selection factor (water)
AIR-RELATED PARAMETERS
• Average wind speed • Accident atmosphere dispersion factors • Dust mobilization rate - hazardous waste facility • Dust mobilization rate - erosion • Dust mobilization rate - intruder

SUMMARY

This paper has summarized the results of the parametric study of the IMPACTS code. An EPRI report will present the results and conclusions in greater detail.

Several considerations should be mentioned at this time, however. IMPACTS-PLUS was designed to facilitate easy use of the IMPACTS code. For this reason, some of the unusual options of the IMPACTS input were omitted, Thus the system has been optimized for running generic cases rather than those with very specific, individualized on-site disposal data. For the sensitivity run of the on-site disposal method, generic site environmental parameters were used. The results may not be meaningful or realistic for actual on-site disposal. EPRI is, however, working on improving this situation and will publish its findings as they become available.

Another area to be more closely examined is the methodology associated with incineration of the waste streams prior to burial. The sensitivity runs involving incineration and disposal yielded realistic but somewhat conservative results. Because we do not yet fully understand the complex methodology of the code, we have less confidence in the results obtained when utilizing the incineration option.

Overall, the IMPACTS-PLUS interface is a potentially valuable tool to a waste manager. Utilities can use this system to easily and accurately evaluate the potential impacts of their waste disposal plans. It can be used, for example, to compare one disposal site with another, or one disposal method to another. Waste management personnel can determine the controlling parameters for disposal at their site, or at a local municipal facility. IMPACTS-PLUS may prove to be a great time, effort, and money saver for nuclear utilities who wish to use the program to analyze their low-level waste disposal problems.

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