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Safeguards Against Insider Collusion

Guide on the Design of Work Rules for Safeguarding Against the Employee Collusion Threat at Nuclear Fuel Facilities

POOR ORIGINAL

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Science Applications, Incorporated

Prepared for
U. S. Nuclear Regulatory
Commission

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ABSTRACT

Guidance is presented for the development of work rules that will assist in protecting nuclear fuel facilities against the threat of employee collusion. Evaluation criteria for safeguards performance against this threat are discussed. Five types of work rules are presented: Area Zoning, Function Zoning, Team Zoning, Time Zoning and Operation Zoning. The strengths and weaknesses of each are discussed and examples are given. Methods for optimization of work rules are described.

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1. INTRODUCTION

Safeguards against the threat of employees at a nuclear facility colluding to commit theft or sabotage are required of nuclear material licensees by regulations in 10 CFR Part 73.20. This report provides guidance on designing the employee work rules so that collusion between individuals in any positions of responsibility will not result in a failure of the safeguards system.

The protection of nuclear fuel processing facilities against theft of nuclear material or radiological sabotage by adversaries who are not employees of the facility is provided by integrated safeguards systems composed of detection equipment, barriers and guard forces. The detection equipment detects covert actions with high probabilities, the barriers delay overt attempts to penetrate into the facility, and the guard forces respond to detection alarms so they can contain the nuclear material before it leaves the site. These safeguards systems alone do not provide an equivalent amount of protection against threats involving people employed by the facility because employees have access to nuclear material and vital equipment, they control the safeguards equipment and the penetrations through barriers, and they comprise the guard force called upon to respond. In fact, a group of employees acting in collusion are potentially capable of accomplishing theft or sabotage by misusing the authority given to them for performing their assigned duties.

Protection against this threat can be provided by properly structured work rules in conjunction with other safeguards measures. These work rules govern the

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access to nuclear material and the control of the safeguards system. It is necessary to integrate these work rules with other safeguards system components so that, after employees have made full misuse of their work privileges, some safeguards will remain undefeated.

The purpose of this guide is to describe generic work rule options, discuss their individual strengths and weaknesses, demonstrate their effectiveness in protecting against employee collusion by the use of sample problems, identify impacts on facility operation and recommend methods for optimizing work rule design. This guide is intended for use by nuclear material licensees in preparing a security plan that meets the requirements for protection against collusion between insiders who occupy any positions of responsibility at the facility. While the primary purpose is guidance on designing work rules, there is a discussion of performance criteria and methods for evaluating safeguards systems to determine if the criteria are met. The reader is encouraged to also make use of related reports on the analysis of safeguards against threats involving insider collusion.[1,2]

This guide is one part of a series of guidance documents that can be used in implementing the upgraded physical protection requirements in 10 CFR Part 73. Proper design of work rules can prevent a total compromise of the safeguards system by colluding employees, but it is equally important to follow guidance on the adequacy of the uncompromised safeguards components that remain for protection.

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2. SAFEGUARDS PERFORMANCE AGAINST INSIDER COLLUSION

An important first step in designing work rules is to determine measures or criteria for the performance of the safeguards system against a range of threats. Performance criteria and factors to be considered in formulating work rules in response to a spectrum of threats are discussed below.

2.1 PERFORMANCE CRITERIA

The primary purpose of a safeguards system is to prevent theft and protect against sabotage. Prevention is not meant to be absolute but rather to mean a low risk or a low probability that theft or sabotage would be successful. However, there are no rigourous formulas or universally accepted probabilities for computing theft or sabotage risks against all threats. The following discussion explains a way to demonstrate a low risk against the threat of employee collusion and especially how the risk is affected by work rule design. Other guidance should be consulted for determining risks associated with the defeat of safeguards by force, stealth or deceit.

One criterion for performance is to establish a minimum number of safeguards that must be defeated by force, stealth, or deceit after all other safeguards have been compromised by misuse of work duties. Thus for every threat analyzed and for each theft or sabotage sequence at least some minimum number of safeguards elements remain in the adversary path to provide protection. For example, assume two employees collude to steal material. If the criterion is that two safeguards components must remain, then no matter how these two insiders misused their controls or authorizations, at least two

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safeguards components of any type must be available to detect the theft attempt. This criterion is the least complex of all the criteria and ignores some important considerations that are discussed next.

In the above example, the two safeguards components can be located anywhere along the path from the point where the first safeguard is encountered until the nuclear material leaves the facility. Intuitively, if the undefeated safeguards were located at the beginning of the path, the ability of response personnel to engage the adversaries is greater than if the safeguards elements were at the end of the path. This is due to the additional time available for response. Thus, detecting the adversaries early in the sequence provides additional protection. This indicates that the location of the remaining safeguards along the path should become a part of the criteria. It is conceivable that additional safeguards will be required if the uncompromised safeguards are all located at the end of the path.

Along the same lines, the effectiveness of the remaining safeguards must be taken into account in formulating criteria. For instance, safeguards that only provide detection of theft by remote surveillance may not provide adequate protection, whereas searches of personnel and packages may be considered quite adequate even if only one uncompromised safeguard remains. Thus the remaining safeguards should provide effective response or deterrence as well as detection capabilities in order to assure adequate protection.

In summary, the criteria for the performance of a safeguards system against the threat of employee collusion are: (1) the number of safeguards remaining after full misuse of work privileges; (2) the location of these safeguards along the path; and (3) the effectiveness of the safeguards in detecting and responding to theft or sabotage actions. It is not the purpose of this guide to define values for the criteria but, to illustrate, one possible set would be: (1) at least

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2 safeguards remaining; (2) one remaining safeguard located so that the adversaries could be intercepted by the guard force if detection occurred; and (3) at least one remaining safeguard is a direct check for access authorization, a direct search for contraband, or a direct search for nuclear material. There are, of course, alternative sets of criteria. One additional requirement could be that the two remaining safeguards must be of different types. The rationale for this is to require that the adversaries devise two different tactics to defeat the safeguards by force, stealth or deceit.

2.2 THREAT

This guide addresses the threat of employee collusion. The following paragraphs discuss issues that must be considered in evaluating the insider threat.

The first issue is the number of employees who make up the adversary team. There is little argument that a single insider should not be capable of theft or sabotage. Presently, considerable emphasis is being placed on protecting against two insiders. Larger adversary teams may be considered but are not as likely because as more individuals become involved there is a higher probability that evidence of the conspiracy will be discovered.

A second issue is the capability of the employees to control safeguards and have access to areas and nuclear material. There are situations where an individual may not be physically able to control a safeguard and allow himself to pass by. For example, a guard may control a portal and yet be unable to allow himself to pass through the portal due to portal design. In other cases control of the safeguard may imply access. For example, the custodian of a storage room key would be able to enter that room at any time. A conservative approach to this problem is to assume every employee has full capability to gain access and allow himself and

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others to pass by safeguards he controls. If vulnerabilities exist then they can be reviewed one by one to uncover inconsistencies.

A third issue is the time span allowed for a credible theft or sabotage sequence to occur. This is especially important in facilities where personnel rotate between different job assignments. A sequence can be envisioned where material is moved to a different location within the facility and is hidden until job rotation and employee safeguards access and controls change. At that time, the material could then be recovered and removed from the facility utilizing the new authorizations. Although these long time sequences increase the adversary's risk of discovery, they are possible and should be considered. Any vulnerabilities should be examined to decide if the time span and number of plausable material hiding places provide a high enough risk of detection that such a sequence is adequately deterred.

In defining an appropriate time span for rotation of employee job assignments, two actions may be taken to reduce the risk of these partial theft sequences being successful. These are a search or facility sweep for hidden material and/or a physical inventory of material prior to job rotation. For example, if these were both conducted simultaneously at one month intervals with no evidence of hidden or missing material, personnel could then be freely rotated with some assurance that no partial theft sequence had taken place.

Another issue related to time and rotation is the number of different facility conditions that could exist during the theft or sabotage sequence. The safeguards system at the facility is dynamic and changes as the plant changes from normal day-shift to night-shift or to emergency conditions. It is possible that the optimum strategy for

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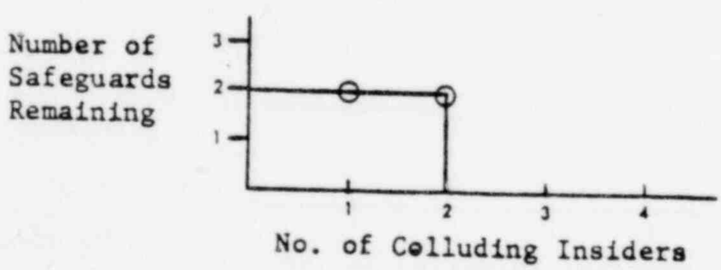
the employees would be to complete the theft or sabotage sequence in steps that occur during different plant conditions. Again, the most conservative approach is to assume this is possible and to review vulnerabilities for inconsistencies and incredible sequences.

2.3 INTEGRATED PERFORMANCE

It is valuable to combine the threat spectrum with the safeguards performance criteria to measure the integrated performance of the safeguards system. That is, instead of taking a single criterion and applying that to all the threats, it may be more reasonable to have multiple criteria applied to the different threats. Assume, for example, a case where the criteria are stated only in terms of the number of remaining safeguards and the threat is stated only in terms of the number of colluding employees. The figure below shows a direct application of a single criterion to all the threats.



Two safeguards must remain for both the single and two insider threats and no safeguards are required against three or more insiders.

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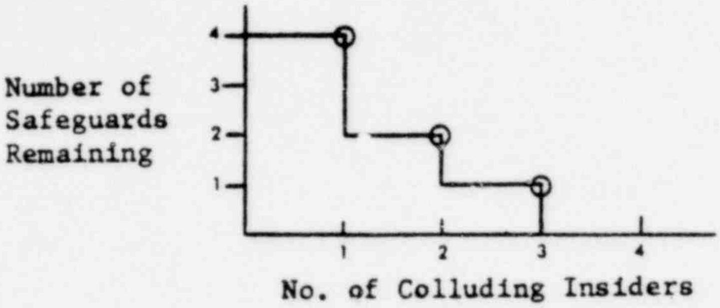
A graded or integrated performance measure would show variation in the criteria depending on the threat. This is indicated below.



In this case, the safeguards system performance is strongest against the most likely threats and decreases as the threat likelihood decreases.

In the design of work rules, it is important to understand how changes in work rules impact these performance measures. The following table summarizes the six issues that must be considered.

Performance Criteria	Threat
1. Number of Remaining Safeguards	1. Number of Employees
2. Location of Remaining Safeguards	2. Capabilities of Employees
3. Effectiveness of Remaining Safeguards	3. Time Span and Facility Conditions

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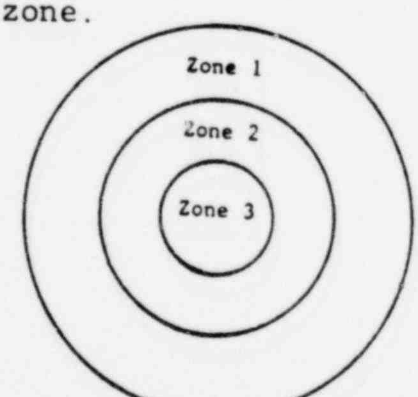
3. TYPES OF WORK RULES

An employee of a nuclear facility can be restricted in a number of ways in order to minimize his overall control of the safeguards system and his access to vital areas and nuclear material. He can be restricted as to who he can work with, what tasks he can perform, when he can enter and work in certain areas, where he can work, and how he performs his assignments. These who, what, when, where and how restrictions can be used to define a set of work rules. A number of work rule options are discussed below along with the safeguards hardware that is important in enforcing the rules.

One of the easiest work rules to apply is area zoning. This work rule restricts where people can work in an effort to provide "layers" or concentric shells of protection. Many facilities already use area zoning by restricting people to areas where they have responsibilities and not allowing them to enter areas where they do not have a need to go. Work areas can be created to actually form concentric shells in which a set of people are restricted to a specific shell and areas outside that shell but are not permitted into inner shells. For example, if a plant can be physically defined to have three concentric zones, with three real physical concentric barriers it can be represented by the figure below. It is assumed that the nuclear material resides in the inner or most protected zone.



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Workers restricted to Zone 1 cannot enter Zones 2 and 3. Workers required to work in Zone 2 can enter Zone 1 but not work there and cannot enter Zone 3. Zone 3 personnel can enter any zone but can only work in Zone 3. The control of safeguards is done by the people who are restricted to that particular zone. Thus Zone 1 workers or guards control entrance and exit for Zone 2 and 3 workers. In this way no single or pair of individuals can bring contraband into Zone 3 or remove material from Zone 3. If there is an equivalent set of safeguards in each zone then this work rule prevents theft or sabotage requiring contraband by N-1 colluding individuals where N is the number of zones.

A second useful work rule is termed function zoning. This rule restricts what tasks a person can do. As in the above case of area zoning, most plants have inherent function zoning by the fact that guards have different responsibilities than process workers. Function zoning must be taken further than these general categories if it is to be useful for safeguards. For example, a portal may control who enters an area by checking identification, what is brought in the area by metal detectors and x-ray devices and what is removed from an area by SNM and metal detectors. By assigning these different functions to different groups of people and restricting these people to their specific functions the single portal becomes a multiple barrier which requires collusion to defeat. Thus, a single portal guard cannot let himself through this barrier and then remove material because he either controls the entry aspects of the portal or the removal safeguards but not both. Therefore, the portal is functionally zoned.

Restricting who a person works with falls into a category of work rules called team zoning. This work rule can be used to specify people who must work together or

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people who must work separately. Its primary use for safeguards is to remedy specific problems rather than to be applied universally. The rule is enforced using entry portal safeguards systems and surveillance to assure teams are together.

Time zoning restricts <u>when</u> people can work and can be used to restrict personnel from plant entry or area except when they are required to be there. Plants may already employ time zoning techniques during late shift operations to prevent day shift workers from entering the plant during non-operation hours when guard forces may be small. This technique also uses entry portal safeguards and can employ such devices as intrusion detectors for certain areas in the plant.

The <u>how</u> category of restriction is covered in operations zoning which consists primarily of procedure specifications and checks. By zoning how a person does his work it may be possible to prevent the defeat of the system. This work rule is primarily used against a single insider but would affect every colluding team as well. Special tamper indicators or computer analysis of operational areas could be used to determine if the work is done properly. These safeguards fall into a closed-loop control system called operations control analysis.

Of the five work rule types discussed above, the first three - area zoning, function zoning, and team zoning - are the most universally useful and are the ones discussed in the remainder of the report.

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4. DESIGNING EFFECTIVE WORK RULES

Many factors contribute to the formulation of an effective set of work rules. Details of the plant, its personnel, the safeguards system, and the existing work rules are needed to determine weaknesses of the existing systems and possible fixes using work rule techniques. This section discusses the basic considerations involved in establishing work rules.

One of the most important factors used in the formulation of work rules is the site geometry. Details of the walls, entrances, exits, and other features of the facility must be taken into account so that the designed work rules are effective. The location within the facility of guard stations, safeguards controls, and SNM will be integrated into the safeguards system. Since the objective of the study is to determine vulnerabilities to theft and sabotage, pathways into and out of the facility must be determined and evaluated. This requires that the site geometry be well defined.

Along with the site geometry, it is necessary to know what safeguards features exist in the plant and where they are located. This is important in not only determining vulnerabilities but also in design of the work rules. By knowing what safeguards are available, it is possible to integrate the work rules with the safeguards sytem. Work rules by themselves are not nearly as effective as when they are designed to utilize the existing safeguards features of the facility. Many of the work rules deal with people who control or maintain safeguards elements which means that the above information is needed just to evaluate what an individual may be capable of doing.

It may be necessary to correct certain situations with hardware rather than work rules. If this is the case,

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it is important to know what capabilities the facility may have in the area of safeguards. Also, additional personnel may be required in order to implement certain work rules. This is also part of the safeguards capabilities and must be taken into account when formulating the work rules for the plant.

Information is needed on personnel responsibilities and capabilities. Where people must go to perform their duties and what control they have over safeguards equipment are both very important considerations in work rule definition. It is these personnel characteristics that may be changed or redefined in the process of creating or revising the work rules. It is important that the work rules do not greatly impact the operation of the plant. Thus, the general responsibilities of the workers also need to be considered in the safeguards work rule system.

Other factors may enter into the analysis depending on special cases. Obviously, the work rules should hinder safety systems or responses to emergencies as little as is possible. The safety of plant employees is an important factor to consider in this process. Also, employee morale may become a factor for certain situations. Costs must be taken into account. These and possibly other considerations must not be ignored so that the final work rule definition is not only effective but also workable.

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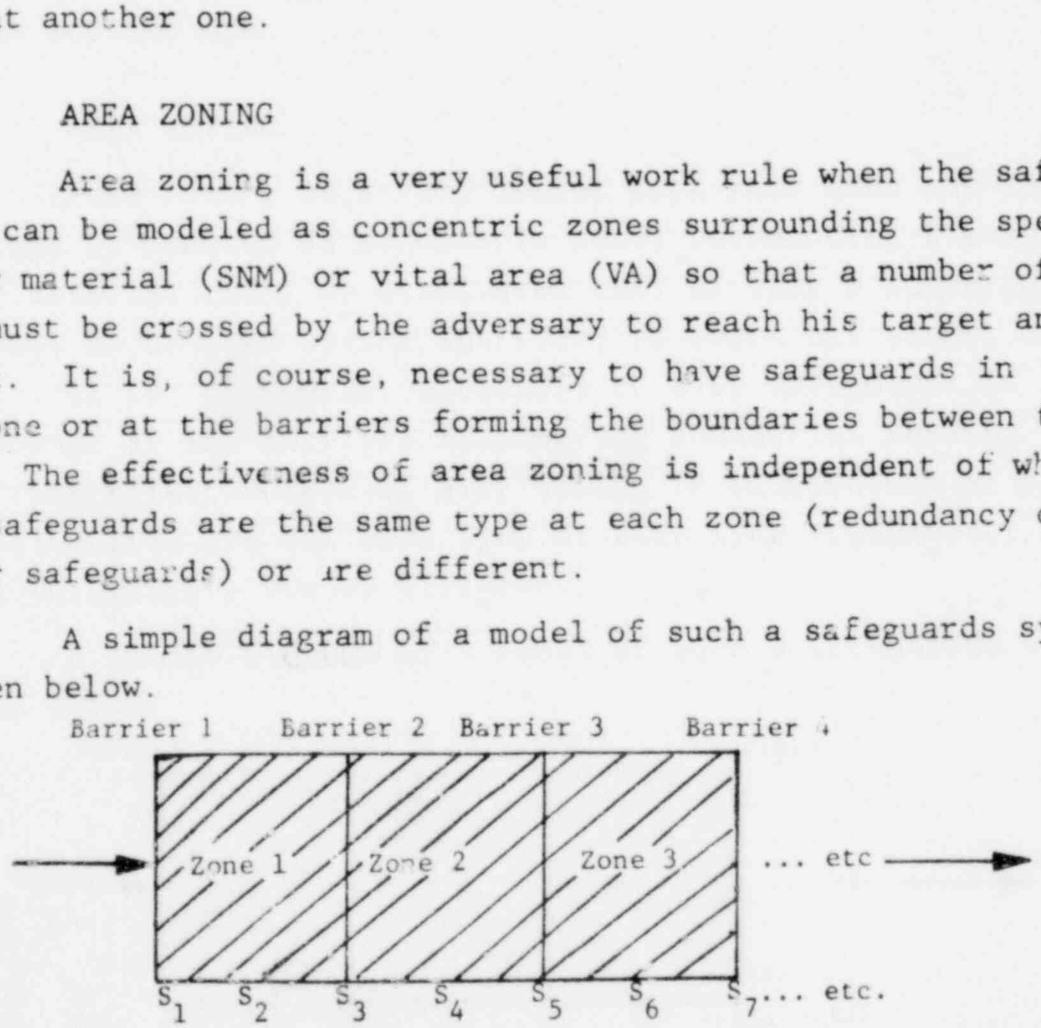
5. STRENGTHS AND WEAKNESSES OF WORK RULES

The design of work rules for an actual safeguards system usually involves the integration of three of the different types of rules: area zoning, function zoning and team zoning. This chapter presents the strengths and weaknesses of each type of rule and provides sample problems illustrating the use of these work rules in two simple models of a safeguards system. The two different models are used to demonstrate that the strength or weakness of a work rule depends on the design of the safeguards system. Thus, the rules that are most useful at one facility may have lesser value at another one.

5.1 AREA ZONING

Area zoning is a very useful work rule when the safeguard system can be modeled as concentric zones surrounding the special nuclear material (SNM) or vital area (VA) so that a number of zones must be crossed by the adversary to reach his target and to exit. It is, of course, necessary to have safeguards in each zone or at the barriers forming the boundaries between the zones. The effectiveness of area zoning is independent of whether these safeguards are the same type at each zone (redundancy of similar safeguards) or are different.

A simple diagram of a model of such a safeguards system is given below.



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The diagram shows (at least) one safeguard at each zone or barrier. These safeguards are numbered sequentially to indicate their multiplicity, not that they are different types.

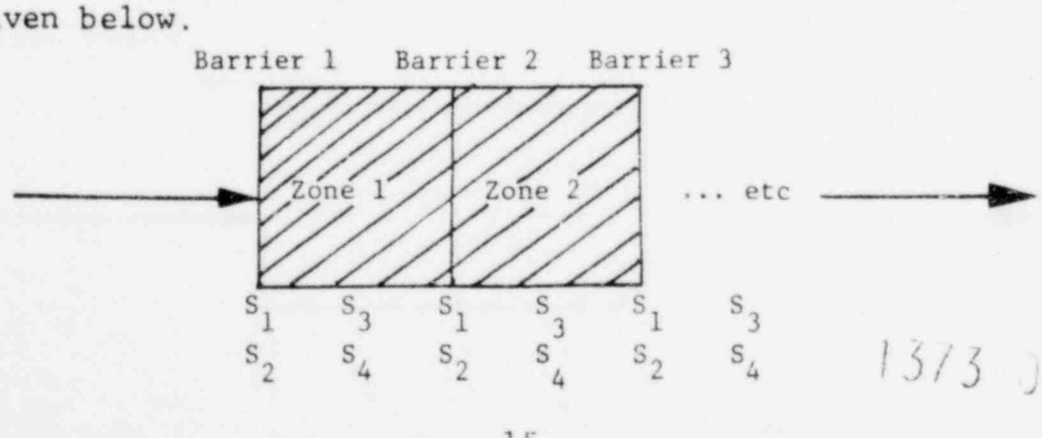
Using the area zoning concept, work rules would be established so that there would be a different class of employees who controlled the safeguards in each zone. Employees in any class could only control one zone and collusion among two classes would be unsuccessful if there are more than two zones.

If the safeguards system can be modeled as concentric zones as described previously, then area zoning is a very valuable work rule, not only because it can prevent theft or sabotage via collusion but also because it doesn't necessarily increase the number of guards or workers at the facility. This conclusion regarding numbers of personnel is based on the observation that there would be at least one person required in each zone to operate the safeguards in that zone. There is, of course, a sacrifice in terms of the amount of rotation that can be tolerated between classes or between zones. This is one of the major weaknesses of area zoning. The other is that the concept does not apply unless the system can be zoned.

5.2 FUNCTION ZONING

Function zoning is a very useful work rule when the safeguards system can only be modeled as a single zone or barrier having many diverse types of safeguards in the zone or at the barrier. It is also useful if the safeguard system can be modeled as concentric zones surrounding the SNM or VA provided there are diverse safeguards in each zone.

A simple diagram of this model of the safeguards system is given below.



The diagram shows (at least) two safeguards at each zone or barrier. The safeguards are numbered in sets of S_1 to S_4 to indicate that the safeguards in each zone are different types but that the sets at subsequent zones could be identical.

Using the function zoning concept, work rules would be established so that a different class of employee controlled each different type of safeguard, e.g. performed one type of duty or function. For example, Class 1 employees would control S_1 type safeguards, Class 2 employees would control S_2 type safeguards, etc. Employees in any class could control only one type of safeguard and collusion among classes would be unsuccesful if there are more than two safeguards types in an adversary path.

If the safeguards system can be modeled as diverse safeguards that must all be encountered, then function zoning is very valuable; however, function zoning may increase the number of employees. This conclusion regarding number of personnel is based on the observation that a single person at each zone could be capable of controlling all the safeguards at that zone even if they are of different types. By function zoning more than one person is required to control these safeguards. If the safeguards system consists of a number of zones with diverse safeguards at each zone, then the application of this work rule does give the employees rotation among posts even though their duties remain the same.

5.3 TEAM ZONING

Team zoning is a very useful work rule when the safeguards system can be modeled in either of the two ways described above, but the number of zones or types of safeguards is few and additional safeguards are required. The use of the two-man rule alone would not prevent collusion if the same pair could rotate together to control all safeguards in the system. However, by judiciously establishing team zoning work rules the

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same pair of employees can be limited to work together only in one zone or only on one type of safeguard.

The rule is applied by treating each pair of employees as a single individual and forming classes as described above. The comments given for area and team zoning regarding the number of employees, the rotation possibilities, and the safeguards effectiveness also hold for team zoning.

5.4 SAMPLE PROBLEMS

5.4.1 Model 1 - Concentric Zones with Redundant Safeguards

A simple model of a safeguards system consisting of concentric zones, each having an identical set of safeguards is shown in Figure 4.1, Model 1. This system has features that should make the application of both area and function zoning useful. Team zoning should also be valuable because there are only two zones (Zone A_1 and Zone A_2) and two types of safeguards (E type [entrance] and R type [removal]). The adversary moves from left to right on the figure encountering the entrance safeguards, the SNM (with an acquisition safeguard) and finally the removal safeguards.

Table 5.1 presents a summary of the possible work rules that can be used, the impact in terms of number of employees and their rotation, and the effectiveness of the safeguards system.

The table is interpreted in the following way. In the first column nine types of work rule combinations are listed. In the next two columns the work rule is defined by identifying the guard (G) or worker (W) who controls the E and R safeguards at the two portals. For example, in case 1 either the guard (G) or worker (W) can control all four safeguards, while for case 5 a different guard (G_1, G_2, G_3, or G_4) controls the different safeguards (E_1, E_2, R_1, and R_2). The symbol G^2 indicates two guards (G) are used in a team concept to control

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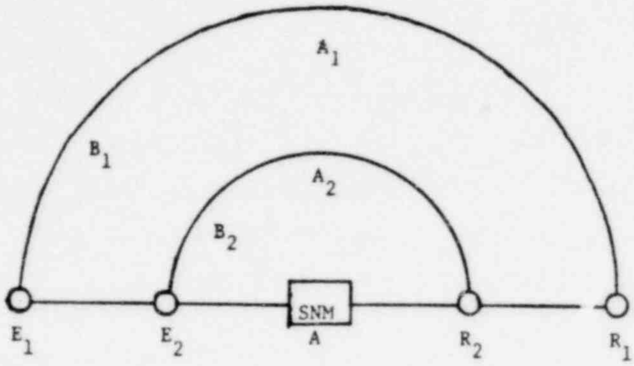


A = Area

B = Barrier

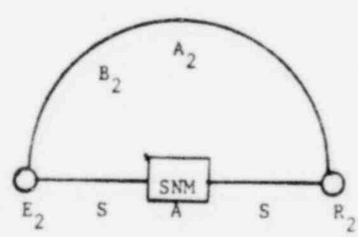
SNM = Special Nuclear Material

E = Entry Safeguard

R = SNM Removal Safeguard

A = Acquisition Safeguard

Model 1. Concentric Zones with Redundant Safeguards



A = Area

B = Barrier

SNM = Special Nuclear Material

E = Entry Safeguard

R = SNM Removal Safeguard

A = Acquistition Safeguard

S = Remote Surveillance Safeguard

Model 2. Diverse Safeguards Concentrated in a Single Zone

Figure 5.1. Models of Safeguards Systems Used to Demonstrate Strengths and Weaknesses of Work Rule Types

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Table 5.1. Summary of Work Rules, Their Impacts, and the Safeguards Effectiveness for a System with Concentric Zones and Redundant Safeguards

TYPE OF WORK RULES	WORK RULES		IMPACT OF RULES		SAFEGUARDS EFFECTIVENESS MEASURED BY NUMBER OF SAFEGUARDS REMAINING (employee team)		
	FIRST PORTAL	SECOND PORTAL					
	E_1 Safeguard Control R_1 Safeguard Control	E_2 Safeguard Control R_2 Safeguard Control	Number of Guards* and Workers	Amount of Rotation	One Man	Two Man	Three Man
1. **No Work Rules**	G or W	G or W	3	Total	*(G or W)	N/A	N/A
2. **Separation of Guard and Worker (Area or Function Zoning)**	G G	G G	3	Post and Duties	1(G) 2(W)	*(GW)	N/A
3. **Area Zoning**	G_1 G_1	G_2 G_2	3	Single Post Rotate Duties	$2(G_2)$ 2(W) $3(G_1)$	1(All)	$*(G_1G_2W)$
4. **Function Zoning**	G_1 G_2	G_1 G_2	5	Single Duty Rotate Posts	$2(G_2)$ 2(W) $3(G_1)$	$*(G_2W)$ $1(G_1G_2)$ $2(G_1W)$	$*(G_1G_2W)$
5. **Area and Function Zoning**	G_1 G_3	G_2 G_4	5	None	2(W) $3(G_2$ or $G_4)$ $4(G_1$ or $G_3)$	$1(G_3W$ or $G_4W)$ $2(G_1W$ or $G_2W)$ $2(G_2G_4$ or G_2G_3 or $G_3G_4)$	$*(G_3G_4W)$
6. **Two-Man Rule**	G^2 G^2	G^2 G^2	5	Posts and Duties	2(W) 4(G)	$1(G^2)$ $2(W^2$ or WG)	$*(G^2W)$
7. **Area Zoning and Two-Man Rule**	${G_1}^2$ ${G_1}^2$	${G_2}^2$ ${G_2}^2$	5	Single Post Rotate Duties	2(W) $4(G_1$ or $G_2)$	$2(W^2$ or WG) $2({G_2}^2)$	$1({G_1}^2W$ or ${G_2}^2W)$
8. **Two-Man Rule with Area Zoning of Pairs (Team Zoning)**	G_1G_2 or G_2G_3 G_1G_2 or G_2G_3	G_3G_4 or G_1G_4 G_3G_4 or G_1G_4	5	Single Post, Rotate Duties (G_2G_4) Posts and Duties (G_1G_3)	2(W) 4(G)	$2(W^2$ or WG) $2(G_1G_4$ or $G_3G_4)$	$1(G_1G_4W$ or $G_3G_4W)$
9. **Function Zoning and Two-Man Rule**	${G_1}^2$ ${G_2}^2$	${G_1}^2$ ${G_2}^2$	9	Single Duty Rotate Posts	2(W) $4(G_1$ or $G_2)$	$2(W^2$ or WG) $2({G_2}^2)$	$*({G_2}^2W)$

* Assuming each portal must be manned and one man is capable of controling both safeguards at each portal if this is authorized.

the safeguard. In the fourth and fifth columns the impact of the rule is given by the number of guards and workers needed to operate the system and the amount of rotation given the guards. We have assumed that each portal must be manned and that one man is physically capable of controlling the E and R safeguards at each portal. The last three columns give the safeguards system effectiveness against the one-man, two-man, and three-man threats. The effectiveness measure is the number of safeguards remaining and in parentheses the worst employee team is given. Only the most critical results are given, i.e., those with the fewest number of safeguards remaining. An asterisk indicates no safeguards remain.

Initially, if there are no work rules (case 1), any single person can defeat the system because there is total rotation. The most obvious work rule is to separate the guards and workers (case 2) so that guards are prevented from acquiring SNM and workers cannot control any safeguards devices except the acquisition safeguard which is a combination of material control procedures and surveillance. This separation is really an application of both area and function zoning; area zoning because only workers can enter area A_2 where nuclear material is handled, and function zoning because only workers have the authority to handle the SNM. This rule alone prevents one man theft but is vulnerable to any guard-worker two man pair. Throughout the remainder of this example we will maintain this division of guard and worker duties and focus on work rules for the guards to prevent collusion.

The application of the area zoning work rule (case 3) is to form two classes of guards, class one (G_1) to man the first portal and class two (G_2) to man the second portal. This presents two-man collusion by providing at least one safeguard remaining against all pairs. Guards are now fixed to a single post but have diverse duties. The number of employees is unchanged.

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The application of the function zoning work rule (case 4) is to form two classes of guards, class one (G_1) to control E type safeguards and class two (G_2) to control R type safeguards. This prevents two-man collusion except for the pair G_2W, who are the worker and the guard who rotates to do all SNM removal searches. Obviously function zoning is not totally effective when there is a class of employees such as the worker who is authorized access through safeguards of two types (E and A) and must only collude with an employee in the class controlling the other type of safeguard. Function zoning also increases the number of employees from 3 to 5.

Combining the area and function zoning work rules (case 5) creates four classes of guards, one to control each of the four safeguards (E_1, E_2, R_1 and R_2). This only gives a minor improvement over area zoning alone and it has a major impact because there is no rotation and there is an increase in the work force size.

The two-man rule without team zoning (case 6) is accomplished with a single guard class but with two guards now at each portal. This prevents collusion only because we have already separated guards and workers. There is still no prevention of three-man collusion and there is still only a single safeguard remaining against two-man collusion.

Area zoning can be combined with the two-man rule (case 7) so that there are two guard classes and two guards of the same class at each portal or team zoning can be used so that there is a two-man rule with area zoning of the pairs (case 8). In this example of team zoning (case 8) we have four classes of guards, each class can be paried with two of the other three classes, and any pair can work at either the first or the second portal but not both. If either of these rules is applied we obtain double protection against two-man collusion and single

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protection against the three-man threat. Notice that the work force size is increased to 5 but there is some rotation, with team zoning giving more rotation than area zoning plus the two-man rule.

Function zoning and the two-man rule (case 9) is applied by forming two classes and having two guards of the same class controlling each safeguard. This does prevent two-man but not three-man collusion and it also results in a large increase in work force size from 3 to 9.

5.4.2 Model 2 - Diverse Safeguards Concentrated in a Single Zone

A simple safeguard system consisting of a single zone with diverse types of safeguards is shown on Figure 5.1, Model 2. This system has features that should make application of function zoning useful. Team zoning will probably not be as useful as for the Model 1 type safeguards system because there are four types of safeguards. Area zoning is not applicable. Notice that in Model 2, as in Model 1, there are a total of five safeguards so that the models and work rule evaluations can be compared. To accomplish this one entrance and one removal safeguard have been replaced by two surveillance(s) safeguards.

A summary of the work rules, their impact, and the safeguards effectiveness for this model is given in Table 5.2. This table is interpreted in the same way as Table 1 except that now there is a single portal and we show the control of the safeguards S and A that are within the area A_2.

Again we start by separating guards and workers only now in one case (case 2) we assign control of the surveillance safeguard (S type) to a worker class and in the other case (case 3) we assign this control to a guard class. The results are essentially independent of how this decision is made. Throughout the rest of this example there is a differentiation between these two possibilities.

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Table 5.2. Summary of Work Rules, Their Impacts, and the Safeguards Effectiveness for a System with Diverse Safeguards Concentrated in a Single Zone

TYPES OF WORK RULES	WORK RULES		IMPACT OF RULES		SAFEGUARDS EFFECTIVENESS (Number of Safeguards Remaining)		
	PORTAL E_2 Safeguard Control R_2 Safeguard Control	SURVEILLANCE S Safeguard Control A Safeguard Control	Number of guards* and workers	Amount of Rotation	One Man	Two Man	Three Man
1. No Work Rule	G or W	G or W	3	Total	*(G or W)	N/A	N/A
2. Separation of Guard and Worker (W surveillance)	G G	W W	3	Rotate post and duties	1(W) 3(G)	*(GW)	N/A
3. Separation of Guard and Worker (G surveillance)	G G	G W	3	Rotate post and duties	1(G) 2(W)	*(GW)	N/A
4. Function Zoning (W surveillance)	G_1 G_2	W_1 W_2	4	None	$2(W_2)$ $3(W_1)$ 4(G)	$1(G_2W_2$ or $W_1W_2)$ $2(G_2W_1$ or G_1W_2 or $G_1W_1)$ $3(G_1G_2)$	$*(G_2W_1W_2)$
5. Function Zoning (G surveillance)	G_1 G_2	G_3 W	4	None	2(W) $3(G_3)$ $4(G_1$ or $G_2)$	$1(G_2W$ or $G_3W)$ $2(G_2G_3$ or G_1W or $G_1G_3)$ $3(G_1G_2)$	$*(G_2G_3W)$
6. Two-Man Rule (W surveillance)	G_2^2 G^2	W^2 W	5	Duties Only (G) Posts and Duties (W)	2(W) 5(G)	$1(W^2)$ 2(GW) $3(G^2)$	$1(G^2W$ or $W^2G)$
7. Two-Man Rule (G surveillance)	G_2^2 G^2	G^2 W	5	None (W) Post and Duties (G)	2(W) 5(G)	$1(G^2)$ $2(GW$ or $W^2)$	$*(G^2W)$
8. Function Zoning and Two-Man Rule (G surveillance)	G_1^2 G_2^2	G_1^2 W	7	None	2(W) 5(G)	$2(W^2$ or $GW)$ $3(G_3^2)$ $4(G_1^2$ or $G_2^2)$ $5(G_xG_y)$	$1(G_2^2W$ or $G_3^2W)$ $2(G_1^2W)$

* Assuming the portal and the remote surveillance station are manned and the man at the portal is capable of controling both safeguards if this is authorized.

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There can be no area zoning in this system but function zoning can be applied (cases 4 and 5) to prevent two-man collusion. In case 4 two guard classes are formed, one to man E type and one to man R type safeguards, and two worker classes are formed, one to man S-type and one to man A-type safeguards. In case 5 one of these worker classes is replaced by creating a third guard class. Again results are independent of whether guards or workers control surveillance. Notice that there is an increase in work force size from 3 to 4 and there is no rotation. This is a much larger impact than in the previous model where area zoning alone was used to prevent two-man collusion.

The application of the two man rule is very effective if the workers control surveillance (case 6). The work force size is increased to 5 but now there is some rotation. The two man rule is not as effective if guards control surveillance. Function zoning and the two-man rule (case 8) must be applied if the guards have surveillance in order to get the same effectivenss as the two-man rule alone when workers have surveillance. However, there is a major impact in terms of increased work force size and no rotation.

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6. IMPACTS OF WORK RULES ON THE FACILITY

Before implementing work rules it is important to understand the effects the rules may have on the personnel and activities in the facility.

One of the impacts of work rules is on the effectiveness of personnel, particulary guards. In some work rule schemes an employee may only be permitted to perform one function or to work at a single location due to functional or area zoning. The employee has a very well defined job but has little or no freedom to expand to other tasks. This type of environment tends to lead to less vigilance because of lack of variety, even though the employee may be better trained and better able to perform the job than if he had diverse duties. If possible, some sort of rotation scheme should be instituted to prevent this from happening. However, rotation allows adversary teams more capabilities and therefore,care must be taken in how the rotation is implemented.

Along a similar line, management will potentially have problems with scheduling. The rigidity of some of the work rule schemes may impact the ability of the plant to arrange reasonable schedules. This may be particulary true if the plant has little or no rotation of job responsibilities.

Some of the plant safeguards procedures such as closeout inspection, operability tests, quality assurance or quality control inspections and security tours may be impacted by work rules. The actual operations or procedures will not be impacted but additional personnel may have to be employed to prevent violations of the work rules. This impact should be small for large plants due to the large staff of available

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workers. Small facilities may need to employ additional high-level personnel (people capable of performing inspections or tests) to a greater extent than the large plants.

Work rules should have little to no impact on safety except for the following cases. If the two man rule is applied extensively, the number of people that can potentially be involved in accidents will increase and thus the risk increases. This impact should be minor for most situations. If the work rules were not sufficient to meet performance objectives without the addition of safeguards elements which are intended to delay adversaries, safety problems may arise. If the adversary is delayed, so is a worker attempting to exit during an emergency or a response team may be delayed in getting to the hazard. Care must be taken in the placement of delaying safeguards to avoid this situation.

Other impacts may occur in specific cases but the above cases should cover most situations. The impact of work rules can be small if some of the above problems are considered in the work rule design process.

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7. OPTIMIZING WORKING RULES

Optimizing the combinations of work rules utilizing area, function and team zoning is relatively straightforward for simple safeguards systems such as those presented in Chapter 5. There obviously is a world of difference between those simple models and the real and complex nuclear facilities that are in operation today. Two different methods appear to have merit for the analysis of real nuclear facilities. The first of these is more appropriate for designing new facilities while the second is more useful in analyzing older facilities where work rules have evolved over a long period of time and, as a result, have become very individualized.

7.1 FACILITY REDUCTION TECHNIQUE

The first technique is called the Facility Reduction Technique because the major task in the analysis is reducing the facility to a replica of one of the model facilities presented earlier. This also involves ascertaining that all employees are collected into classes for that model facility and that their access and control capabilities correspond directly to those in the model. Figure 7.1 is a schematic representation of this approach.

This does not mean that there can be only one removal path for material from the MAA in a real facility but rather, that all of the personnel controlling the removal safeguards at MAA exits have limitations analogous to those of the equivalent personnel in the model facility.

Once work rules similar to those presented in the problems have been designed it is appropriate to analyze the

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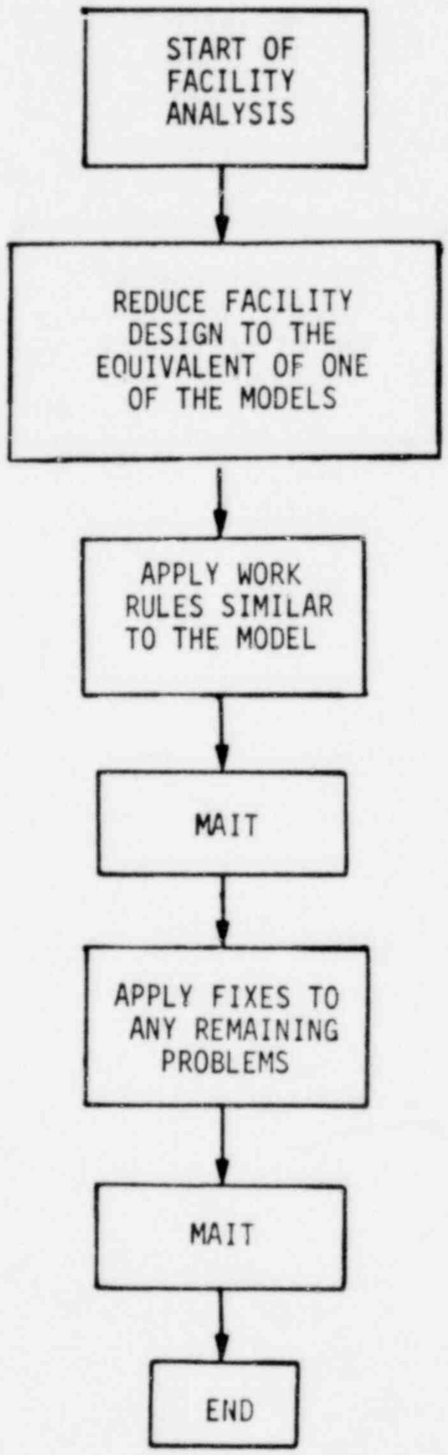

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Figure 7.1 Facility Reduction Technique for Facility Design and Analysis facility in detail to be certain that it is indeed resistant to insider collusion. The MAIT method of analysis[1,2] is specifically tailored to this type of problem.

If the facility has been precisely modeled after one of the simple demonstration facilities, the MAIT analysis (See NUREG-0532 Vol. 2) should show that, using the criteria developed in Section 2.1, the desired resistance to collusion does exist in the facility as described in the tables of Chapter 5.

In most cases, once supervisory or management personnel are added to the model facility and if they have a wide latitude of responsibilities and authorities certain problems could remain in the reduced facility. In this situation, some specific modifications may be required. These could include adding two-man rules for these personnel in critical plant locations or refining the safeguards functions of other personnel. These modifications could involve redefining the plant organization chart to provide more balanced safeguards coverage.

As a final verification that the safeguards system is adequate it is advisable to reanalyze using the MAIT method. This ensures that changes in responsibility brought about by the modifications have not caused problems in areas that were previously adequately safeguarded.

7.2 SAFEGUARDS SYNTHESIS TECHNIQUE

This analysis technique is capable of synthesizing an effective safeguards structure by employing and combining the elements of area, functional and team zoning. It is effective on facilities that cannot be easily reduced to an analog of one of the models discussed previously. Figure 7.2 shows schematically how the synthesis method would be employed to analyze and upgrade safeguards for a given facility. This approach is

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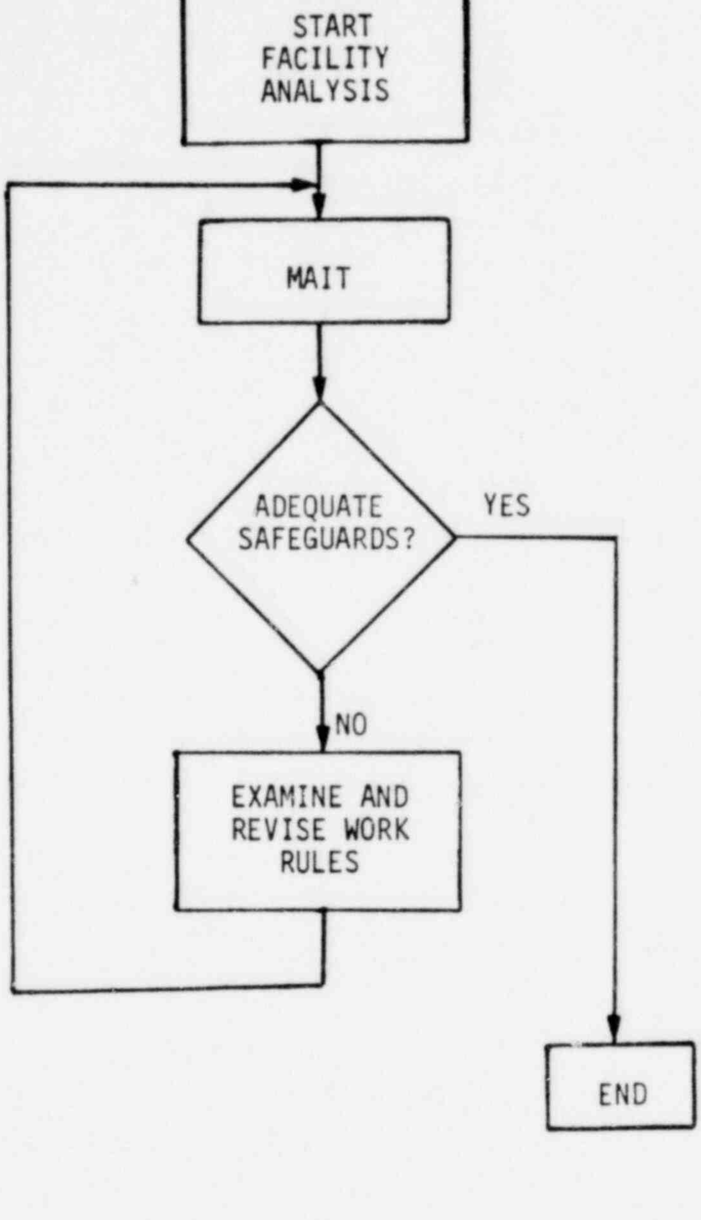

Figure 7.2 Safeguards Synthesis Technique for Facility Analysis

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iterative rather than being a "straight through" analysis as the Facility Reduction Technique is.

The first step in the synthesis method is to determine the facility baseline. This is most easily done using a detailed analysis of floor plans, safeguards devices, personnel authorities and responsibilities, facility conditions to be expected and any other factors that impact on safeguards against the employee collusion threat. Again the MAIT method of facility analysis[2] is an ideal tool for this step of the assessment.

The results of the detailed analysis will possibly show weaknesses in one or more areas. These areas could include targets that are susceptible, adversaries or adversary pairs that can defeat all or most safeguards along a path, paths that many personnel can control or facility conditions that are poorly safeguarded. If weaknesses are observed, the analyst will draw from the techniques discussed in this report to solve them on a universal basis first. For example, if Person A is part of most of the scenarios that are successful for the adversaries a redesign of his work rules could be the only modification required. Another example would be that Safeguard B is in most paths that are successful for the adversary(ies). Here a redesign of the access authority and control responsibilities for this safeguard would be an appropriate universal fix. Of course certain weaknesses will probably surface that are individual problems for a certain specific situation. These must be dealt with individually.

It was assumed in developing Figure 7.2 that the inadequacy of the safeguards system could be corrected in every case by a modification of the work rules. This may or may not be true and it may or may not be the most appropriate solution in a given situation. This is generally assumed to be the most

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cost effective method of resolving a safeguards problem if it does not require the addition of extra personnel. Another potential solution is to add safeguards along critical paths. These safeguards would be controlled by personnel who are not members of the adversary groups that can defeat the other safeguards along the paths.

Once these upgrades have been designed on paper a second MAIT analysis is conducted on the upgraded facility. Evaluation of the results shows the progress made and any further problems. Changes followed by MAIT analyses can continue until satisfactory results are obtained.

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REFERENCES

1. Glancy, et al., "Analysis of Nuclear Fuel Facility Safeguards Against Threats Involving Insider Collusion," Science Applications, Inc., SAI-78-547-LJ, April 1978.

2. McDaniel, et.al, Safeguards Against Insider Collusion, "The MAIT (Matrix Analysis of the Insider Threat) Method for Analysis of Facility Safeguards Against Insider Collusion - User's Manual" NUREG/CR-0532, Vol. 2, Science Applications, Inc. SAI-78-960-LJ, June, 1979.

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This report provides guidance for the development of work rules (i.e., procedures) that will assist in protecting nuclear fuel cycle facilities against threats involving employee collusion. The work rules discussed in this report also have applicability to other sensitive technology environments such as automated industries, nuclear power reactors, communications networks and certain military-industrial complexes. Evaluation criteria fo safeguards performance against the threat of insider-inspired crimes of collusion are discussed. The five types of work rules presented in the report include the following: area zoning, function zoning, team zoning, time zoning and operation zoning. The strengths and weaknesses of each are discussed and examples given. The report also presents methods for optimizing safeguards or security through the establishment of certain kinds and mixes of work rules.

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