

EXCOMP: AN EXPOSURE COMPARISON METHODOLOGY

J. C. Lavender
A. L. Franklin
Pacific Northwest Laboratory
Richland, Washington 99352

ABSTRACT

When designing new facilities or modifying existing facilities that involve radioactive material, handling or processing, an area of concern is the radiological exposure received by facility personnel and the environment. The computerized models that are currently used for exposure evaluations are capable of evaluating only one relationship at a time, i.e., the effects of one source, its strength and location, on one work location. EXCOMP, (EXposure COMParison) is a methodology developed for the IBM-PC to evaluate radiological exposures. It is capable of evaluating each identified work location in a facility with respect to each identified source effecting it.

INTRODUCTION

When designing new facilities or modifying existing facilities that involve radioactive material, handling or processing, an area of concern is the radiological exposure received by facility personnel and the environment. Therefore, designers and licensing agencies need a method to determine if the radiological exposures received by facility personnel or the environment, with respect to ALARA, have been considered when modifying existing and/or when designing new facilities.

The computerized models that are currently used for exposure evaluations are capable of evaluating only one relationship at a time, i.e., the effects of one source, its strength and location, on one work location. When evaluating a work location that is affected by many sources, the current practices can be time consuming and costly. Therefore, a need exists for a method that can be used to identify areas or processes within a facility where the potential for significant exposures exist.

A methodology to evaluate exposures (EXCOMP, EXposure COMParison) has been developed to meet this need. It is capable of evaluating each identified work location in a facility with respect to each identified source affecting it. EXCOMP simplifies exposure analysis procedures, reduces analysis time and costs, and makes analysis capabilities available to a wider range of potential users. EXCOMP is capable of performing an analysis based on a specific work location or on the complete facility, i.e., a floor by floor analysis and is primarily intended to be used to perform comparative analyses. EXCOMP is also capable of performing exposure analyses based on user defined job descriptions or personnel profiles. The personnel profile analysis projects the total daily and quarterly exposure a particular employee profile will receive.

EXCOMP can be used effectively by persons involved in operations or in the design of any radioactive materials facility. EXCOMP does not require the user to have programming skills, but presently the user will need some knowledge of using dBaseIII. In later versions of EXCOMP this requirement will be eliminated. The designer can use the results of the comparative analysis to specify facility modifications, i.e., increasing or decreasing shielding thickness, hence

reducing or increasing construction costs. Licensees can use EXCOMP to identify areas where ALARA considerations should be well documented. Facility management can use the personnel profile projections to aid in projecting staff requirements.

Methodology

The primary objective of EXCOMP is to provide the user a reasonable approximation of the anticipated exposure to be received by facility personnel and the environment, due to the handling and storage of radioactive materials. By developing information regarding personnel profiles, work locations and the time spent at those locations, long and short term exposure rates can be projected for a typical employee. These anticipated or projected exposure rates can then be used to perform comparative analyses of the facility design.

There are three components in EXCOMP (see Fig. 1). These consist of an Interpreter, Facility Description and Source Description. The Facility Description database is used to identify the target locations and the source locations. The source locations identify locations where radioactive materials can be found. This may include hot cells, decon stations, waste processing areas, and lag or field storage locations. The target locations are the locations that are normally occupied by facility personnel. These locations may not necessarily contain sources of radioactive materials. Also identified in this database is the distance in feet and the sum of the thicknesses of the barriers or walls separating the source from the target location.

The Source Description database is used to identify the source locations, the source type, and to characterize the source with respect to the barriers. The source location is the same source location used in the Facility database. The source type is used for two purposes, the first is to verify that the proper type of source is used for each location, and the second is to establish the quantity of material found at that location. The source strength is characterized and the attenuation value is identified. This value is based on the energy levels of each source type and represents the specific attenuation value for the barrier materials present in the facility.

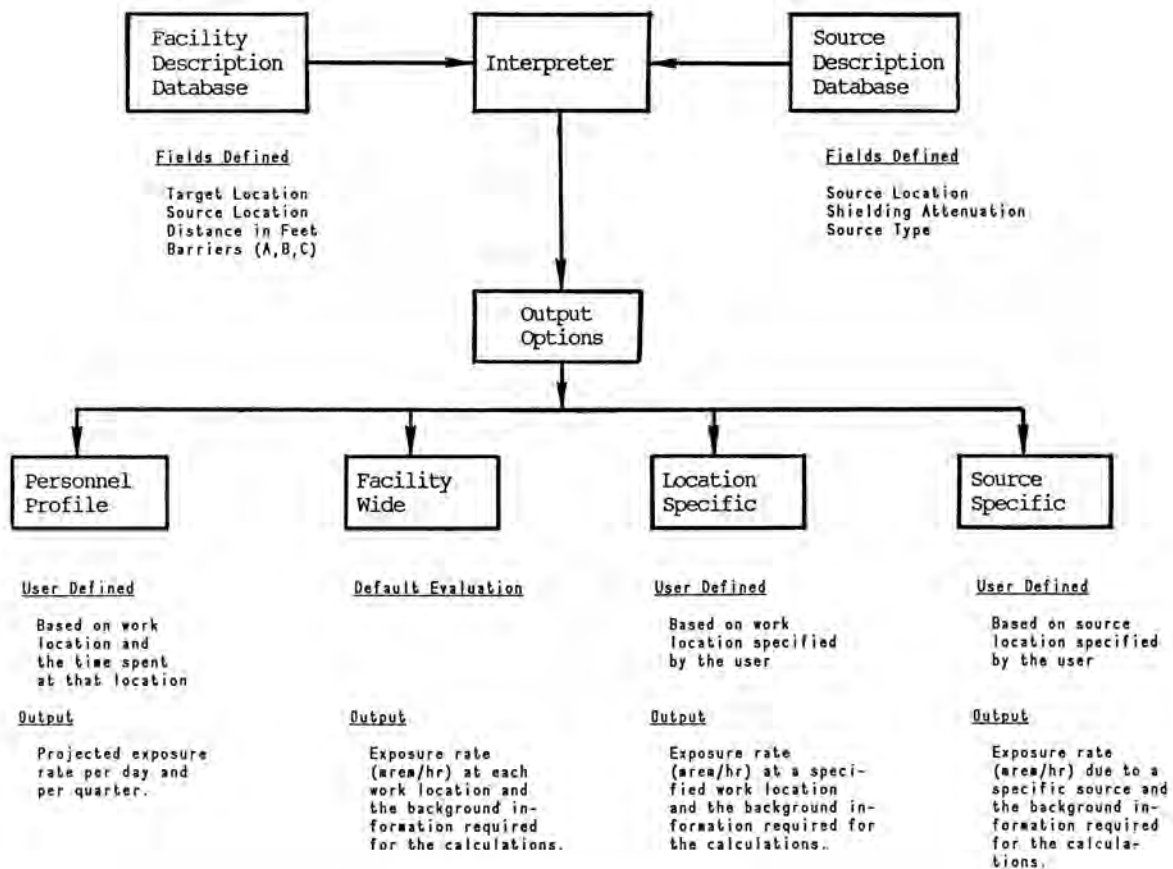


Fig. 1. Structure of EXCOMP

The Interpreter prompts the user for the type of analysis to be performed. As an example, if the user is evaluating the total facility or specific work locations the Interpreter module reads the facility database and identifies the first or specified target location. For each target location a number of source locations may be considered. When the first source location is identified for that target location, the Interpreter module searches the source database for that source location. Then using the information in the facility database, i.e. distance to the source, and the thickness of shielding encountered, a radiological exposure is calculated based on the attenuation value with respect to the shielding encountered and the distance the target location is from the source. This process is repeated until each target-to-source relationship has been evaluated.

Program Description

The Interpreter in EXCOMP is a computer program that interfaces with two databases and extracts the information required to perform an exposure analysis. Given a user specified work location, EXCOMP will search the source database until the source location(s) corresponding to the work location is found. The main program, referred to as the Interpreter, controls the database searches and calculates the exposure rates at various locations throughout the facility. When the source location has been found, the Interpreter calculates the exposure rate for that location. The calculations are based on the sources characteristics, the distance the source is from the work location and

the amount of shielding separating the source from the work location. The source is characterized based on the type of material, energy levels, quantity, and the attenuation of the shielding. The distances are input in feet as are the shielding thicknesses.

The user sets the parameters controlling the search, based on the option selected. The options available are a Total Facility Analysis, a Specific Work Location Analysis, a Specific Source Location Analysis, and a Particular Personnel Profile Analysis.

The method used to calculate the exposure rates for each of these options are basically the same. However, the Total Facility, Specific Work Location and Specific Source Location Analyses predict the exposure rate per hour to facility personnel, and the Personnel Profile option projects the exposure per day and sums these values, based on work locations, to project a quarterly exposure rate.

Output Options

There are four output options: Total Facility, Specific Work Locations, Specific Source Locations, and Personnel Profile. The Total Facility option is selected when performing the initial evaluation of the facility. The results of this evaluation are used as the base case of the comparative analysis and are also used to identify locations requiring further investigation or those locations with unacceptable exposure rates. The output from this evaluation (see Table I) identifies the target location (e.g. the room number),

the source location, the distance to the target, the total shielding thickness, the personnel exposure rate, and the type or form of the radioactive material.

The Specific Work Location option is used to examine the exposure potential of one work location. If this option is selected and no modifications have been made to the databases, the results will be identical to the results of the facility wide evaluation (see Table II). Therefore, this option should be selected when investigating a specific location to establish a base case for the comparative analysis or after modifying the facility database with respect to one or more work locations.

The Specific Source Location is used when the investigator wants to adjust the quantity of material at a particular source location. This option does not alter the original source database and is useful after performing a comparative analysis indicating that an increase in shielding or distance will not produce satisfactory exposure reductions. The user has the option to reduce or change the type or quantity of material found at that source location. The user also has the option to increase the weight or type of material found at that source location (see Table III).

The Personnel Profile option is used when the user wants to investigate the exposure received by a specific employee type, i.e., manipulator operator, office staff, etc. This analysis provides projected exposure rates for the daily and quarterly exposures received at each of the employees work locations (see Table IV.). These projected results are totaled to indicate the exposure rate an employee of a particular personnel profile will receive due to their movements throughout the facility.

Applications of EXCOMP

When using EXCOMP as a design or licensing tool, an initial evaluation of the total facility should be performed. This evaluation may identify areas with exposure rates that may warrant a more detailed analysis using other methods available to the analyst. If the primary objective is the evaluation of the exposure to a particular personnel type, the initial facility wide evaluation is optional. The initial Total Facility evaluation formulates a base case for the comparative analyses that are performed with each design change.

TABLE I

Total Facility Analysis: Sample Facility

USER: USER1 RUN ID:001
 FSAMPLE.DBF SSAMPLE.DBF
 THIS EVALUATES THE DOSE FACILITY WIDE

SOURCE LOCATION	DIST. TO TARGET (FT.)	SHIELDING THICKNESS (FT.)	CONTRIBUTION TO EXPOSURE (MREM/HR)	WASTE TYPE *	TOTAL
ROOM 1000					
1100	25	5	1.047462E-04	LRW	
1102	50	12.5	1.256736E-10	PWR	
1103	70	14.4	5.890321E-14	HLW	1.047464E-04 MREM/HR
ROOM 1001					
1100	30	6.4	5.406448E-07	LRW	
1102	62	13.1	2.874943E-11	PWR	
1103	65	23.2	3.082993E-22	HLW	5.406735E-07 MREM/HR
ROOM 1002					
1002	43	14.8	6.358628E-17	LRW	
1102	70	18.9	5.503419E-17	PWR	
1103	65	12.5	5.570963E-12	HLW	5.571082E-12 MREM/HR
ROOM 1003					
1100	50	15.8	6.038932E-18	LRW	
1102	78	24.7	2.345117E-22	PWR	
1103	65	12.5	5.570963E-12	HLW	5.570969E-12 MREM/HR
ROOM 1004					
1100	38	10.7	1.414696E-12	LRW	
1102	15	5	1.689005	PWR	
1103	20	5	6.137475E-02	HLW	1.75038 MREM/HR
ROOM 10051					
1100	10	2.5	2.752627	LRW	
1102	25	5	1.216084	PWR	
1103	40	13	2.29251E-12	HLW	3.968711 MREM/HR
ROOM 10052					
1100	33	9.399999	4.628471E-11	LRW	
1102	40	13.1	3.799585E-11	PWR	
1103	28	5	4.801426E-02	HLW	4.801426E-02 MREM/HR

*
 ARC--RECEIVED CASK
 BWR--ONE ASSEMBLY
 HLW--HIGH LEVEL WASTE

TRU--RECEIVED TRU
 CHE--CONTACT HANDLED
 LRW--LIQUID RAD WASTE
 EXPOSURE RATES <1E-35 ARE SHOWN AS 0.0

PWR--ONE ASSEMBLY
 RHE--REMOTE HANDLED
 SRW--SOLID RAD WASTE

TABLE II

Location Specific Analysis: Sample Facility

USER: USER1 R/N ID:002
 FSAMPLE.DBF SSAMPLE.DBF
 THIS CALCULATES THE EXPOSURE AT WORK LOCATION(S) (2)

SOURCE LOCATION	DIST. TO TARGET (FT.)	SHIELDING THICKNESS (FT.)	CONTRIBUTION TO EXPOSURE (MREM/HR)	WASTE TYPE *	TOTAL
ROOM 1000					
1100	25	5	1.047462E-04	LWR	
1102	60	12.5	1.256736E-10	PWR	
1103	70	14.4	5.890321E-14	HLW	1.047464E-04 MREM/HR
ROOM 10052					
1100	33	9.399999	4.628471E-11	LRW	
1102	40	13.1	3.799585E-11	PWR	
1103	28	5	4.801426E-02	HLW	4.801426E-02 MREM/HR

*

ARC--RECEIVED CASK
 BWR--ONE ASSEMBLY
 HLW--HIGH LEVEL WASTE

TRU--RECEIVED TRU
 CHE--CONTACT HANDLED
 LRW--LIQUID RAD WASTE
 EXPOSURE RATES <1E-35 ARE SHOWN AS 0.0

PWR--ONE ASSEMBLY
 RHE--REMOTE HANDLED
 SRW--SOLID RAD WASTE

TABLE III

Specific Source Location Analysis: Sample Facility
(Quantity of Material in 1102 Increased 2X)

USER: USER1 R/N ID:004
 FSAMPLE.DBF SSAMPLE.DBF
 THIS CALCULATES THE EXPOSURE DUE TO A SOURCE LOCATED IN 1102
 TYPE OF MATERIAL: PWR NEW WEIGHT: 924 KG.

TARGET LOCATION	DIST. TO TARGET (FT.)	SHIELDING THICKNESS (FT.)	CONTRIBUTION TO EXPOSURE (MREM/HR)	WASTE TYPE *
1000	60	12.5	2.513471E-10	PWR
1001	62	13.1	5.749886E-11	PWR
1002	70	18.9	1.100684E-16	PWR
1003	78	24.7	4.690235E-22	PWR
1004	15	5	3.378011	PWR
10051	25	5	2.432168	PWR
10052	40	13.1	7.59917E-11	PWR

*

ARC--RECEIVED CASK
 BWR--ONE ASSEMBLY
 HLW--HIGH LEVEL WASTE

TRU--RECEIVED TRU
 CHE--CONTACT HANDLED
 LRW--LIQUID RAD WASTE
 EXPOSURE RATES <1E-35 ARE SHOWN AS 0.0

PWR--ONE ASSEMBLY
 RHE--REMOTE HANDLED
 SRW--SOLID RAD WASTE

TABLE IV

Personnel Profile Analysis: Sample Facility

USER: USER1 R/N ID:003
 FSAMPLE.DBF SSAMPLE.DBF
 THIS SECTION EVALUATES THE EXPOSURE BASED ON A PERSONNEL PROFILE.

JOB TITLE: OPERATOR

LOCATION	HRS/DAY	MREM PER DAY	MREM PER QTR
10051	4	15.87484	952.4906
10052	4	1.92057	11.52342
TOTALS:		16.0669	964.0141

Design Application

Following the creation of the facility and the source databases, an initial evaluation is made of the total facility. The results of this evaluation are analyzed to determine if the exposure levels are acceptable, i.e., less than or equal to DOE requirements, at each work location. If the exposure rates are unacceptable in easily identified work locations the designer can perform the Specific Work Location analysis, thereby reducing the length of computer processing time. However, if the exposure rates are high throughout the facility the designer should re-evaluate and/or modify the facility and perform a new analysis of the total facility.

Licensing Review Application

The licensing criteria for any facility are not based entirely on the exposure rates to the facility personnel or the public. However, exposure is a consideration in granting an application for a license for a facility that handles radioactive materials. EXCOMP is a tool that could be used to examine the exposure rates from a licensing agent's perspective. If the licensing agent is unfamiliar with the exposure potential of a facility design, a facility wide analysis using EXCOMP can be performed to suggest areas that may be of interest and warrant detailed examinations.

Personnel Application

Management can use EXCOMP to determine personnel needs throughout the facility based on an employee's work location or the time an employee is at a specific work location. The personnel profile analysis requires the investigator to identify a personnel type and the average hours per day an employee will be at a specific work location. The personnel profile analysis will project the daily and quarterly exposures received for each personnel type investigated. Using these projections, management can determine the personnel requirements and assignments to operate the facility within the required exposure limits. When evaluating the results derived from an EXCOMP analysis, management can identify specific work locations where high exposures are expected. With this information, management can perform a location specific analysis to confirm the results or request design changes to reduce personnel requirements.

Although each type of analysis will use the same database the results required by each are different. Designers can use EXCOMP to substantiate the proposed facility design or recommend or initiate design changes. Licensing Agents can use EXCOMP to evaluate the

exposures to facility personnel and the public to determine if the criteria regarding exposure limits have been satisfied. If limits have not been satisfied, design recommendations, based on EXCOMP results, can be forwarded to the designer. Management can use EXCOMP to predict personnel specific exposures and can also provide the designer with the information necessary to initiate design changes to reduce personnel requirements.

Comparative Analyses

Each of these applications can use EXCOMP to perform a comparative analysis. When performing a comparative analysis it is important that only those elements that the user wants to modify be changed. EXCOMP operates on this basic principle if the proposed change is a facility modification, the characteristics and assumptions used to describe the source are not changed.

The comparative analysis can be used by the designer and management prior to changing the facility design or operation. As each investigator determines some change is appropriate a new EXCOMP analysis can be performed. The results from these analyses can be compared to the first or original analysis to determine the changes in exposure rates. These analyses, prior to facility construction, can allow for reducing the costs involved when an existing facility has to be modified or when new personnel are required to operate the facility.

SUMMARY

The primary objective of EXCOMP is to provide the user a reasonable approximation of the anticipated exposure to be received by facility personnel and the environment, due to the handling and storage of radioactive materials. EXCOMP can be used effectively by persons involved in operations or in the design of any radioactive materials facility. EXCOMP does not require the user to have programming skills, but presently the user will need some working knowledge of dBaseIII. The designer can use the results of the comparative analysis to specify facility modifications, hence reducing or increasing construction costs. Licensees can use EXCOMP to identify areas where ALARA considerations should be well documented. Facility management can use the personnel profile projections to aid in projecting staff requirements. Furthermore, decisions to restrict employee movements throughout the facility, or to modify operations and personnel requirements in areas with significant exposure potential, can be made on a more informed basis.