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**HAZARDOUS MATERIAL LIFE-CYCLE COST MODEL**

**SYSTEM MANAGER'S GUIDE**

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BETHESDA, MARYLAND**



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# **Hazardous Material Life-Cycle Cost Model**

## **System Manager's Guide**

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## Summary

The Hazardous Material Life-Cycle Cost (HMLCC) Model was developed to estimate the total life-cycle costs of using various hazardous materials in the construction, maintenance, and repair of U.S. Naval systems and facilities. The model estimates those costs derived from the need to protect the health and safety of workplace personnel and the need to protect the environment. The purpose of this guide is to provide the system manager detailed instructions on how the HMLCC model operates and how to provide the model with cost information.

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# Table of Contents

		<b>Page</b>
<b>Preface</b>	<b>Summary</b>	i
	<b>Table of Contents</b>	ii
<b>Section 1</b>	<b>Introduction</b>	
	1.1 Purpose of the Model	1
	1.2 Background	1
	1.3 The Model	3
<b>Section 2</b>	<b>Setting Parameters</b>	
	2.1 Accessing the "Set Parameters" Option	7
	2.2 Materials	7
	2.3 Life-cycle Phase	8
	2.4 Process	9
	2.5 Exposure Type	9
	2.6 Cost Factors	10
	2.7 Cost Factor Elements	11
	2.8 Cost Factor Element Items	11
	2.9 Build Hazmat Table	12
	2.10 References	15
<b>Section 3</b>	<b>Appendixes</b>	
	A Summary of Environmental Health Laws and Regulations	17
	B Summary of Navy Environmental Health Policies	18
	C Cost Sources	19
	D Hazardous Waste Disposal Flow Chart	20
	E Life-cycle Phases	21
	F Definitions of Cost Factors	22
<b>Section 4</b>	<b>Glossary of Acronyms</b>	24

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# Section 1 Introduction

## 1.1 Purpose of the Model

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Hazardous materials are frequently required in the construction, maintenance, and repair of U.S. Navy platforms, systems, equipment, and facilities. Because of the need to protect individuals' health and the environment from these hazardous materials, actions are taken which lead to costs beyond their initial purchase price. To limit these additional costs, the Navy has implemented vigorous programs to minimize use of hazardous materials and the risks they impose on the worker and the environment.

## 1.2 Background

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It has been estimated that the U.S. Military generates more than 500,000 tons of hazardous waste each year. [1] It is difficult, however, to provide an accurate estimate of the military's annual waste generation, partially because the definitions for hazardous waste are multiple and variable. Because hazardous materials become hazardous waste, some definitions refer to hazardous waste and some definitions refer to hazardous materials. The Conservation and Recovery Act (RCRA) of 1976, an environmental health law regulating generation and disposal of hazardous waste, broadly defines hazardous waste as, "Any substance that causes or contributes to an increase in mortality or an increase in illness or poses a present or potential hazard to human or environmental health." [2] The U.S. Department of Transportation (DOT) defines hazardous materials as, "Chemicals which are determined by the Secretary of Transportation to present risks to safety, health, and property during transportation." [3] While the Navy defines hazardous materials/waste as, "Any substance that may pose a substantial hazard to human health or the environment when purposely released or accidentally spilled." [4]

In the last 30 years over 50 laws, statutes, and regulations, which pertain to the use and disposal of hazardous materials, have been enacted to protect our health and the environment. The Federal regulations which have provided the most impact in protecting our health and environment, are summarized in Appendix A. The RCRA and the Pollution Prevention Act, in particular, are laws which directly regulate the generation of hazardous waste. These Acts require waste generators to reduce the volume of hazardous waste they produce. The RCRA mandates waste generators to establish plans to meet these goals. In addition to these acts, the National Environmental Policy act of 1969 was passed to regulate the procurement of hazardous materials. It states that all Federal agencies must consider environmental effects when implementing or purchasing new products. They must also to prepare detailed statements describing considerations that affected their final decision. [5]

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Because the Navy is a major waste generator and consumer of hazardous materials, many Navy and Department of Defense (DOD) Directives have been written to instruct Navy commands on the implementation of these Federal laws (See Appendix B). In one policy [6], the Chief of Naval Operations (CNO) delineated the Navy's goals to minimize the use of hazardous materials. The policy states that decisions concerning reduction of hazardous waste should be made only after evaluating all hidden cost factors (any costs which go beyond the procurement cost) associated with the hazardous material. Reduction must be based on economic or environmental factors. The main focus of this policy was to meet the requirements of RCRA and the Pollution Prevention Act. In two other Navy instructions [7,8], the CNO establishes requirements for selecting hazardous materials. These policies state that less hazardous materials should be used whenever possible. In 1987, the CNO instructed Navy commands to reduce the amount of hazardous waste 50 percent by December, 1992, from the levels present in 1987. [9] The Navy's long term goal is to reduce the generation of hazardous waste to the maximum extent possible by eliminating hazardous materials or substituting less toxic substances for hazardous materials, or by implementing management control practices and up to date technology.

It is difficult, considering the variety of cost factors as well as the different laws and policies, for the Navy to make economically accurate, as well as environmentally sound decisions when purchasing a hazardous material. Estimation of the total life-cycle cost resulting from the use of a hazardous material involves the accumulation of the projected costs incurred because of measures taken to protect the health of employees and to preserve the environment. Although these costs cover activities such as the expense of medical treatment and the clean-up conducted after a hazardous material spill, these costs are only a portion of the total cost. Total life-cycle cost also includes those actions taken to avert personal and environmental exposures. Therefore, factors such as the engineering controls designed to contain the material, training provided employees, and disposal costs must be included. When determining costs for the hazardous material disposal factor, costs associated with elements (as depicted in Appendix D) must be ascertained. The disposal factor is related to other cost factors, so care must be taken to assign these costs to only one factor. For example, cost of storage must not be assigned to both the storage factor and the disposal factor.

Total life-cycle costs must also account for the chain of events that may unfold during different life-cycle phases. For example, the cost of painting a surface with a lead based paint should include the cost of removing the paint during repair or maintenance operations, as well as the cost of applying the paint. Finally, determination of the life-cycle cost resulting from the use of a hazardous material requires that the circumstances surrounding the use of the material be specified.

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To better ascertain the costs associated with the use of hazardous materials and to estimate the potential savings that would be accomplished by eliminating them, a prototype Hazardous Materials Life-Cycle Cost HMLCC Model was developed. The objective of this model is to quantify for a specific process, using a specific hazardous material, the total costs incurred to prevent personal or environmental exposures or to recover from such exposures. The following section describes this model.

### **1.3 The Model**

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Formulation of the Hazardous Material Life-Cycle Cost Model starts with the concept of life-cycle phases. These phases identify evolution levels in the development of a product, platform, or system. The model includes five phases: 1) research and development, 2) acquisition, 3) construction, 4) maintenance/repair, and 5) final disposition. Definitions of these phases are provided in Appendix E.

At a particular life-cycle phase a product may be associated with one or more processes. For example, during the construction phase, lead may be used for ballast or it may be present in the paint applied to a ship's hull. Clearly, the precautions to be taken, and therefore, the costs associated with a hazardous material, depends upon the process involved.

The model also includes three different exposure states: 1) no exposure, 2) personal exposure (the people involved are exposed over the Personal Exposure Limit (PEL)), and 3) environmental exposure (unacceptable amounts of a hazardous material escape the confinements of the facility). For each exposure state, for each material, at each phase, for each process, a probability of occurrence is assigned. Because "no exposure" is a base-state, it will always be assigned a probability of 1.0. The probabilities of personal exposure or environmental exposure are typically small values which are multiplied times the cost of activities taken to protect individuals health and to preserve the environment to obtain expected values for those events.

The computation of the cost for activities taken at each exposure level is approached by first grouping them into cost factors. These factors include claims and compensation, disposal, engineering controls, fines and penalties, medical surveillance, medical treatment, permits and certification, personal protective equipment, procurement, spill containment and cleanup, storage, training, and workplace monitoring. Definitions of these factors are provided in Appendix F. For each of these factors, a list of cost elements are specified. For example, the cost elements for the personal protective equipment factor include such things as gloves, boots, and aprons. When these cost elements are specified, a determination is made regarding parameters that affect the cost element. Thus, for each cost element there is an indication whether it varies according to the number

of people involved in a operation, the number of days required, and/or the quantity of material used. Finally, at least one item is linked to each cost element. These items are the specific products that are acquired to conduct the activities taken to avert exposure. For example, for the cost element "gloves", there may three different brands available - consequently, there would be three items. The model requires each of these items to be identified, and the cost for each must be specified in terms of the parameters set for the element. For instance, if the cost of gloves is related to the number of people and number of days involved in the operation, then the glove cost is expressed as the dollar value per person per day. When multiple items are specified for an element, a probability of use for each one must be specified.

Once item costs are specified, a scenario must be defined before life-cycle costs can be computed. A scenario consists of one or more steps, where each step specifies a material, phase, process, number of people involved, the duration of the task, and quantity of material. After the item costs are specified and a scenario is defined, the life-cycle cost for a hazardous material is determined for each step separately. This is accomplished by first deriving a cost for each element. This cost is computed as the weighted average of the individual item costs as follows:

let  $A_i$  = the cost of the  $i^{\text{th}}$  item of an element.

$P_i$  = the probability that the  $i^{\text{th}}$  item will be used

$I$  = the number items

then, the weighted average ( $AW$ ) is computed is follows:

$$AW = \sum_{i=1}^I A_i P_i$$

These weighted item costs are then multiplied by the relevant parameters to form factor costs ( $F$ ) as follows:

let,

- $J$  = the number of element
- $K$  = the number of factors
- $AW_{jk}$  = the weighted cost of the  $j^{\text{th}}$  element on factor  $k$
- $N$  = the number of people
- $D$  = the number of days
- $Q$  = the quantity of material

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$X_{1j} =$  the relevance of the number of people for element  $j$ , where yes = 1 and no =  $1/N$

$X_{2j} =$  the relevance of the number of days for element  $j$ , where yes = 1 and no =  $1/D$

$X_{3j} =$  the relevance of the quantity of material for element  $j$ , where yes = 1 and no =  $1/Q$

$$\text{Then, } F_k = \sum_{j=1}^J [(Aw_{jk})(N \cdot X_{1j})(D \cdot X_{2j})(Q \cdot X_{3j})]$$

is the total cost of factor  $k$  at a particular exposure state. Summing these costs for each state, multiplying each total by the exposure state probability, and adding the results for the three states yields the life-cycle cost for one step.

Let  $L =$  the number of exposure states (i.e., three)

$M =$  the number of steps in a scenario

$E_l =$  the probability of the  $l^{\text{th}}$  exposure state and

$C_m =$  the cost of step  $m$

$$C_m = \sum_{l=1}^L E_l \sum_{k=1}^K F_k$$

Finally, the total life-cycle cost ( $T$ ) for a hazardous material used according to a given scenario is:

$$T = \sum_{m=1}^M C_m$$

In addition, to the calculation of the total life-cycle cost of a hazardous material, the capability to conduct a bootstrap analysis has been developed. This capability was included because life-cycle costs will vary depending upon the item actually

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used for each cost element. By conducting a bootstrap analysis, then, one can ascertain the variance of the total-life cycle cost values that would occur because of the different choices that could be made for the various cost element. The bootstrap technique [10] is implemented by randomly selecting items for each cost element instead of using the weighted average (AW). For each element a random number is generated and is used to select one of the possible items for the element. These selections are made so that each item is selected in proportion to the individual item probabilities ( $P_i$ ). Once an item has been selected for each cost element a total cost ( $T^*$ ) is obtained. To be able to estimate the variance many iterations must be performed. After  $R$  iterations are conducted a mean and standard deviation are computed as follows:

let,  $\bar{T}$  = the mean life-cycle cost  
 $S$  = the standard deviation of  $T^*$

then  $\bar{T} = \frac{1}{R} \sum_{r=1}^R T_r^*$

$$S = [ \frac{1}{R-1} \sum (T_r^* - \bar{T})^2 ]^{1/2}$$

In this analysis  $\bar{T}$  should approximate the value  $T$  obtained in the cost analysis using the AW values.

A difference between the  $\bar{T}$  and  $T$  values would suggest that the value of  $R$  is too small and should be increased. Generally, an  $R$  value of 200 should be sufficient.

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## Section 2 Setting Parameters

The following section provides information necessary for the system manager to set the parameters of the Hazardous Material Life-Cycle Cost Model using the Primary System Manager Options. There are nine Primary System Manager Options:

1. Materials
2. Life Cycle Phase
3. Process
4. Exposure Type
5. Cost Factors
6. Cost Factor Elements
7. Cost Factor Element Items
8. Build HAZMAT Table

### 2.1 Accessing the "Set Parameters" option

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1. The system manager must first boot up the system as described in the Users Guide. At the "ENTER PASSWORD" prompt, type "SYSHAZ". This will allow access to the "Set Parameters" option.
2. After typing in the password, press "enter" or <CR>. The "Desktop" menu bar will appear on the screen.
3. Next, type "S" while holding down the "Alt" key. A new set of options will appear on the screen.
4. Choose "HMLCCM" by typing "H". A new set of options will appear on the screen.
5. Choose "Set Parameters" by typing "S". The Primary System Manager Options will appear on the screen.

### 2.2 Materials

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This option allows the system manager to add new materials and reference information about the materials to the system.

1. Choose "Materials" from the list of Primary System Manager

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Options by typing "M". A new menu will appear on the screen entitled "Hazardous Materials". This menu allows the system manager to add information about new hazardous materials to the system or to edit information about hazardous materials that are already in the system.

2. To add information about a new hazardous material, press <CR>. The cursor will move to the "Name" prompt.
3. Type in the name of the hazardous material and press <CR>. The option "Synonym/Trade Names" will be highlighted.
4. Press <CR>. A window for typing in free text will appear.
5. Type in as much information as necessary. When you have finished entering the text, press "Tab" while holding down the "Ctrl" key. The text is now filed in the system and the Hazardous Materials main menu will appear again. The option "Common Uses" will be highlighted.
6. Press <CR> to enter information into that section or move the cursor to another section that you may wish to edit.
7. When you are finished entering all information about a material, you may save it by pressing the "Tab" key while holding down the "Alt" key until the <Save> prompt on the right side is highlighted.
8. Press <CR> and the information will be filed.
9. When you wish to exit the "Materials" section, move the cursor to the <Exit> option on the right side and press <CR>. You will be returned to the Primary System Manager Options list.

### **2.3 Life-cycle Phase**

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This option allows new Life-cycle Phases to be identified and entered into the system.

1. Choose "Life Cycle Phase" from the Primary System Manager Options list by typing "L". A new menu will appear on the screen entitled "HM Life Cycle Phases". The option <Add> will be highlighted.
2. Press <CR>. The cursor will move to "Phase Name". Enter the

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name of the life cycle phase and press <CR>. The cursor will move to the <Save> prompt.

3. Press <CR> and the new Life Cycle Phase will be filed. To cancel, move the cursor to <Cancel> and press <CR>.
4. To exit this Primary Option move the cursor to the <Exit> option on the right side and press <CR>. This will return you to the Primary System Manager Options list.

## **2.4 Process**

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This option allows the system manager to add new processes to the system.

1. Choose "Process" from the list of Primary System Manager Options by typing "P". A new menu will appear on the screen entitled "HM PROCESSES". This menu allows the system manager to add new processes to the process table.
2. Type <CR>. A window for free text will open up next to the "process" prompt. The <Save> prompt on the bottom will be highlighted.
3. Press the "Tab" key while holding down the "Shift" key. The cursor will appear in the window for open text.
4. Type in a brief description of a process you wish to add to the "Process Table". When you have finished typing in the text, press <CR>. The <Save> prompt at the bottom will be highlighted.
5. Press <CR> to file the information.
6. To exit Process Options, move the cursor to the <Exit> prompt on the right and press <CR>.

## **2.5 Exposure Type**

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This option allows the system manager to add new Exposure Types to the system.

1. Choose "Exposure Type" from the Primary Systems Manager Options list by typing "X". A new menu will appear on the screen entitled "Exposure Type". The option <Add> will be highlighted.
2. Press <CR>. The cursor will move to "Exposure Type". Enter the

---

name of the exposure type and press <CR>. The cursor will move to the <Save> prompt.

3. Press <CR> and the new Exposure Type name will be filed. To cancel an entry before you file it, move the cursor to <Cancel> and press <CR>.
4. To exit this Primary System Manager Option, move the cursor to the <Exit> option on the right side and press <CR>. This action will return you to the main menu.

## 2.6 Cost Factors

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The cost data necessary for the life-cycle cost model to function is organized in a three-level hierarchical structure. The top level variables are **Cost Factors**. Some examples of these are Personal Protective Equipment, Medical Surveillance, and Workplace Monitoring. The next level variables are **Cost Elements**. **Cost Elements**, when grouped together form a **Cost Factor**. For example, the **Cost Factor** labeled **Personal Protective Equipment** contains **Cost Elements** such as gloves, respirators, and safety glasses. Finally, **Cost Elements** are made up of specific **Cost Items**. For example, the **Cost Element** labeled "gloves" might contain **Cost Items** such as gloves manufactured by ACME Glove Company costing \$.30 per person per day, gloves manufactured by Dow for \$.50 per person per day, and gloves manufactured by WearGuard for \$1.00 per person per day. The **Cost Items** are the most specific of the variables and contain the actual dollar amounts that are entered into the system for calculating total life-cycle costs of using a specific hazardous material. The dollar amounts must be specified per logical unit of measurement. For example, disposal costs would be specified per gallon while gloves would be specified per person per day as illustrated above.

The system manager sets parameters for the system by first entering cost factors. Then, for each cost factor, the manager enters the cost elements that apply to that cost factor, and finally, for each cost element, the cost items and their actual costs per unit of measurement (e.g., per person per day, or per gallon).

1. Choose "Cost Factors" by typing "F". A new screen will appear entitled "Cost Factors". There are five options listed on the right side of the screen.
2. Move the cursor to <Add> and choose that option by pressing <CR>. The space labeled "Cost Factor" will be highlighted.
3. Type in the name of the cost factor you are adding to the system. Press <CR>. The "Save" prompt at the bottom of the screen will

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be highlighted.

4. Press <CR> again. The new Cost Factor is now added to the system. To exit this menu move the cursor to <Exit> on the right side of the screen and press <CR>.

## **2.7 Cost Factor Elements**

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This option allows Cost Elements to be linked to Cost Factors.

1. Repeat the same steps described above but select "Cost Factor Elements" by typing "E" at the third menu option list that is presented. A new screen will appear entitled "Cost Factor Elements".
2. Move the cursor to <Add> on the list of options to the right of the screen. Press <CR>. The space for Cost Factor Element will be highlighted.
3. Type "?" to get a list of the existing Cost Factor table.
4. Move the cursor to the Factor you wish to add an Element to and press <CR>. The cursor will move to "Element".
5. Type in the name of the new Cost Factor Element that you are adding to the system. Press <CR>. The <Save> option at the bottom of the screen will be highlighted.
6. Press <CR>. The new Cost Factor Element is now added to the system.
7. To exit this module, move the cursor to the <Exit> option on the right side of the screen and press <CR>.

## **2.8 Cost Factor Element Items**

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This option allows Cost Items to be linked to Cost Elements.

1. Select "Cost Factor Element Items" by typing "I" from the Primary System Manger Options list.
2. The <Add> option will be highlighted. Press <CR>, then Tab

- 
- twice. The cursor will now be on "Factor".
3. Enter "?" then <CR>. The existing table of Factors will be listed. Move the cursor to your choice and press return. The cursor will now be located on "Element".
  4. Enter "?" and press <CR> for the list of "Elements". Move the cursor to your choice and press <CR>. The cursor will now be on "Item".
  5. Type in the name of the Cost Factor Element Item you wish to add to the table and press <CR>. The cursor will move to "Cost".
  6. Enter the cost of the Cost Factor Element Item in dollars and cents per logical unit of measurement as explained at the beginning of Section VI above. Press <CR>. The <Save> prompt will be highlighted. Press <CR>. The Item has now been added to the table.
  7. To exit, move the cursor to <Exit> and press <CR>.

## **2.9 Build Hazmat Table**

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This option is used to specify the relevant Cost Factors and Cost Elements for a material used in a Process at a specific Life-cycle Phase. These procedures will recognize only combinations of Materials, Processes, and Life-cycle Phases that have been previously defined.

1. Choose "Build HAZMAT Table" from the Primary System Manager Options list by typing "B".
2. A new menu will appear with the cursor at the prompt labeled "Material". Enter the name of a hazardous material or enter "?" for a list of materials already in the system. Move the cursor to the material you wish to select and press <Enter>. The name of the material will be displayed in the blank.
3. The <OK> prompt at the bottom of the window will be highlighted. Press <CR> to accept the material. If you change your mind, move the cursor to <Cancel> and press <CR>.
4. The next menu is entitled "Hazardous Materials Table". The <Add> prompt will be highlighted. Press <CR>. The cursor will

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move to the "Phase" prompt.

5. Type "?", then press <CR>. A list of "Life Cycle Phases" will appear on the screen. Move the cursor to the one you wish to select and press <CR>. The cursor will move to "Process".
6. Enter a "?" to see a list of choices or type in a new process. Press <CR> to file your choice. The cursor will move to "Exposure Type".
7. Type "?", then press <CR>. A list of "exposure Types" will appear on the screen. Move the cursor to the one you wish to select and press <CR>. The cursor will move to "Probability of Exposure".
8. Enter "1" for "No Exposure" or a number between .01 and .99 for "Personal" or "Environmental" exposures. Press <CR>. The cursor will move to "Factor".
9. Enter a "?" to see list of choices. Select a "Cost Factor" by moving the cursor to your choice and pressing <CR>. The factor name will appear in the blank space.
10. Press <CR>. A window will pop up with two columns labeled "Factors" and "Elements". Move the cursor to till the "Element" you wish to select is highlighted and press <CR>.
11. A new window will pop up with two columns labeled "Elements" and "Items". Move the cursor till the "Item" you wish to select is highlighted and press the "Esc" key. The cursor will move to "Cost".
12. Enter "Cost" and press <CR>. The cursor will move to "Probability". Enter the probability that the Cost Factor Element Item you have defined will be used in this process. This must be a number between .01 and 1.00. The probabilities of all the Cost Factor Element Items for this particular Element must add up to 1.00. Press <CR>.
13. Finally, you must enter the units of measurement for the Cost you have provided to the system. For example, if you provided the cost of a certain type of work glove as an item, its cost would have been calculated as the cost of the gloves per person per day. To accomplish this, you would move the cursor to the "Yes" choice for "By Person" and press <CR>. Next, you would move the cursor to the "Yes" choice for "By Day" and press <CR>. Finally,

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you would move the cursor to the "No" choice for "By Quantity" and press <CR>. The cursor will move to the <Save> option on the side panel.

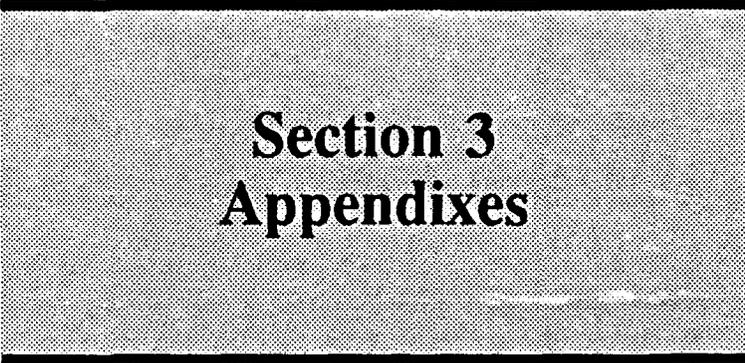
14. Press <CR> to file this table in the system.
15. To exit, move the cursor to the <Exit> option on the side panel and press <CR>.

---

## References

1. Guide to the management of hazardous materials and waste (1989). Rockville, MD: The Defense Reutilization and Marketing Service.
2. Sullivan, J. B. & Krieger (1992). Introduction to hazardous materials toxicology. In Sullivan, J. B. & Krieger, G. R. (Eds.), *Hazardous materials Toxicology: Clinical principles of environmental health*. (pp 5) Baltimore: Williams & Wilkins.
3. NEESA (1990) Commanding Officer's Guide to Environmental Compliance. Naval Energy and Environmental Support Activity.
4. OPNAVINST (1989, June). *Hazardous Material Control and Management* (Report No. 4110.2). Washington, D.C.: Department of the Navy, Office of the Chief of Naval Operations.
5. NEESA (1990) Navy Commanding Officer's Guide to Environmental Compliance. Naval Energy and Environmental Support Activity.
6. OPNAVINST (1989, June). *Hazardous Material Control and Management* (Report No. 4110.2). Washington, D.C.: Department of the Navy, Office of the Chief of Naval Operations.
7. OPNAVINST (1990, October). *Environmental and Natural Resources Program Manual*. (Report No. 5090.1A Section 9-5.9). Washington, D.C.: Department of the Navy, Office of the Chief of Naval Operations.
8. OPNAVINST (1990). *Navy System Safety Program*. (Report No. 5100 24A). Washington, D.C.: Department of the Navy, Office of the Chief of Naval Operations.
9. OPNAVINST (1990, October). *Environmental and Natural Resources Program Manual*. (Report No. 5090.1A Section 9-5.9.2). Washington, D.C.: Department of the Navy, Office of the Chief of Naval Operations.
10. Efron, B. Bootstrap Methods: Another look at the jackknife. *The Annals of statistics*, 1979, 7, 1-26.

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## **Section 3 Appendixes**

1. **Summary of Environmental Health Laws and Regulations**
2. **Summary of Navy Environmental Health policies**
3. **Cost Sources**
4. **Hazardous Waste Disposal Flow Chart**
5. **Life-cycle Phases**
6. **Definitions of Cost Factors**

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# Appendix A

## Summary of Environmental Health laws and Regulations

<i>Legislation</i>	<i>Administering Agency</i>	<i>Description</i>
Toxic Substances Control Act (TSCA) 1976.	EPA	Regulates hazardous chemicals currently in use and evaluates the safety of new chemicals entering the market. If a chemical is determined unsafe the EPA will prohibit the use of it.
Resource Conservation and Recovery Act (RCRA) 1976.	EPA	Regulates the generation and disposal of hazardous waste. It states that generators must record waste products and are liable for the proper transport, storage, treatment, and disposal of these wastes. Waste generators must also establish plans to reduce the hazardous waste they produce.
Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) 1980.	EPA	Regulates the cleanup of hazardous waste sites. The Act created a fund to pay for the cleanup of hazardous substances that pose a health risk to the individual and the environment.
Pollution Prevention Act 1990	EPA	Directed at the reduction or prevention of pollution. It states that waste generators must work towards reducing pollution by using the newest technology available. For example recycling and treating the waste.
National Environmental Policy Act 1969	EPA	Directs all Federal agencies to give predecisional considerations to environmental effects when implementing something new.
Occupational Safety and Health Act 1970.	OSHA, NIOSH	Regulates toxic chemicals used in the workplace and directs employers in reducing hazards in the workplace by implementing new or improved safety and health programs.

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## Appendix B

### Summary of Navy Environmental Health policies

<i>Title</i>	<i>Reference</i>	<i>Description</i>
Hazardous Material Pollution Prevention	DoDD 4210.15	Requires substitution of less hazardous material and establishes pollution prevention, rather than control, as the primary focus of effort.
System Safety, Health Hazards, and Environmental Impact	DoDI 5000.2	Requires hazard assessments using criteria based on MIL-STD-882B and approval at levels above System Acquisition Program Managers for risks categorized as "High" and "Serious."
Environmental and Natural Resources Program Manual.	OPNAVINST 5090.1A	Discuss requirements for compliance with all codes, standards, and regulations concerning the environment.
Hazard Communication Program (HAZCOM)	DoDI 6050.5	Establishes policy, responsibilities, and procedures for a comprehensive Hazard Communication Program. The HAZCOM program ensures that DoD Personnel are aware of potential health hazards associated with their occupation, are informed of safe work practices and proper use of engineering controls and are trained in the use of personal protective equipment.
Hazardous Material Control and Management (HMC&M)	OPNAVINST 4110.2	Establishes Navy policy and assigns actions to control HM and reduce HW throughout system life cycles. the instruction requires the substitution of less HM and the performance of risk and economic analyses of HM. Furthermore, it requires that HMC&M be incorporated into weapon system
Navy System Safety Program	OPNAVINST 5100.24A	Establishes requirements for the evaluation of hazards and selection of less hazardous items, where feasible.

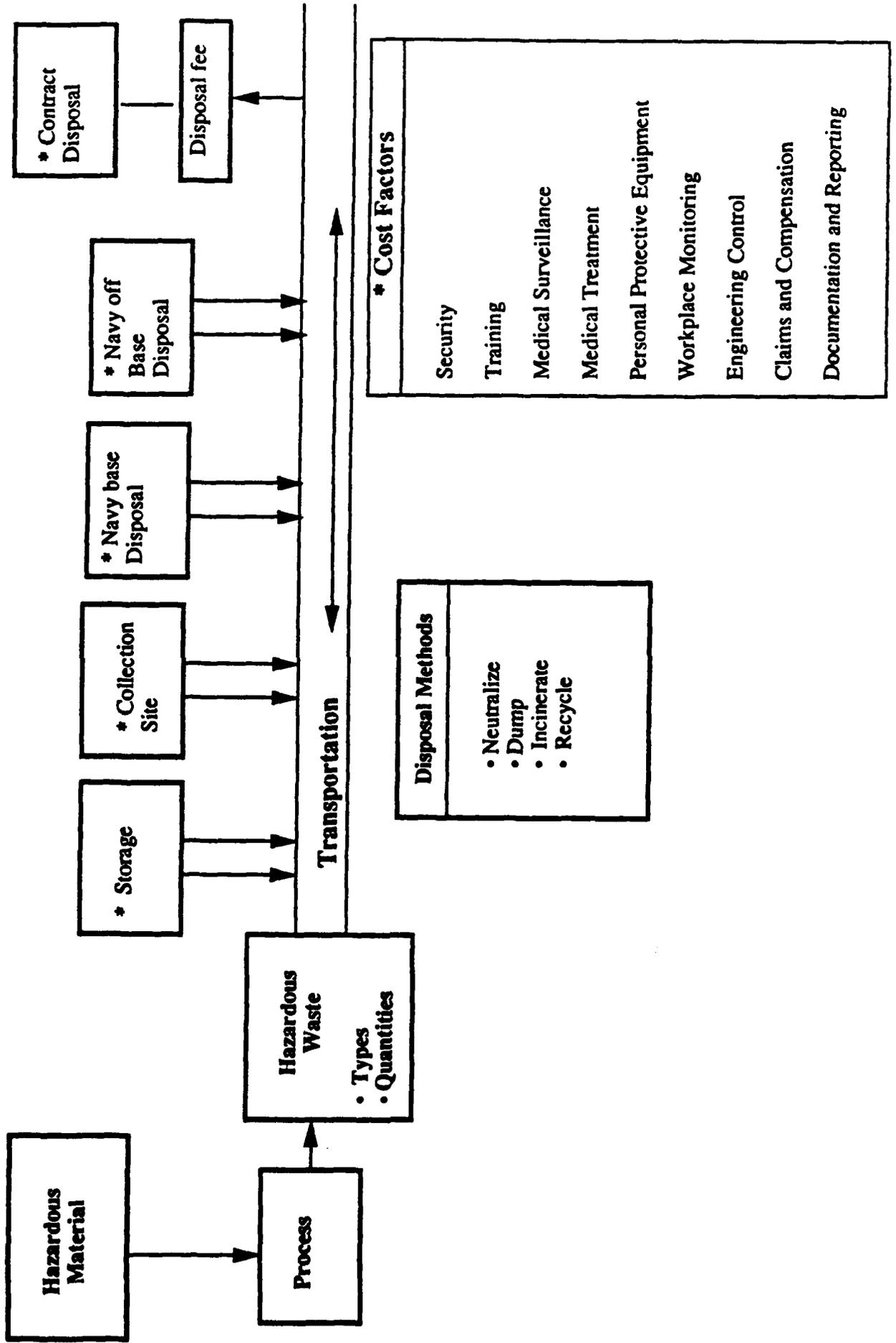
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# Appendix C

## Cost Sources

<i>Description</i>	<i>Source</i>
Cost of Material	Hazardous Material Department
Cost associated with transporting hazardous materials/waste	Hazardous Materials Department
Cost of storing and securing hazardous materials/waste	Hazardous Materials Department
Cost of disposing hazardous waste	Environmental Planning and Compliance Department
Cost of medical surveillance	Medical Surveillance Procedures Manual and Medical costs paid by San Diego County to private health care facilities.
Cost of personal protective equipment	Industrial safety equipment catalogue
Cost associated with claims and compensation	Office of Personnel Management and Department of Labor
Cost of monitoring the workplace	Industrial Hygiene Department.
Cost of engineering controls	Industrial Hygiene Department/Environmental Planning and Compliance Department
Cost of spill Containment	Environmental Planning and Compliance Department
Cost of Permits that allow facilities to use the material.	Environmental Planning and Compliance Department
Cost of EPA fines	Environmental Planning and Compliance Department

# Appendix D Hazardous Waste Disposal Flow Chart



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# Appendix E

## Life-cycle Phases

<b>Design/R &amp; D</b>	Developing the specifications for a planned system.
<b>Acquisition/Procurement</b>	Activities associated with obtaining a product or substance for a system, including contracting, purchase, and receiving the material, or the process of acquiring the system itself.
<b>Construction</b>	The initial assemblage of the system.
<b>Maintenance/Repair</b>	Routine upkeep, damage repair, refurbishing, and remodeling conducted to maintain or extend the life of the system.
<b>Final Disposition</b>	The methods by which a system is recovered from the Navy's inventory.

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# Appendix F

## Definitions of Cost Factors

<b>Claims and Compensation</b>	Processing claims, monitoring cases, conducting interventions to resolve problems, assessment of liability, and providing appropriate payment.
<b>Disposal</b>	Discard, permanent containment, or treatment to eliminate the toxic potential of a hazardous substance, product, or waste.
<b>Engineering Controls</b>	Construction, maintenance, and repair of structural equipment used to prevent personal and environmental exposures to hazardous materials.
<b>Fines and Penalties</b>	Costs incurred because of federal, state, or local safety and environmental regulatory violations, including improper or incomplete recordkeeping, unsafe working conditions, and environmental pollution.
<b>Medical Surveillance</b>	Medical consultations, examinations, tests, and procedures, including baseline and periodic, as well as event driven medical encounters.
<b>Medical Treatment</b>	Medical care for occupational injuries or illnesses due to exposure to a hazardous substance, product, or waste.
<b>Permits and Certification</b>	Local, state, and federal permits required for transportation, storage, and use of certain hazardous materials at a facility.
<b>Personal Protective Equipment (PPE)</b>	Gear that is issued to individual workers to prevent exposure to hazardous materials, including maintenance, inspection, distribution, replacement, and inventory.
<b>Procurement</b>	The initial cost of the material

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**Spill Containment  
and Cleanup**

Responses to spills of hazardous materials including costs of equipment and personnel.

**Storage**

Storage of the hazardous material before use and storage of any resulting hazardous waste before disposal.

**Training**

Instructions regarding the legal requirements pertaining to hazardous materials, and information regarding methods and procedures for minimizing the risk of exposure to a hazardous material.

**Workplace  
Monitoring**

Surveys, inspections, and monitoring of workplace, processes, materials, and personnel for the purpose of maintaining the health and safety of workers, and to protect the environment.

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## Glossary of Acronyms

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CERCLA	Comprehensive Environmental Response, Compensation and Liability Act (1980)
CNO	Chief Of Naval Operations
DOD	Department of Defense
DOT	Department of Transportation
EPA	U.S. Environmental Protection Agency
HAZCOM	Hazard Communication
HAZMIN	Hazardous Waste Minimization.
HM	Hazardous Material
HMCM	Hazardous Material Control and Management
HW	Hazardous Waste
HWMP	Hazardous Waste Management Plan
NAVOSH	Navy Occupation Safety and Health (Program)
NEESA	Naval Energy and Environmental Support Activity
OPNAVINST	Navy Instructions
OSHA	Occupational Safety and Health Administration
RCRA	Resource conservation and Recovery Act (1976)
TSCA	Toxic Substances Control Act (1976)

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