Diversion Path Analysis Handbook

Volume 1 (of 4 Volumes)

Methodology

Prepared for the

U.S. Department of Energy

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PREFACE

Anticipating that many people with varying interests and backgrounds will have an interest in the Diversion Path Analysis (DPA) methodology, an effort has been made to structure the DPA Handbook so that each reader can best utilize those sections which pertain to him. The DPA Handbook, therefore, is divided into four volumes. Volume 1 provides a description of the methodology and its implementation while Volume 2 sets forth the results and complete documentation of an example DPA. Volumes 3 and 4 provide information on two computer programs that have been written to assist in assembling and analyzing the data resulting from a DPA.

Volume 1 contains a brief executive summary, a chapter explaining the basic concepts behind the DPA methodology, and a chapter which details the steps necessary to implement DPA at a facility. There are also several appendices which provide additional detailed information necessary either to understand or to implement the methodology.

Volume 1 provides, in Chapter 1, an explanation of the DPA methodology, intended principally to serve the needs of management. It relates: (1) the purpose of DPA; (2) the scope of a typical analysis; (3) the type of personnel needed to perform the analysis; and (4) a general description of the five basic steps for performing an analysis. Chapter 2 contains the details of implementing the methodology. It is intended primarily for use by the DPA team and contains numerous cross references to Volume 2, the example DPA. This chapter gives the step-by-step procedures necessary to insure a thorough analysis.

Volume 2, the example DPA, a plutonium bar to button conversion process, illustrates typical results obtained for a hypothetical process and demonstrates the type of documentation recommended for a completed DPA. It is divided into two parts, the workpaper documentation and the summary documentation. The DPA team should give careful attention to the example as it serves to answer numerous questions on the fine points of the analysis.

In Volumes 3 and 4, two computer programs are described. DPA Computer Program 1 (Volume 3) assembles data derived for vulnerabilities and DPA Computer Program 2 (Volume 4) provides statistics on modifications. Tables produced by these programs assist the DPA team in establishing findings and recommendations.

It is recommended that the DPA team carefully read and study all volumes of the DPA Handbook before starting their first analysis.

EXECUTIVE SUMMARY

Diversion Path Analysis (DPA) is a safeguards evaluation tool which is used to determine the vulnerability of the Material Control and Material Accounting (MC&MA) Subsystems to the threat of theft of Special Nuclear Material (SNM) by a knowledgeable Insider. DPA specifically addresses Diversion of SNM from its authorized location within the facility by a person who has access to the process area and/or the material. It is used to evaluate the ability of the MC&MA Subsystems to detect the loss of a fraction of the amount of SNM needed to construct a crude nuclear explosive device. The threat of sabotage to the nuclear facility and the threat of dispersal of a small amount of nuclear material are *not* addressed by DPA. Using the methodology, facility personnel systematically determine: (1) how, from a diverter's point of view, to covertly acquire SNM and conceal the theft from the MC&MA Subsystems; (2) how soon, if ever, the MC&MA Subsystems would indicate the theft; and (3) what modifications to the facility's Safeguards System would be necessary to eliminate, or reduce the severity of, the identified vulnerabilities.

The decision to perform DPA at a given facility is based on the premise that the facility has a significant quantity of SNM which might be considered "highly attractive" from a diverter's point of view. If a portion of a Process has very "unattractive" material, that portion of the Process need not be analyzed.

The DPA team should consist of two individuals who have technical backgrounds. Knowledge of the DPA methodology is less important than a knowledge of the Process being analyzed. DPA is a team effort and interaction with process personnel is essential in order to clarify points concerning the actual operations in the Process.

The implementation of DPA is divided into five basic steps including "Information and Data Gathering," "Process Characterization," "Analysis of Diversion Paths," "Results and Findings," and "Documentation." The purpose of the "Information and Data Gathering" step is to insure that the DPA team is sufficiently knowledgeable of the Process to analyze it and to document characteristics of the Process which do not agree with the requirements set forth in the procedure manuals. The objective of the "Process Characterization" step is to examine the details of the Process and to classify the specific operations in the Process according to: (1) the materials handled; (2) the information received, utilized, and generated; and (3) the responsibilities of the personnel who work in the

process area. During the "Analysis of Diversion Paths" step, the DPA team mentally assumes the role of the diverter and, using each of the General Diversion Paths (specified by the DOE) in turn, tries to determine specific ways of removing SNM from the Process. Having identified a Diversion Path, the DPA team also determines: (1) which Abnormal Situation might occur first and who would observe it; (2) the length of time before the Diversion is detected via the MC&MA Subsystems; and (3) a possible low cost modification which would eliminate the vulnerability or reduce the Detection Time. After determining all the Diversion Paths, the DPA team utilizes two computer programs to assemble the results and prepare tables for documentation of the analysis. The team also analyzes the results to determine some possible Major Modifications which will improve the general response capability of the Safeguards System and may reduce the Detection Time for a number of vulnerabilities. Finally, the DPA team collects all the papers, tables, and charts prepared during the analysis and documents the analysis. The documentation provides a record of the analysis which will be evaluated by the Office of Safeguards and Security, DOE.

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1.0 DPA OVERVIEW

1.1 SAFEGUARDS PROBLEM

With the increased use of nuclear materials worldwide, there is a recognition that the public could face a substantial risk if Special Nuclear Material (SNM)[1] was acquired by an adversary and used in a manner not permitted by law or treaty. This risk has prompted the nuclear industry to establish a safeguards structure which is designed to protect the public against such willful, anti-social acts [1][2]. The Safeguards System at a facility is composed of three basic interrelated subsystems: (1) Physical Protection; (2) Material Control; and (3) Material Accounting. With the establishment of Safeguards Systems at nuclear facilities has come the need to develop techniques to evaluate how well each subsystem is performing and thus, how well the public is being protected against this potential risk.

1.2 PURPOSE OF DPA

Diversion Path Analysis (DPA) is a safeguards evaluation tool which is used to determine the vulnerability of a facility's Material Control and Material Accounting (MC&MA) Subsystems to the threat of theft of SNM by a person authorized to enter the Material Access Area (MAA), i.e., a knowledgeable Insider. DPA specifically addresses Diversion of SNM from its authorized location within the facility by a person who has access to the process area and/or the material. It is used to evaluate the capability of the MC&MA Subsystems to detect the loss of a fraction of the amount of SNM needed to construct a crude nuclear explosive device. The threat of sabotage to the nuclear facility and the threat of dispersal of a small amount of nuclear material are *not* being addressed by DPA. Using the DPA methodology, facility personnel systematically determine: (1) how, from a diverter's point of view, to covertly acquire SNM and conceal the theft from the MC&MA Subsystems; (2) how soon, if ever, the MC&MA Subsystems would indicate the theft; and (3) what modifications to the facility's Safeguards System would be necessary to eliminate, or reduce the severity of, the identified vulnerabilities.

Removal of SNM from the facility-site is not addressed in DPA since the fact that SNM is missing from its authorized location within the facility is sufficient

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[1] Abbreviations are listed in Appendix A. All words underscored are defined in the Glossary, Appendix B, and are capitalized throughout the text.

[2] Numbers in brackets refer to references, page 171.

to pose a credible threat. DPA does not address the physical protection aspects of the facility Safeguards System. Instead, the MC&MA Subsystems are evaluated assuming that the Physical Protection Subsystem will fail to detect removal of SNM from the site when an individual, authorized to enter the facility, uses Deceit and/or Stealth when perpetrating Diversion. In this way, the capability of the MC&MA Subsystems as a second line of defense are independently determined.

Diversion of SNM by upper-level facility management is not addressed by DPA and thus, anyone in this category is not considered as a potential diverter. If the upper-level management chooses to divert material, their access to the MC&MA Subsystems would probably permit them to completely conceal the removal and preclude detection.

It is intended that the results of DPA will provide facility management with guidance concerning procedural changes in the MC&MA Subsystems which will enhance detection of Diversion of SNM by a knowledgeable Insider using strategies of Stealth and/or Deceit. The results should also help facility management to prepare more effective safeguards upgrading plans. The safeguards staffs at the DOE Operations Offices and Headquarters should use the results of DPA to determine which facilities should receive safeguards upgrading funds first and for assessing the overall safeguards posture of the facilities.

1.3 THE DPA TEAM

DPA is a systematic method for analyzing the problem of covert Diversion of SNM by people who are authorized to be in the Material Access Area. The methodology is relatively straightforward and is easily mastered.

DPA is a team effort and the team should consist of two or three facility personnel who have technical backgrounds and work well together. Detailed knowledge of the DPA methodology is less important initially than a knowledge of the Process[3] being analyzed. In fact, having a technical background in the Process prepares a person to do a more thorough analysis in a shorter period of time. The team members should be inquisitive and should have the ability to analyze how something, in this case the Process, works. Interaction with process personnel is essential in order to clarify points concerning the actual

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[3] The term Process is used in the general sense and encompasses any series of actions directed to some end. For a nuclear facility, a Process may thus be associated with actions related to the transportation of SNM between facilities, shipping, receiving, storage, production, transfers, measurements, analyses, testing, etc.

operations in the Process. Therefore, the team must have a good rapport with the process personnel and their management. Because there are a great many details to be considered when doing the analysis, DPA should be the full time effort of the team until the analysis is completed. Under no circumstances should the DPA team be composed of personnel whose functions are being analyzed for diversion potential.

To do a good job, the DPA team must:

a)   gather and assimilate sufficient data to have a working understanding of the details of the Process;

b)   partition the Process into sub-processes and characterize each sub-process in terms of the material flows, the information flows, and the organizational responsibilities of the process personnel; and

c)   synthesize methods of stealing SNM.

The thoroughness of part "c" above, is highly dependent upon how well the DPA team performs parts "a" and "b."

1.4   ESTABLISHING THE SCOPE OF THE ANALYSIS

Before the DPA team can begin, the scope of the analysis must be defined. The first aspect of this problem is determining which portions of the facility must be analyzed. The decision to perform DPA at a given facility is based on the premise that the facility has a significant quantity of SNM which might be considered "highly attractive" from a diverter's point of view. DPA should be performed for that portion of each Process in which:

a)   there is a quantity of SNM, equal to the Working Mass,[4] in residence for a period of at least 24 hours; and

b)   the particular material has a Material Attractiveness factor[4] greater than one-tenth (0.1).

Some examples of nuclear Processes include:

a)   a research or production reactor;

b)   a vault;

c)   a scrap recovery line or laboratory;

d)   a fuel pin fabrication line;

e)   a weapons parts fabrication line;

f)   a weapons assembly line; and

g)   an enrichment process.

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[4] See Appendix C to determine the Working Mass and the Material Attractiveness factor for each Material Type and Material Description.

If a portion of a Process has very "unattractive" material, that portion need not be analyzed. An example of this is the "head-end" of a plutonium (or uranium) recovery Process in which the material is highly radioactive. Similarly, the fuel assemblies in a reactor which has "gone critical" are not analyzed. On the other hand, DPA should be performed on the receiving, storing, and loading operations at a production reactor. DPA need not be performed in those laboratory situations in which there are many samples, located throughout the laboratory, each containing only a few (less than five) grams of "highly attractive" material.

The other aspect involved in establishing the scope of the DPA is determining how many DPA's must be performed on each Process. It is important to limit the size of the process area being analyzed so that the DPA team is able to absorb all the process-related information that is necessary to do the analysis. Ideally, a DPA should include no more than one Material Balance Area (MBA) or, within a large MBA, only part of the process operations. It is recommended that the DPA team should analyze the activities of no more than ten to twelve process operators having "hands on" access to the SNM. These operators must perform a set of process steps in succession (e.g., adjacent steps in a fuel fabrication plant). Foremen, SNM custodians, health physics personnel, and other supportive type personnel are generally not included in the group of successive operators. These types of personnel may or may not be considered in the analysis as potential diverters. Also, if Material Surveillance Procedures are in effect, each of the two or more persons should be counted as one operator. Often, however, the portions of the Process which need to be analyzed are too large for a single analysis. If it becomes necessary to partition the Process, for purposes of the analysis, it is recommended that the division occur at a point in the Process where production control or accounting measurements are made. If this is not possible, it is recommended that the Process be divided at a point where the SNM is "item identified." The important thing is to limit the size of the process area for which the DPA is to be performed and to insure that there are production or accounting controls on the SNM entering and leaving that Process.

1.5 DPA METHODOLOGY

The implementation of DPA can be divided into five basic steps. These steps, illustrated in Figure 1-1, include "Information and Data Gathering," "Process Characterization," "Analysis of Diversion Paths," "Results and Findings," and "Documentation."

DECISION TO PERFORM DPA

INFORMATION AND DATA GATHERING

PROCESS CHARACTERIZATION

APPLICATION OF ANALYSIS GUIDELINES

ANALYSIS OF DIVERSION PATHS

RESULTS AND FINDINGS

WORKPAPERS

DOCUMENTATION

SUMMARY REPORT

TO FACILITY SAFEGUARDS SYSTEM DESIGN OR MODIFICATION SEQUENCE
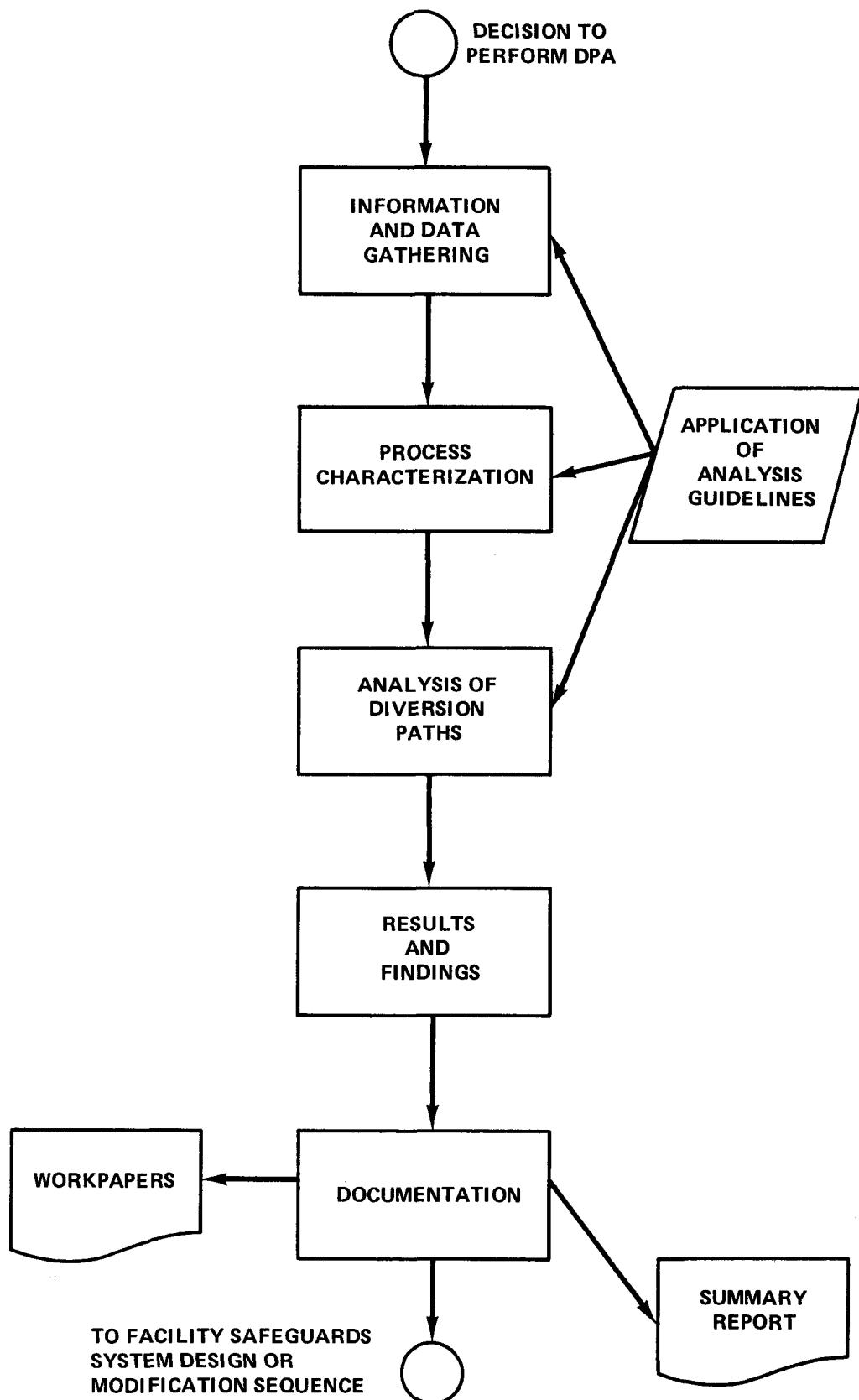
BASIC STEPS OF DIVERSION PATH ANALYSIS

FIGURE 1-1

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1.5.1 INFORMATION AND DATA GATHERING

"Information and Data Gathering" forms the basis for an accurate and complete DPA. Several "DPA Information and Data Gathering Worksheets" have been developed to assist the DPA team in this step of the methodology. The purposes of this step are to insure that the DPA team has sufficient knowledge of the Process to analyze it and that the DPA team finds and documents characteristics of the Process which do not agree with the requirements set forth in the procedure manuals. The "DPA Information and Data Gathering Worksheets" are intended to be used as checklists which will prompt the DPA team to investigate details of the Process for which they may have little background. The worksheets are general and some of the information requested may not apply to the specific Process being analyzed. Also, the worksheets can be used to document any information that the DPA team wishes to preserve. While completion of the first worksheet is required, completion of the remaining ten worksheets is left to the discretion of the team. Completion of all worksheets would benefit a DPA team who had to update the analysis at some future date as well as benefiting those who must assess the accuracy and completeness of the DPA. The level of effort required to complete this step of the methodology is entirely dependent upon the background of the DPA team and the extent to which management wishes to preserve a record of the information which supports the analysis.

1.5.2 PROCESS CHARACTERIZATION

"Process Characterization" reinforces the first step in DPA by guiding the DPA team as they organize the information and data that was collected. The objective is for the DPA team to examine the details of the Process and to classify the specific operations in the Process according to: (1) materials handled; (2) information received, utilized, and generated; and (3) responsibilities of the personnel who work in the process area.

The first phase of "Process Characterization" is accomplished by considering the Process divided into small Unit Processes. A Unit Process may be defined as an analyzable segment of the process stream which can be characterized in terms of material flow. The Unit Process concept is important because it helps the analyst identify all material flows and examine material balance closures. The next phase is to quantify each material flow in terms of its size and frequency. To characterize each flow, it will be necessary to study actual process data.

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After characterizing each material flow to the greatest extent possible, the DPA team should determine what facility personnel have control over each Unit Process. In so doing, the DPA team should specify:

a)   what material flows are being controlled by each person;

b)   what information is received, acted upon, and generated by each person; and

c)   the specific actions taken by each person as he processes the material.

The above information is organized so that the responsibilities of each person in the Process are grouped into Operational Areas. After examining the Process in this manner, the DPA team should be thoroughly knowledgeable of the Process and how it actually operates. The DPA team should also be ready to determine the specific ways knowledgeable Insiders can steal SNM.

1.5.3 ANALYSIS OF DIVERSION PATHS

During the "Analysis of Diversion Paths" step, the DPA team mentally assumes the role of the diverter and, using an ordering concept described below, tries to determine specific ways of removing SNM from each Operational Area. For each Specific Diversion Path (SDP) identified, the analyst also determines:

a)   the first Abnormal Situation guaranteed to occur;

b)   the person who will observe the Abnormal Situation;

c)   the maximum Detection Time for the Abnormal Situation;

d)   any possible Innocent Cause for the Abnormal Situation; and

e)   a Minor Modification, involving little or no cost, which would eliminate the vulnerability or reduce the Detection Time significantly (if possible).

Thus, the DPA team specifies vulnerabilities to theft by a knowledgeable Insider as well as some possible low cost modifications which will eliminate or reduce the severity of the safeguards vulnerabilities.

The ordering concept mentioned above is based on a universal set of General Diversion Paths (GDPs) specified by the Office of Safeguards and Security, DOE (DOE/SS). Use of the GDPs assures uniformity among analyses from different facilities and provides all DPA teams with a common basis for performing a thorough analysis. Each GDP is characteristized in terms of six Diversion Path Parameters: Material Attractiveness; Diverted Amounts; Deceit By Records; Deceit In Removal; Number Of Insiders; and Type Of Insider. Each parameter has several attributes and each attribute has been assigned a Relative Weight Factor by the DOE/SS.

For the Material Attractiveness parameter, the Relative Weight Factors denote the relative attractiveness of the material for use in a nuclear explosive device. Figure C-3 in Appendix C shows that this parameter takes account of the Type of material, the form it is in, and the hazard an adversary would face, from radiation exposure, when trying to steal the material.

The Relative Weight Factors for the attributes of each of the other parameters denote the relative "complexity" of the task of removing the SNM as viewed by the diverter (see Figure C-4 in Appendix C). The Relative Weight Factors should *not* be viewed as measures of the probability of an adversary choosing to divert material using that particular attribute. Rather, these factors serve as a relative measure of the complexity (or difficulty) of using one attribute as compared to another. For example, the diverter's task becomes more complex if he must substitute another material for the material he takes rather than just steal the material in the first place. Similarly, to involve a second person as a colluder is more complex because the diverter must choose this person with care and run the risk that the second person may report him to the authorities.

The GDPs are composed of the combinations of one attribute from each parameter (see Figure C-5 in Appendix C). By multiplying the Relative Weight Factors of the attributes comprising the GDP, a Relative Path Weight (RPW) is derived. Note that the GDP list in Appendix C is ordered or ranked such that the first GDP has the highest RPW and the last GDP has the lowest RPW value. From a diverter's point of view, the first GDP should be the easiest to accomplish and the last GDP should involve the most complex set of tasks. Again, the RPW value is a measure of the Path Complexity rather than a measure of the probability that the diverter will choose that path. Thus, for Processes having very attractive forms of SNM, DOE/SS has specified that the DPA team must consider each of the 16 GDPs.

A Diversion Path may be ignored if the Material Attractiveness factor, Diverted Amounts factor, RPW value, or the product of these values is less than one-tenth (0.1). This provides a mechanism for the "graded safeguards" approach in that the DPA methodology places greater emphasis on: (1) those Processes involving relatively attractive materials; and (2) Diversion Paths which involve less complex tasks for the diverter.

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1.5.4 RESULTS AND FINDINGS

The fourth step in the DPA methodology involves collecting and sorting the results of the analysis step and examining these results to determine the findings and recommendations. To assist the DPA team, a computer program has been developed to summarize the Specific Diversion Path data into five tables which cross-reference:

a) potential diverters and SDPs;

b) observers and SDPs;

c) detection times and SDPs;

d) observers and abnormal situations; and

e) abnormal situations and SDPs.

Using the five cross-reference tables, the DPA team should be in a position to determine the Major Modifications which will improve the general response capability of the MC&MA Subsystems and thereby reduce the Detection Time for several vulnerabilities simultaneously. The tables may also help the DPA team to determine modifications which will eliminate the "worst case" Diversion Paths. It is most likely that these modifications: (1) will involve significant costs; (2) may take a significant amount of time to implement; and (3) may involve the Physical Protection Subsystem, the MC&MA Subsystems, or both.

Once the DPA team has determined some Major Modifications to the Safeguards System, they can enter the information into a second computer program that will assemble the data and prepare tables to be included in the documentation presented for management review.

1.5.5 DOCUMENTING THE DPA

The fifth and final step in conducting a DPA is "Documentation" of the analysis. Documentation is important because each analysis will receive an independent review by DOE/SS and it is necessary to have a standard format. This step of the DPA is divided into two parts; the workpaper documentation and the summary documentation.

The workpaper documentation provides the "backup" or support for all conclusions and recommendations. It also serves as a reference when the facility safeguards and security team needs to review their situation for possible upgrading. Because this document provides information which would help an adversary to steal SNM, it should be classified "Secret/NSI." It is intended that the facility Nuclear Materials Control Office will maintain the workpaper documentation

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along with the backup references collected during the "Information and Data Gathering" step. This document should be kept up to date as changes are made to the Process or as safeguards modifications are implemented.

The summary documentation is intended to provide the facility management with a concise overview of the safeguards posture of the area analyzed and with information which will help management decide how to best allocate their safeguards resources. The DPA team will be expected to present and discuss the results of the DPA with their management. The summary document forms the basis for this briefing. Furthermore, the summary documentation should be made available for review by the DOE Operations Office and by DOE/SS. Because this document gives both the number of and examples of vulnerabilities at a facility, it should be classified "Secret/NSI." The summary report should give management:

a) the assumptions upon which the analysis was based;

b) the number of the Diversion Paths which were identified and their respective Detection Times;

c) a summary of the proposed modifications that the DPA team has identified to improve the facility safeguards posture;

d) a description of a few of the "worst case" vulnerabilities to internal covert Diversion that currently exist at the facility; and

e) the recommendations of the DPA team.

While the above documentation is deemed adequate for evaluation by the DOE/SS staff, the DPA team should include additional information in the summary document as directed by facility management or the pertinent DOE Operations Office.

2.0 IMPLEMENTATION OF THE DPA METHODOLOGY

2.1 INTRODUCTION

At this point, it is assumed that facility management, in conjunction with the DOE Operations Office safeguards staff, has determined: (1) which portions of the facility must be analyzed; (2) the number of DPAs to be performed on each Process; and (3) the personnel who will perform the DPA. This chapter will detail the steps necessary to perform a comprehensive DPA. Many references will be made to the ten appendices in this volume and to the example DPA in Volume 2 [2].

2.2 APPLYING THE DPA GUIDELINES

The DOE/SS has established certain guidelines in DPA to assure uniformity among analyses. These guidelines are explained in Appendix C. The DPA team should review the information given in Appendix C prior to taking an initial tour of the process area to be analyzed. During the tour, the DPA team should determine the following information.

1) The distinct Description of each Type of SNM found in the Process. It may be helpful to carry a process flow diagram (if available) on the tour and make notes on the diagram.

2) The types of personnel (by job classification) who are authorized to be in the Material Access Area *for any reason*. They may possibly be distinguished by the type of badge that they wear.

3) The extent to which the Material Surveillance Procedures are enforced. The two individuals should be able to maintain "eye contact" and/or be in close proximity to each other at all times.

After the tour, the DPA team should use Appendix C to establish the specific guidelines for the DPA.

First, Figure C-3 should be used to determine the Material Attractiveness of each Description of SNM found in the Process. Figure C-1 should be used to determine the Working Mass for each Material Type and Material Description (if the material is a mixed oxide or a mixed carbide, use Figure C-2) based on the Assigned Mass Constant for that Material Type.

Next, the DPA team should describe the physical locations (buildings and rooms) which encompass the process area. Removal of SNM beyond these boundaries should not be considered in the analysis.

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Third, the DPA team should list all the potential diverters using the guidelines in Section B of Appendix C. Personnel having access to the MAA should be divided into three groups: (1) those who have access to the SNM and who routinely work with it; (2) those who have access to the SNM in a supportive capacity only (e.g., to monitor radiation, take inventory, etc.); and (3) those not authorized access to the SNM. Visitors and personnel who make deliveries to the MAA should also be included in the latter group. Personnel who have access to the MAA during non-working hours should be included in the group according to their SNM access authorization. All those in "Group 1" above will probably be classified as potential Embezzlers as will those in "Group 2" who can relieve a person in "Group 1" and perform his tasks without challenge (e.g., foremen, process engineers, QA personnel, etc., may have this authority). The rest of the personnel in "Group 2" and all personnel in "Group 3" are potential Thieves. Section C of Appendix C provides guidelines which should be used to exclude some of these personnel from consideration in the analysis. Personnel in "Group 1" may not be excluded. Personnel in "Group 2" and "Group 3" may be excluded only if Material Surveillance Procedures are very strictly enforced and the second person is not included in "Group 1."

Section D of Appendix C specifies the criteria for evaluating the response capability of the Safeguards System. All DPA teams shall use these criteria.

The number of GDPs to be considered in the analysis is entirely dependent upon the materials in the Process. The GDPs are listed in Figure C-5. Their significance to the analysis and the derivation are discussed in Section E, Appendix C. Having already determined the Material Attractiveness for each material, Figure 2-1 can be used to determine which GDPs must be analyzed for these materials. The DPA team should note that it will be necessary to consider all GDPs having an "X" in the column representing the Material Attractiveness in Figure 2-1. For example, if the Material Attractiveness is 0.3, the DPA team must consider the first eight GDPs. (See also Section C, Appendix G.)

The application of the DOE/SS guidelines to a Process is illustrated in the example DPA presented in Volume 2. The suggested format for expressing the specific guidelines and assumptions used by the DPA team is shown on pages 9 and 10 in that Volume. In this example, only plutonium metal was present in the process; there were no other Types of SNM considered. The Working Mass and Material Attractiveness (Item I) were determined from Figures C-1 and C-3 (Appendix

Material Attractiveness

	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1
GDP 1	X	X	X	X	X	X	X	X	X	X
GDP 2	X	X	X	X	X	X	X	X	X	
GDP 3	X	X	X	X	X	X	X	X	X	
GDP 4	X	X	X	X	X	X	X	X	X	
GDP 5	X	X	X	X	X	X	X	X	X	
GDP 6	X	X	X	X	X	X	X	X	X	
GDP 7	X	X	X	X	X	X	X	X		
GDP 8	X	X	X	X	X	X	X	X		
GDP 9	X	X	X	X	X	X	X			
GDP 10	X	X	X	X	X	X				
GDP 11	X	X	X	X	X	X	X			
GDP 12	X	X	X	X	X	X				
GDP 13	X	X	X	X	X	X				
GDP 14	X	X	X	X	X					
GDP 15	X	X	X	X						
GDP 16	X	X								

GDPs to be Evaluated for Each Material Attractiveness

FIGURE 2-1

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C), respectively. The entire process area analyzed encompasses the vault and room 123 of building 207, as seen in the floor plan shown on page 59 of Volume 2. A brief description of this area is given in Item II. All personnel authorized to be in building 207, under any circumstances, are listed in Items III and IV on page 9 in the example. In accord with the guidelines (Section C, Appendix C) engineers, management and "Nuclear Material Control" (NMC) personnel are excluded from consideration as potential diverters. Because visitors and vendors are *always* escorted by a member of the guard force or one of the process engineers, they were also excluded from consideration. Health physics personnel, the guard on night patrol and the maintenance man, on the other hand, could possibly be found in the process area unescorted and are therefore deemed to be potential diverters. The "Criteria for Classes of Detection Time" (Item V) are as specified in Appendix C. Because Pu metal has a Material Attractiveness of 1.0, all 16 GDPs are considered in the example Process as noted in Item VI.

When the DPA team has applied the DOE/SS guidelines to their specific Process and has set forth the assumptions they have made for the analysis, they are in a position to start collecting detailed information and data about the Process to be analyzed.

2.3 GATHERING INFORMATION AND DATA FOR THE ANALYSIS

As the first step in conducting a DPA, the DPA team should collect any information which they feel is necessary to provide them with a thorough understanding of the Process. The items outlined in the eleven "DPA Information and Data Gathering Worksheets" in Appendix D indicate the depth of knowledge the DPA team must have.

The DPA team should use the "DPA Information and Data Gathering Worksheets" as a guide to assist them in learning how the Process operates. The most efficient way to retain process information and data is to record it directly on the worksheets. However, this is required only for the first worksheet, "Source Information." The worksheets can also be used to record instances where actual process operations deviate from the procedures as specified in the procedure manuals. In cases where the DPA team already has a good understanding of the Process, it may be convenient to use the worksheets as checklists and merely reference the source of the information by listing the applicable document and page on the appropriate worksheet. It may be necessary to tour and observe the area under analysis several times and to interview process foremen, engineers,

and other personnel in order to verify that the information collected is accurate.

The first worksheet, "Source Information," enumerates in its headings typical sources of information that should be examined by the DPA team. The indicated source documents should be gathered and reviewed. Documents identified as pertinent to the analysis should be retained, if possible, in a convenient location so that frequent reference can be made to them. The permanent location of all source information documents used in the analysis must be recorded on the "Source Information" worksheet. This will assist the DPA team in retrieving information sources no longer in its possession and, more importantly, assist a future DPA team should update of the DPA be necessary. Also, the DOE/SS assessment team will make use of this worksheet to locate information which it will need to verify details of the Process during DPA review.

The DPA team should verify that the floor plans are current and reflect the building(s) and Process as it is actually laid out. If accurate, up-to-date floor plans do not exist, facility engineering might be requested to prepare new ones. If this is not feasible, the DPA team can update existing drawings or prepare sketches of the area. Floor plans are useful since a great deal of information can be conveniently recorded directly on them.

The procedure manuals should contain the latest revisions and should represent the Process as it is intended to operate at the time of analysis.

Original copies of blank operational logs and accounting forms should be collected. Obtaining an original of multi-part forms (form-sets) is particularly important. The individual parts of these forms are usually color-coded and, when tracing routing of the forms, reference is usually made to the color of the particular copy. It is important that the team be familiar with the various copies. The team must determine whether the form-set uses carbon paper or one of the newer methods of "carbonless" pressure sensitive transfer. Each transfer method presents different characteristics when considering Falsification and Alteration. Further, an original of the form will allow the team to assess the ease with which it might be forged. Forms prepared by "Multilith" and "Xerox" processes can be duplicated rather easily while printed forms, particularly with colored copies, pose more difficulty.

The archival data to be gathered should be representative of current (or most recent) activities within the Process.

Many items in the "DPA Information and Data Gathering Worksheets" may not apply to every Process. The intent of the worksheets is to help the DPA team to familiarize itself with all aspects of the Process in question. Secondly, the worksheets help the DPA team to organize information and data from several sources into logical groupings, serving as a convenient cross reference of information. Finally, the worksheets provide the DPA assessor with a mechanism for learning how the Process operates.

Volume 2, Part I, Section II illustrates the information gathered for the example DPA. It should be noted that all sources of information listed in the first "DPA Information and Data Gathering Worksheet" (Section 1.0, Source Information) are hypothetical and do not actually exist. However, the DPA team should gather this type of information from its own facility and state explicitly where it is retained. The rest of the worksheets indicate: (1) the types of information which the DPA team may find convenient to record; (2) shortcuts to referencing certain types of data; and (3) examples of the details of the Process which the DPA team must understand. If the DPA team already has a good understanding of its Process, to the level of detail indicated, there is no requirement to document the information on the worksheets.

2.4 PROCESS CHARACTERIZATION

Once the guidelines have been applied for the analysis and the DPA team thoroughly understands the Process, it is in a position to characterize the Process, the second step in conducting a DPA. When characterizing the Process, the DPA team will: (1) determine how material moves through the Process; (2) quantify each material flow; and (3) determine the responsibilities of the process personnel assigned the task of controlling the material.

2.4.1 UNIT PROCESS CONCEPT - IDENTIFYING MATERIAL FLOWS

The easiest way to analyze the material flows in a Process is to imagine the Process divided into very small parts. The concept of a Unit Process serves this purpose and has been developed to help characterize material flows. A Unit Process may be defined as an analyzable segment of the process stream in a facility which contains a point where:

a) there are changes in Material Description; or

b) a material flow starts, ends, or merges with another flow; or

c) significant material accounting information is generated.

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A Unit Process may occasionally include a point where more than one of the above characteristics occurs. For example, one operation may involve a chemical reaction between two inputs yielding product, recoverable Scrap or Recycle and Waste as a measured discard. The entire process stream of a facility can, however, be represented as a series of Unit Processes. Figure 2-2 shows the eight distinct possible types of material flows associated with a Unit Process.

Examples of a Unit Process include:

a) the combination of two (or more) feed sources into a single product;

b) machining a casting (product and scrap material flows are generated);

c) changing the valence of Pu (chemical change);

d) machine turnings to be recast with new material (recycle from another Unit Process); and

e) a mass measurement taken in a processing step (significant material flow accounting information is generated).

The important feature of the Unit Process is that the material flows at each point are well defined. This includes the origin and destination of the material, the Material Type (^{239}Pu, ^{235}U, etc.) and Description (metal, nitrate solution, etc.), and the specific quantity of material (if possible).

It will be necessary to study in detail the procedure manuals for the Process and to observe the Process in operation, if possible, in order to determine all the possible material flows. The "Nuclear Materials Control" manuals may also provide insight as to where process control or accounting information is generated. Every effort should be made to break the Process down into its most basic material flows and then to characterize those flows. Sometimes, analysis of the chemical reactions at each point in the Process may indicate material flows which are not discussed in the facility procedure manuals. In this case, the DPA team should contact the process personnel to determine the extent of these unspecified flows.

In the example Process described on page 55, Volume 2, "MBA-A" was divided into four Unit Processes. The "Receiving Box" is a Unit Process because significant material accounting information is generated when the "Receiving Box Operator" accepts the plutonium bars and completes the "Material Transfer Report." The "Chopping Box" becomes another Unit Process because the material changes Description (a single piece is chopped into many pieces). The material changes

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1. FEED (FROM THE PRECEDING UNIT PROCESS OR FACILITY STORAGE)

2. PRODUCT (TO FACILITY STORAGE OR THE NEXT UNIT PROCESS)

PROCESSING ACTIVITIES

THE UNIT PROCESS

3. MEASURED OR CHARACTERIZED RECYCLE FROM THIS UNIT PROCESS

8. SAMPLES TO LABORATORY

7. WASTE TO MEASURED DISCARD

6. SCRAP TO RECOVERY

5. RECYCLE TO ANOTHER UNIT PROCESS

4. RECYCLE FROM ANOTHER UNIT PROCESS
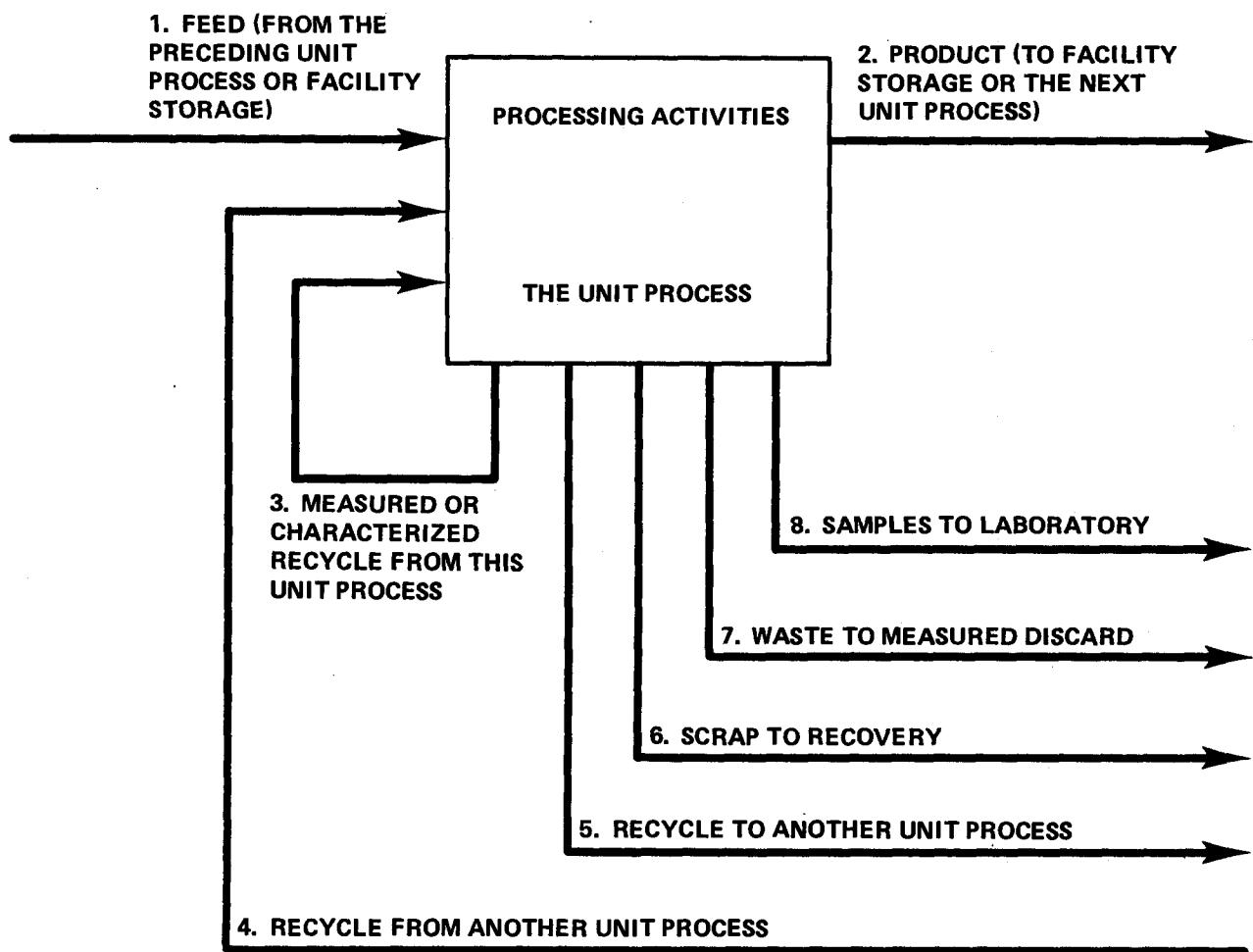
UNIT PROCESS MATERIAL FLOWS

FIGURE 2-2

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Description again in the "Casting Box," the third Unit Process, since four batches of small pieces are combined to form a button and a sample of the button is generated. The "Vault" is a fourth Unit Process because significant material control and accounting information is generated in the form of a "Vault Log" and the "Material Transfer Report."

It should be noted that the example Process was developed to demonstrate the technique of performing a DPA. In an effort to keep the example relatively simple, some material flows and associated information flows, which are found in actual Processes have been omitted. For example, most casting operations would normally exhibit some Waste, recoverable Scrap, and possible internal Recycle of material.

2.4.2 MATERIAL FLOW DIAGRAMS

When detailing the material flows, it is helpful to draw diagrams of each Unit Process and its material flows. These "Unit Process Material Flow Diagrams" should include:

a)   the Type, Description, and origin of each material entering the Unit Process;

b)   the Type, Description, and destination of each material leaving the Unit Process; and

c)   the general processing activities which occur in that Unit Process.

Pages 60 and 61 in Volume 2 show the "Unit Process Material Flow Diagrams" for each of the four Unit Processes in the example DPA.

Having characterized all material flows in terms of Material Type and Description, origin of flow, and destination of the flow, the DPA team must quantify these material flows to the extent possible.

2.4.3 NUMERIC CHARACTERIZATION OF THE MATERIAL FLOWS

Once the "Unit Process Material Flow Diagrams" are drawn, the DPA team must review the process documentation to determine specific characteristics of each material flow. These specifics include:

a)   the amount of material in each flow;

b)   the frequency of each material flow;

c)   how the material flow varies by quantity and time;

d)   how the material flow is identified;

e)   whether the material flows continuously;

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f)   measurements made on each flow; and

g)   how often the measurements are made.

To characterize each flow, it will be necessary to study actual process data. These data may come from formal process logs or accounting forms as well as informal process records maintained by the process foremen and others. Quality control specifications and data may also be helpful. The DPA team should characterize each material flow in terms of its average, standard deviation, minimum value, maximum value, and possible outliers. Where possible, each flow should be analyzed to determine if there are any long-term trends in the flows. The reasons for these trends and the outliers should be noted, if known. All data used in this analysis should reflect the current operating procedures or the most recently completed sequences, for the Process in question. It may not be possible to numerically characterize every material flow since records may not be available to indicate the magnitude; this is quite often the case with material that is Recycled. The material flow should be identified and quantified to the extent possible, however. It may be necessary to rely only on statistical data from previous process operations for quantification of these flows. In this case, note should be made of the uncertainty of the estimate. Consideration should be given to a future measurement of this flow if the quantities significantly affect other flows or if variations in the flow provide a possible indication of diversion.

Pages 62 and 63 in Volume 2 show the numeric characterization of material flows for the example DPA. All of these data are hypothetical. Much of the data would come directly from accounting forms and process records. The rest of the data might be derived. For example, the "scrap weight" is quantified by calculating the difference of two other measurements. It is important to note that each material flow identified on pages 60 and 61 has been quantified.

2.4.4 CHARACTERIZATION OF PERSONNEL RESPONSIBILITIES

After characterizing the material flows to the greatest extent possible, it is necessary for the DPA team to determine the facility personnel that have control over each material flow. This is done by examining each Unit Process and referring back to Section 4.8 of the "DPA Information and Data Gathering Worksheet." Generally, one person will control material flows in an entire Unit Process. This person may also control other Unit Processes. (In case Material Surveillance Procedures are in effect, the two (or more) individuals are considered as one person for purposes of DPA.)

Operating personnel in the facility have three types of responsibilities:

a) controlling the flow of material;

b) receiving, acting upon, and generating information concerning the material; and

c) processing the material in some manner.

By determining the person having these responsibilities for the Unit Process(es), the DPA team may partition the entire Process into Operational Areas. An Operational Area is a region in which one decision maker (a process operator or Material Surveillance Procedure "team") exercises direct control over the material flows, the information flows, and the processing activities associated with the material. Therefore, each Operational Area will include one or more Unit Processes, but only one decision maker.

The DPA team should now prepare worksheets which detail the responsibilities of the decision maker in terms of: (1) the material handled; (2) the information received, generated, and sent; and (3) the work activities performed. The format of a "Material, Information, and Activities Worksheet," taken from the example DPA is shown on page 64 in Volume 2.

This worksheet shows all three types of responsibilities for the "Receiving Box Operator" (RBO) when he has direct access to the material. In the example, this operator is responsible for only one Unit Process, the "Receiving Box." The worksheet is divided into three sections, one for each type of responsibility.

The first section deals with the responsibility for material flows and is divided into two categories; incoming material flows and outgoing material flows. These flows are merely taken from the "Material Flow Diagrams" explained in Section 2.4.2. It is important to specify the Type, Description, and quantity of the material in the flow as well as its origin or destination. If the Operational Area includes more than one Unit Process, it is not necessary to record the flows between Unit Processes. In the example DPA, if the same operator, rather than two operators, performed the receiving and chopping operations, the first section of the "Material, Information, and Activities Worksheet" would appear as shown in the top portion of Figure 2-3. This should be compared with pages 64 and 65 in Volume 2.

The second section of the "Material, Information, and Activities Worksheet" deals with the decision maker's responsibility for information flows. It is divided into "incoming flows" and "outgoing flows." "Incoming flows" will

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Special Nuclear Material Flows

Incoming
1.   600 g Pu metal bar from MBA-B Bar Transfer Operator (BTO)

Outgoing
1.   600 g Pu metal (bagged pieces) to the Casting Operator (CO)

Information Flows

Incoming
1.   Oral instructions from F-A concerning:
     A.   Amount and type of material to be received.
     B.   Acceptance and storage procedures for material received.
     C.   Special "chopping" instructions from F-A.
2.   MTR copies #1, #2, and #3 from the BTO.

Outgoing
1.   MTR copies #1 and #3 to F-A after receiving the material.
     F-A forwards copy #1 to Nuclear Materials Control and forwards
     copy #3 to F-B by the end of the shift.
2.   MTR copy #2, when completed (about 2 days), to F-A. F-A forwards
     this copy within 1 day to MBA-A SNM Custodian.
3.   BAL to F-A when completed (about 3 days). F-A retains this form.
4.   BIT to the CO with the material.
5.   Abnormal situation report (oral) to F-A.

Activities

1.   As bars are passed through the gate, compare the bar serial number to
     the MTR. If in agreement, place "/" in the right margin next to the
     appropriate line on MTR copies #1, #2, and #3.
2.   If a bar serial number is unreadable, do not accept it from MBA-B.
     Make no "/" on the MTRs.
3.   Store all bars (10-32) in the receiving box until needed (normally 1-
     3 days). Bars can also be stored over a weekend.
4.   Summon the SNM Custodian to lock the gate to MBA-B.
5.   After F-A has opened the gate between the receiving and chopping
     boxes, transfer a bar from the receiving box to the chopping box as
     needed.
6.   Compare the bar serial number to MTR copy #2 and complete "X" in the
     right margin on the appropriate line. If no match, call F-A.
7.   Weigh bar and compare to weight given on MTR copy #2. If within ± 5 g
     tolerance, place "/" in left margin of appropriate line number on MTR
     copy #2. If not in tolerance, call F-A.
8.   Chop bar and reweigh the aggregate. If within ± 1 g tolerance, complete
     the "X" in left margin on MTR copy #2. If not in tolerance, call F-A.
9.   Complete all information on the BAL and BIT.
10. Place aggregate in a slip-top can, seal with tape, and mark the can
     with the BIT serial number.
11. Place the can in a bag and seal.
12. Transfer the bag to the Casting Box and bag it in.

FIGURE 2-3

normally come from the foreman and the process operator responsible for the preceding Operational Area. Section I of Appendix F illustrates the different types of information which might possibly be given to the process operator. The operator is also responsible for acting on this information as he processes the material under his control and then generating information for others to use. "Outgoing information" flows would normally be sent to: (1) the foreman; (2) the decision maker responsible for the next Operational Area; and/or (3) others who need information concerning the material. Section V of Appendix F shows different types of information which process operators might pass on. The DPA team should complete this section of the "Material, Information, and Activities Worksheet" by referring back to the "DPA Information and Data Gathering Worksheets" 1, 3, 4, and 8. Figure 2-3 indicates the information flows for a person who might perform the combined duties of the "Receiving Box Operator" and "Chopping Box Operator" in the example DPA. These flows should be compared with the information flows indicated on pages 64 and 65 in Volume 2.

The last section of the "Material, Information, and Activities Worksheet" addresses the processing and/or operational activities that the process operator is responsible for as a decision maker. The DPA team should list each step that the process operator performs when handling the material. These steps should be listed sequentially, in the order that they would normally be performed. Activities which relate to information and data generation, record keeping, and decision making should be listed along with the material handling activities. Sections II, III, and IV of Appendix F show different types of information generating activities that a process operator may have. Again, it may be helpful to refer back to "DPA Information and Data Gathering Worksheets" 1, 3, 4, 6, 7, 8, 9, 10, and 11 when determining what activities each decision maker performs. Figure 2-3 shows the activities of the individual who performs both the receiving and chopping operations in the example DPA. These activities should be compared to those indicated on pages 64 and 65 in Volume 2.

2.4.5 MATERIAL/INFORMATION FLOW DIAGRAMS

Using information assembled in the "Material, Information, and Activities Worksheet," the control exercised by a process operator can be shown in a single diagram. In such a diagram, the process operator of *one* Operational Area is depicted as a decision maker and his responsibilities for the material flows and the information flows are concisely illustrated. Intercomparison of these

diagrams allows the DPA team to easily trace the information flows associated
with the process operators so that none are overlooked. Review of Appendix E,
containing a brief discussion of the concept of nodes and flows and the symbols
used to represent them, will be helpful when preparing these diagrams.

Figure F-1 (Appendix F) shows the generalized process operator as a decision
maker exercising control over:

  a)   the material flows;

  b)   the information flows; and

  c)   the activities performed.

In these "Material/Information Flow Diagrams," symbols having "dashed" borders
represent: (1) other decision makers with whom this decision maker interacts; or
(2) material handling activities in adjacent Operational Areas.

The lower portion of the diagram represents those Unit Processes over which
the decision maker exercises direct control of the material. Material flows are
seen entering and leaving the Operational Area under the control of the decision
maker. This may encompass one or more Unit Processes. The upper portion of the
diagram shows the information flows associated with the decision maker. The
nodes and flows can be related to the information flows described in Appendix F.

The DPA team should convert the information gathered in the "Material,
Information, and Activities Worksheet" into a "Material/Information Flow Diagram."
Page 69 in Volume 2 shows the "Material/Information Flow Diagram" for the "Receiv-
ing Box Operator" (RBO). This diagram was constructed from the information
listed on page 64. Note that this diagram shows only those individuals who have
direct contact with the decision maker. Therefore, the diagram on page 69 does
not show that "Nuclear Material Control" (NMC) personnel ultimately receive copy
1 of the Material Transfer Report (MTR). However, this information flow is
depicted on page 73 where the Foreman of MBA-A" (F-A) is portrayed as the decision
maker.

2.5 ANALYSIS OF DIVERSION PATHS

The DPA team has now gathered all the information and data concerning the
Process to be analyzed and has totally characterized the Process in terms of:

  a)   how material flows through the Process;

  b)   who controls the material flows; and

  c)   how that control is exercised.

It is now time to analyze how it is possible to divert material from the Process and how to detect that Diversion, the third step in conducting a DPA.

2.5.1 CONCEALMENT STRATEGIES

In DPA, no assumptions are made about the diverter concerning his:

a)   intelligence;

b)   motivation; or

c)   rationality.

However, it is assumed that the diverter believes that he can successfully divert the SNM.   Therefore, he will have a <u>Concealment Strategy (CS)</u> or plan in mind when diverting the material.   These Concealment Strategies are important because they represent the adversary's perception of how he can shift responsibility for the missing material.   The possible Concealment Strategies include making the SNM loss:

1)   appear in the given Operational Area, but with the diverter neither observed in the act of Diversion nor apprehended with the SNM on his person;

2)   appear in another Operational Area of the same MBA;

3)   appear in an Operational Area of another MBA; or

4)   be attributed to the facility.

Each succeeding Concealment Strategy is considered to be more desirable from the diverter's point of view.   In strategy #1, the diverter is only concerned about getting the SNM out of the authorized location in a Process before the Diversion is detected.   He does not care if he is considered a possible suspect when the theft is discovered.   In strategy #2, the diverter wants to place the blame on a co-worker.   In strategy #3, the diverter anticipates that the theft will be attributed to another MBA.   In strategy #4, the diverter believes that, although the theft may eventually be discovered, safeguards officials will be unable to discover the location of the theft.   When developing the <u>Scenarios</u>, the DPA team should consider each of these strategies in turn.

2.5.2 ANALYSIS OF THE SPECIFIC DIVERSION PATHS

The DPA team is now ready to determine the specific methods of diverting SNM from the Process, that is, identifying each Specific Diversion Path (SDP) associated with the Process.   To do this, the team mentally assumes the role of the diverter.   Figure 2-4 shows a flow chart portraying the methodology for conducting the analysis.   It is necessary to follow the entire procedure shown

DIVERSION PATH ANALYSIS
FLOW CHART

Start

Have all materials been considered? — No → Determine GDPs to be considered for this material.

Yes

Stop.

Go to the first Operational Area.

Select the first GDP.

Consider the first Concealment Strategy

Consider the next Concealment Strategy.

Using this GDP and Concealment Strategy, is there any way the decision-maker, or his alternate, can divert a quantity of SNM equal to the Working Mass?

No

Is this the last Concealment Strategy?

No

No

Yes

Is this the last GDP involving Collusion to be considered?

Yes

Have all the Operational Areas been considered?

Yes

Determine the first Abnormal Situation guaranteed to occur as a result of this Scenario.

No

No

Yes

Consider the first GDP involving collusion.

Determine the range of Diverted Amounts indicated by this Abnormal Situation.

Analyze the next Operational Area.

Prepare a "SDP Worksheet" for this Path.

Consider GDP 1.

No

Have all the Operational Areas been considered?

Yes

Is this the last GDP involving no Collusion to be considered?

No

Have discrete Diversions throughout the entire range of Diverted Amounts been analyzed?

Yes

Yes

Is this the last GDP to be considered?

Yes → A

No

No

Return to the first Operational Area.

What new Abnormal Situation indicates a Diversion in the range of Diverted Amounts not previously considered?

Consider the next GDP.

FIGURE 2-4
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in Figure 2-4 for each distinct Material Type and Description found in the Process.

The flow chart indicates that the DPA team should start with the first Operational Area in which the material to be analyzed is found. This Operational Area has been well characterized at this point in time by means of:

a) a "Material, Information, and Activities Worksheet" which covers only this Operational Area;

b) a "Material/Information Flow Diagram" portraying the control exercised by the decision maker;

c) a "Material Flow Diagram" for each Unit Process in the Operational Area; and

d) the numeric characterization of each material flow within the Operational Area.

Using the first GDP indicated in Figure C-5 and the first CS, the team must determine if there is any *possible* method of successfully removing this material from the first Operational Area. Assuming the role of the adversary, the analyst must answer the question: "As the decision maker in this Operational Area, how can I satisfy the CS and acquire SNM from the process via the first GDP?" The answer to the above question is a Scenario in which the adversary is satisfying the CS as he exercises the GDP. At this point, the analyst must make a judgment. Is this Scenario possible given the plant's MC&MA Subsystems? If no Scenario is found for the first CS, the team should re-evaluate the first GDP assuming that the diverter is utilizing the second CS. The analysis should be continued until a "successful" Scenario is found.

Once the DPA team has found a "successful" Scenario, they must determine what Abnormal Situation, if any, would result if the Scenario was carried out. Abnormal Situations provide "indication" that SNM *may* have been diverted and reflect *any* unusual occurrence which may be encountered in the Process. Abnormal Situations may take on many forms including, but not necessarily limited to:

a) Shipper-Receiver Difference (S-R);

b) unusual yields or production results;

c) missing inventory;

d) unusual physical appearances;

e) missing records, forged records, etc.; and

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f)   accounting forms out of sequence.

In many cases, an Abnormal Situation may be a false alarm. There may be an Innocent Cause for the Abnormal Situation. For example, the Abnormal Situation of a low production yield may possibly be due to the Innocent Cause of an operator inadvertently making a processing error. Also, it is important to note that carrying out a Scenario may result in several different Abnormal Situations. However, the analyst should record the first Abnormal Situation guaranteed to occur as a result of using the Scenario.

For a given Scenario, the diverter may have several options available in regard to the amount of material to be taken at one time. The options depend upon the particular processing and/or material control constraints associated with the material. The DPA team must determine, for each Scenario, the range of Diverted Amounts that will be indicated by the same Abnormal Situation. This parameter refers to the number of Diversions, assumed to be equal in size, that are utilized for removal of a quantity of SNM totaling the Working Mass. The detailed description of the concept of Diverted Amounts is given in Appendix G.

For example, assume a Diversion of Pu metal from a casting operation with substitution of inert material. Also assume that the final casting weight is 1000 g and that the Pu content can be determined to ±1% by means of laboratory analysis. The range of Diverted Amounts indicated by an "out-of-spec" lab- oratory analysis (the Abnormal Situation), would be any quantity between 10.0 g and 500.0 g (the Working Mass for Pu metal).

At this point, the DPA team should complete a "Specific Diversion Path Worksheet" (see Figure 2-5). These worksheets should be completed in a legible manner, but need not be typed. The items, indicated by numbers in Figure 2-5, should be completed as follows:

ITEM   DESCRIPTION

1. Enter the generic title of the Operational Area.
2. Enter the material being analyzed.
3. Enter the Material Attractiveness of the material being analyzed
    (Figure C-3).
4. Enter the GDP number (Figure C-5).
5. Enter the RPW value for the GDP being analyzed (Figure C-5).
6. Place an "X" next to the appropriate attribute of the Deceit By
    Records parameter.

SPECIFIC DIVERSION PATH WORKSHEET

DECEIT BY RECORDS: ⑥

_____UNCHANGED
_____FALSIFIED
_____ALTERED

┌─────────────────────────────┐
│ MATL. AT. FAC. ___③___   │
│ × DIV. AMT. FAC. ___⑯___   │
│ × RPW FACTOR ___⑤___   │
│ = ARPW VALUE ___⑰___   │
└─────────────────────────────┘

DECEIT IN REMOVAL: ⑦

_____NO SUB.
_____SUB.

OPERATIONAL AREA _____①_____

MATERIAL _____②_____

GDP _④_

SDP _㉔_

DIVERTERS: _____⑧_____

_____

_____

DIVERTED AMOUNT: ⑮

_____SINGLE THEFT OF_____ (G) (ML)
_____SEVERAL THEFTS RANGING FROM _____ TO _____(G) (ML)

CONCEALMENT STRATEGY: ⑨

_____ LOSS IN THIS OPERATIONAL AREA, DIVERTER GETS AWAY
_____ LOSS IN ANOTHER OPERATIONAL AREA
_____ LOSS IN ANOTHER MBA
_____ LOSS IN PLANT

_____

_____

_____

_____

* * * * * * * * * * * * * * * SCENARIO # _____ * * * * * * * * * * * * * * * *

___⑩_____

_____

_____

_____

_____

_____

ABNORMAL SITUATION #_____:_____⑪_____

_____

_____

INFORMATION NEEDED: ___⑫_____

_____

OBSERVER: ___⑬_____ TIME RESPONSE (DAYS) ___⑭_____

INNOCENT CAUSE #_____: ___⑱_____

_____

MODIFICATION #_____: ___⑲_____

_____

ABNORMAL SITUATION #_____:_____⑳_____

_____

INFORMATION NEEDED: ___㉑_____

_____

OBSERVER: ___㉒_____ TIME RESPONSE (DAYS) ___㉓_____

FIGURE 2-5

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7. Place an "X" next to the appropriate attribute of the Deceit In Removal parameter.

8. List the generic title of *each* adversary (or pair of adversaries in the case of Collision) who could complete this Diversion Path. The title should be followed by the identifying number[5] which will be used by the computer to represent that potential diverter.

9. Place an "X" next to the applicable CS.

10. Describe the Scenario in detail (using the space on the back of the worksheet, if necessary). The description should include the records Falsified or Altered, the materials substituted, the amount of SNM taken, and all other assumptions the analyst makes. Number the Scenario.

11. Describe the first Abnormal Situation guaranteed to occur when the diverter follows the Scenario listed in item 10. Number the Abnormal Situation.

12. List the information that is needed to verify the Abnormal Situation in item 11.

13. List the generic title of the person who observes the Abnormal Situation in item 11. The title should be followed by the identifying number[5] which will be used by the computer to represent this observer.

14. Enter the time (in days) that elapses between the Diversion and guaranteed observation of the Abnormal Situation listed in item 11.

15. Enter the range of Diverted Amounts "indicated" by observance of the Abnormal Situation listed in item 11.

16. Calculate and enter the Diverted Amounts factor, D.

$$D = \sqrt{\frac{\text{maximum amount in the range of Diverted Amounts}}{\text{Working Mass}}}$$

17. Calculate and enter the Adjusted Relative Path Weight (ARPW).

18. Describe the possible Innocent Causes for the observed Abnormal Situation given in item 11. Number the Innocent Causes.

---

[5] As the observers and the potential diverters are identified, a list of them should be made using abbreviations (up to 8 alphanumeric characters in length) as indicated on any SDP Worksheet found in Volume 2. Only one list is needed since an observer in one SDP may be considered a potential diverter in another. The entries in this list should be numbered (not exceeding 99). This number is used to identify the observers/diverters when using the computer program.

19. Describe the best possible Minor Modification[6] to the MC&MA Subsystems which will reduce the Detection Time for the Abnormal Situation listed in item 11. It is possible that the DPA team can think of no Minor Modification at this time. It is not mandatory that the analyst determine a modification for every SDP. Number the modification.

20. Once the modification has been made, describe the Abnormal Situation that will result if the diverter follows this Scenario (item 10) and this CS (item 9). Number this Abnormal Situation.

21. List the information that is needed to verify the Abnormal Situation in item 20.

22. List the generic title of the person who observes the Abnormal Situation in item 20. The title should be followed by the identifying number[5] which will be used by the computer to represent this observer.

23. Enter the time (in days) that elapses between the Diversion and guaranteed observance of the Abnormal Situation listed in item 20.

24. Assign this SDP an identifying number according to XX-YY, where:

   XX = number representing the Operational Area; and

   YY = Path number within Operational Area XX.

---

[6] At this point in the analysis, primary emphasis should be placed on determining Minor Modifications which:

   a)   affect only the existing MC&MA Subsystems; and
   b)   involve little or no implementation and/or follow-on costs.

A modification which satisfies the above two criteria should be recorded on the "Specific Diversion Path Worksheet" (Figure 2-5). If the analyst determines a modification which does not satisfy both of the above criteria, it should be recorded on a "DPA Modification Worksheet" but not on the "Specific Diversion Path Worksheet." Instructions for completing the "DPA Modification Worksheet" are given in Section 2.6.2.2.

It should be noted that the existing MC&MA Subsystems may be improved, at little or no cost, by means of modifications:

   a)   to the existing process related, standard operating procedures;
   b)   to the existing accounting procedures;
   c)   to the accounting forms; and/or
   d)   to the types of process and accounting data obtained.

The first ten modifications on page 201 in Volume 2 are Minor Modifications which satisfy the two criteria above.

Particular care should be taken to assure that all potential diverters are listed in Item 8. The number of potential diverters who could perpetrate a given scenario affects the true importance of that scenario. Each SDP should, ideally, relate to a single potential diverter but to do so would often require preparation of repetitious "SDP Worksheets." The importance of SDPs having more than one potential diverter is adequately accounted for in the "Potential Diverter - Specific Diversion Path" cross-reference table prepared by the computer (see Appendix I).

After the "SDP Worksheet" is completed, the analyst must decide if he has considered all possible amounts of SNM that a diverter could remove when executing the chosen Scenario. If only part of the range of Diverted Amounts has been considered, the analyst must determine if there is another Abnormal Situation which would indicate that Diversion of a lesser amount has taken place. This is an iterative process in which the DPA team is trying to find the resulting Abnormal Situation for each discrete amount of SNM that a diverter could possibly remove as part of the chosen Scenario. After the entire range of Diverted Amounts has been examined, the DPA team should try to find another Scenario which fits GDP #1 and the Concealment Strategy. When no more Scenarios can be found, for any Concealment Strategy assuming GDP #1, the team should start this portion of the methodology over again, using GDP #2. This iterative process is continued until the GDPs that do not involve Collusion have been analyzed for the first Operational Area. In a similar manner, the DPA team analyzes the next Operational Area for the same material. This analysis is continued until the team has analyzed all the GDPs that do not involve Collusion for each Operational Area in which the first material is found. The team should now consider the next material (if there is one) and repeat the analysis, starting at the first Operational Area, for all GDPs that do not involve Collusion. Similar analyses are repeated for each material until all materials have been considered. Now, the DPA team should return to the first Operational Area and repeat the analysis for the GDPs that involve Collusion. In this way, Diversion Paths associated with each material will be analyzed, in each Operational Area, for each GDP involving Collusion of two individuals. When all iterations are completed, the DPA team will have finished the "Analysis of Diversion Paths" step.

When evaluating GDPs in which the adversary is a Thief rather than an Embezzler, the analyst must consider those actions which could possibly be taken

by someone who is authorized to be in the area but who is not authorized to relieve the decision maker of his assigned activities. Individuals who are authorized to relieve the decision maker should be considered as Embezzlers; all others authorized to enter the area must be considered as Thieves. In many cases, Thieves can execute the same Scenarios as Embezzlers. Compare, for example, the Scenario on page 89 in Volume 2 with the Scenario on page 77. It must be remembered, however, that Scenarios involving Falsification of records cannot be performed by a Thief. Embezzlers have a better opportunity to carry out each Scenario because their actions are less likely to arouse suspicion in the process area. The primary issue is to determine:

1) what other personnel could steal SNM from the process area; and

2) if the MC&MA Subsystems would react any differently if the adversary is a Thief rather than an Embezzler.

The second point is important because, while it is mandatory that process personnel have access to the area and the material, there may be some modifications which would further restrict the access of those individuals who are not essential to the process operations. For example, a procedural modification might restrict the access of the "Maintenance Man" to times when no SNM is in the process area so that he no longer poses a threat (see pages 156, 159, and 163 in Volume 2).

In some cases, the DPA team will be unable to find any SDP for a particular GDP. If this happens, a "SDP Worksheet" should be completed using "NP" (for "No Path") in item #24 of Figure 2-5. However, items #1 through #8 should be completed and the appropriate explanation should be entered in item #10. Two examples of this situation can be found on pages 93 and 107 in Volume 2.

When conducting the analysis step, the DPA team will undoubtedly think of some Scenarios in which the diverter would be detected before he had sufficient time to remove the SNM from its authorized location within the facility. The diverter would be unable to accomplish the first Concealment Strategy before the MC&MA Subsystems produced the Abnormal Situation. As the analyst thinks of these Scenarios, it is recommended that they be recorded on a "SDP Worksheet" even though the Path poses no threat. At some future date, the DPA team or management may want to know why a particular Scenario was rejected. Items #1 through #15 in Figure 2-5 should be completed and "NP" should be entered in item #24. The Scenario given on page 185 in Volume 2 is illustrative. The identified adversaries would be detected by the "Vault Custodian" before they could get away because the vault cannot be opened unless the "Vault Custodian" is present.

2.5.3 EVALUATION OF PATHS INVOLVING COLLUSION

In DPA, it has been assumed that Collusion will occur only if a diverter is willing to accept the added risk of involving a second individual. For those Paths involving Collusion, each colluder must:

a) have knowledge of the intended Diversion; and

b) contribute to the success of the Path by: (1) performing activities expected of him; or (2) failing to report an Abnormal Situation which he should observe.

This rules out the possibility of some individual becoming an "unwitting" colluder. Also ruled out are those individuals who do nothing more than serve as a "lookout" while the Diversion is taking place or merely provide an alibi for the real diverter.

The end result of Collusion must be:

a) making possible a previously blocked (impossible) Path by involving the observer of the Abnormal Situation as a colluder;

b) an increase in the Detection Time of the Diversion; or

c) an upgrading of the Concealment Strategy.

Page 166 in Volume 2 provides an example of a previously blocked path being made possible when the "Vault Custodian" fails to report a "light" button and reflects a) above. Without Collusion, this Path would be impossible for the "Casting Operator" to carry out since the "Vault Custodian" would immediately report a "light" button to the "Foreman of MBA-A." A comparison of pages 90 and 108 reflects b), showing that Collusion prevents the possible detection by the "Casting Operator" and thus significantly extends the Detection Time.

The purpose of first evaluating each Operational Area for all Paths which do not involve Collusion, is to give the DPA team a better idea of the constraints in each Operational Area. It also serves to point out how the Operational Areas are interrelated, by identifying individuals in other Operational Areas who might observe an Abnormal Situation relating to a Diversion in the Operational Area being considered.

As shown in Figure 2-4, the Paths involving Collusion are evaluated in each Operational Area. While a SDP requiring Collusion may involve more than one Operational Area, it should be recorded under the Operational Area in which the SNM would actually be removed from the Process. In this way, the DPA team can avoid listing duplicate SDPs.

When evaluating Paths involving Collusion, the DPA team must consider all the possible combinations of individuals who could possibly complete the Scenario. In some cases, such as those shown on pages 97 and 98 in Volume 2, a change in the colluding pair will affect the detection capability of the Safeguards System. Here, different colluding pairs, using the same Scenario, produce different Abnormal Situations. Therefore, the SDP on page 98 is different from that on page 97; it must be recorded separately.

2.5.4 OTHER CONSIDERATIONS

At times, the DPA team may become preoccupied with determining which GDP most closely fits a particular Scenario. This problem sometimes occurs when the Scenario involves the Falsification attribute. Page 82 in Volume 2 provides an example of this dilemma. It can be argued that the "Receiving Box Operator" is Falsifying the "Material Transfer Report" when he places a "/" in the right hand margin representing the bar he is stealing and replacing with a substitute bar. The people who receive the "Material Transfer Report" ("Foreman of MBA-A" and the "Bar Chopping Operator") will assume that the bar contains Pu when in fact it is made of some other material. Thus, the information on the form is mis- leading and should help the "Receiving Box Operator" to conceal the Diversion. However, it can also be argued that the "/" on the "Material Transfer Report" does not represent Falsification because the "/" indicates that the "Receiving Box Operator" did in fact receive a bar made of Pu. One certainly would not expect the "Receiving Box Operator" to fail to record a "/" for the diverted bar, knowing that he is going to replace the bar with a substitute. This would only draw attention to the attempted Diversion. In situations such as this, the DPA team should arbitrarily record the Scenario with the GDP that it feels is most appropriate. The GDPs help the analyst to consider all the possible Scenarios. The completeness of the analysis is far more important than having each Scenario associated with the most correct GDP. The Scenario on page 82 in Volume 2 was associated with GDP #3, rather than GDP #4, because GDP #3 has the higher RPW. This is the more conservative approach.

The DPA methodology gives no special consideration to the number of times an adversary must Falsify (or Alter) a particular form in order to carry out his chosen Scenario. Likewise, no special consideration is given to the number of forms which must be Falsified (or Altered) while completing the Scenario. Instead, it is assumed that perpetual Falsification (or Alteration) of the same

form, to extend the Detection Time, is about as difficult as Falsifying (or Altering) the form only once. SDP 4-11 on page 183 in Volume 2 is an example of the perpetual Falsification of a form.

The DPA team may encounter a Scenario which involves more than one attribute for a given Diversion Path Parameter. When this occurs, the Scenario should be recorded under the GDP having the lower RPW value. For example, if a Scenario involving simple theft by an Embezzler requires Falsification of some records and Alteration of others, the Scenario would be recorded under GDP #5 rather than GDP #2. This is consistent with the philosophy of decreasing the RPW of the more complex Paths. SDP 1-36 (page 114 in Volume 2) provides another example of this concept.

It may be possible for a Scenario to apply to more than one Concealment Strategy. This occurs most often when the resulting Abnormal Situation provides no clear indication as to where the Diversion occurred. For example, the Scenario on page 78 in Volume 2 shows that the adversary could use this Scenario to place the blame on a co-worker in his MBA or on a worker in another MBA.

In the case of Collusion, it is also important to note that if a GDP requires Unchanged as one of its attributes, neither colluder is allowed to Falsify or Alter any data. If Falsification is one of the attributes, at least one of the colluders must Falsify data that he is responsible for recording. If the Path requires Alteration as one of its attributes, one or both of the colluders must Alter data recorded outside of their own Operational Areas.

The DPA team may often identify more than one potential diverter for a given Scenario. Each should be indicated on the "SDP Worksheet."

There is also a possibility that the DPA team will determine a Minor Modification for one of these Scenarios in which one of the diverters becomes the observer of the Abnormal Situation associated with the modification. In this case, the team should complete two separate SDP worksheets. One example of this situation is given in the SDPs shown on pages 94 and 95 in Volume 2. The "Foreman of MBA-A" could execute Scenario #17. However, if modification #5 is implemented, he cannot be expected to report himself. Therefore, the "Foreman of MBA-A" should be shown as the adversary on SDP 1-18 rather than SDP 1-17. This adequately reflects the uniqueness of the path. The SDPs given on pages 100 and 101 provide another example of this situation.

If the DPA team has included the "Foreman" as a potential diverter, it will be necessary to determine the SDPs available to him because of his authority to cross Operational Area boundaries. For example, it can be seen on page 109 in Volume 2, that the "Foreman of MBA-A," acting alone, can execute the same scenario as the "Receiving Box Operator" and the "Bar Chopping Operator" acting in Collusion (see Volume 2, page 97).

2.6 RESULTS AND FINDINGS

The fourth step in conducting a DPA involves: (1) collecting and sorting the results of the "Analysis of Diversion Paths" step; and (2) examining those results to determine findings and recommendations. All necessary information will be taken directly from the "Specific Diversion Path Worksheets." While two computer programs have been developed [3,4] to do most of this step, it will be necessary to prepare some tables by hand.

2.6.1 COMPILATION OF THE RESULTS

The first summary to be completed is an "Abnormal Situation List." The DPA team may compile this list by merely searching through the "Specific Diversion Path Worksheets." Both the Abnormal Situation number and a verbal description should be written down. It is easier to complete this list as the Paths are being analyzed since in this manner, the analyst has a convenient record of all Abnormal Situations previously considered. Pages 199 and 200 in Volume 2 show the "Abnormal Situation List" for the example DPA.

In a similar manner, a "Modification List" and an "Innocent Cause List" should be prepared. Both lists are compiled either by reviewing the "Specific Diversion Path Worksheets" or by listing the items as they are identified. The appearance of these lists is similar to the "Abnormal Situation List" and examples are shown on pages 201 and 202 in Volume 2.

Two computer programs have been written to simplify compilation of the analysis results. The first program, "Diversion Path Analysis Computer Program 1" (DPACP-1) [3], assembles the data from the "SDP Worksheets" and produces several tables which the DPA team should use to determine the findings and recommendations. Some of the tables produced will become part of the documentation of the DPA. See Appendix I for a description of this computer program and for instructions concerning preparation of the input data.

The second program, "Diversion Path Analysis Computer Program 2" (DPACP-2) [4], complements "DPACP-1" and produces the tables and statistics on Minor and

Major Modifications that are included in the documentation of the DPA. "DPACP-2" uses the same data deck for the SDPs as "DPACP-1." The "header" cards for the two programs, however, differ. "Header" cards for "DPACP-1" provide data on observers and diverters while, for "DPACP-2," information is provided on the lifetime and estimated costs of the proposed modifications. Appendix J contains a general description of "DPACP-2" and instructions for preparation of the input data.

The DPA team should have the data on the "SDP Worksheets" transferred to cards or other appropriate input medium which can be read by the computer.

The objective of the first run of both programs is to determine the improvement in the status of the Safeguards System if all the Minor Modifications are implemented. The DPA team should meet with the facility management to discuss the results of the DPA thus far. Special emphasis should be placed on a discussion of the:

a) "DPA Summary Table;"

b) "Distribution of System Response Time" table; and

c) "DPA Modification Proposals."

In addition to reporting the progress of the analysis, the objective of the meeting should be to determine if the facility management is willing to implement all of the proposed Minor Modifications. Although Minor Modifications normally involve little or no cost, it is possible that they could adversely impact the process operations. For example, a modification requiring the process foreman to check a measurement of a process operator, by remeasuring the item himself, could:

a) cause a renegotiation of a contract if union rules prohibit foremen from handling the SNM; or

b) overburden the process foreman if the "verification" requirement takes up a significant portion of his time; or

c) cause a "bottleneck" in the process operations if the process operator must stop his operation (and the flow of material through the process) until the foreman has verified the measurement.

Facility management will want to insure that the proposed Minor Modifications do not adversely impact the process operations.

If management rejects some of the proposed Minor Modifications, "DPACP-1" should be run again with the SDP data changed appropriately. If management accepts all the proposed Minor Modifications, there is no need to make another computer run.

Judicious use of the programs, particularly "DPACP-1," allows the DPA team to determine the impact, on the facility Safeguards System, of implementing a selected set of "proposed" modifications. Flexibility has been designed into the programs so that the DPA team can quickly determine the impact of alternative modification proposals and easily keep the analysis up to date. Each run of either program contrasts the status of the facility Safeguards System assuming that a specified set of modifications are to be implemented. "Coverage 1" indicates the status "before" implementation while "Coverage 2" indicates the status "after" implementation. Comparison of the "Coverage 1" status and the "Coverage 2" status represents the change to be expected from implementing the specified set of modifications. A notation or date is assigned to both "Coverage 1" and "Coverage 2" to reference the status to a specific point in time.

For example, the following runs *might* be made (with the notations for status indicated in parentheses).

RUN #	COVERAGE 1	COVERAGE 2
1	Identified Modifications not as yet implemented (Pre-DPA)	Proposed implementation of all Minor Modifications (Proposed)
2	Actual implementation of all Minor Modifications (6-1-78)	Proposed implementation of Major Modification #1 (Proposed)
3	Actual implementation of all Minor Modifications (6-1-78)	Proposed implementation of Major Modification #2 (Proposed)
4	Actual implementation of all Minor Modifications (6-1-78)	Proposed implementation of Major Modifications #1 and #2 (Proposed)
5	Actual implementation of all Minor Modifications (6-1-78)	Actual implementation of Major Modifications #1 and #2 (9-1-

Run #1 represents the first run made on completion of the analysis. "Coverage 1" will indicate the initial status of the system while "Coverage 2" will ass the DPA team in assessing the impact of implementing the Minor Modifications.

The impact of implementing Major Modification #1 on the system, already having all Minor Modifications implemented, can be studied by the team after Run #2. Run #3 provides the team with similar information about Major Modification #2. Since these Major Modifications might interact, the same type of information as gained in Runs #2 and #3 can be obtained in Run #4 for the two Major Modifications employed at the same time. Run #5 provides the team with a record of the update in system status after the two Major, as well as the Minor, Modifications have been implemented.

2.6.2 ANALYZING THE RESULTS

Having obtained management's approval to implement the Minor Modifications, the DPA team must analyze the data to determine the most significant vulnerabilities, and to determine some Major Modifications which would lessen (or eliminate) these vulnerabilities.

2.6.2.1 SELECTION OF "WORST CASE" PATHS

First, it will be necessary to determine which Specific Diversion Paths present the greatest risk if successfully carried out. These "worst case" Paths are chosen from the entire group of SDPs based on the criteria of longest Detection Time, for the "most attractive" material. In other words, if a diverter has a choice, he would probably attempt to execute a Diversion Path in which:

a)   he removed the "most attractive" material available at the facility; and

b)   he remained undetected for the longest period of time.

Here, it is important to remember that all SDPs identified in the "Analysis of Diversion Paths" step could be successfully carried out by a diverter. The DPA team is not assessing the probability that a diverter will choose a particular Path, but rather identifying those Paths in which the loss of the "most attractive" material would remain undetected for the longest period of time.

Therefore, to give facility management an overview of the safeguards posture for a particular Process, the DPA team should select a minimum of three SDPs with the longest Detection Times. If several SDPs have equally long Detection Times, those with the highest ARPW value should be chosen. These SDPs should be selected from among those Paths which involve the "most attractive" material. Therefore, these "worst case" Paths should be determined by searching through the "Detection Time-SDP Cross Reference Table" for the "most attractive" material, and selecting those Paths which have the longest Response Time. Page 222 in

Volume 2 shows one method for presenting this information to facility management. In addition, these "worst case" Paths should be placed in proper perspective by showing management the distribution of Response Times for all SDPs in the Process. This is illustrated best by the "Distribution of System Response Time" table (see page 221 in Volume 2).

2.6.2.2 DEVELOPING MAJOR MODIFICATIONS

During the conduct of the "Analysis of Diversion Paths" step of DPA, the team:

a)   identifies specific methods for removing SNM from the Process;

b)   determines the particular aspect of the MC&MA Subsystems which would indicate that SNM is missing; and

c)   determines a modification to the MC&MA Subsystems which would prevent theft or reduce the Detection Time.

All modifications determined in "c" above are the result of analyzing a Specific Diversion Path. Also, the proposed modifications to the MC&MA Subsystems involve little or no cost and can be implemented in a relatively short time. While some of the modifications affect only one Path, most modifications affect several Paths.

However, when reviewing the "DPA Summary Table" and the "Detection Time-SDP Cross Reference Table," the team will note that some Paths may remain which still have very long Detection Times after the Minor Modifications to the MC&MA Subsystems have been adopted. There are two approaches to selecting further modifications to improve the future coverage. Modifications developed by either approach:

a)   will involve significant costs;

b)   may take a significant amount of time to implement; and

c)   may involve the Physical Protection Subsystem, the MC Subsystem, the MA Subsystem, or a combination of elements from two or more.

The first approach is directed toward finding modifications for the "worst case" Paths (or other SDPs which represent significant vulnerabilities in the opinion of the DPA team). While the objective is to "plug the hole" by eliminating the Path, it may be necessary to settle for reducing the amount of time it takes to detect a Diversion when the Path is used. Modifications should be directed toward changing the Abnormal Situation so that it "indicates" Diversion

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from a specific location or Operational Area within the facility in a shorter time. The DPA team should assess modifications such as;

a) CCTV, to oversee the specific operation in which SNM may be diverted;

b) portal monitors, to prevent the SNM from leaving its authorized location, within the process area;

c) NDA equipment, to indicate that SNM has been diverted; and/or

d) establishment or enforcement of Material Surveillance Procedures to increase the risk of detection when a process operator tries to remove SNM from a specific location.

Each of the above types of modifications will lead to earlier detection of a removal of SNM from the Process. In many instances, the modification may make it impossible for a diverter to execute the Specific Diversion Path.

The second approach is directed toward improving the general response capability of the MC&MA Subsystems. Improved coverage may be obtained on several Paths simultaneously by:

a) determining which Abnormal Situation or "indicator" in the MC&MA Subsystems "detects" the most Paths; and

b) developing a modification to more quickly detect the Abnormal Situation.

Looking at page 206 in Volume 2, the analyst should note that 14 Specific Diversion Paths will result in Abnormal Situation #9 being observed (see page 199 for a description of Abnormal Situation #9). In this example, to significantly reduce the time it takes to analyze samples, the facility could:

a) increase the number of lab technicians; or

b) purchase better lab equipment.

While neither of these modifications will make any of the 14 Specific Diversion Paths impossible to execute, both will reduce the Detection Time of each of the 14 paths. "DPA Modification Proposals" #11 (page 267) and #12 (page 224) illustrate this concept.

The DPA team should apply both approaches to develop Major Modifications which will improve the safeguards posture of the facility.

When considering a Major Modification, the DPA team should complete a "DPA Modification Worksheet" (one for each modification). This worksheet, shown in Figure 2-6, should be completed as follows:

DPA MODIFICATION WORKSHEET

MODIFICATION: ①_____

_____

_____

_____

SDP ②	AS ⓐ	TIME ⓑ	OBSERVER ⓒ

MODIFICATION NO. _____ ③ _____

INITIAL COST $ ④ _____

ANNUAL COST $ ⑤ _____

EST. LIFE (YRS) _____ ⑥ _____

SDP ②	AS ⓐ	TIME ⓑ	OBSERVER ⓒ

FIGURE 2-6

1. Enter a complete description of the modification being proposed.

2. Enter the identifying number of all SDPs that would be affected by the
   proposed modification in item "1" above. For each SDP listed, complete the
   line entering:

   a)   the Abnormal Situation number after the modification is implemented;

   b)   the time (in days) that elapses between Diversion and guaranteed
        observation of the Abnormal Situation listed in item a) above; and

   c)   the generic title (and identification number) of the person who observes
        the Abnormal Situation listed in item a) above.

3. Enter the number of the proposed modification.

4. Enter the estimated "Initial Cost" of the proposed modification.

5. Enter the estimated "Annual Cost" of the proposed modification.

6. Enter the estimated number of years that this modification will remain in
   effect at the "Annual Cost" shown in item 5 above.

The "Initial Cost" is a rough estimate of the expenditure needed to make
the modification operational. Included in this estimate would be purchase
costs, installation costs, costs of initial supplies, etc. The "Annual Cost" is
a rough estimate of the expenditure needed to operate the modification on a
yearly basis. This estimate would include the cost of services such as power,
costs of supplies and repairs, salaries of personnel, etc. It should be emphasized
that the DPA team is not responsible for preparing budget quality estimates of
costs for Major Modifications. The intent is to determine rough cost estimates
for each proposed modification so that comparisons can be made. These comparisons
should help management to decide which Major Modifications, if any, they can
afford to undertake. After deciding which proposals to implement, management
should request that detailed cost estimates be prepared for budget submission.

Having determined some possible Major Modifications to the facility Safeguards
System, the DPA team should again use the two computer programs ("DPACP-1" and
"DPACP-2") to determine the improvement in the status of the Safeguards System
under alternative situations. The new results will allow the DPA team to show
management the impact of a given modification on the safeguards posture of the
Process in terms of reduced Detection Times.

To set up for this computer run, the DPA team should prepare a data card for each SDP which could be affected by that modification. The format for these cards is shown in Appendix J. If more than one Major Modification can affect a SDP, a SDP data card must be prepared for each modification. "DPACP-2" should be run with CARD 2 (columns 5 and 6) and CARD 4 reflecting all modifications which were implemented previously. The output of "DPACP-2" will be:

a) a "DPA Modification Proposal" for each modification not yet implemented (see pages 224, 225, 226, and 267 in Volume 2); and

b) a "Modification Summary Table" which summarizes the decision parameters for all modifications, either proposed or implemented. See page 227 for an example of this table.

Space has been left at the top of each "Modification Proposal" so that a brief description of the modification can be typed in.

It should be noted that, in the example DPA, modifications #11 and #12 (pages 267 and 224 respectively) affect the same 14 SDPs in the same way. They are alternative approaches to improving the ability of the facility lab to detect substitution strategies in a shorter time. The "Modification Summary Table" on page 227 in Volume 2 accurately reflects the decision parameters intended to assist facility management. In the example DPA, facility management rejected modification #11 because, while it provided the same improvement in Response Time as modification #12, its Equivalent Annual Cost (EAC) and Marginal Cost were significantly higher.

Each modification proposal should reflect *all* SDPs which could be affected by its implementation. In this way, management will be able to evaluate each modification proposal based on its own merits. For example, SDP 3-10 will be eliminated if either modification #13 (page 225) or modification #14 (page 226) is implemented. Note that the decision parameters for modifications #13 and #14 on page 227 (also found on each modification proposal) both include the impact of eliminating SDP 3-10.

To compare the current status of the Safeguards System against the status of the Safeguards System after the proposed modifications are implemented, the DPA team will have to make some preliminary assumptions concerning the order in which the modification proposals should be implemented. In effect, this will be the recommended implementation plan presented to facility management. Page 230 in Volume 2 shows the DPA team's recommendations in the example DPA.

The DPA team should now utilize "DPACP-1" to show the impact of their recommended implementation plan. On this run of "DPACP-1," care must be taken to insure that each SDP is affected by no more than one modification. In the example DPA, it was assumed that management would reject modification #11 in favor of modification #12 and that SDP 3-10 would be eliminated by implementing modification #13 rather than modification #14. Pages 228 and 229 in Volume 2 show the final run of "DPACP-1." Note that this is a comparison of the current status of the Safeguards System (the date when the last modification was implemented) against the "proposed" status of the Safeguards System after modifications #12, #13, and #14 have been implemented.

2.7 DOCUMENTING THE DPA

The fifth and final step in conducting a DPA is documenting the analysis. The DPA documents provide a complete record of the analysis. Because each analysis will be independently reviewed by the DOE/SS, it is desirable to have a standard format. This step of DPA will be discussed in two parts; the workpaper documentation and the summary documentation.

2.7.1 WORKPAPER DOCUMENTATION

The workpaper documentation provides the "backup" or support for all conclusions and recommendations. It also serves as a reference when the facility safeguards and security review team examines their situation for possible upgrading. It is intended that the facility "Nuclear Materials Control" staff will maintain the workpaper documentation in their office along with the backup references collected during the "Information and Data Gathering" step. The workpaper documentation should be kept up-to-date. It contains six separate sections as shown in the Table of Contents for Part I, Volume 2, page 5.

The first section, "Analysis Guidelines," indicates the limiting assumptions used by the DPA team. It should include the:

      a)   materials analyzed;

      b)   physical locations analyzed;

      c)   personnel considered as potential diverters;

      d)   personnel exempt from consideration as potential diverters;

      e)   criteria for classes of Detection Time; and

      f)   list of General Diversion Paths.

The recommended format for this information is shown on pages 9 and 10 in Volume 2. It is important to state the specific assumptions used for the DPA being

documented since these assumptions might have to be changed, e.g., to reflect Process changes, at some future date.

The second section of the workpaper documentation (pages 11 through 51 in Volume 2) formalizes the "Information and Data Gathering" step. This section should include all the completed "DPA Information and Data Gathering Worksheets" as well as blank copies of forms and logs. Any notes or other information resulting from observation of the Process or interviews with process personnel should also be included.

The third section (pages 53 through 73 in Volume 2) includes all the diagrams and calculations which were prepared to characterize the Process. In addition, the DPA team should prepare a brief description of the Process. This is recommended because some individuals who review the workpaper documentation may be unfamiliar with the Process. Also, Processes change and it is important to describe the Process as it was operating at the time of the DPA. This description should briefly characterize the operations that take place, the personnel controlling the Process, the accounting information that is gathered, and some of the important timing information relevant to performing the operations. Page 5, Part I (Volume 2) shows the recommended ordering of information in this section.

Section four of the workpaper documentation (pages 75 through 195 in Volume 2) is a compilation of all the "Specific Diversion Path Worksheets." It is recommended that the "SDP Worksheets" be grouped by Material Description and then by Operational Area within each Material Description. As Paths are eliminated by implementing modifications, the affected "SDP Worksheets" should be removed and filed in Appendix B.

The fifth section of the workpaper documentation (pages 197 through 230 in Volume 2) contains: (1) listings of Abnormal Situations, Minor and Major Modifications and Innocent Causes identified in the course of the analysis; (2) tables indicating the *current* status of the facility Safeguards System; (3) the listing of *current* "worst case" Paths; (4) modification proposals being recommended for implementation along with the "Modification Summary Table;" (5) the "DPA Summary Table" and the "Distribution of System Response Time" table indicating the status of the facility Safeguards System "before" and "after" the proposed modifications are implemented; and (6) the recommendations that the DPA team intends to present to facility management. If more than one Material Description was analyzed, "DPA Summary Tables" for each should be included as well as the

table that summarizes the data for "All Materials." Page 5, Part I (Volume 2) shows the ordering of this information.

As proposed modifications are adopted and implemented, "DPACP-1" and "DPACP-2" should be rerun with the updated information. The tables in Section V, showing the status at an earlier time, should be replaced with updated output of the computer runs representing the status of the Safeguards System after the modifications are implemented. The tables removed from Section V should be put in Appendix C, as discussed below.

The DPA team should be prepared to make recommendations to facility management concerning general observations that were made during the conduct of the DPA. For example, if the DPA team found that very few material flows in the Process were characterized, they might recommend that an engineering study be performed to determine the feasibility of including additional measurement points in the Process. If the team found several small vaults, or in-process storage locations, they might recommend that an effort be made to consolidate the inventory. If they found that the facility was very susceptible to diversion of SNM by process operators who work alone, a recommendation might be made to evaluate the adoption of facility-wide Material Surveillance Procedures.

The last section of the workpaper documentation, the appendices, contains supplementary information and should include:

Appendix A: a list of abbreviations used in the analysis;

Appendix B: the SDP worksheets for Paths eliminated by implementing a
                modification; and

Appendix C: information and data on previously implemented modifications
                including the "DPA Modification Proposals," the "DPA Summary
                Tables" and "Distribution of System Response Time" tables
                for those modifications.

Modification proposals which were rejected by management should also be included in Appendix C. The recommended format for this section is shown on pages 231 through 267 in Volume 2.

2.7.2 SUMMARY DOCUMENTATION

The summary documentation is intended to provide the facility management with a concise overview of the safeguards posture of the process area analyzed and with information which will help them decide how to best allocate safeguards resources. The DPA team will be expected to present and discuss the results of

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the DPA with their management. The summary document forms the basis for this briefing. Furthermore, the summary documentation should be made available for review by the DOE Operations Office and the DOE/SS.

The summary document should give management:

a) a description of the Process analyzed and the scope of the analysis;

b) a description of the specific vulnerabilities to internal covert Diversion that may exist in the Process;

c) the number and time classes of Diversion Paths; and

d) the specific modifications or alternatives the DPA team has identified to improve the facility safeguards posture.

The first section, "Analysis Guidelines," is identical to Section I of the workpaper documentation. It will provide management with an understanding of the scope of the analysis and a background for understanding which Diversion Paths were considered.

The second section, "Results and Recommendations," is shown on pages 11 through 23 (Part II) in Volume 2. This section of the summary document should include:

a) all the "DPA Summary Tables,"

b) the "Distribution of System Response Time" tables;

c) a list of the selected "worst case" Paths;

d) the "Modification Summary Table;"

e) the "DPA Summary Table" and "Distribution of System Response Time" table assuming the DPA team's recommendations are adopted; and

f) any recommendations that the DPA team wishes to make.

The "DPA Summary Table" provides management with the number of identified different ways to remove SNM from the Process studied and the relative complexity of those different methods. Second, this table should give management an understanding of how much time is required to detect a Diversion of SNM from the Process. Finally, this table shows the merit of the proposed modifications in terms of the change in the status of the facility safeguards posture. Each "DPA Summary Table" is followed by a "Distribution of System Response Time" table which shows the number of paths, for the indicated system status, associated with each Detection Time.

The list of "worst case" Paths shows management some existing specific ways to remove SNM from the Process analyzed. This list, in conjunction with the "DPA Summary Table" and the "Distribution of System Response Time" table, serves to clearly identify the extent of the facility's vulnerability to the internal covert threat for that Process.

After reviewing the previous tables and having the recommended "DPA Modification Proposals" explained to them, facility management is in a better position to evaluate the "Modification Summary Table." The table, along with the recommendations, serves as a guide for management when preparing budget requests for safeguards.

The final section of the summary document should include, as appendices, a process description, a list of all proposed modifications, and a list of abbreviations found in the report.

While the above documentation is deemed adequate for evaluation by the DOE Headquarters safeguards staff, the DPA team should include additional information in the summary document as directed by facility management or the DOE Operations Office.

Appendix A

Abbreviations

ABBREVIATIONS

AMC	Assigned Mass Constant
ARPW	Adjusted Relative Path Weight
AS	Abnormal Situation
BAL	Batch Acceptance Log
BIT	Batch Identification Ticket
CCTV	Closed Circuit Television
CS	Concealment Strategy
DOE	United States Department of Energy
DOE/SS	Office of Safeguards and Security, United States Department of Energy
DPA	Diversion Path Analysis
DPACP-1	Diversion Path Analysis Computer Program 1
DPACP-2	Diversion Path Analysis Computer Program 2
F-A	Foreman of MBA-A
F-B	Foreman of MBA-B
GDP	General Diversion Path
IC	Innocent Cause
M	Material Attractiveness
MAA	Material Access Area
MBA	Material Balance Area
MC&MA	Material Control and Material Accounting
MDF	Material Description Factor
MTF	Material Type Factor
MTR	Material Transfer Report
NDA	Non-Destructive Assay
NMC	Nuclear Materials Control
NP	No Path
Pu	Plutonium
QA	Quality Assurance
RBO	Receiving Box Operator
RHF	Radiation Hazard Factor
RPW	Relative Path Weight
SDP	Specific Diversion Path
SNM	Special Nuclear Material

S-R	Shipper-Receiver Difference
VC	Vault Custodian
WM	Working Mass

Appendix B

Glossary

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GLOSSARY

ABNORMAL SITUATION

An occurrence inconsistent with historical experience and/or normal Process operation which can be related to possible Diversion of SNM.

ADJUSTED RELATIVE PATH WEIGHT (ARPW)

The numerical value of the Relative Path Weight (RPW), adjusted to reflect the Relative Weight Factors for Material Attractiveness and for Diverted Amounts. This value is used to order or rank the Specific Diversion Paths.

ALTERED (ALTER, ALTERATION)

An attribute of the Diversion Path Parameter "Deceit By Records," indicating intentional changing, by the diverter, of data previously recorded on forms/logs/records by another person, as a means of concealing the fact of Diversion. The other person is responsible for originally recording the correct data. The types of data that can be altered relate to: (1) non-measurements (serial numbers, etc.); (2) measurements (net weights, etc.); (3) concentrations (grams SNM per liter, etc.); and (4) measurement uncertainties (limits of error, etc.).

ASSIGNED MASS CONSTANT

The amount of a Type of SNM to be protected against Diversion by an Insider using Stealth and/or Deceit. The Assigned Mass Constant for each Material Type is established by the Office of Safeguards and Security, DOE.

CATEGORY I QUANTITY OF SNM

1. Uranium enriched to 20% or more in the isotope ^{235}U alone, or in combination with plutonium and/or ^{233}U when (multiplying the plutonium and/or ^{233}U content by 2.5) the total is 5,000 grams or more.

2. Plutonium and/or ^{233}U when the plutonium and/or ^{233}U content is 2,000 grams or more.

COLLUSION

Two persons acting in concert to divert SNM using the same Diversion Path.

CONCEALMENT STRATEGY (CS)

A plan by means of which a diverter believes that he can successfully conceal the fact of Diversion by having the loss appear in: (1) his Operational Area (but he will be neither observed in the act of diverting nor apprehended with the SNM on his person); (2) another Operational Area in his MBA; (d) an Operational Area in another MBA; or (4) the facility at large.

COVERED PATH (COVERED)

A Diversion Path for which indication of an Abnormal Situation would result within one day or less (Time Class 2).

DECEIT

An action mode where the adversary utilizes misrepresentation of his character or of his act.

DECEIT BY RECORDS

A Diversion Path Parameter for characterizing the use of recorded information and data as a means of concealing the fact of Diversion. The attributes of this parameter are: (1) Unchanged; (2) Falsified; and (3) Altered.

DECEIT IN REMOVAL

A Diversion Path Parameter for indicating one of two removal schemes available to a diverter, namely: (1) removal of SNM without replacement of any kind; and (2) removal of SNM accompanied by substitution of inert material or SNM having a different isotopic composition. The attributes of this parameter are: (1) No Substitution; and (2) Substitution.

DESCRIPTION

See Material Description.

DETECTION TIME

The elapsed time between Diversion of SNM and observation of the Abnormal Situation indicating the theft.

DIVERSION

The successful illicit removal of SNM from the authorized location in a Process for uses other than those permitted by law or treaty. Illicit removal includes theft òr unauthorized or illegal acts committed·by persons in authority. (Authorized transfer of SNM from one use to another in the materials management sense, also called diversion, is not implied).

DIVERSION PATH (PATH)

A modus operandi, devised by a diverter as an independent method, for the Diversion of a quantity of SNM, equal to the Working Mass, from the authorized location in a Process and concealing the fact of removal.

DIVERSION PATH ANALYSIS (DPA)

A methodology for systematically analyzing, within specified bounds, facility operations and the associated MC&MA Subsystems in order to identify (1) potential means for diverting SNM from the Process and (2) the time required for MC&MA Subsystems to indicate such Diversion.

DIVERSION PATH PARAMETER

An element of a General Diversion Path, such as: (1) Material Attractive-
ness; (2) Diverted Amounts; (3) Deceit By Records; (4) Deceit In Removal;
(5) Type Of Insider; and (6) Number Of Insiders. Each of the six parameters
has several attributes.

DIVERTED AMOUNTS

A Diversion Path Parameter for characterizing the number of separate
removals included in a Diversion Path. Its values represent a single
removal, or a series of equal removals, totaling the Working Mass.

EMBEZZLER

An attribute of the Diversion Path Parameter "Type Of Insider" indicating
an individual who is: (1) authorized to enter the Material Access Area;
(2) authorized to access the Operational Area; (3) authorized to handle and
is responsible for the SNM in the Operational Area; and (4) authorized to
make entries in logs/forms/ records associated with the SNM related work
activities in the Operational Area. In addition, he is sufficiently knowl-
edgeable of the record system pertaining to the SNM related activities in
the Operational Area to Falsify and/or Alter records.

FALSIFIED (FALSIFY, FALSIFICATION)

An attribute of the Diversion Path Parameter "Deceit By Records," indicating
intentional misrepresentation, by the diverter, of information or data
elements recorded on logs/forms/records, as a means of concealing the fact
of Diversion. The diverter is the individual responsible for recording the
information or data on the log/form/record. The types of data that can be
Falsified relate to: (1) non-measurements (serial numbers, etc.); (2)
measurements (net weights, etc.); (3) concentrations (grams SNM per liter,
etc.); and (4) measurement uncertainties (limits of error, etc.).

GENERAL DIVERSION PATH (GDP)

A description, in terms of the six Diversion Path Parameters, of a potential
means for diverting SNM from the Process and concealing the fact of Diversion.
In developing the GDPs, the Relative Weight Factor for the Material Attrac-
tiveness parameter and for the Diverted Amounts parameter has been assigned
a value of 1.0.

INNOCENT CAUSE

An unusual, but possible, occurrence in a Process that would produce the same Abnormal Situation as Diversion of SNM.

INSIDER

Any person who is authorized to be in the Material Access Area (MAA) at a facility.

MAJOR MODIFICATION

A revision of some aspect of the Safeguards System that involves considerable expense for implementation, e.g., purchase and use of a large piece of NDA equipment, hiring additional personnel, etc.

MATERIAL ACCESS AREA (MAA)

An area within a facility, containing a Category I Quantity of SNM, which is specifically defined by physical barriers, located within a Protected Area, and subject to specific access controls.

MATERIAL ACCOUNTING SUBSYSTEM

That part of the Safeguards System encompassing administrative policies, management and procedures directed to: (1) performing measurements of SNM; (2) maintaining records related to SNM; (3) providing reports related to SNM; (4) performing data analyses to account for SNM; and (5) verifying the "book inventory" by means of a measured "physical inventory."

MATERIAL· ATTRACTIVENESS

A Diversion Path Parameter for characterizing the implied utility of specific SNM for making a nuclear explosive device. The parameter has three factors: (1) Material Type Factor; (2) Material Description Factor; and (3) Radiation Hazard Factor. Each factor has several variables.

MATERIAL BALANCE AREA (MBA)

An identifiable physical area within a facility such that the quantity of SNM being moved into or out of the area is represented by a measured value. Material records for an MBA are maintained such that, at any time, a balance can be obtained to show the material for which the area is responsible.

MATERIAL CONTROL SUBSYSTEM

That part of the Safeguards System encompassing administrative policies, management and procedures directed to: (1) assigning and exercising responsibility for SNM; (2) limiting access to SNM by means of process controls; (3) maintaining vigilance over SNM; (4) governing the internal movement,

location and utilization of SNM; and (5) monitoring, by means of measurements, the inventory and process status of SNM.

MATERIAL DESCRIPTION

The physical form (solid, liquid, gas) or physical shape (particularly for solids) and chemical form (metal, compound, isotopic composition, purity, concentration, etc.) of the SNM as distinguished from material type.

MATERIAL DESCRIPTION FACTOR

A factor of the Diversion Path Parameter "Material Attractiveness," the variables of which serve to rank, by means of relative weights, various Descriptions of SNM according to implied utility for making a nuclear explosive device. The relative weight of each variable has been assigned by the Office of Safeguards and Security, DOE.

MATERIAL SURVEILLANCE PROCEDURES

Procedures developed to assure the observation of an area containing SNM by at least two cleared and authorized persons who may be doing other work but who can give an alarm in time to prevent the unauthorized removal of SNM. One of the persons who maintains such surveillance must be "Q" cleared and the other must possess at least an "S" or "L" access authorization.

MATERIAL TYPE

The nuclear properties of the SNM (depleted uranium, enriched uranium, low 240-plutonium, etc.).

MATERIAL TYPE FACTOR

A factor of the Diversion Path Parameter "Material Attractiveness," the variables of which serve to rank, by means of relative weights, various Types of SNM according to implied utility for making a nuclear explosive device. The relative weight of each variable has been assigned by the Office of Safeguards and Security, DOE.

MINOR MODIFICATION

A revision of some aspect of the Safeguards System that involves little or no cost for implementation, e.g., procedural changes, use of some piece of inexpensive equipment to perform a check, etc.

NO SUBSTITUTION

An attribute of the Diversion Path Parameter "Deceit in Removal," indicating that the diverter does not replace the diverted SNM with any other kind of material.

NUMBER OF INSIDERS

A Diversion Path Parameter for indicating the number of persons that knowingly participate in a Specific Diversion Path. The attributes of this parameter are: (1) 1 (person acting alone); and (2) 2 (persons acting in Collusion).

OPERATIONAL AREA

A segment of a Process having one decision maker who exercises direct control over material flows, information flows, and processing activities associated with SNM in the segment. A decision maker may be a single person, or two or more persons performing the same task under Material Surveillance Procedures.

PATH

See Diversion Path

PATH COMPLEXITY

All Diversion Path Parameters, except Material Attractiveness, considered collectively.

PHYSICAL PROTECTION SUBSYSTEM

That part of the Safeguards System encompassing administrative policies, management, procedures and equipment directed to: (1) protecting SNM from Diversion through use of egress controls and physical barriers; (2) limiting access to SNM by means of physical controls; (3) detecting attempts at Diversion through use of surveillance measures and alarm systems; and (4) responding to Diversion attempts through use of on-site security personnel and off-site law enforcement assistance.

PROCESS

Any series of actions directed to some end, within the operation of a nuclear facility, that involve SNM. A Process may be associated with actions related to the transportation of SNM between facilities, shipping, receiving, storage, transfers, production, measurements, analyses, testing, etc.

PROTECTED AREA

A specifically defined area within a facility that is enclosed by physical barriers meeting standards established by the DOE.

RADIATION HAZARD FACTOR

A factor of the Diversion Path Parameter "Material Attractiveness," the variables of which serve to rank, by means of relative weights, the implied

risk to the diverter from radiation exposure. The relative weight of each variable has been assigned by the Office of Safeguards and Security, DOE.

RECYCLE

SNM suitable for use in another Unit Process without undergoing prior chemical processing.

RELATIVE PATH WEIGHT (RPW)

The numerical value derived as the product of Relative Weight Factors, one each for the Diversion Path Parameters "Deceit By Records," "Deceit In Removal," "Type Of Insider," and "Number Of Insiders." (The Relative Weight Factors of the Diversion Path Parameters "Diverted Amounts and for "Material Attractiveness" are assumed to be 1.0.) This value is used to order or rank the General Diversion Paths.

RELATIVE WEIGHT FACTOR

The relative numerical value assigned to a particular attribute of a Diversion Path Parameter.

RESPONSE TIME

See Detection Time.

SAFEGUARDS SYSTEM

The plan of organization and all of the coordinate methods and measures adopted by a nuclear facility to protect, control and account for SNM within the facility, and to assure adherence to prescribed DOE policies.

SCENARIO

The complete and detailed description of the modus operandi used by a diverter when carrying out a Diversion Path.

SCRAP

The by-product forms of SNM generated by a Process that must undergo some type of reprocessing before further use is possible.

SPECIAL NUCLEAR MATERIAL (SNM)

(1) Plutonium, uranium enriched in the isotope 233 or in the isotope 235, and any other material which the DOE, pursuant to the provisions of Section 51 of the Atomic Energy Act of 1954, determines to be special nuclear material, but does not include source material, or (2) any material artifically enriched by any of the foregoing, but does not include source material.

SPECIFIC DIVERSION PATH (SDP)

The Diversion Path that results when the parameters of a General Diversion Path are applied in a particular Operational Area for a particular Material Type and Description.

STEALTH

An action mode where the adversary acts to avoid detection of his presence or of his act.

SUBSTITUTION

An attribute of the Diversion Path Parameter "Deceit in Removal," indicating that the diverter replaces some or all of the diverted SNM with inert material or with SNM having a different isotopic composition.

THIEF

An attribute of the Diversion Path Parameter "Type Of Insider" indicating an individual who is authorized to enter the Material Access Area but who lacks at least one of the following authorizations: (1) access to the Operational Area; (2) to handle the SNM in the Operational Area; (3) access to records pertaining to SNM related operational activities; or (4) to make entries in logs/forms/records associated with SNM related activities performed in the Operational Area. He may be sufficiently knowledgeable of the record system pertaining to the SNM related activities in the Operational Area to Alter records.

2 INSIDERS

An attribute of the Diversion Path Parameter "Type Of Insider" indicating Collusion between: (1) 2 Embezzlers; or (2) an Embezzler and a Thief.

TYPE

See Material Type.

TYPE OF INSIDER

A Diversion Path Parameter for characterizing individuals who are authorized to enter the Material Access Area and who are considered as potential diverters. The attributes of this parameter are: (1) Embezzler; (2) Thief; and (3) 2 Insiders.

UNCHANGED

An attribute of the Diversion Path Parameter "Deceit By Records," indicating that the diverter makes no attempt to Falsify or Alter any log/form/record as a means of concealing the fact of Diversion.

UNIT PROCESS

An analyzable segment of the process stream of a facility which contains a point where: (1) there are changes in Material Description; or (2) a material flow starts, ends, or merges with another flow; or (3) significant material accounting information is generated. The entire process stream of a facility can be represented as a series of Unit Processes.

WASTE

The by-product forms of SNM generated by a Process which are no longer useful.

WORKING MASS

The amount of SNM, of a specified Type and Description, which if diverted by an Insider, using Stealth and/or Deceit, should be indicated by the Safeguards System.

Appendix C

Guidelines for the Conduct of a DPA

In DPA, the analyst is trying to determine the different ways in which some given quantity of SNM can be removed from the Process *and* how soon the facility Safeguards System will respond to that removal. Having done this, it is then possible to determine modifications to the Safeguards System which will reduce the facility's overall vulnerability to covert Diversion by a person who is authorized to be in the process area.

Because of limited funds which can be used to upgrade the Safeguards Systems of nuclear facilities, it is important to have guidelines which will minimize the differences resulting from inter- and intra-facility analyses. Therefore, guidelines have been established so that all DPAs will be based upon detecting the Diversion of an equivalent amount of SNM. Also, the response capability of the Safeguards System at each nuclear facility will be judged against common, fixed criteria. All analysts will be looking at potential diverters who exhibit equivalent types of authorizations. Finally, all analysts will compare their Process against the same generic set of General Diversion Paths.

A.   Selection of the Working Mass for a Process

The Working Mass (WM) represents the amount of SNM in a Process which, for the purposes of DPA, the Safeguards System must be able to account for and control. It is a derived quantity which is based on a set of standards (Assigned Mass Constants) established by the Office of Safeguards and Security, DOE. The Assigned Mass Constant (AMC) may be defined as:

> the amount of a Type of SNM to be protected against Diversion by an Insider using Stealth and/or Deceit.

For the purposes of DPA, there are three Types of SNM which have been given Assigned Mass Constants. These Types together with their Assigned Mass Constant are:

MATERIAL TYPE	ASSIGNED MASS CONSTANT
^{239}Pu	500 g
^{233}U	500 g
^{235}U	1500 g/enrichment factor

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Because each of the above SNM Types may have several Descriptions (different chemical and physical forms) in a given Process, it is necessary to adjust the AMC to reflect these Descriptions. The Working Mass is therefore defined as:

the amount of SNM, of a specified Type and Description, which if diverted by an Insider, using Stealth and/or Deceit, should be detected by the Safeguards System.

Notice that the Assigned Mass Constant is dependent only upon Material Type while the Working Mass is dependent upon both the Material Type and Material Description of SNM found in a given Process. Figure C-1 shows how to calculate the WM for several different SNM Descriptions. Figure C-2 lists the WM for mixed oxides and mixed carbides; it may be necessary to interpolate in order to determine the WM corresponding to the Description of SNM found in the Process.

B. <u>Personnel to be Considered in the Analysis</u>

DPA is restricted to addressing the threat of covert theft by an Insider thus, all persons to be considered as potential diverters must:

a) be authorized to be in the Material Access Area; *and*

b) be limited to strategies of Stealth and/or Deceit.

Potential diverters fall into two general classes, Embezzlers or Thieves. The primary distinction between these two classes is that Embezzlers are responsible for the SNM in their care. To be more explicit, Embezzlers:

a) are authorized to be in the Operational Area;

b) are authorized to work with and handle the SNM in the Operational Area;

c) are authorized to complete records that pertain to the work activities performed in the Operational Area; *and*

d) understand the records system associated with the SNM in the Operational Area and are responsible for completing some or all of the records.

Thieves, while authorized to be in the Material Access Area, lack at least one of the three authorizations possessed by the Embezzler. Potential Thieves, therefore, may include such people as health physics personnel; guards responsible for patrolling the area; maintenance personnel; quality assurance or control personnel; employees responsible for safety in the process areas; unescorted, non-company, workers (e.g., cafeteria employees, vending machine personnel, etc.); and other facility employees outside their own Operational Areas.

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WORKING MASS (WM) AS A FUNCTION OF MATERIAL DESCRIPTION

METALS[*] - The Working Mass for any metal is equal to the Assigned Mass Constant for the Material Type.

EXAMPLE: 93% enriched ^{235}U

$$WM = 1500 \text{ g}/0.93$$
$$= 1612 \text{ g}$$
$$= 1600 \text{ g (rounded)}$$

MIXED OXIDES AND MIXED CARBIDES[*] - The Working Mass for mixed oxides and mixed carbides is shown in Figure C-2.

GASES AND BINARY SOLIDS[*] - The Working Mass for any gas or binary solid is the contained fissile equivalent to the Assigned Mass Constant for that Material Type.

EXAMPLE: $^{239}PuO_2$

$$WM = \{(239 + 16 + 16)/239\}\{500 \text{ g}\}$$
$$= 567 \text{ g}$$
$$= 550 \text{ g (rounded)}$$

SOLUTIONS[**] - The Working Mass for any solution is the Assigned Mass Constant of the Material Type divided by the concentration of the solution.

EXAMPLE: 200 g/liter $^{235}U(NO_3)_4$ where the ^{235}U is 93% enriched.

$$WM = (1500 \text{ g}/0.93)/(200 \text{ g/liter})$$
$$= 8.06 \text{ liters}$$
$$= 8 \text{ liters (rounded)}$$

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[*] Any calculated Working Mass which is less than 1000 g should be rounded to the nearest 50 g; in excess of 1000 g, the Working Mass should be rounded to the nearest 100 g.

[**] The calculated Working Mass should be rounded to the nearest liter.

FIGURE C-1

$$\% \text{ ENRICHMENT OF } ^{235}\text{U} \ (E)$$

E / x	N*	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
100%	750	750	750	750	750	750	750	750	750	750	750
90%	850	850	850	850	850	800	800	800	800	800	800
80%	950	950	950	950	900	900	900	900	900	900	850
70%	1100	1100	1100	1100	1000	1000	1000	1000	1000	950	950
60%	1300	1200	1200	1200	1200	1200	1100	1100	1100	1100	1000
50%	1500	1500	1500	1400	1400	1400	1300	1300	1200	1200	1100
40%	2000	1900	1800	1800	1700	1600	1600	1500	1400	1300	1300
30%	2700	2500	2400	2300	2200	2000	1900	1800	1700	1500	1400
20%	4200	3700	3500	3200	3000	2700	2400	2200	2000	1800	1600
10%	10000	7200	6400	5500	4700	4000	3400	2900	2500	2200	1900
0%	——	150000	37500	18500	11300	7500	5500	4200	3400	2800	2300

(Left axis: % Pu IN BLEND (x))

GRAMS OF MIXED OXIDES OR MIXED CARBIDES

* Natural Uranium (E = 0.00711)

WORKING MASS (WM) OF MIXED OXIDES OR MIXED CARBIDES

FIGURE C-2

C.   Personnel to be Exempted from Consideration as Potential Diverters

Even though an individual is authorized to be in the Material Access Area, he may be exempted from consideration as a potential diverter if he is escorted by a "Q" cleared individual who cannot be considered an Embezzler at *any* location in the Material Access Area.

Engineering and operations supervisory personnel (above the foreman level), the "Plant Safeguards Authority," and corporate management at all levels are to be exempted from consideration as potential diverters when performing the analysis. However, the diversion potential of the foreman should be analyzed with the following guidelines in mind:

a)   the foreman should be considered as a potential Embezzler in those Operational Areas in which he can relieve the authorized process operator and perform the operator's tasks without challenge;

b)   the foreman should be considered as a potential Thief in all Operational Areas in which he is not also considered a potential Embezzler; and

c)   when considering the foreman as a potential diverter, only those actions which he can carry out on his own should be analyzed. No consideration should be given to situations in which he could use his authority to "deceive" or influence another process operator into helping him divert SNM (i.e., the process operator becomes an "unwitting" diverter).

The DPA team may exempt other personnel from consideration as potential diverters on a case-by-case basis. This determination should be made after a careful review of the types of personnel who have been in the MAA during the past year and personal observation of how well Material Surveillance Procedures are adhered to in the MAA.

D.   Criteria for Classes of Detection Time

Part of the DPA involves evaluating how soon the facility MC&MA Subsystems are able to respond to the possibility that a Diversion has occurred. In effect, this is a measure of how soon the MC&MA Subsystems are able to detect the removal of SNM equal to the Working Mass. Because the adversary may choose any one of a number of Paths, the MC&MA Subsystems must be capable of responding over a wide range of times. Therefore, the capability of the MC&MA Subsystems to detect covert Diversion has been divided into six ranges or time classes:

Class 1 - Diversion is impossible;

Class 2 - Diversion is detected within 1 day;

Class 3 - Diversion is detected between 2 and 7 days;

Class 4 - Diversion is detected between 8 and 30 days;

Class 5 - Diversion is undetected for more than 30 days;

Class 6 - Diversion is never detected.

Class 1 is reserved for those Paths that the DPA team perceives to be impossible because: (1) of process characteristics; (2) an attempted Diversion will be detected before removal occurs; or (3) the diverter will be either observed in the act of Diversion or apprehended with the SNM on his person. The latter two conditions will lead to essentially instantaneous detection if used. Class 2 represents the desired "response capability" to be provided by the MC&MA Subsystems. A Path is therefore considered Covered if the MC&MA Subsystems indicate the removal of SNM, equal to the Working Mass, within one day.

E.   General Diversion Path List

A Diversion Path requires six parameters for complete definition. These are:

a)   Material Attractiveness;

b)   Diverted Amounts;

c)   Deceit By Records;

d)   Deceit In Removal;

e)   Number Of Insiders; and

f)   Type Of Insider.

Each parameter has several attributes. The attributes for the Material Attractiveness parameter are found in Figure C-3. These values are based upon the relative value of the material for the diverter's end use, assumed to be assembly of a nuclear explosive device. Relative Weight Factors are assigned to each attribute within a parameter in order to rank the Diversion Paths according to "ease of accomplishment." The attributes (and their Relative Weight Factors) for the other five parameters are shown in Figure C-4. Relative Weight Factors range in value from 0.1 to 1.0. A value of 0.1 implies that the attribute is relatively difficult to accomplish, while a value of 1.0 implies that the attribute is relatively easy to accomplish. Values were assigned on an arbitrary basis after considering observations of actual facility operations and have been approved by DOE/SS.

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MATERIAL ATTRACTIVENESS

Material Attractiveness (M) is the product of three factors reflecting Material Type, Material Description, and Radiation Hazard. When computing Material Attractiveness, the following formula is used, and the result is rounded to the nearest tenth:

$$M = MTF \times MDF \times RHF.$$

Material Type Factors (MTF)

^{239}Pu	1.0
^{233}U	1.0
^{235}U	1.0
Pu-U mixtures	1.0

Material Description Factors (MDF)

Unalloyed metals	1.0
Oxides or carbides of a single Type	1.0
Alloyed metals	0.9
Mixed oxides or carbides	0.8
Nitrate solutions	0.8
Solid binary compounds of a single Type other than oxides or carbides	0.8
Solutions other than nitrates	0.7
Sintered fuel pellets of a single Type	0.7
Mixed solid binary compounds other than mixed oxides or carbides	0.6
Sintered mixed oxide fuel pellets	0.6
Fuel elements (all Types and Descriptions)	0.5
Gases	0.5
Fuel assemblies (all Types and Descriptions)	0.4
Contamination in or on other materials (e.g., box sweeps, gloves, wipes, etc.)	0.4
U in milling or refining operations	0.0
U ore	0.0

Radiation Hazard Factors (RHF)

0 - 5 rem/hr at surface of material or usual containment	1.0
6 - 10 rem/hr at surface of material or usual containment	0.8
11 -25 rem/hr at surface of material or usual containment	0.5
> 25 rem/hr at surface of material or usual containment	0.0

FIGURE C-3

RELATIVE WEIGHT FACTORS FOR DIVERSION PATH PARAMETERS

PARAMETERS AND ATTRIBUTES	RELATIVE WEIGHT FACTORS
1. MATERIAL ATTRACTIVENESS	1.000 TO 0.100
MATERIAL "X"	
2. DIVERTED AMOUNTS	1.000 TO 0.100
$\sqrt{Q_{MAX}/\text{WORKING MASS}}$	
3. DECEIT BY RECORDS	
UNCHANGED	1.000
FALSIFIED	0.875
ALTERED	0.600
4. DECEIT IN REMOVAL	
NO SUBSTITUTION	1.000
SUBSTITUTION	0.800
5. NUMBER OF INSIDERS	
1	1.000
2	0.250
6. TYPE OF INSIDER	
EMBEZZLER	1.000
THIEF	0.500
2 INSIDERS	1.000

FIGURE C-4

The GDPs are composed of the combinations of one attribute from each of the six Diversion Path Parameters. The Relative Path Weight (RPW) of each GDP is derived as the product of the Relative Weight Factors assigned to the parameter attributes of the GDP. Figure C-5 shows the ordering of the GDPs, according to RPW values, for a material that has an attractiveness value of 1.0 and a Diverted Amounts Relative Weight Factor of 1.0. The latter represents a single diversion of SNM equal to the Working Mass. The RPW value indicates the relative "complexity" of accomplishing the Path from the diverter's point of view; it is *not* a measure of the probability that a diverter will choose that Path.

A Diversion Path may be ignored if the product of the RPW value, Material Attractiveness value and the Diverted Amounts factor (referred to as the Adjusted Relative Path Weight or ARPW value) is less than 0.1.

GENERAL DIVERSION PATH LIST

NO COLLUSION

GDP	DECEIT BY RECORDS	DECEIT IN REMOVAL	TYPE OF INSIDER	RPW
1.	UNCHANGED	NO SUBSTITUTION	EMBEZZLER	1.000
2.	FALSIFIED	NO SUBSTITUTION	EMBEZZLER	0.875
3.	UNCHANGED	SUBSTITUTION	EMBEZZLER	0.800
4.	FALSIFIED	SUBSTITUTION	EMBEZZLER	0.700
5.	ALTERED	NO SUBSTITUTION	EMBEZZLER	0.600
6.	UNCHANGED	NO SUBSTITUTION	THIEF	0.500
7.	ALTERED	SUBSTITUTION	EMBEZZLER	0.480
8.	UNCHANGED	SUBSTITUTION	THIEF	0.400
9.	ALTERED	NO SUBSTITUTION	THIEF	0.300
10.	ALTERED	SUBSTITUTION	THIEF	0.240

COLLUSION BY 2

GDP	DECEIT BY RECORDS	DECEIT IN REMOVAL	TYPE OF INSIDER	RPW
11.	UNCHANGED	NO SUBSTITUTION	2 INSIDERS	0.250
12.	FALSIFIED	NO SUBSTITUTION	2 INSIDERS	0.219
13.	UNCHANGED	SUBSTITUTION	2 INSIDERS	0.200
14.	FALSIFIED	SUBSTITUTION	2 INSIDERS	0.175
15.	ALTERED	NO SUBSTITUTION	2 INSIDERS	0.150
16.	ALTERED	SUBSTITUTION	2 INSIDERS	0.120

FIGURE C-5

Appendix D

Information and Data Gathering Worksheets

DPA INFORMATION AND DATA GATHERING WORKSHEET

1.0 SOURCE INFORMATION

1.1 Floor Plans
1.1.1 Locating operational area(s) in building(s)
1.1.2 Locating physical bounds, doorways, windows, other barriers, etc., associated with each operational area identified in 1.1.1

1.2 Procedure Manuals - General
1.2.1 Operational
1.2.2 Quality Control (if not in 1.2.1)
1.2.3 Nuclear Materials Control
1.2.4 Accountability (if not in 1.2.3)
1.2.5 Shipping and Receiving (if not in 1.2.3)
1.2.6 Transportation (if not in 1.2.3)
1.2.7 Criticality
1.2.8 Safety
1.2.9 Physical Security

1.3 Procedure Manuals - Operation Specific
1.3.1 Operational
1.3.2 Quality Control (if not in 1.3.1)
1.3.3 Nuclear Materials Control
1.3.4 Accountability (if not in 1.3.3)
1.3.5 Shipping and Receiving (if not in 1.3.3)
1.3.6 Transportation (if not in 1.3.3)
1.3.7 Criticality
1.3.8 Safety
1.3.9 Physical Security

1.4 Other Types of Documentation
1.4.1 Specifications for material(s) in operational area(s)
1.4.2 Part or engineering drawings for material(s) in operational area(s) (if applicable)
1.4.3 Piping schematics (if applicable)
1.4.4 Chemistry and/or chemical engineering (if applicable)
1.4.5 Engineering calculations

1.5 Forms, Logs and Records
1.5.1 Accountability forms
1.5.2 Operational logs
1.5.3 Other records

1.6 Archival Data
1.6.1 Copies of forms, logs and records identified in 1.5, completed during most recent operational sequence(s) performed in area(s)
1.6.2 Statistical data obtained during most recent operational sequence(s)

ITEM	DRAWING/ DOCUMENT	PAGE/ SECTION	DESCRIPTION	RETENTION LOCATION

ITEM	DRAWING/ DOCUMENT	PAGE/ SECTION	DESCRIPTION	RETENTION LOCATION

DPA INFORMATION AND DATA GATHERING WORKSHEET				
ITEM	DRAWING/ DOCUMENT	PAGE/ SECTION	DESCRIPTION	RETENTION LOCATION

DPA INFORMATION AND DATA GATHERING WORKSHEET				
ITEM	DRAWING/ DOCUMENT	PAGE/ SECTION	DESCRIPTION	RETENTION LOCATION

DPA INFORMATION AND DATA GATHERING WORKSHEET

2.0 PHYSICAL DESCRIPTION OF OPERATIONAL AREA(S)

2.1 Equipment

2.1.1 Placement in each operational area iden-
tified in 1.1 (describe and indicate
location on floor plans)

2.1.2 Features which affect access to material,
e.g., glove-ports, bag-out ports, sample
ports, control gates, valves, etc., (des-
cribe and indicate location(s) on floor
plans)

2.1.3 Tanks (include volumes and indicate
location(s) on floor plans)

2.2 Physical Security Controls Protecting
Against Unauthorized Movement of SNM Within
Area(s)

2.2.1 Personnel monitors, vehicle monitors, guard
stations, etc., for building(s) identified
in 1.1 (describe, including times when ac-
tivated, and indicate location(s) on floor
plans)

2.2.2 Personnel monitors, vehicle monitors, guard
stations, intrusion detectors, special doors
or windows, etc., associated with each oper-
ational area identified in 1.1.2 (describe,
including times when activated, and indicate
location(s) on floor plans)

ITEM	DRAWING/ DOCUMENT	PAGE/ SECTION	DESCRIPTION

ITEM	DRAWING/ DOCUMENT	PAGE/ SECTION	DESCRIPTION

DPA INFORMATION AND DATA GATHERING WORKSHEET

ITEM	DRAWING/ DOCUMENT	PAGE/ SECTION	DESCRIPTION

DPA INFORMATION AND DATA GATHERING WORKSHEET			
ITEM	DRAWING/ DOCUMENT	PAGE/ SECTION	DESCRIPTION

ITEM	DRAWING/ DOCUMENT	PAGE/ SECTION	DESCRIPTION

DPA INFORMATION AND DATA GATHERING WORKSHEET

3.0 PHYSICAL DESCRIPTION OF STORAGE AREA(S) (VAULTS AND IN-PROCESS STORAGE) FOR MATERIAL USED IN THE OPERATION(S)

3.1 Location(s)
3.1.1 Vault(s) (indicate on floor plans)
3.1.2 In-process storage (include tanks (with volumes) and indicate on floor plans)

3.2 Storage Area(s)
3.2.1 Description of individual material locations within storage area(s) (include monitoring devices and/or special features)

3.3 Physical Security Controls Protecting Against Unauthorized Movement of SNM Within Area(s)
3.3.1 Personnel monitors, vehicle monitors, guard stations, intrusion detectors, special doors, etc., associated with each storage area (describe, including times when activated, and indicate location(s) on floor plans)

3.4 Keys and Locks
3.4.1 Control of keys when not in use
3.4.2 Control of keys when in use
3.4.3 Combination change frequency

3.5 Seals
3.5.1 Type(s) used

3.6 Personnel
3.6.1 With access to each storage area
3.6.2 With access to keys or combinations
3.6.3 Responsible for key or combination control documentation
3.6.4 With access to unused seals
3.6.5 Performing sealing
3.6.6 Responsible for seal control documentation

3.7 Documentation
3.7.1 For receipts and removals of material
3.7.2 For key or combination control
3.7.3 For seal control
3.7.4 Physical location of each document identified in 3.7.2 and 3.7.3

3.8 How Material is Physically Moved Between Storage Area(s) and Operational Area(s)
3.8.1 Description
3.8.2 Route (indicate on floor plans)

ITEM	DRAWING/ DOCUMENT	PAGE/ SECTION	DESCRIPTION

DPA INFORMATION AND DATA GATHERING WORKSHEET			
ITEM	DRAWING/ DOCUMENT	PAGE/ SECTION	DESCRIPTION

DPA INFORMATION AND DATA GATHERING WORKSHEET

4.0 DESCRIPTION OF OPERATION(S) (MUST REFLECT MOST RECENT OPERATIONAL SEQUENCE(S))

4.1 Operation(s) Performed
4.1.1 Description of overall operation performed in area(s)
4.1.2 Description of operational steps comprising 4.1.1

4.2 Location(s)
4.2.1 Each operational step identified in 4.1.2 (indicate on floor plans showing equipment placement)
4.2.2 Operator station(s) in relation to equipment placement shown on floor plans
4.2.3 Discontinuities in operational steps, e.g., where material is transferred to or received from a noncontiguous operational step

4.3 Timing Information
4.3.1 Time required for completion of each operational step
4.3.2 Elapsed time between each operational step

4.4 Procedures and Instructions
4.4.1 Written procedure(s) associated with each operational step
4.4.2 Oral instructions given at each operational step

4.5 Variations Observed Between Written Procedures and Actual Practice
4.5.1 Description (relate to operational step)

4.6 Variations Observed Between Oral Instructions and Actual Practice
4.6.1 Description (relate to operational step)

4.7 Operational Problems
4.7.1 Typical problems encountered
4.7.2 Frequency
4.7.3 Cause(s)

4.8 Personnel
4.8.1 Performing each operational step identified in 4.1.2 (note if same individual performs (1) more than one operational step or (2) a series of contiguous operational steps)
4.8.2 Supervising each operational step identified in 4.1.2
4.8.3 Giving oral instructions for each operational step (note under 4.8.2 if same individual)
4.8.4 Moving material between storage area(s) and operational area(s)

4.9 Containment Afforded Material at Discontinuities Identified in 4.2.3
4.9.1 Procedures
4.9.2 Container(s) used
4.9.3 Seal(s) used

ITEM	DRAWING/ DOCUMENT	PAGE/ SECTION	DESCRIPTION

ITEM	DRAWING/ DOCUMENT	PAGE/ SECTION	DESCRIPTION

DPA INFORMATION AND DATA GATHERING WORKSHEET

DPA INFORMATION AND DATA GATHERING WORKSHEET

5.0 DESCRIPTION OF MATERIAL IN OPERATION(S)

5.1 Feed Material for Overall Operation
5.1.1 Material type(s)
5.1.2 Physical and/or chemical form (each type)
5.1.3 Containment on receipt if applicable (each type)
5.1.4 How identified (item/batch) (each type)
5.1.5 Quantity received (each type)
5.1.6 Origin (each type)

5.2 Product Material for Overall Operation
5.2.1 Material type(s)
5.2.2 Physical and/or chemical form (each type)
5.2.3 Containment on transfer if applicable (each type)
5.2.4 How identified (item/batch) (each type)
5.2.5 Quantity transferred (each type)
5.2.6 Destination (each type)

5.3 Material at Each Operational Step
(Use Item 5.3 Table)

5.4 Material in Storage Area(s) (Vaults and In-Process Storage)
5.4.1 Material type(s)
5.4.2 Physical and/or chemical form (each type)
5.4.3 Containment (each type)
5.4.4 How identified (each type)
5.4.5 Quantity on hand (each type)
5.4.6 Origin (each type)
5.4.7 Residence time (each type)
5.4.8 Destination (each type)

5.5 Criticality, Health and/or Safety Considerations
5.5.1 Quantity restrictions imposed on each operational step identified in 4.1.2 (each type)
5.5.2 Time limitations imposed on personnel for each operational step identified in 4.1.2 (each type)

ITEM	DRAWING/ DOCUMENT	PAGE/ SECTION	DESCRIPTION

DPA INFORMATION AND DATA GATHERING WORKSHEET			
ITEM	DRAWING/ DOCUMENT	PAGE/ SECTION	DESCRIPTION

ITEM 5.3   REFERENCE(S):   OPERATIONAL STEP:

MATERIAL CATEGORY	MATERIAL TYPE(S)	PHYSICAL AND/OR CHEMICAL FORM (EACH TYPE)	CONTAINMENT IF APPLICABLE (EACH TYPE)	HOW IDENTIFIED (ITEM/BATCH) (EACH TYPE)	QUANTITY ON HAND OR GENERATED (EACH TYPE)	MATERIAL RESIDENCE TIME (EACH TYPE)	ORIGIN (O)/ DESTINATION (D) (EACH TYPE)
FEED							(O)
INTERMEDIATE PRODUCT							
PRODUCT							(D)
SAMPLES							(D)
RECYCLE							(O)
							(D)
SCRAP							(D)
WASTE							(D)

DPA INFORMATION AND DATA GATHERING WORKSHEET

ITEM 5.3   REFERENCE(S):   OPERATIONAL STEP:

MATERIAL CATEGORY	MATERIAL TYPE(S)	PHYSICAL AND/OR CHEMICAL FORM (EACH TYPE)	CONTAINMENT IF APPLICABLE (EACH TYPE)	HOW IDENTIFIED (ITEM/BATCH) (EACH TYPE)	QUANTITY ON HAND OR GENERATED (EACH TYPE)	MATERIAL RESIDENCE TIME (EACH TYPE)	ORIGIN (O)/ DESTINATION (D) (EACH TYPE)
FEED							(O)
INTERMEDIATE PRODUCT							⨉
PRODUCT							(D)
SAMPLES							(D)
RECYCLE							(O)
							(D)
SCRAP							(D)
WASTE							(D)

DPA INFORMATION AND DATA GATHERING WORKSHEET

DPA INFORMATION AND DATA GATHERING WORKSHEET

6.0 MEASUREMENTS

6.1 Location(s)
6.1.1 Measurement point(s) in operational area(s) (indicate on floor plans)
6.1.2 Measurement(s) not made in operational area(s), e.g., on-site or off-site laboratories (indicate on floor plans or describe)

6.2 Measurement(s) Made
6.2.1 At measurement point(s) identified in 6.1.1 (relate to operational step and note if more than one measurement is made, e.g., before and after operation using same instrument(s))
6.2.2 At location(s) identified in 6.1.2 (relate to operational step)
6.2.3 Smallest sub-unit for recording data (each measurement)
6.2.4 Calibration data and/or reference material(s) used (each measurement)
6.2.5 Accuracy and precision (each measurement)
6.2.6 Procedure(s) used (each measurement)

6.3 Instrumentation
6.3.1 Instrument(s) used for measurement(s) identified in 6.2.1 and 6.2.2
6.3.2 Accuracy and precision (each measurement)

6.4 Comparison, Analysis or Review of Measurement Data
6.4.1 Description
6.4.2 Elapsed time between measurement(s) and comparison, analysis or review of data
6.4.3 Frequency

6.5 Personnel
6.5.1 Performing measurement(s)
6.5.2 Supervising measurement(s)
6.5.3 Recording measurement data
6.5.4 Reviewing measurement data
6.5.5 Performing comparisons, analyses or reviews of measurement data
6.5.6 Reviewing comparisons, analyses or reviews of measurement data

6.6 Documentation
(See Item 8.0)

6.7 Timing Information
6.7.1 Elapsed time between taking measurement(s) and entering data into operational and/or accountability data base(s)
6.7.2 Elapsed time between sending routine sample(s) to laboratory and return of analysis data
6.7.3 Elapsed time between sending inventory sample(s) to laboratory and return of analysis data

ITEM	DRAWING/ DOCUMENT	PAGE/ SECTION	DESCRIPTION

ITEM	DRAWING/ DOCUMENT	PAGE/ SECTION	DESCRIPTION

DPA INFORMATION AND DATA GATHERING WORKSHEET

DPA INFORMATION AND DATA GATHERING WORKSHEET

7.0 CALIBRATION(S) OF INSTRUMENTS

7.1   For Each Instrument Identified in 6.3.1   7.3   Documentation of Calibration Results
7.1.1 Primary standards used   7.3.1 Where maintained
7.1.2 Secondary ("working") standards used   7.3.2 Retention time
7.1.3 Standard reference material(s) used
7.1.4 Procedures used
7.1.5 Frequency of calibration

7.2   Personnel
7.2.1 Performing calibration (each instrument)
7.2.2 Supervising calibration (each instrument)
7.2.3 Reviewing calibration data
7.2.4 Documenting calibration data

ITEM	DRAWING/ DOCUMENT	PAGE/ SECTION	DESCRIPTION

ITEM	DRAWING/ DOCUMENT	PAGE/ SECTION	DESCRIPTION

DPA INFORMATION AND DATA GATHERING WORKSHEET

DPA INFORMATION AND DATA GATHERING WORKSHEET

8.0 ACCOUNTABILITY FORMS, OPERATIONAL LOGS AND OTHER RECORDS

8.1 For Each Form, Log and Record Identified in 1.5

8.1.1 Explanation of data entered in each field (include entries made in margins, e.g., "ticks" or "check-marks")

8.1.2 Source of data entered in each field (relate to operational step and indicate on copy of blank form, log or record)

8.1.3 Personnel recording data entered in each field (relate to operational step and indicate on copy of blank form, log or record)

8.1.4 Elapsed time between making first and last entries

8.1.5 Elapsed time between last entry and comparison, analysis or review of recorded data

8.1.6 Elapsed time between last entry and entry of data in accountability and/or operational data base(s) (if different from 8.1.5)

8.2 Routing of Each Form, Log and Record
8.2.1 Sender
8.2.2 Receiver

8.3 Location(s) (Relate to Operational Step and/or Indicate on Floor Plans)
8.3.1 Where personnel actually make entries and/or complete each form, log and record
8.3.2 Where supplies of each blank form, log and record are maintained
8.3.3 Where partially completed forms, logs and records are maintained if completed by more than one individual or in different operational steps (each form, log and record)

8.4 Procedures
8.4.1 Forms control if applied (each form, log and record)
8.4.2 Accounting for "spoiled" controlled forms identified in 8.4.1
8.4.3 Making corrections (each form, log or record)
8.4.4 How material leaving item control is documented ("item kills") (if applicable)
8.4.5 How "batch makeup" is documented (if applicable)
8.4.6 How "prior period adjustments" are made

8.5 Short Term File Maintenance (Each Form, Log and Record)
8.5.1 Where maintained
8.5.2 Retention time

8.6 Archival Maintenance (Each Form, Log and Record)
8.6.1 Where maintained
8.6.2 Retention time

8.7 Personnel
8.7.1 Maintaining supplies of each blank form, log and record
8.7.2 With access to blank copies of each form, log and record
8.7.3 With access to partially completed forms, logs and records if completed by more than one individual or in different operational steps (each form, log and record)
8.7.4 Reviewing and/or comparing information recorded on each form, log or record
8.7.5 Documenting "item kills" (if applicable)
8.7.6 Documenting "batch makeup" (if applicable)
8.7.7 Performing "prior period adjustments"
8.7.8 Maintaining short term files
8.7.9 Maintaining long erm files

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ITEM	DRAWING/ DOCUMENT	PAGE/ SECTION	DESCRIPTION

DPA INFORMATION AND DATA GATHERING WORKSHEET

DPA INFORMATION AND DATA GATHERING WORKSHEET

9.0 OPERATIONAL RESULTS

9.1 Expected or Predicted
9.1.1 Based on theory (if applicable)
9.1.2 Based on engineering calculations (if applicable)
9.1.3 Based on experimental findings (if applicable)
9.1.4 Based on past operational sequence(s) (if applicable)
9.1.5 Data used for determinations identified in 9.1.1, 9.1.2 and 9.1.3 (as applicable)

9.2 Experienced
9.2.1 Based on analyses of data for each operational step

9.3 Shipper-Receiver Difference(s)
9.3.1 Overall operation
9.3.2 Each operational step

9.4 Trends and Biases (Derived From Statistical Analyses of Data for Current or Previous Operational Sequence(s) of Overall Operation and/or Each Operational Step)
9.4.1 Short term
9.4.2 Long term
9.4.3 Personnel dependent
9.4.4 Start-up dependent
9.4.5 Cause(s) if amenable to determination

9.5 Judgments and Decisions
9.5.1 Based on determination(s) of operational results identified in 9.1, 9.2, 9.3 and 9.4 (as applicable)

9.6 Personnel
9.6.1 Responsible for determining results identified in 9.1, 9.2, 9.3 and 9.4
9.6.2 Responsible for judgments and decisions identified in 9.5

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ITEM	DRAWING/ DOCUMENT	PAGE/ SECTION	DESCRIPTION

DPA INFORMATION AND DATA GATHERING WORKSHEET

DPA INFORMATION AND DATA GATHERING WORKSHEET

10.0 OPERATIONAL CONTROLS

10.1   Checks and Verifications
10.1.1 For determining completion of operational
        step(s) and/or overall operation

10.2   Acceptance Limits (As Applicable to Each
        Operational Step)
10.2.1 Physical and/or chemical properties
10.2.2 Dimensions and/or volumes
10.2.3 Flow rates
10.2.4 Intermediate and/or final product yield
10.2.5 Measured discard and/or accidental loss
10.2.6 Operational holdup
10.2.7 Shipper-receiver difference
10.2.8 Trends and biases
10.2.9 Go/no-go criteria

10.3   Procedure(s) When Non-Conformance to Lim-
        it(s) Identified in 10.2 Encountered

10.4   Physical Appearance
10.4.1 If deviation from normal could indicate a
        possible abnormal situation

ITEM	DRAWING/ DOCUMENT	PAGE/ SECTION	DESCRIPTION

DPA INFORMATION AND DATA GATHERING WORKSHEET			
ITEM	DRAWING/ DOCUMENT	PAGE/ SECTION	DESCRIPTION

DPA INFORMATION AND DATA GATHERING WORKSHEET

11.0 DESCRIPTION OF INVENTORY ACTIVITIES

11.1 Frequency
11.1.1 Unwitnessed
11.1.2 Witnessed

11.2 Percentage of "Items" Accounted For

11.3 Attribute Checks Employed

11.4 NDA Measurements Employed

11.5 Sampling Plans
11.5.1 For overall inventory
11.5.2 For attribute checks
11.5.3 For NDA measurements

11.6 Book-Physical Inventory Difference (BPID)
11.6.1 Value of BPID for each operational step and/or overall operation
11.6.2 Components of BPID "EXPLAINED"
11.6.3 Control of BPID "RESIDUAL" (if applicable)
11.6.4 CONTROL LIMITS for overall operation
11.6.5 Components of CONTROL LIMIT calculation
11.6.6 CONTROL LIMIT program

11.7 Personnel
11.7.1 Taking inventory
11.7.2 Witnessing inventory
11.7.3 Recording data (if different from 11.7.1 and/or 11.7.2)
11.7.4 Making attribute checks and/or NDA measurements (if different from 11.7.1 and/or 11.7.2)
11.7.5 Supervising inventory
11.7.6 Responsible for BPID calculations and CONTROL LIMIT program

ITEM	DRAWING/ DOCUMENT	PAGE/ SECTION	DESCRIPTION

DPA INFORMATION AND DATA GATHERING WORKSHEET			
ITEM	DRAWING/ DOCUMENT	PAGE/ SECTION	DESCRIPTION

Appendix E

Symbols Used in DPA

Symbols are often used to represent people, locations, and information flows. For the purposes of DPA, several symbols and concepts have been employed as shown in Figure E-1.

Some "nodes" are used to express:

a)   physical locations, such as a facility or portion of a facility;

b)   decision points or decision makers;

c)   analysis points or analyses;

d)   sources within locations where data and information are generated; and

e)   activities performed at locations.

Other "nodes" are important because of their content. The "content of nodes" refers to the documentation maintained at the "node" and includes:

a)   records and reports, either manually prepared or computer generated;

b)   files in the form of papers, computer cards, magnetic-tapes, drums, or disks;

c)   operational logs prepared in this or another "node;" and

d)   procedure manuals prepared at this or another "node."

The concept of "flow" refers to the transmittal of data and information from an origin to a destination; that is, between any two "nodes." A flow involving an intermediate "node" can be considered as two separate flows of the same information or data, where the intermediate "node" is the destination on the one hand and the origin on the other. There are three important aspects of a "flow;" purpose, method, and content.

The "purpose of flow" refers to the reason for the transmittal and divides "flows" into two types, "reporting flows" and "administrative flows." "Reporting flows" are important because the content of the "flow" serves as the basis for actions or decisions, while "administrative flows" serve only to inform.

The "methods of flow" fall into two general categories, oral and written. "Oral flows" include direct conversations between individuals or other means of voice communication, such as telephone or radio. "Written flows" consist of hardcopy reports (either manually prepared or computer generated), teletype (TTY) messages, output from data links, and computerized video displays (CRT displays).

DPA SYMBOLS
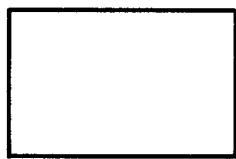
LOCATION
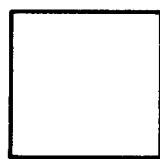
INFORMATION OR
DATA SOURCE
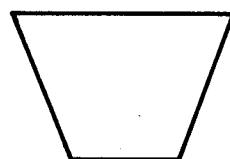
INSPECTION ACTIVITY
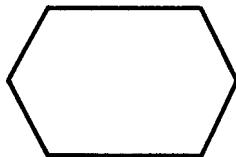
ANALYSIS POINT

DATA ACQUISITION
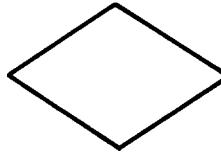
DECISION MAKER OR
DECISION POINT

NODE SYMBOLS

HARDCOPY REPORT
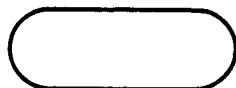
FILE OR LOG OF INFORMATION OR
DATA (PAPER, CARD, OR MAGNETIC)

NODE CONTENT SYMBOLS

ORAL INFORMATION FLOW

WRITTEN INFORMATION FLOW

ORAL OR WRITTEN INFORMATION
FLOW (AT FACILITY OPTION)

ADMINISTRATIVE INFORMATION
FLOW
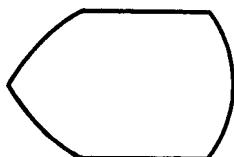
COMPUTERIZED VIDEO DISPLAY
(CRT DISPLAY)

PURPOSE AND METHOD OF FLOW SYMBOLS

FIGURE E-1

The "content of flow" is the type of information that is conveyed and includes:

    a)   alarms;

    b)   alerts;

    c)   data elements such as measurements or identifications; and

    d)   information elements such as processed and/or analyzed data, observations, historical perspective, conclusions and assurance statements.

The symbols in Figure E-1 should be used when preparing the Material/Information Flow Diagrams.

Appendix F

Information Flows Associated With The Process Operator

I. INCOMING INFORMATION FLOWS TO THIS OPERATIONAL AREA

    A. From process operator of preceding processing operational area[1]

        ⑥ [2]   1. Data traveling with material

                a. Tag information

                        1) Date prepared

                        2) Identification of process operator preparing tag

                        3) Identification of batch, item or container

                        4) SNM content of material

                        5) Physical/chemical form (type-/description-code)

                        6) Gross and/or net weight

         2. Processing instructions

         3. Specifications and drawings

         4. Material use information

    B. From shipping dock clerk

         1. Data traveling with material

                a. Tag information (same as I.A.1.a.)

         2. Material transfer information (first operational area in MBA)

    C. From vault manager

         1. Data traveling with material

                a. Tag information (same as I.A.1.a.)

    D. From process foreman

         1. List of material to be received (first operational area in MBA)

         2. List of material to be shipped (last operational area in MBA)

     ⑨   3. Vault and/or process area storage withdrawal instructions

                a. List of items or containers to be stored or withdrawn

                b. Authorization (may be copy of work instructions)

     ⑩   4. Routine information about normal process activities such as results to be expected, information enabling process operator to know that process is operating properly, and abnormal situations to be observed

         5. Work instructions for activities in this operational area

         6. Specifications and drawings for items

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[1] See Part B of NOTE at end of outline for identification of adjacent operational areas.

[2] See footnote, page 123.

7. Solutions to process related problems

8. Adversary action intelligence (outside adversary)

    a. Adversary characterization

        1) Probable resources

            a) Personnel

            b) Technical skills

            c) Materiel

        2) Probable modus operandi

        3) Probable target

            a) Material type

            b) Quantity

        4) Probable time scale

9. Abnormal situation information

    a. Elapsed time allowed before notifying next echelon

    b. Innocent cause or resolution information

    c. Feedback information

10. Safeguards policy from plant management

E. From MBA SNM custodian

    1. List of items or containers transferred (first operational area in MBA)

II. INFORMATION AND DATA GENERATED AT THIS OPERATIONAL AREA

A. Receiving activities

    1. Check of item or container identification

    2. Gross weight measurement

    3. Observation of Shipper-Receiver difference

    4. Appropriate measurements (depending on diversion paths associated with this operational area)

        a. NDA

        b. Dimensional

        c. Chemical or isotopic analyses

B. Processing activities

    1. Varies with functional aspects of the operational area

C. Shipping activities

    1. Check of item or container identification

    2. Observation of transfer from operational area (tag and transfer data usually generated during II.B.)

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3. Appropriate measurements just prior to transfer (depending on diversion paths associated with this operational area)

D. Receiver's data for off-site receipts

E. Physical inventory data

F. Observations for abnormal situations

G. Observations for process operations

III. RECORDS MAINTAINED AT THIS OPERATIONAL AREA

A. Abnormal situation log

B. Process activity logs

C. Process temporary storage log

IV. RECORDS AND REPORTS PREPARED AT THIS OPERATIONAL AREA

(15) A. Abnormal situation log

1. Date and time of discovery

2. Identification of discoverer (man or badge number)

3. Brief description of pertinent facts

a. Material type

b. Quantity (estimated or actual)

c. Location

d. Initial actions taken

B. Process activity records and reports

1. Production logs

2. Status reports

3. Data sheets .

C. Process temporary storage log

D. Data to travel with material

E. Physical inventory records

F. Receiver's data for off-site receipts

G. Lists of material receipts, shipments or item identity change

V. OUTGOING INFORMATION FLOWS FROM THIS OPERATIONAL AREA

(7) A. To process operator of following processing operational area

1. Data to travel with material

a. Tag information (same as I.A.1.a.)

2. Transfer information if last operational area in MBA

3. Instructions for operations to be performed in next operational area

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4. Material use information

B. To vault manager

    1. List of items or containers to be stored or withdrawn

    2. Authorization to store or withdraw material

C. To shipping dock clerk

    1. Data to travel with material when shipped

        a. Tag information on inner package (same as I.A.1.a.)

        b. Serial numbers on inner package seals

D. To process foreman

⑬   1. Process activity reports (plant option, see V.G.)

        a. Production logs

            1) Production throughput

            2) Operator identification

            3) Process control and parameter information

            4) Traceback for quality control

        b. Data sheets

        c. Status reports

⑭   2. Abnormal situation information and alerts

        a. Discovery information

        b. Initial action information

        c. Investigative information

        d. Innocent cause or resolution information

    3. Other information

        a. Observations relating to processing activities

        b. Problems arising from processing activities

        c. Assurance information

E. To MBA SNM custodian

⑫   1. Notification of receipts into first operational area in MBA

    2. Notification of shipments from last operational area in MBA

    3. Notification of item identity change resulting from processing activities

    4. Physical inventory data at inventory time

    5. Receiver's data for off-site receipts

F. To plant physical inspector

    1. Data traveling with material to next operational area

        a. Tag information (same as I.A.1.a.)

(11) G. To plant data acquisition

For direct transmission of information to the plant data processing system. Use of this flow is optional with the plant and depends on the sophistication of the data processing system employed for maintenance of the safeguards data base (manual, dedicated mini-, local-, or central-computer).

If used, information on material movements, item identity change and production parameters; data and variables would typically be transmitted directly (on-line acquisition) to the plant data processing system. If not used, production data and accountability information would be sent to the process foreman and entered into the data processing system by another decision maker at a later time.

(16) H. To process foreman and process engineer

A copy of the abnormal situation log entry (IV.A.) is sent to each in order to provide a record for use during investigative actions.

(17) I. To process engineer and plant safeguards authority

Periodic review of abnormal situation log when these decision makers verify that the plant safeguards system is correctly designed and properly functioning.

NOTE: Adjacent operational areas are further characterized by:

A. Material handling activities

(1)   1. From preceding operational area

    a. Product from processing operational area in same MBA

    b. Product from processing operational area in different MBA

    c. Material stored in same MBA

    d. Material stored in different MBA

    e. Recycle from this processing operational area

    f. Recycle from another processing operational area

    g. Material received from off-site

(5)   2. To following operational area

    a. Product to processing operational area in same MBA

    b. Product to processing operational area in different MBA

    c. Material for storage in same MBA

    d. Material for storage in different MBA

    e. Recycle to another processing operational area

    f. Samples to analytical laboratory

g. Material to R&D area

h. Scrap to recovery

i. Waste to measured discard

j. Material to be shipped off-site

B. Operators

(18) 1. Preceding operational area

a. Process operator (processing operational area in same MBA)

b. Process operator (processing operational area in different MBA)

c. MBA SNM custodian (storage operational area in same MBA)

d. MBA SNM custodian (storage operational area in different MBA)

e. Vault manager (storage operational area in different MBA)

f. Analytical chemist (analytical laboratory)

g. R&D technologist (R&D area)

h. Shipping dock clerk (off-site receiving)

(8) 2. Following operational area

a. Process operator (processing operational area in same MBA)

b. Process operator (processing operational area in different MBA)

c. MBA SNM custodian (storage operational area in same MBA)

d. MBA SNM custodian (storage operational area in different MBA)

e. Vault manager (storage operational area in different MBA)

f. Analytical chemist (analytical laboratory)

g. R&D technologist (R&D area)

h. Shipping dock clerk (off-site shipping)
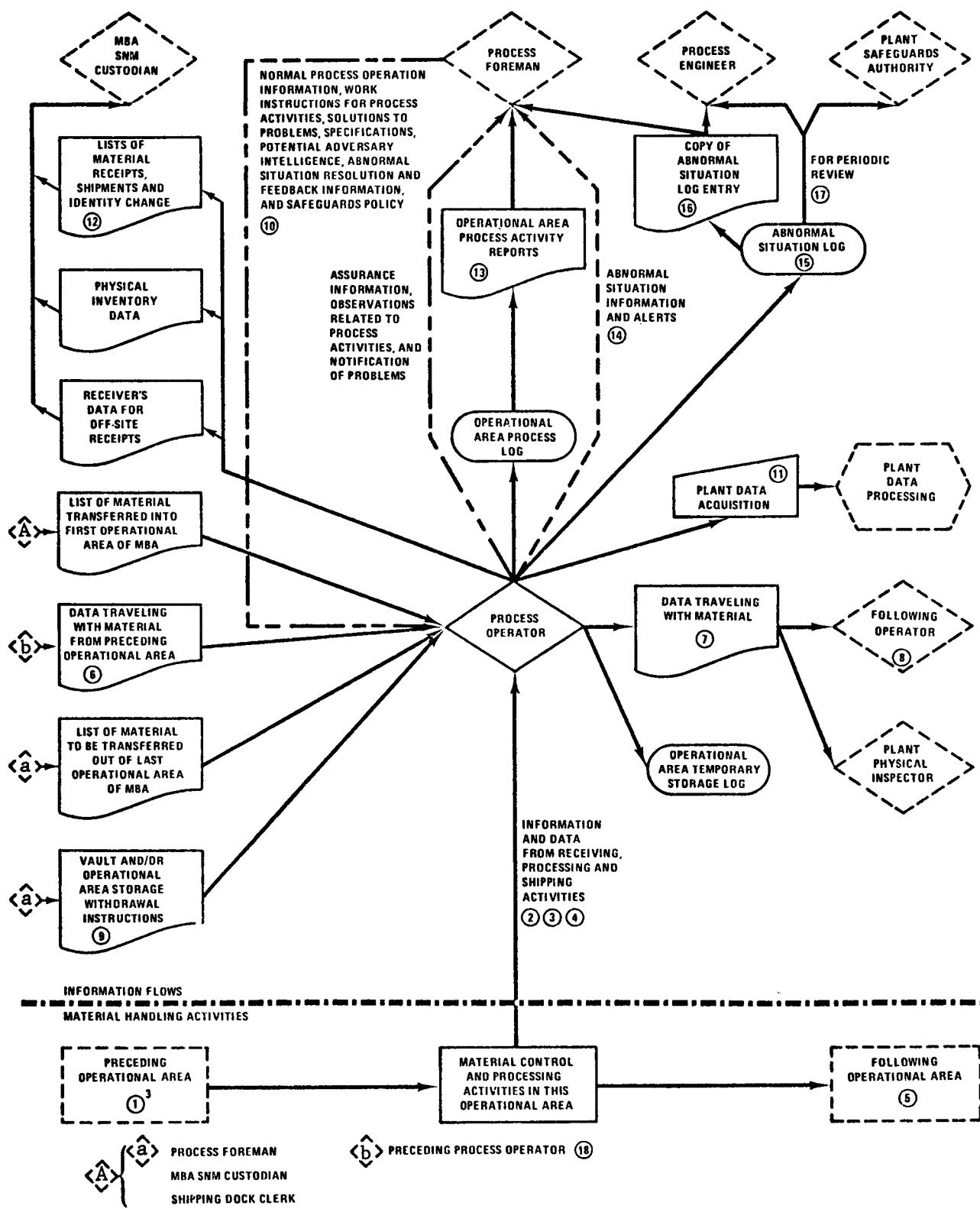
FIGURE F-1 INFORMATION AND MATERIAL HANDLING FLOWS ASSOCIATED WITH
THE GENERALIZED OPERATIONAL AREA

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[3] Information in diagram necessarily condensed; refer to similarly numbered circle in outline for details of indicated contents or flow.

Appendix G

Diverted Amounts Parameter

A. The Basic Concept

Diverted Amounts is a Diversion Path Parameter used to account for the number of times a diverter attempts to remove SNM from the Process. It is important to remember that a diverter may choose to take a quantity of SNM, equal to the Working Mass (WM), in a single removal or he may choose to remove a lesser quantity, Q, of SNM a number of discrete times, N, in order to accumulate the Working Mass quantity. He has the option of trading off a greater number of Diversions of smaller quantities against the removal of larger quantities on fewer attempts. In any event, the analyst is trying to determine how long it will take the MC&MA Subsystems to indicate that a Working Mass of SNM has been removed.

Thus,

$$WM = NQ \qquad (1)$$

where:

WM = the Working Mass:

N = the number of discrete Diversions necessary to remove a WM quantity of SNM from a Process; and

Q = the amount of SNM removed during each of the N discrete Diversions.

By Eq. (1), it is seen that if the Working Mass of SNM is 500 g, a diverter can remove the entire 500 g in one Diversion (WM = 500 g, N = 1, Q = 500 g) or he can remove 500 g by accumulating 250 g during 2 Diversions (WM = 500 g, N = 2, Q = 250 g). In fact, he has N options available where N varies from 1 to some practical upper limit. It is important to note, however, that the diverter is always trying to accumulate a Working Mass of SNM.

From a diverter's point of view, each additional discrete Diversion needed to accumulate a Working Mass of SNM adds to the complexity of the Path. In DPA, this added complexity is accounted for by adjusting the Relative Path Weight (RPW) of each General Diversion Path (GDP) by a Diverted Amounts factor, D. This factor is assumed to be

$$D = \sqrt{1/N} \qquad (2)$$

The Diverted Amounts factor, D, is used to reduce the Adjusted Relative Path Weight (ARPW) value for each Specific Diversion Path (SDP) as the number of discrete Diversions, N, increases, thus indicating increased complexity.

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While it is easy to think of D in terms of N, it may be more practical to determine the value of D from another point of view. A more convenient method of addressing the problem results if D is calculated on the basis of the amount, Q, of SNM removed during each discrete Diversion. It should be noted that Eq. (2) can be stated

$$D = \sqrt{Q/NQ} \qquad (3)$$

or

$$D = \sqrt{Q/WM} \qquad (4)$$

It is possible, therefore, to calculate D when the values of WM and Q, the amount of SNM being removed from the Process during each Diversion, are known.

B. Application of the Concept to GDPs

When analyzing the Diversion possibilities in a particular Operational Area, the analyst first determines the Scenario which fits the GDP and Concealment Strategy being analyzed. Next, he finds an Abnormal Situation which will indicate that a Diversion may have taken place. Having done this, he is in a position to establish a range of Diverted Amounts, bounded by the maximum, Q_{max}, and minimum, Q_{min}, amounts of SNM that a diverter could remove in discrete Diversions that will be indicated by the same Abnormal Situation. While the analyst could prepare a "SDP Worksheet" for each discrete quantity, the end result would be a large number of "SDP Worksheets" in which the only change would be the quantity of SNM removed during each attempt. The GDP, Concealment Strategy, Scenario, and Abnormal Situation would all be the same for each of the Paths.

If D is calculated on the basis of Q_{min} and Q_{max}, only one "SDP Worksheet" is needed. Actually, after the range of Diverted Amounts, Q_{min} and Q_{max}, that are indicated by a particular Abnormal Situation has been determined, only Q_{max} is needed to calculate the Diverted Amounts factor. By using Q_{max} to calculate D, the analyst is assigning a higher ARPW value to the Path; this is the more conservative approach. Thus,

$$D = \sqrt{Q_{max}/WM} \qquad (5)$$

represents the Diverted Amounts factor for all amounts of SNM between Q_{min} and Q_{max} which will be indicated by a given Abnormal Situation.

Assume that by means of this procedure, the analyst has found an Abnormal Situation, AS #1, which indicates that a Diversion may have taken place, based on a specific Scenario. Also, the range of Diverted Amounts, Q_{min} to Q_{max}, has

been determined that will be indicated by AS #1. Using the same Scenario, however, it may be possible to remove an amount less than the Q_{min} indicated by AS #1. In this case, the analyst must try to determine a new Abnormal Situation, AS #2, which will indicate discrete Diversions of amounts less than Q_{min}. Once AS #2 is determined (if there is one), the analyst must find the new range of Diverted Amounts (Q'_{min} to Q'_{max}, where Q'_{max} is the previous Q_{min}) indicated by AS #2. The process is repeated until all possible amounts, which might be removed in discrete Diversions, have been considered. A new "SDP Worksheet" is prepared for each Abnormal Situation.

Consider, for example, that an operator is going to divert some Pu metal and substitute an equal amount of inert material when casting a Pu button averaging 2400 g in mass. Also assume that the operator sends a sample of good material to the laboratory for analysis prior to substitution. The laboratory will not, therefore, detect the Diversion on the basis of the sample. This is essentially a Scenario which fits GDP #3. One Abnormal Situation might arise when the button is sent to the vault for long term storage. In this case, the "Vault Custodian" (VC) might be able to detect any substitution in which the inert material is more than 20% of the total button simply by making a rough attribute check with a small radiation meter. The range of Diverted Amounts, indicated by the "go/no go" attribute check is 480 g (20% of 2400 g) to 500 g (the Working Mass for Pu metal). If the operator substituted quantities less than 480 g, it might not be detected until the annual witnessed inventory of the vault when a non-destructive assay (NDA) measurement of the button is performed. Assuming that the NDA measurement will determine the Pu content to ±5%, this new Abnormal Situation (unacceptable Pu content determined by NDA measurement) would indicate all substitutions between 120 g (5% of 2400 g) and 480 g (the detection threshold when VC observes the button). After being stored in the vault for about a year, the button is sent to another MBA where a 1.0 g sample is taken. The sample is sent to the laboratory where the Pu content is determined to ±1%. The laboratory would, therefore, detect all substitutions of inert material between 24 g (1% of 2400 g) and 120 g (the minimum amount detected by the NDA measurement). If the operator substituted less than 24 g in each button, his Diversion would go undetected. Therefore, for this Scenario, the Abnormal Situations, the range of Diverted Amounts indicated by each Abnormal Situation, and in the Diverted Amount factors, D, are:

Abnormal Situations	Range of Diverted Amounts	D
Fails "go/no go" attribute check by VC	480 to 500 g	1.000
"Unacceptable" NDA measurement	120 to 480 g	0.980
"Out of specification" lab analysis	24 to 120 g	0.490
None	0 to 24 g	0.219

It should be noted, that for this Scenario, the entire range of Diverted Amounts (0 g to 500 g, the Working Mass) that might possibly occur, has been analyzed. This type of procedure is repeated for each Scenario.

Generally, it will not be necessary to analyze discrete Diversions of very small quantities. For any Material Attractiveness, M, and a GDP having a given RPW value, the analyst can calculate the minimum quantity, Q_{min}, that should be considered for any discrete Diversion. To do this, the value of the Diverted Amounts factor, D_{min}, is calculated that will cause the ARPW value to equal 0.1 for the RPW and Material Attractiveness being analyzed. Since,

$$ARPW = RPW \times M \times D_{min} = 0.1, \qquad (6)$$

or

$$D_{min} = 0.1/(RPW \times M) . \qquad (7)$$

The value of the Diverted Amounts factor, D_{min}, can be used to calculate the quantity of SNM that will force the ARPW value to be equal to 0.1. In practice, the square of D_{min} is more convenient to use since Eq. (4) can be restated as

$$D_{min} = \sqrt{Q_{min}/WM}$$

or

$$Q_{min} = D^2_{min} \times WM . \qquad (8)$$

This calculated value of Q_{min} represents the minimum value of the total range of Diverted Amounts or the minimum amount of SNM that needs to be considered for any Diversion involving a particular RPW and a particular Material Attractiveness.

The values of the square of the Diverted Amounts factor, D^2_{min}, for use with Eq. (8), have been computed and are given in Figure G-1 as a function of GDP number and M. During the "Analysis of Diversion Paths" step, the DPA team should refer to Figure G-1 when calculating the minimum amount of SNM that need be considered for any discrete Diversion.

If the material in a certain operational area is Pu metal, for example, and the analyst is evaluating GDP #6, he need not consider discrete Diversions in which the amount removed is less than 20 g ($M = 1.0$, $WM = 500$ g, $D^2_{min} = 0.040$). Diversion of amounts less than 20 g will cause the ARPW value to be less than 0.1 and thus fall outside the bounds of the analysis. To carry out the Path, a diverter would need to make 25 discrete Diversions in order to accumulate 500 g of Pu.

C. Identifying GDPs to be Evaluated

During the "Analysis of Diversion Paths" step, it is necessary to identify (a) which GDPs need to be evaluated in each Operational Area for each material, as well as (b) the range of values of D^2 for each GDP when evaluating each material. The DPA team identifies the Type and Description of each material as well as the size of each material flow in each Operational Area during the "Process Characterization" step. Using this information, the analyst can determine M, WM, and the maximum amount of material, Q_A, available to a diverter at any one time in each Operational Area.

The analyst can then determine the square of the Diverted Amounts factor, D^2_A, which represents a single Diversion of the maximum amount of material available to a diverter, since

$$D^2_A = Q_A/WM . \tag{9}$$

If the calculated value of D^2_A is greater than 1.0, it should be set equal to 1.0 since the value of D is restricted to the range of 0.1 to 1.0 (see Appendix E).

Once the analyst has calculated D^2_A for a particular material in a particular Operational Area, he can use Figure G-1 to determine which GDPs to evaluate. For a particular Material Attractiveness, M, the analyst must evaluate all GDPs for which

$$D^2_A \geqslant D^2_{min} . \tag{10}$$

A "-" in Figure G-1 indicates that the ARPW value for a particular GDP will be less than 0.1, i.e., the Path will fall outside the bounds of the analysis. Thus, for a given GDP and M value, D^2 ranges from a minimum of D^2_{min} to a maximum of D^2_A.

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D^2_{min} As A Function of GDP Number and M

GDP Number	M=1.0	M=0.9	M=0.8	M=0.7	M=0.6	M=0.5	M=0.4	M=0.3	M=0.2	M=0.1
1	0.010	0.012	0.016	0.020	0.028	0.040	0.062	0.111	0.250	1.000
2	.013	.016	.020	.027	.036	.052	.082	.145	.327	—
3	.016	.019	.024	.032	.043	.062	.098	.174	.391	—
4	.020	.025	.032	.042	.057	.082	.128	.227	.510	—
5	.028	.034	.043	.057	.077	.111	.174	.309	.694	—
6	.040	.049	.062	.082	.111	.160	.250	.444	1.000	—
7	.043	.054	.068	.089	.121	.174	.271	.482	—	—
8	.062	.077	.098	.128	.174	.250	.391	.694	—	—
9	.111	.137	.174	.227	.309	.444	.694	—	—	—
10	.174	.214	.271	.354	.482	.694	—	—	—	—
11	.160	.198	.250	.327	.444	.640	1.000	—	—	—
12	.209	.257	.326	.426	.579	.834	—	—	—	—
13	.250	.309	.391	.510	.694	1.000	—	—	—	—
14	.327	.403	.510	.666	.907	—	—	—	—	—
15	.444	.549	.694	.907	—	—	—	—	—	—
16	.694	.857	—	—	—	—	—	—	—	—

FIGURE G-1

Assume, for example, that a diverter has access to no more than a 10 g sample of Pu metal (M = 1.0, WM = 500 g) at any one time. Then,

$$D_A^2 = Q_A/WM = 10 \text{ g}/500 \text{ g} = 0.020 \ .$$

Referring to Figure G-1 (for M = 1.0), only the first four GDPs meet the criterion of Eq. (10). The range of values to be used when evaluating these GDPs would be:

GDP	RPW	D_{min}^2	D_A^2	Q_{min}	Q_A
1	1.000	0.010	0.020	5 g	10 g
2	0.875	0.013	0.020	6.5 g	10 g
3	0.800	0.016	0.020	8 g	10 g
4	0.700	0.020	0.020	10 g	10 g

The above data indicate that, for GDP #1, the analyst needs to consider only discrete Diversions which range between 5 g and 10 g each. For GDP #4, on the other hand, only Diversion of the entire sample is considered.

Appendix H

Other Worksheets

Cover Pages

Title Page

SDP Worksheet

DPA Modification Worksheet

DIVERSION PATH ANALYSIS

WORKPAPER DOCUMENTATION

DIVERSION PATH ANALYSIS

SUMMARY DOCUMENTATION

DIVERSION PATH ANALYSIS

_____

DATE: _____

DPA NO. _____

LOCATION

_____

DPA TEAM

_____

_____

_____

DATE REVIEWED: _____

REVIEWED BY: _____

APPROVED BY: _____

SPECIFIC DIVERSION PATH WORKSHEET

DECEIT BY RECORDS:
_____ UNCHANGED
_____ FALSIFIED
_____ ALTERED

DECEIT IN REMOVAL:
_____ NO SUB.
_____ SUB.

MATL. AT. FAC. _____	
x DIV. AMT. FAC. _____	
x RPW FACTOR _____	
= ARPW VALUE _____	

OPERATIONAL AREA _____

MATERIAL _____

GDP _____

SDP _____

DIVERTERS: _____

_____

DIVERTED AMOUNT:
_____ SINGLE THEFT OF _____ (G) (ML)
_____ SEVERAL THEFTS RANGING FROM _____ TO _____ (G) (ML)

CONCEALMENT STRATEGY:
_____ LOSS IN THIS OPERATIONAL AREA, DIVERTER GETS AWAY
_____ LOSS IN ANOTHER OPERATIONAL AREA
_____ LOSS IN ANOTHER MBA
_____ LOSS IN PLANT

* * * * * * * * * * * * * * * * * * * **SCENARIO #** _____ * * * * * * * * * * * * * * * * * *

_____

_____

_____

_____

_____

_____

_____

ABNORMAL SITUATION # _____ : _____

_____

_____

INFORMATION NEEDED: _____

_____

OBSERVER: _____ **TIME RESPONSE (DAYS)** _____

INNOCENT CAUSE # _____ : _____

_____

MODIFICATION # _____ : _____

_____

ABNORMAL SITUATION # _____ : _____

_____

_____

INFORMATION NEEDED: _____

_____

OBSERVER: _____ **TIME RESPONSE (DAYS)** _____

DPA MODIFICATION WORKSHEET

MODIFICATION: _____

_____

_____

_____

SDP	AS	TIME	OBSERVER

MODIFICATION NO. _____

INITIAL COST $ _____

ANNUAL COST $ _____

EST. LIFE (YRS)   _____

SDP	AS	TIME	OBSERVER

Appendix I

DPA Computer Program 1

DIVERSION PATH ANALYSIS

COMPUTER PROGRAM 1

"Diversion Path Analysis Computer Program 1" (DPACP-1) [3] assembles the data recorded on the "SDP Worksheets" and produces several tables which the DPA team should use to determine Major Modifications and recommendations. The following tables (by Material Type and by "All Materials" collectively) are produced for each run.

TABLE	TITLE
1	Input Parameters Table
2	Specific Diversion Path Data
3-11	DPA Summary ("All Materials" Only)
12	DPA Summary Table (2 copies)
13	Abnormal Situation-SDP Cross Reference Table - "Coverage 1"
14	Abnormal Situation-SDP Cross Reference Table - "Coverage 2"
15	Detection Time-SDP Cross Reference Table - "Coverage 2"
16	Distribution of System Response Time (2 copies)
17	Observer-Abnormal Situation Cross Reference Table - "Coverage 2"
18	Observer-SDP Cross Reference Table - "Coverage 1"
19	Observer-SDP Cross Reference Table - "Coverage 2"
20	Potential Diverter-SDP Cross Reference Table - "Coverage 2"

The input parameters used for the computer run are listed in Table 1. The assigned identification numbers of the Observers/Diverters are correlated with their alphanumeric abbreviations used when developing the Specific Diversion Paths (see items 8, 13, and 22 in Figure 2-5). These data are entered on CARD 3. Information provided to the computer for the control of the options related to modification data are then listed. These options include: (1) the designation of modifications as being implemented; (2) the deletion of modification data only for all Paths affected by a given modification; (3) the deletion of the data for all Paths affected by a given modification; and (4) the deletion of the data for specific Paths identified by modification and SDP number. Modification numbers used by the various options are entered on CARDS 4 through 7. The

information related to the options is printed only if the option is being used (i.e., modification numbers have been entered for a paricular option). Examples of this table are shown in Volume 3.

In the case of the first option, previously implemented modifications, "DPACP-1" is assuming that these modifications represent the "base case" ("Coverage 1") and is determining the effect ("Coverage 2") of implementing other modifications (not listed on this line but entered in columns 33 and 34 on CARD 9). It was assumed, as indicated on page 203 in Volume 2, that modifications 1 through 5 were already a part of the facility Safeguards System (Coverage 1) when the run was made on 1/31/78. The output on pages 204 through 221 represents the effect ("Coverage 2" vs. "Coverage 1") of implementing modifications 6 through 10.

Table 2 is a listing of the data from the "SDP Worksheets" as sorted and used by "DPACP-1." This listing of data will be different than the data entered into the computer on the SDP data cards (CARD 9) if some modifications have already been implemented and are a part of the facility Safeguards System or if the other options are in effect. Pages 204 and 205 in Volume 2 show a listing of the SDP input data as used by "DPACP-1" for the 1/31/78 run. Data for any SDP affected by modifications #1 through #5 have been shifted from the columns under the heading "Modified" to the columns under the heading "Current." In instances where a previously implemented modification (page 203) eliminated a path, all reference to that path is deleted from the listing. For example, there are no data on page 204 for SDPs 1-31, 1-32, and 1-33 because these SDPs were eliminated when modification #1 was implemented (see pages 109, 110, and 111). This feature makes it unnecessary to repunch the SDP data cards as modifications are implemented.

Tables 3 through 11 provide a comparison of the Response Times of SDPs "before" and "after" the implementation of some proposed modifications. There is one table for each of the nine ARPW ranges. If more than one Material Type and Material Description is being considered in a given DPA, the nine "DPA Summaries" are printed only for "All Materials" collectively. For each ARPW range, these tables provide the following information:

a) GDP number;
b) SDP number;

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c) Material Type and Material Description;

d) Abnormal Situation number;

e) Detection Time in days;

f) time class;

g) number of the modification to be implemented, if any;

h) number of the Abnormal Situation after the modification is implemented;

i) Detection Time (in days) after the modification is implemented; and

j) time class of the Path after modification.

The total number of Paths and the number of Paths in each time class are given for each Material Type and Description and for "All Materials" collectively. This table provides the DPA team with a listing of all the SDPs which are about equally "attractive" to a diverter. Pages 211 through 219 show the nine DPA Summaries for the example DPA in Volume 2.

Table 12, the "DPA Summary Table," assembles the totals from the nine "DPA Summaries." This table shows the number of Diversion Paths in each DOE specified Detection Time category (rows). Within each of these categories, the Paths are also classified according to the ARPW value (columns). The table indicates the distribution of the vulnerabilities in the facility Safeguards System. There is a "DPA Summary Table" for each distinct Material Type and Description found in the Process as well as for all Material Types and Descriptions collectively. Several Safeguards System indices for "Coverage 1" and "Coverage 2" are also shown. "Remaining Paths" represents the number of vulnerabilities to covert diversion of SNM by an individual authorized to enter the Material Access Area. The summation of Detection Times for all vulnerabilities is indicated as "Total Number of Path Days." In this calculation, all undetected Paths (Class 6) have been assigned a Detection Time of 999 days. The average number of days required for indication of a vulnerability via the MC&MA Subsystems are shown as the "Average System Response Time." An example of this table is provided on page 220 in Volume 2.

Tables 13 and 14 correlate the SDPs associated with each Abnormal Situation. SDPs having no Abnormal Situation, as well as those which are eliminated by a modification, are indicated in these tables. The DPA team should use these tables to determine Major Modifications which will improve the facility Safeguards

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System. This is done by identifying the Abnormal Situation under current status ("Coverage 1") having the most SDPs associated with it and determining a modification which would: (1) result in a faster Detection time; or (2) eliminate the cause for the Abnormal Situation. The change in relationship between Abnormal Situations and SDPs, assuming implementation of proposed modifications, is shown in the table indicating the status for "Coverage 2." This table can be used, in a manner similar to that of the table for "Coverage 1," to identify additional Major Modifications. Also, in the event an Abnormal Situation is reported, facility management should use this table to quickly determine the potential Diversion Paths which might be involved. Page 206 in Volume 2 shows the "Abnormal Situation-SDP Cross Reference Table" for the example DPA. This table reflects the SDPs in existence at the facility on 1/31/78 ("Coverage 2").

Table 15 correlates the SDPs associated with each Detection Time. The DPA team should try to determine modifications for the particular Paths which have the longest Detection Times. Page 207 in Volume 2 provides an example of this table.

Table 16 is intended to provide facility management with an overview of the Safeguards System improvement to be gained by implementing the proposed modifications. This table (see page 221 in Volume 2) shows the number of Diversion Paths associated with each Detection Time "before" and "after" implementation of the proposed modifications. Other information available from this table includes:

a) the number of SDPs eliminated by modifications;

b) the total number of SDPs "before" and "after" implementation of the modifications;

c) the summation of Detection Times (Total Path Days) for all Paths "before" and "after" implementation of the modifications; and

d) the average Detection Time (System Response Time) for each Path "before" and "after" implementation of the proposed modifications.

Table 17 identifies which person (process operator, foreman, guard, etc.) observes a given Abnormal Situation. An example of this table is shown on page 208 in Volume 2. Consideration should be given to having facility procedures include Abnormal Situation information for each observer work-station and require that observers report Abnormal Situations to facility supervision promptly. The observer need not know any details of the SDP to which the Abnormal Situation applies; he need only know that he must report it should it occur.

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Tables 18 and 19 correlate the observer of an Abnormal Situation with the SDP to which that Abnormal Situation applies. Paths which are eliminated by the implementation of a modification and Paths which have no observer are also indicated. This table should be held by facility management. When an observer reports an Abnormal Situation, facility management can use the "Abnormal Situation-SDP Cross Reference Table" to quickly determine which Paths might be involved. Reference to the "SDP Worksheets" will then provide facility management with the details of the Path, possible Innocent Causes, and the potential diverters. An example of this table is shown on page 209 in Volume 2.

Table 20 correlates potential diverters with the Specific Diversion Paths they are capable of perpetrating. This table highlights those facility personnel having the greatest opportunity, in terms of variety of ways, to divert SNM. The DPA team might use this information as the basis for modifications directed to strict adherence to Material Surveillance Procedures. An example of this table can be found on page 210 in Volume 2.

[L] Data left justified in field   [R] Data right justified in field

- <u>CARD 1 (1 for each analysis)</u> SAME AS CARD 1, DPA COMPUTER PROGRAM 2 (DPACP-2)
  Cols. 1- 8 Beginning Status Information (alphanumeric) [L]
  Cols. 9-16 Ending Status Information (alphanumeric) [L]
  Cols. 17-36 DPA Identification Number (alphanumeric) [L]
  Cols. 37-56 Facility Area Analyzed (alphanumeric) [L]

- <u>CARD 2 (1 for each analysis)</u>
  Cols. 2- 3 Count of fields used on CARD(S) 3 [R]   BLANK IF ZERO
  Cols. 5- 6   "   "   "   "   "   "   4 "   "   "   "   "
  Cols. 8- 9   "   "   "   "   "   "   5 "   "   "   "   "
  Cols. 11-12   "   "   "   "   "   "   6 "   "   "   "   "
  Cols. 14-15   "   "   "   "   "   "   7 "   "   "   "   "

- <u>CARD 3 (up to 12 for each analysis)</u>
  8 fields 10 columns wide (maximum of 99 fields)

	1	2	3	4	5	6	7	8	
Cols.	1- 2	11-12	21-22	31-32	41-42	51-52	61-62	71-72	Observer/Diverter Identification Number [R]
Cols.	3-10	13-20	23-30	33-40	43-50	53-60	63-70	73-80	Observer/Diverter Designation (alphanumeric) [L]

- <u>CARD 4 (up to 2 for each analysis)</u> NOT USED IF COLS. 5-6, CARD 2, ARE BLANK
  26 fields 3 columns wide (40 fields maximum)
  Modification Numbers of previously implemented modifications (1 per field) [R]
  Computer will reposition data given on SDP data cards (CARD 9) as follows--
  Cols. 33-34 set to zero
  Cols. 22-23 overwritten by Cols. 37-38 and Cols. 36-38 set to zero
  Cols. 25-27   "   "   "   40-42 "   "   40-42 "   "   "
  Cols. 29-30   "   "   "   44-45 "   "   44-45 "   "   "

- <u>CARD 5 (up to 2 for each analysis)</u> NOT USED IF COLS. 8-9, CARD 2, ARE BLANK
  26 fields 3 columns wide (40 fields maximum)
  Modification Numbers for which modification data will be deleted (fields in Cols. 33-45, CARD 9, set to zero) but other SDP data will remain (1 per field) [R]

- <u>CARD 6 (up to 2 for each analysis)</u> NOT USED IF COLS. 11-12, CARD 2, ARE BLANK
  26 fields 3 columns wide (40 fields maximum)
  Modification Numbers for which all associated SDP data will be deleted (1 per field) [R]

- <u>CARD 7 (up to 5 for each analysis)</u> NOT USED IF COLS. 14-15, CARD 2, ARE BLANK
  8 fields 10 columns wide (40 fields maximum)
  Modification Numbers with associated SDP Numbers for which all specified SDP data will be deleted

	1	2	3	4	5	6	7	8	
Cols.	1- 3	11-13	21-23	31-33	41-43	51-53	61-63	71-73	Operational Area Number [R]
Cols.	5- 7	15-17	25-27	35-37	45-47	55-57	65-67	75-77	SDP Worksheet Number [R]
Cols.	9-10	19-20	29-30	39-40	49-50	59-60	69-70	79-80	Modification Number [R]

- <u>CARD 8 (1 for each Material Type and Description)</u> SAME AS CARD 8, DPACP-2
  Col.   1   "*"
  Cols. 2- 3 Material Type and Description Identification Number [R]
  Cols. 5-16 Material Type and Description Designation (alphanumeric) [L]

- <u>CARD 9 (1 for each SDP)</u>   SAME AS CARD 9, DPACP-2

Cols.	2- 3	Material Type and Description Identification Number [R]
Cols.	6- 7	GDP Number [R]
Cols.	9-10	Operational Area Number [R] ⎫
Cols.	12-14	SDP Worksheet Number [R] ⎬ These 2 fields form the SDP Number
Cols.	17-19	ARPW Value (decimal point assumed to be in Col. 16 and it need not be punched unless ARPW=1.000; e.g., if ARPW=0.800, punch "800" and if ARPW=1.000, punch "1.0")
Cols.	22-23	Current Abnormal Situation Number; "0" if none [R]
Cols.	25-27	Current Detection Time in days; "0" if impossible, "1" if one day or less, "999" if undetected [R]
Cols.	29-30	Current Observer Identification Number; "0" if none [R]
Cols.	33-34	Modification Number [R] ⎫
Cols.	37-38	Abnormal Situation Number after modification implemented; "0" if none [R] ⎪
Cols.	40-42	Detection Time in days after modification implemented; "0" if impossible, "1" if one day or less, "999" if undetected [R] ⎬ See COMMENT 3
Cols.	44-45	Observer Identification Number after modification implemented; "0" if none [R] ⎭
Cols.	47-48	1st Potential Diverter Identification Number [R]
Cols.	50-51	2nd " " " " " "
Cols.	53-54	3rd " " " " " "
Cols.	56-57	4th " " " " " "
Cols.	59-60	5th " " " " " "
Cols.	62-63	6th " " " " " "
Cols.	65-66	7th " " " " " "
Cols.	68-69	8th " " " " " "
Cols.	71-72	9th " " " " " "
Cols.	74-75	10th " " " " " "

- <u>CARD 10 (1 for each Material Type and Description)</u>   SAME AS CARD 10, DPACP-2

Col.	1	"*" if another Material Type and Description is included in this analysis
		BLANK if last Material Type and Description in this analysis

- <u>CARD 11 (1 for each analysis)</u>   SAME AS CARD 11, DPACP-2

Cols.	2- 3	"99" if another analysis is to be performed in this computer run
		BLANK if end of computer run

<u>COMMENTS ON INPUT DATA</u>

1. Maximum number of entries per analysis:
    SDPs, 500;
    Material Types and Descriptions, 10;
    Observers/Diverters, 99;
    Operational Areas, 10;
    SDPs/Operational Area, 126; and
    Modifications, 40.

2. Largest integer value that can be used to identify indicated parameter:
    Material Type and Description, 10;
    Observer/Diverter, 99;
    Operational Area, 10;
    SDP Worksheet Number/Operational Area, 126; and
    Modification, 40.

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COMMENTS ON INPUT DATA (continued)

3. If SDP has no minor modification, Cols. 33-45 should be left blank when data are originally punched. Major modification data, when identified, will be entered in these columns.

4. Observer/Diverter data, entered in the fields of a CARD 3 (Cols. 1-10, 11-20, etc.), need not be sequential in regard to Observer/Diverter Identification Numbers and blank fields between entries are allowed. The count of entries input on a CARD 2 (Cols. 2-3), however, *must* agree with the number of fields (including blank fields between entries) used on the CARD(S) 3.

5. There may be Observer/Diverter Identification Numbers (and associated Observer/Diverter Designations) input on a CARD 3 that are not used on any CARD 9.

6. The Observer/Diverter Identification Numbers used on the SDP data cards (CARD 9) *must* correlate with one of the Observer/Diverter Identification Numbers (and its associated Observer/Diverter Designation) input on a CARD 3.

7. Modification Numbers, entered on CARD(S) 4, 5 and/or 6, or Modification Numbers with associated SDP Numbers entered on CARD(S) 7, need not be entered sequentially and blank fields between entries are allowed. The count of entries input on a CARD 2, however, *must* agree with the number of fields (including blank fields between entries) used on the CARD(S) 4, 5, 6 and/or 7.

8. There may be Modification Numbers input on CARD(S) 4, 5, 6 and/or 7 that are not associated with a Modification Number on any CARD 9.

9. The SDP Numbers *must* be unique, preferably sequential, if more than one Material Type and Description is analyzed in a given Operational Area; e.g., if two Material Types and Descriptions are analyzed in Operational Area 1 and the last SDP for material 1 is "1-33," then the first SDP Number for material 2 could be "1-34." The sequence need not be complete; SDP Numbers may be skipped.

10. The SDP data cards (CARD 9) for a given Material Type and Description may be input in any order.

11. For modifications not selected for implementation, the modification data indicated on the SDP data card (CARD 9) *must* be deleted. When updating, using a data deck prepared for DPA Computer Program 2 (that has these modification data punched), the *modification data only* (Cols. 33-45) can be deleted from the data used by the computer (a) by using the option provided by CARD 5, or (b) by repunching the affected SDP data cards leaving Cols. 33-45 BLANK, or (c) by setting up the input data deck so that all SDP data cards having the modification data punched in Cols. 33-45 are *before* a duplicate set of SDP data cards that have Cols. 33-45 BLANK.

12. There can be only one modification associated with a given SDP data entry. When updating, using a data deck prepared for DPA Computer Program 2, this may not be the case. If two or more modifications affect the same SDP, the duplicate SDP data *must* be deleted for those modifications not selected for implementation. For example,

    a. If modifications 11 and 12 apply to the same SDPs and modification 12 is rejected, *all SDP data* associated with modification 12 must be deleted from the data used by the computer. This can be

COMMENTS ON INPUT DATA (continued)

done (1) by using the option provided by CARD 6, or (2) by removing, from the input data deck, all SDP data cards (CARD 9) having a "12" in Cols. 33-34, or (3) by setting up the input data deck so that all SDP data cards having a "12" in Cols. 33-34 are *before* the equivalent SDP data cards that have an "11" in Cols. 33-34.

b. If modifications 13 and 14 both apply to SDP 4-3, the choice must be made as to which modification will be used to cover SDP 4-3. Assume that modification 14 is to be used. The SDP data for modification 13 must be deleted from the data used by the computer. This can be done (1) by using the option provided by CARD 7, or (2) by removing, from the input data deck, the SDP data card (CARD 9) for SDP 4-3 (modification 13), or (3) by setting up the input data deck so that the SDP data card for SDP 4-3 (modification 13) is *before* the SDP data card for SDP 4-3 (modification 14).

INPUT DATA DECK MAKEUP

1st Analysis
{
CARD 1
CARD 2 (Assume Cols. 5-6, 8-9, 11-12, 14-15 BLANK)
CARD(S) 3
CARD 8 ⎫
CARD(S) 9 ⎬ 1st Material Type and Description
CARD 10 ("*") ⎭
CARD 8 ⎫
CARD(S) 9 ⎬ 2nd Material Type and Description
CARD 10 ("*") ⎭
⋮
CARD 8 ⎫
CARD(S) 9 ⎬ "nth" Material Type and Description
CARD 10 (BLANK) ⎭
CARD 11 ("99")
}

2nd Analysis
{
CARD 1
CARD 2 (Assume Cols. 5-6, 11-12 have entries; 8-9, 14-15 BLANK)
CARD(S) 3
CARD(S) 4
CARD(S) 6
CARD 8 ⎫
CARD(S) 9 ⎬ 1st Material Type and Description
CARD 10 ("*") ⎭
CARD 8 ⎫
CARD(S) 9 ⎬ 2nd Material Type and Description
CARD 10 ("*") ⎭
⋮
CARD 8 ⎫
CARD(S) 9 ⎬ "nth" Material Type and Description
CARD 10 (BLANK) ⎭
CARD 11 ("99")
}

⋮

"nth" Analysis
{
CARD 1
CARD 2 (Assume Cols. 5-6, 8-9, 11-12, 14-15 have entries)
CARD(S) 3
CARD(S) 4
CARD(S) 5
CARD(S) 6
CARD(S) 7
CARD 8 ⎫
CARD(S) 9 ⎬ 1st Material Type and Description
CARD 10 ("*") ⎭
CARD 8 ⎫
CARD(S) 9 ⎬ 2nd Material Type and Description
CARD 10 ("*") ⎭
⋮
CARD 8 ⎫
CARD(S) 9 ⎬ "nth" Material Type and Description
CARD 10 (BLANK) ⎭
CARD 11 (BLANK)
}

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Appendix J

DPA Computer Program 2

DIVERSION PATH ANALYSIS
COMPUTER PROGRAM 2

"Diversion Path Analysis Computer Program 2" (DPACP-2) [4] complements "DPACP-1" and produces the tables and statistics on Minor and Major Modifications that are included in the summary documentation. "DPACP-2" uses the same Specific Diversion Path (SDP) input data cards as "DPACP-1," however, data for Major Modifications are punched in the appropriate fields of the cards as these modifications are identified. The following tables are produced by the program: (1) "Input Parameters Table"; (2) "Specific Diversion Path Data"; (3) "DPA Modification Proposal" for each modification; and (4) "Modification Summary Table."

The Input Parameters Table lists the data for the modifications, the data provided to the computer for the control of the options related to the modification data and the SDPs having two or more input data cards. The options include: (1) the designation of "Modification Proposals" not to be printed in this computer run; (2) the deletion of modification data only for all Paths affected by a given modification; (3) the deletion of the data for all Paths affected by a given modification; and (4) the deletion of the data for specific Paths identified by modification and SDP number. The modification data and control data are entered on CARDS 3 through 7. The information related to the options is printed only if the option is being used (i.e., modification numbers have been entered for a particular option). Examples of this table are shown in Volume 4.

The "Specific Diversion Path Data" table provides a listing of the data from the "SDP Worksheets" as sorted and used by "DPACP-2." This listing of data will differ from the data entered into the computer on the SDP data cards (CARD 9). Since this program does not use data on Observers and Diverters, these data have been deleted. There are no data in the listing for SDPs that have no modifications and the data are adjusted to reflect deletions specified by use of the options. Examples of this table are found in Volume 4.

The remaining two tables display some decision parameters intended to assist management when evaluating the modifications. These parameters include the "Equivalent Annual Cost," "Marginal Cost," number of "Paths Affected," "Detection Days Saved," and the "Incremental Protection" afforded by the modification. They give some guidance concerning: (1) the costs of implementation; and (2) how much improvement can be expected from the modification.

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The "Equivalent Annual Cost" represents the amount of money that would be required to "lease" the modification for one year. It is a derived quantity based on the estimated "Initial" and "Annual Costs" together with the estimated life expectancy or life cycle of the modification. It is interpreted as the annual cost of implementing the modification and makes possible the comparison of implementation costs of modifications having differing life cycles. The "Marginal Cost" indicates the relative *value* of the modification and represents the amount of money that must be expended annually to improve the Response Time of the Safeguards System by one day for each Path that the modification affects. Smaller numbers indicate greater value than do larger numbers. "Paths Affected" indicates the number of vulnerabilities that are changed in some way by the modification while "Detection Days Saved" provides the cumulative number of days by which the Response Time of the Safeguards System will be improved if the modification is adopted. The *quality* of the modification is represented by "Incremental Protection" which gives the average number of days the Detection Time is reduced for each Path affected by the modification. Larger values indicate a greater reduction in Detection Time than do smaller values.

The decision parameters are derived as follows:

$$EAC = AC + IC \left\{ \frac{(0.1) \ (1.1)^N}{(1.1)^N - 1} \right\}$$

$$IP = \frac{DDS}{PA}$$

$$MC = \frac{EAC}{IP}$$

where:

EAC = Equivalent Annual Cost

IP = Incremental Protection

MC = Marginal Cost

AC = Annual Cost

IC = Initial Cost

N = years the modification will remain in effect at the "Annual Cost," AC

DDS = Detection Days Saved

PA = Number of Paths affected.

The "Modification Input Data" table is a listing of the estimated "Initial" and "Annual Costs," years of estimated life expectancy, and date of implementation of each modification to be analyzed.

The "Modification Proposals" indicate the SDPs affected by each modification and show as well the material identification, Adjusted Relative Path Weight (ARPW), Abnormal Situation, Detection Time, and time class associated with each of these SDPs. The last three entries are given for both the current status (Coverage 1) and for the status after implementing the modification (Coverage 2). The "Initial," "Annual," "Equivalent Annual," and "Marginal Costs" for the modification are shown together with the "Detection Days Saved" and the "Incremental Protection" afforded by the modification. The format of this table is shown on page 224 in Volume 2.

The "Modification Summary Table" lists, for each modification, the "Initial," "Equivalent Annual," And "Marginal Costs" along with the number of Paths affected, "Detection Days Saved," "Incremental Protection," and the date of implementation. The number of previously undetected Paths that will be detected as a result of implementing a modification is also indicated. The format of this table is shown on page 227 in Volume 2.

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[L] Data left justified in field   [R] Data right justified in field

- <u>CARD 1 (1 for each analysis)</u> SAME AS CARD 1, DPA COMPUTER PROGRAM 1 (DPACP-1)

Cols.	1- 8	Beginning Status Information (alphanumeric) [L]
Cols.	9-16	Ending Status Information (alphanumeric) [L]
Cols.	17-36	DPA Identification Number (alphanumeric) [L]
Cols.	37-56	Facility Area Analyzed (alphanumeric) [L]

- <u>CARD 2 (1 for each analysis)</u>

Cols.	2- 3	Count of fields used on CARD(S) 3 [R] BLANK IF ZERO
Cols.	5- 6	" " " " " " 4 " " " "
Cols.	8- 9	" " " " " " 5 " " " "
Cols.	11-12	" " " " " " 6 " " " "
Cols.	14-15	" " " " " " 7 " " " "

- <u>CARD 3 (up to 14 for each analysis)</u>
  3 fields 26 columns wide (40 fields maximum)

	Field		
Cols.	1- 2	27-28	53-54	Modification Number [R]
Cols.	3- 9	29-35	55-61	Dollars - Initial Cost [R] BLANK IF ZERO
Cols.	10-16	36-42	62-68	Dollars - Annual Cost [R] BLANK IF ZERO
Cols.	17-18	43-44	69-70	Years Life Expectancy [R] BLANK IF INITIAL AND ANNUAL COSTS ARE ZERO
Cols.	19-26	45-52	71-78	Date Implemented (alphanumeric) [L] BLANK IF NOT YET IMPLEMENTED

- <u>CARD 4 (up to 2 for each analysis)</u> NOT USED IF COLS. 5-6, CARD 2, ARE BLANK
  26 fields 3 columns wide (40 fields maximum)
  Modification Numbers for which Modification Proposals are not to be printed
  (1 per field) [R]

- <u>CARD 5 (up to 2 for each analysis)</u> NOT USED IF COLS. 8-9, CARD 2, ARE BLANK
  26 fields 3 columns wide (40 fields maximum)
  Modification Numbers for which modification data will be deleted (fields in Cols.
  33-45, CARD 9, set to zero) for other SDP data will remain (1 per field) [R]

- <u>CARD 6 (up to 2 for each analysis)</u> NOT USED IF COLS. 11-12, CARD 2, ARE BLANK
  26 fields 3 columns wide (40 fields maximum)
  Modification Numbers for which all associated SDP data will be deleted (1 per
  field) [R]

- <u>CARD 7 (up to 5 for each analysis)</u> NOT USED IF COLS. 14-15, CARD 2, ARE BLANK
  8 fields 10 columns wide (40 fields maximum)
  Modification Numbers with associated SDP Numbers for which all specified SDP data
  will be deleted

	Field							
	1	2	3	4	5	6	7	8	
Cols.	1- 3	11-13	21-23	31-33	41-43	51-53	61-63	71-73	Operational Area Number [R]
Cols.	5- 7	15-17	25-27	35-37	45-47	55-57	65-67	75-77	SDP Worksheet Number [R]
Cols.	9-10	19-20	29-30	39-40	49-50	59-60	69-70	79-80	Modification Number [R]

- <u>CARD 8 (1 for each Material Type and Description)</u> SAME AS CARD 8, DPACP-1

Col.	1	"*"
Cols.	2- 3	Material Type and Description Identification Number [R]
Cols.	5-16	Material Type and Description Designation (alphanumeric) [L]

● CARD 9 (1 for each SDP)   SAME AS CARD 9, DPACP-1

Cols.	2- 3	Material Type and Description Identification Number [R]
Cols.	6- 7	GDP Number [R]
Cols.	9-10	Operational Area Number [R] ⎫ These 2 fields form the SDP Number
Cols.	12-14	SDP Worksheet Number [R] ⎭
Cols.	17-19	ARPW Value (decimal point assumed to be in Col. 16 and it need not be punched unless ARPW=1.000; e.g., if ARPW=0.800, punch "800" and if ARPW=1.000, punch "1.0")
Cols.	22-23	Current Abnormal Situation Number; "0" if none [R]
Cols.	25-27	Current Detection Time in days; "0" if impossible, "1" if one day or less, "999" if undetected [R]
Cols.	29-30	Current Observer Identification Number; "0" if none [R]
Cols.	33-34	Modification Number [R] ⎫
Cols.	37-38	Abnormal Situation Number after modification implemented; "0" if none [R] ⎪
Cols.	40-42	Detection Time in days after modification implemented; "0" if impossible, "1" if one day or less, "999" if undetected [R] ⎬ See COMMENT 3
Cols.	44-45	Observer Identification Number after modification Implemented; "0" if none [R] ⎭
Cols.	47-48	1st Potential Diverter Identification Number [R]
Cols.	50-51	2nd " " " " "
Cols.	53-54	3rd " " " " "
Cols.	56-57	4th " " " " "
Cols.	59-60	5th " " " " "
Cols.	62-63	6th " " " " "
Cols.	65-66	7th " " " " "
Cols.	68-69	8th " " " " "
Cols.	71-72	9th " " " " "
Cols.	74-75	10th " " " " "

● CARD 10 (1 for each Material Type and Description)   SAME AS CARD 10, DPACP-1

Col.	1	"*" if another Material Type and Description is included in this analysis
		BLANK if last Material Type and Description in this analysis

● CARD 11 (1 for each analysis)   SAME AS CARD 11, DPACP-1

Cols.	2- 3	"99" if another analysis is to be performed in this computer run
		BLANK if end of computer run

COMMENTS ON INPUT DATA

1. Maximum number of entries per analysis:
     SDPs, 500;
     SDPs/Modification, 126; and
     Modifications, 40.

2. Largest integer value that can be used to identify indicated parameter:
     Material Type and Description, 10;
     Operational Area, 10;
     SDP Worksheet Number/Operational Area, 126; and
     Modification, 40.

3. If SDP has no minor modification, Cols. 33-45 should be left blank when data are originally punched. Major modification data, when identified, will be entered in these columns.

COMMENTS ON INPUT DATA (continued)

4. Modification data, entered in the fields of a CARD 3 (Cols. 1-26, 27-52 and 53-78), need not be sequential in regard to Modification Numbers and blank fields between entries are allowed. The count of the entries input on a CARD 2 (Cols. 2-3), however, *must* agree with the number of fields (including blank fields between entries) used on the CARD(S) 3.

5. Modification Numbers, entered on CARD(S) 4, 5 and/or 6, or Modification Numbers with associated SDP Numbers entered on CARD(S) 7, need not be entered sequentially and blank fields between entries are allowed. The count of entries input on a CARD 2, however, *must* agree with the number of fields (including blank fields between entries) used on the CARD(S) 4, 5, 6 and/or 7.

6. There may be Modification Numbers (and associated data) input on a CARD 3 that are not used on any CARD 9.

7. There may be Modification Numbers input on CARD(S) 4, 5, 6 and/or 7 that are not associated with a Modification Number on any CARD 9.

8. The SDP Numbers *must* be unique, preferably sequential, if more than one Material Type and Description is analyzed in a given Operational Area; e.g., if two Material Types and Descriptions are analyzed in Operational Area 1 and the last SDP for material 1 is "1-33," then the first SDP Number for material 2 could be "1-34." The sequence need not be complete; SDP Numbers may be skipped.

9. If more than one modification applies to a SDP, a CARD 9 *must* be prepared for each modification.

10. The SDP data cards (CARD 9) for a given Material Type and Description may be input in any order.
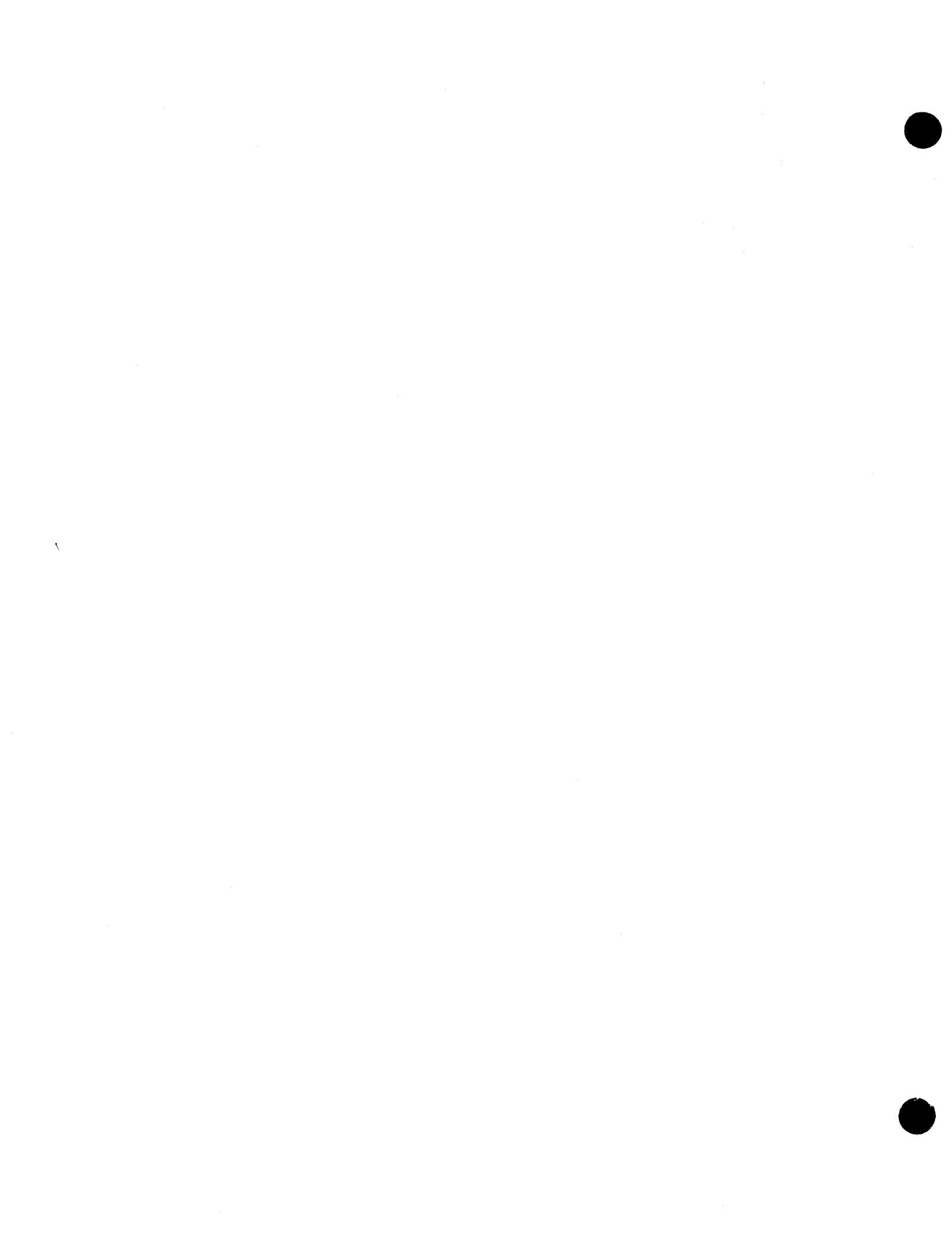
INPUT DATA DECK MAKEUP

1st Analysis
{
CARD 1
CARD 2 (Assume Cols. 5-6, 8-9, 11-12, 14-15 BLANK)
CARD(S) 3
CARD 8 ⎫
CARD(S) 9 ⎬ 1st Material Type and Description
CARD 10 ("*") ⎭
CARD 8 ⎫
CARD(S) 9 ⎬ 2nd Material Type and Description
CARD 10 ("*") ⎭
⋮
CARD 8 ⎫
CARD(S) 9 ⎬ "nth" Material Type and Description
CARD 10 (BLANK) ⎭
CARD 11 ("99")
}

2nd Analysis
{
CARD 1
CARD 2 (Assume Cols. 5-6, 11-12 have entries; 8-9, 14-15 BLANK)
CARD(S) 3
CARD(S) 4
CARD(S) 6
CARD 8 ⎫
CARD(S) 9 ⎬ 1st Material Type and Description
CARD 10 ("*") ⎭
CARD 8 ⎫
CARD(S) 9 ⎬ 2nd Material Type and Description
CARD 10 ("*") ⎭
⋮
CARD 8 ⎫
CARD(S) 9 ⎬ "nth" Material Type and Description
CARD 10 (BLANK) ⎭
CARD 11 ("99")
}
⋮

"nth" Analysis
{
CARD 1
CARD 2 (Assume Cols. 5-6, 8-9, 11-12, 14-15 have entries)
CARD(S) 3
CARD(S) 4
CARD(S) 5
CARD(S) 6
CARD(S) 7
CARD 8 ⎫
CARD(S) 9 ⎬ 1st Material Type and Description
CARD 10 ("*") ⎭
CARD 8 ⎫
CARD(S) 9 ⎬ 2nd Material Type and Description
CARD 10 ("*") ⎭
⋮
CARD 8 ⎫
CARD(S) 9 ⎬ "nth" Material Type and Description
CARD 10 (BLANK) ⎭
CARD 11 (BLANK)
}

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REFERENCES

REFERENCES

[1] "Societal Risk Approach to Safeguards Design and Evaluation," Bennett, C. A., Murphey, W. M., and Sherr, T. S., ERDA-7, June 1975.

[2] "Diversion Path Analysis Handbook - Example," Volume 2, Goodwin, K. E., Schleter, J. C. and Maltese, M. D. K., HCP/D6010-01/2, November 1978.

[3] "Diversion Path Analysis Handbook - Computer Program 1," Volume 3, Schleter, J. C., HCP/D6010-01/3, November 1978.

[4] "Diversion Path Analysis Handbook - Computer Program 2," Volume 4, Schleter, J. C., HCP/D6010-01/4, November 1978.