
Psychological Stress for Alternatives of Decontamination of TMI-2 Reactor Building Atmosphere

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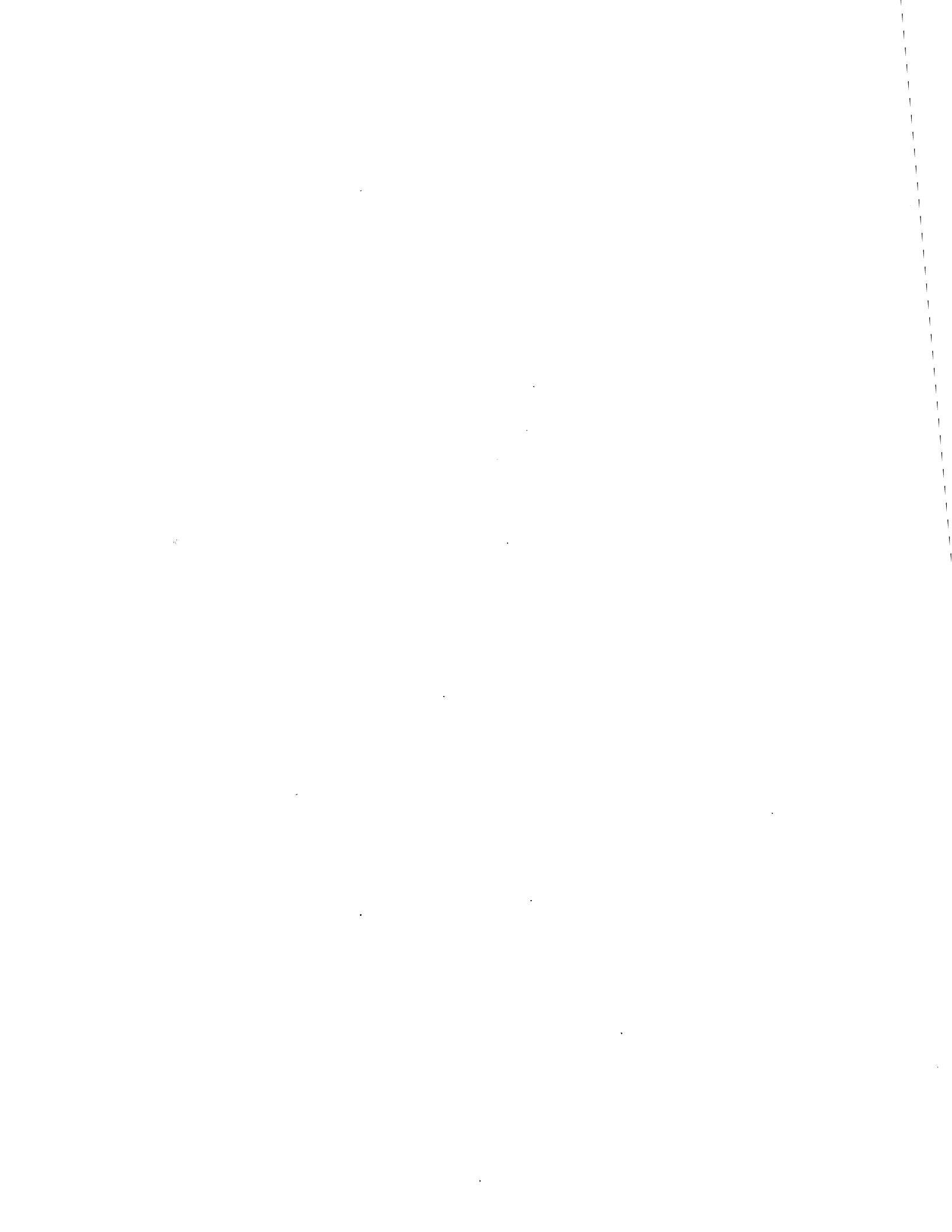
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I. INTRODUCTION

The purpose of this report is to consider the nature and level of psychological stress that may be associated with each of several alternatives for decontamination of the Three Mile Island (TMI) Unit 2 reactor building atmosphere. This report will briefly review some of the literature on stress, response to major disasters or life stressors, provide opinions on each decontamination alternative, and consider possible mitigative actions to reduce psychological stress. This report provides background for conclusions on psychological stress presented in Section 7.2 of NUREG-0662, Volume 1, "Final Environmental Assessment for Decontamination of the Three Mile Island Unit 2 Reactor Building Atmosphere." The Nuclear Regulatory Commission staff analyses and conclusions on the need for atmospheric decontamination and on the possible health impacts of each alternative, as reported in NUREG-0662, were adopted as givens for the purposes of this report. These assumptions are beyond the scope of this report. Thus, we have assumed that the health effects of venting Kr-85 into the atmosphere are negligible.

It should also be noted that this report is not a definitive statement on the situation at TMI. Our conclusions apply only to decontamination alternatives designed to remove Kr-85 from the reactor building atmosphere. They are based on research on stress responses to other threatening events, none of which are comparable to the situation at TMI. Further, our knowledge of stress responses by residents of the TMI area is based on a number of recent studies, many of which have not yet been completed. As a result, some of our conclusions are necessarily speculative. However, to the extent that this information can be applied to decontamination alternatives, they form the basis for our conclusions.

The focus of this report is stress. We will examine the literature on stress and attempt to determine the extent to which the accident at TMI, the psychological aftermath of the accident, and the steps to be taken towards atmospheric decontamination of the plant might have caused (or will cause) stress. We will review research on stress and derive hypotheses regarding stress among residents of the TMI area. A review of the research that has recently been conducted in response to the TMI accident will provide tentative tests of these hypotheses. Those that seem to be supported will then be used to evaluate alternatives for decontamination.

II. THE SITUATION AT TMI: AN OVERVIEW

Research conducted over the past year has indicated that the incident at Three Mile Island has had a stressful impact on residents of the area surrounding TMI (Bromet, 1980; Flynn, 1979; Houts et al., 1980). These and other studies of stress in response to the accident itself and of continuing stress as a function of the prolonged uncertainty at the site has indicated that better than half of those area residents sampled had perceived the accident as a serious or a very serious threat. The closer they lived to the plant, the more likely they were to appraise the accident as threatening (Flynn, 1979). Pregnant women with children were particularly likely to perceive threat as a result of the accident.

Flynn also reports greater emotional upset following the accident. Again, proximity to TMI and pregnancy seemed to predispose respondents to being upset. More than half of those sampled also indicated disruption of normal activities.

By midsummer, some of these responses had changed. Concern and perception of threat had decreased, but 41% still felt that TMI represented a serious or very serious threat (Flynn, 1979). Long-term or chronic effects, due partly to the accident and partly to the continuing perceptions of instability of the plant, were apparent. The Houts et al., (1980) report suggest that chronic stress may be relevant concern to the TMI area.

These studies suffer from limitations that make their conclusions somewhat tentative. Many, such as Bromet's research, are in progress and our reporting of them is based on preliminary reports. Many are based entirely or largely on self-report data, i.e., people's feeling about the TMI situation, rather than on more robust behavioral data. Finally, these studies do not have a pre-accident sampling of feelings to compare their findings with; since it was obviously not known that the accident would occur, data about others before the accident could not be collected. Yet, against the backdrop of stress research conducted over the past few decades, they do add up to evidence for existence of TMI related stress.

Psychological stress (e.g., Lazarus, 1966) is typically defined as the appraisal or perception of an event or situation as threatening some kind of danger, harm, or loss. The key is in the notion of appraisal; the actual danger is less important than what a person thinks the danger is. Since the appraisal of threat seems to set off a complex physiological and psychological response pattern including arousal (increased levels of circulating adrenalin, increased heart rate and blood pressure, etc.) as well as a search for coping alternatives, it is the interpretation of a stressful event that must be considered crucial. At TMI, then, the actual dangers or threats are less important than what residents perceive that has occurred or will occur.

Before any further consideration of the stress response of residents to the TMI incident and before making any attempt to estimate the likelihood of further stress as the result of decontamination procedures, it should be noted that the prevailing scientific opinions about the accident are at odds with

interpretations held by some residents. The general conclusion among most who have written on the subject is that the health impact of the accident is likely to be small. Yet, some fraction of the residents do not believe this; they are frightened by what happened, by what could have happened, and by what may yet happen. They are unconvinced that they will not develop cancer or that their children will be normal. Contributing to these feelings are many things: the confusion surrounding the accident itself, the continued debate and uncertainty, accidental releases of small amounts of radioactive gas since the accident, general discomfort with and fear of nuclear power in general, and what people consider to be weekly examples of what they fear may be radiation poisoning from the accident. While these "examples" have been explained fully and are probably not related to the accident, some residents believe that they are. As a result, it is unlikely that stress will be abated by simple documentation of the safety of the reactor or of the planned decontamination of the reactor building.

To some extent, this problem may have been exacerbated by the quality of documentation and information made available by the utility and the NRC. Letters received by the NRC suggest that residents perceived that information provided by different sources during the accident were sometimes contradictory. Furthermore, subsequent NRC reports such as the preliminary environmental assessment statement, seemed at times to be more concerned with collecting data, saving time and money, and salvaging equipment rather than saving lives, preventing further accidents, minimizing dangerous radioactivity leaks, and so on. Since the impressions or interpretations one makes are more important than what was intended, this kind of public relations is not helpful in minimizing stress. Already strained relations between the residents and the NRC become worse whenever the NRC appears concerned primarily about the utility or the plant rather than about the residents' safety. Credibility as the agency that stands between them and utility is low and results in great suspicion when new facts or plans are presented. This problem is also evident from letters received by NRC in response to NUREG-0662. One comments, "I strongly feel the Commission is steam-rolling our municipal officials into accepting its proposal and minimizing the health effects to the public." Others speak of a lack of concern by the utilities and the NRC for human consequences of decontamination.

It is important to note that not all residents of the TMI area share these opinions and fears. Some exhibit trust in the utility, the NRC, and in nuclear power. It is difficult to really know whether those who are more skeptical form a modest majority of residents or whether they are a large minority. However, it should be recognized that opinion is not universal; there are many levels to each of the many positions that have been taken by residents.

Given these considerations, it seems clear that stress may be one of the most important effects of the accident. Since stress can lead to a range of emotional, cognitive, and physiological problems, this consideration is important. While the degree of relationship between stress and illness has not been specified to most scientists' satisfaction, the fact that stress is associated with psychological and physical illness has been widely documented. Similarly,

stress has been shown to cause emotional disturbance, loss of cognitive abilities, decrements in school performance, and related problems. Because of these effects of stress, it is important to reduce the likelihood of any further trauma and to minimize fears of future uncontrolled function by the reactor. Stress-induced problems of either a psychological or medical nature are not any less disruptive than if caused by radiation.

III. STRESS

This section reviews some of the pertinent literature on stress and its consequences. Stress is defined as a complex of emotional, mental, behavioral, and biological responses to the threat of being harmed or of loss of something dear. Acute stress is the short-lived response to threats that occur, but dissipate rapidly. Thus, acute stress is a response to short-term threat. While threatened, response occurs, but following termination of the threat, stress disappears. Chronic stress on the other hand, is the result of threats which persist over long periods of time or which are repeatedly encountered. By definition, stress response in this case lasts longer.

In this discussion, then, the psychological effects of both acute and chronic stress produced by an environmental accident, such as that which occurred at TMI, will be reviewed. The general concept of stress, and how it can affect the psychological and physiological functioning of an individual, will first be discussed. Next, research demonstrating how perceived control/ noncontrol can significantly affect the negative impact of a particular stressful event will be reviewed. Individual differences in response to stress will then be discussed. Finally, some of the clinical work on psychological reactions to civilian catastrophes will be presented.

A. The Concept of Stress

Stress is viewed as a major contributing factor to the production of a variety of psychological problems such as depression and psychosomatic illness (Mears and Gatchel, 1979) and medical disorders such as hypertension (Pickering, 1968), peptic ulcers (Mirsky, 1958) and even sudden death (Rahe and Lind, 1971). Although there is still not a complete or precise definition and understanding of the concept of stress, there is a growing amount of research which demonstrates the important role that environmental, social, and psychological stress factors play in determining what we feel and do.

Selye (1956) presented the first comprehensive and influential model of stress, which he called the General Adaptation Syndrome, suggesting that the body reacts to a stressful/threatening situation by mobilizing its physiological resources. Stressors may be any events or things which are threatening to the body such as extreme temperatures, pathogens, and the like. Generally, the body has the capacity to defeat or overcome the effects of these stressors. However, if the stressor is too prolonged, these coping resources may become exhausted and a variety of physical symptoms may appear. Selye refers to these symptoms as diseases of adaptation.

The initial phase of the stress response is called the alarm reaction. It represents the first exposure of the organism to the stressor, during which time the organism "mobilizes" to meet the threats posed. The next phase is the stage of resistance, during which the organism responds to the stressor and attempts to actively cope with it. If this adaptation is successful, the stress response ends and adaptation is achieved. However, if unsuccessful (or if the stressor continues to exist over a long period of time), the stressful event is likely to continue to arouse the individual and require responding. Resistance causes wear and tear on the body, and if too prolonged, may cause so much wear and tear that the organism falls into a stage of exhaustion. At this point, the organism can no longer effectively cope with the stressful event. If the organism's adaptation resources are depleted, and coping is exhausted, diseases of adaptation such as hypertension and ulcers are more likely to occur.

Lazarus (1966) has pointed out that stress has an important psychological component. He has also emphasized the important impact that psychological stressors, such as losing a job, the death of a loved one, sudden catastrophes, etc. can have on individuals. Stressors are appraised or interpreted by people. If they are seen as threatening, stress may result. This is important since many events which may not really be cause for alarm can be interpreted as threatening and therefore stressful. For example, let us say that emissions from an electrical generating plant are determined to pose no threat to the health of those living nearby. To the degree that nearby residents believe this, there should be no stress response. However, those people who do not believe this, who choose to interpret the emissions as threatening, are likely to experience stress.

Lazarus and Cohen (1977) have noted some general classes of such stressors. The first, cataclysmic phenomena, refers to sudden, unique, and powerful single events or clusters of related occurrences. Most major disasters are included here, such as earthquakes, tornados, volcanic eruptions, major fires, and other natural disasters. The accident at Three Mile Island would be considered to be in this category. The consequent hardships, disruption, and heightened vulnerability provide powerful acute threats that require a great deal of immediate effect and adaptive abilities.

Lazarus and Cohen refer to another group of stressors as "background stressors" or "daily hassles"--stable or repetitive problems encountered in daily life that individually do not present great adaptive difficulty. In other words, encountering any one of these events alone does not generally cause great problems. Rather, each is coped with fairly easily. However, when experienced repeatedly or in combination with other problems, these low level stressors may eventually cause great difficulty. Many of these are more chronic than the stressors described in the first category, and may make coping with each subsequent stressor more difficult. Job dissatisfaction, neighborhood problems, uncertainty, and constant low levels of fear are examples of such stressors that may persist over long periods of time, present stress that can be dealt with but which create a chronic level of discomfort and tension. The long period of uncertainty concerning possible dangers and actions which has been present since the TMI accident is another example of this category.

These stressors are often chronic, and the apparent ease with which people may adapt to them initially may belie their long-term impact. The chronicity of these stressors may result in them having deceptively severe consequences. Because of regular and prolonged exposure to them, they may not be perceived as severe, but they may require far more adaptive responses over time than other stressors. Psychiatric problems and negative emotional states have been shown to be associated with these psychological stressors. Prolonged stress has been found to be associated with depression, anxiety, hostility, and psychosomatic illness (Holmes and Rahe, 1967). Psychologists have also identified aftereffects of stress. Aftereffects do not occur during exposure to stress, but rather are likely after adaptation or termination of the stressor. One way of viewing these effects is to think of adaptive energy being depleted while the stressor is present and costs being exacted after exposure while the organism is recovering. We may be less able to pay attention to things or perform tasks following stress (Glass and Singer, 1972) or may "fall apart" more readily if confronted with another stressor.

Perhaps most important among aftereffects is the simple effect stress seems to have on ability to adapt in the future. Calhoun's (1970) discussions of crowding included "refractory periods" during which organisms recover from interactions with others, and several studies have suggested that repeated or prolonged exposure to stress can reduce one's ability to cope. Support for this position has also come from studies of adjustment to life change (Dohrenwend and Dohrenwend, 1974; Holmes and Rahe, 1967). This work has suggested that there are physiological and psychological costs associated with adaptation, especially when events that require adjustment or adaptation are clustered together in time. When people must adapt to a number of changes of varying magnitude, either serially or at once, ease and success of adjustment decreases and adaptation becomes increasingly difficult. If the amount of adjustment required is large enough, it may render the individual unable to cope and lead to severe consequences.

B. Control and Stress

Perceptions of control, or the degree to which a stressor is seen as under an individual's control, are also important in the appraisal of threat. Cataclysmic events and chronic, unsolvable problems are typically not viewed as being under an individual's control. Such events can often lead to feelings of helplessness, depression, or a tendency to give up efforts to cope with environmental demands.

Seligman (1975) originally introduced the concept of learned helplessness on the basis of a series of studies on traumatic avoidance learning in dogs. In these studies, it was found that inescapable and uncontrollable aversive events, such as the administration of electric shock by the experimenter, significantly affected their behavior and resulted in their inability to learn to escape the shocks when they were subsequently given the chance to do so. These dogs began to demonstrate a helpless, "giving up" form of behavior in which they stopped moving around the experimental chamber, lay down, and quietly whined. Even if they were then placed in a situation in which they could escape the electric shock by performing some behavior, they failed to

try to do so. Their past experience of "learned helplessness" apparently eliminated their motivation to initiate any behavior. The significance of this for residents of the TMI area is in the fact that similar effects have been shown for humans exposed to a range of uncontrollable stressors of which the TMI accident may be considered one.

Learned helplessness was interpreted as a phenomenon that develops when an organism learns that responding and reinforcement (e.g., escape from shock) are independent; that is, it is perceived that one's behavior cannot control environmental events. Seligman uses this concept to explain reactive depression that develops as a reaction to environmental stress and is characterized by apathy and inertia. He has noted a number of parallels between symptoms produced by learned helplessness and those symptoms found in depression. Helplessness has been found in human populations as well, and appears to cause reductions in mental abilities, negative emotional states, a reduction in motivation, and, in some cases, maladaptive behavior and depression (e.g., DeVellis, Wallston, Wallston, and DeVellis, 1980; Seligman, 1975). Further studies of people exposed to chronic stress over which little control was obtainable suggest that motivational and behavioral effects are likely (e.g., Baum and Gatchel, 1980; Rodin, 1976). There have also been a number of recent studies demonstrating that the negative emotional impact (such as anxiety and depression) of a stressful event appears to be a function of the degree to which a subject can control it (cf. Gatchel, 1980). Personal control appears to decrease significantly the negative emotional impact of a stressor; perceived noncontrol will increase the negative impact. In the case of the TMI accident and its aftermath, the perception of noncontrol of events by the local residents most likely maximized the negative emotional impact of this stressor.

C. Individual Differences in Response to Stress

Lazarus (1975) has also pointed out the importance of coping behavior in response to the above types of stressors. That is to say, people will try to deal with stressful situations so as to reduce the danger they perceive. These behaviors may take a number of forms. They be direct action behaviors, where the person tries to directly manipulate or change his or her relationship to the stressful situation. Thus, individuals may change the setting, flee or otherwise remove the physical presence of the stressor. When this is not possible, indirect coping behaviors may be necessary. Here, the person copes with a stressful situation by altering his or her "internal environment" by taking drugs, using alcohol, developing psychological defense mechanisms.

There appear to be significant differences in people's ability to effectively employ adaptive coping behaviors. For example, the existence of a high-stress risk personality has been implicated in a number of studies. One such early study was reported by Grinker and Spiegel (1945). They noted that only a small percentage of air corps combat crews who fought in World War II developed serious or diagnosable stress-related disturbances. This led to the argument that people differ in their vulnerability to stress. Severe disturbances, particularly those that persisted after cessation of combat, were related to "neurotic difficulties" that existed prior to combat and reduced tolerance for

stress. This analysis is similar to others in that it postulates an individual behavior pattern or style that makes stress reactions more likely, more severe, or both. For example, Glass (1976) has described a coronary-prone behavior pattern (Type A) that distinguishes between people on the basis of reaction to stress, loss of control, and challenge. Type A's, who respond more competitively, with greater time urgency, and with more hostility, are considered to be prone to coronary artery disease and a number of other stress-related problems. Similarly, coping styles such as "screening" where people are classified in terms of their resilience or ability to prioritize demands and ignore some aspects of a stressor are seen as mediating stress responses. Preferences for certain kinds of settings or activities also mediate stress (e.g., Epstein, 1967; Lazarus, 1975).

An example of how these styles and preferences interact with the environment can be drawn from the literature on occupational stress (e.g., House, 1974). Some people enter the work place with strong preferences for responsible, self-determined, or complex and involving occupations. When these expectations are not met, (jobs are excessively redundant, boring, pressured, controlled by others, or do not carry responsibility with them), dissatisfaction and stress are more likely.

In terms of the stress produced by the TMI accident, it can be expected that some individuals would have greater difficulty coping with this stressor than others. These individuals would be the ones who experience the greatest degree of psychological distress.

D. Psychological Reactions to Civilian Catastrophes

In civilian life, people exposed to catastrophes such as automobile accidents, explosions, earthquakes or other terrifying experiences often show "shock" reactions characterized by transient personality deterioration. Although these "shock" reactions may show a wide range of symptoms depending on factors such as severity of the terrifying experience, degree of surprise and uncertainty, and the personality characteristics of the individuals in the disaster area. This syndrome can be categorized according to the initial reactions to the traumatic experience, and also according to possible later post-traumatic complications.

The initial reaction phase is usually referred to as the shock stage. It is at this point in time that the victim is suddenly stunned, dazed, and becomes apathetic. If the victim is injured, he or she frequently is unaware of the injuries, has a tendency to wander about aimlessly, and not be able to make any major effort at aiding himself/herself or others. The second phase is labeled the suggestible stage. It is at this time that the person has a tendency to be passive and suggestible. He or she is willing to take orders and directions from rescue workers. There is also a tendency to express extreme concern over the welfare of others involved in the disaster and an attempt to be of assistance. However, these behavioral attempts are not very efficient or helpful. Finally, during the recovery stage the person may, even though remaining somewhat tense, anxious, and apprehensive, gradually regain his or her psychological equilibrium. There is also a need to repetitively tell about the catastrophic event during this stage.

During the initial reaction phase of the disaster syndrome, the various clinical symptoms displayed appear to result from the sudden impact of the psychological stress produced by the traumatic event. They also appear to be a result of psychological defense mechanisms being used to protect the person from the full impact of the catastrophe until he or she is better able to deal with this sudden trauma.

During the post-traumatic reaction phase of the disaster syndrome, there may be some individuals for whom psychological symptoms endure for weeks, months, or even years. These symptoms, as presented by Coleman (1976), may involve the following: (1) Anxiety, which can vary from mild states of apprehension to more intense episodes of anxiety prompted by situations that stimulate memories of the traumatic event; (2) Chronic tension and irritability, which is frequently accompanied by insomnia, fatigability, and the complaint that "I just can't seem to relax;" (3) Repetitive nightmares that depict the traumatic event directly or symbolically; (4) Complaints of impaired memory and concentration; (5) Feelings of depression. These various symptoms associated with this recovery phase appear to be residual effects of the initial shock reaction. They seem to reflect the person's realization that the world can suddenly become dangerous and overwhelmingly threatening. Indeed, many of these above symptoms have been noted to residents living in the TMI area (Houts et al., 1980). These continuing effects are made more likely by events which are not completely ended. If, following the occurrence of a disaster, uncertainty and threat (even if at a low level of intensity) continue, psychological effects are more likely to persist through recovery.

Thus, in addition to the immediate psychological effects caused by acute stress, more prolonged effects can occur if the individual remains for an extended period of time in a situation where he or she feels threatened. This may result in more chronic maladjustment, dependency, and greater severity of his or her problems in life. Symptoms such as chronic fatigue, lowered work efficiency, and excessive drinking and drug usage are common. If there are feelings of being "trapped" and being unable to control the situation, then individuals may become resistant, irritable, fault-finding, and extremely resentful about being "pushed around." For other individuals, feelings of apathy may develop.

As an example of a study of individuals feeling "trapped" and isolated in an uncomfortable life situation, Satloff (1967) and Serxner (1968) assessed groups of individuals confined to submarines for 60-day periods (during which time the submarines were continuously submerged and no "escape" was possible). In these groups, approximately 5 percent of the men developed certain psychological disturbances which appeared to be precipitated by the constant environmental/ psychological stress. Symptoms such as anxiety, depression, insomnia, headaches, and other somatic concerns were common. In another such study, Popkin and colleagues (1974) examined the behavior of a 22-man team in a South Pole station during the 6-month antarctic night. It was found that 12 of the 22 men demonstrated a condition termed "drifting" during this period. This condition was characterized by apathy, inattention, and a general reduction of cognitive functioning. Thus, exposure to chronic environmental stress can have significant effects on the psychological functioning of an individual.

Research has addressed the psychological consequences of disasters. Some studies have indicated that these major stressors have some psychological effects on their victims varying in severity and longevity (Menninger, 1952; Moore, 1958; Titchener and Kapp, 1976; Fritz and Williams, 1957; Taylor, 1976). Many studies find initial reactions which quickly subside in the face of increases in social cohesiveness in the community and in coping skills (e.g., Quarantelli and Dynes, 1977). At TMI, however, coping may have been blunted by the confusion surrounding the accident and the long-term uncertainty characterizing the state of the plant. The rather unique characteristics of the TMI incident render the situation less amenable to analysis than would be desired.

E. Psychological Effects of Stress

We earlier discussed the fact that there are certain individuals who do not respond well to high-stress situations. In general, the more integrated and stable an individual's personality before a psychologically stressful event, the more adaptive and quicker his or her recovery will be. If attempts are not made to help individuals deal with the acute and chronic stress, the less stable individuals would be expected to demonstrate some significant degree of psychological symptoms. Statistics suggest the following prevalence rates for major forms of psychological disorders (from Mears and Gatchel, 1979): Anxiety disorders (2-5% of the population); depressive disorders (5-15% of the population), and psychosomatic illnesses are even more common.

Anxiety disorders are emotional problems that are characterized, as the term suggests, primarily by the presence of anxiety. Anxiety is defined as a generalized state of fear or apprehension. The afflicted individual will begin to experience anxiety and distress in everyday situations that do not normally elicit such behavior from other persons. These disorders are characterized by diffuse and often severe "free-floating" anxiety that may not be related to any one immediate situation or object threat. The individual may not be able to identify the source of fear or apprehension. Physiological symptoms, reflective of heightened autonomic nervous system arousal, include responses such as elevated heart rate and blood pressure level, sweating, intestinal distress, and muscular tension and weakness. Anxious individuals also report symptoms such as insomnia, worry, forgetfulness, difficulty in concentrating, irritability, and frequently, mild depression. Besides their clinically high level of anxiety, these individuals often experience acute episodes of panic. Such anxiety attacks usually last anywhere from a few seconds to well over an hour. They come on suddenly, climb quickly to a high intensity, and then gradually subside. The attacks are accompanied by intense feelings of panic over some presumed impending distress or catastrophe. Acute symptoms include shortness of breath, profuse sweating, and dizziness. Such anxiety attacks can be extremely painful psychological experiences for the individual while they last.

Depressive disorders are marked by disturbances of mood which can cause a great deal of debilitating distress for the afflicted person. Depression is characterized by a dejected mood, loss of desire to do things, general tiredness, and inability to concentrate. It can be a significant problem that

seriously interferes with an individual's everyday functioning. With the intensification of a dejected mood, the individual often loses interest in the world, and lacks the motivation and desire to get involved in tasks. The future looks bleak, and the person believes that nothing can be done to change this condition. Moreover, the depressed individual may often experience crying spells, loss of appetite, weight, sleep, and sexual desire, and a desire to avoid people.

It has been estimated that a significant porportion of the population (up to 20%) may be especially susceptible to acute or chronic stress and to psychological disorders or deficits caused by stress (Mears and Gatchel, 1979). In other words, one might expect up to a fifth of a population to experience continuing problems as a result of a major life stressor. Thus, the finding (considered in the next section) that 10-20% of the residents of the TMI area (e.g., Houts et al., 1980) is still experiencing some psychological symptoms as a result of the TMI accident, is not necessarily out-of-line with what would be expected.

Nonpathologic, but generally negative psychological consequences of stress, are not as severe or debilitating as these "clinical" consequences. However, decreases in problem-solving abilities, increases in general negativity, impatience, irritability, feelings of worthlessness, and emotionality may all accompany a stress response.

F. Physiological Effects of Stress

The effects of stress are not limited to the mind. The functioning of the body may also suffer. As suggested by Selye, stress may, under chronic conditions, overwhelm bodily resistance and cause or predispose the organism to illness.

Stress, by activating the pituitary and adrenal glands, is associated with increased secretion of adrenalin and noradrenalin. These catecholamines in turn increase cardiovascular responding (heart rate, blood pressure, etc.) and increase respiration, perspiration, and other boidly functions. Thus, increased levels of catecholamines and increased physiological reactivity are associated with stress. This stress-related arousal has been explained in terms of the resistance to stressors; increased adrenalin, noradrenalin, and corresponding systemic change readies the organism to fight the stressor or flee from it (e.g., Cannon, 1931). Chronic arousal and chronically elevated levels of adrenalin and noradrenalin may exert a toll in wear and tear on the cardiovascular, renal, gastrointestinal or respiratory systems and may result in illness or death (e.g., Paulus, McCain, and Cox, 1978; Warheit, 1974). For example, research conducted at the Kennedy Space Center in Florida studies the effects on employees under a number of conflicting pressures over a relatively long period of time. Increased alcoholism, divorce, and personal difficulty increased as pressure to complete the Center's mission increased, and employees showed a spontaneous rise in sudden death rates (e.g., Elliot and Buell, 1971). Of course, the magnitude and nature of this stressor is different from those we have been considering. However, more comparable stressors have been

linked to diseases such as coronary heart disease, hypertension, gastric ulceration, atherosclerosis, and arthritis (e.g., Glass, 1976; Kasl and Cobb, 1970).

G. Summary

Stress is a syndrome of arousal and resistance evoked by a threat of harm or loss. Psychological appraisal of stressors leads to activation of the pituitary and adrenal glands, to increased physiological arousal, and to attempts to cope with and overwhelm the stressor. Successful coping or the spontaneous elimination or termination of a stressor will end the stress response, and physiological and psychological responding will return to "normal." Unsuccessful coping or a prolonged or repeated exposure to a stressor will result in chronic elevations of bodily responding, continued psychological problems, and possible complications.

The strength of the stress response is, of course, an important determinant of these effects. High magnitude stressors of an acute nature are potentially more arousing and disruptive than low-level stressors. Chronic low-level stress, however, may increase the consequences for psychological and physiological function. High magnitude acute stress followed by a recovery period characterized by low-level stress may be even more debilitating. It appears that the current situation at TMI is most like this later case where the accident and immediate aftermath were highly stressful and short-lived but the recovery period was characterized by continuing uncertainty and threat at considerably lower levels.

Based on this determination and the review we have just presented, several general conclusions about stress and the situation at TMI can be drawn:

1. The accident at TMI was an acute stressor. The threats by the accident were severe but short-lived; the emergency period of two weeks was followed by reduction of the danger associated with the plant. Thus, one might expect an acute stress response by residents of the TMI area and some fraction of these residents to experience continuing problems.
2. While one would expect most residents to recover from the stressful effects of the accident, the continued uncertainty characterizing the plan during the post-accident period may have interfered with recovery. As a result of this chronic condition of uncertainty, people who might normally recover might instead experience continued problems. Thus, the number of people suffering from psychological stress as a result of the accident and aftermath should be greater than one would expect from a major acute stressor.
3. Although those residents experiencing stress are a minority of all residents, it is likely that even those who do not experience symptoms of stress may have been rendered less able to cope with subsequent stressors. Since persistent exposure to stressors with which people can cope seems to reduce ability to cope in the future,

i.e., successful coping exacts costs, it should be expected that most residents have experienced at least a modest decrease in coping reserves. As the length of time during which residents are uncertain of what threats may still exist at TMI increases, their ability to cope with independent or related problems should decrease somewhat. Tolerance for frustration, success at problem solving, and other adaptive behavior may suffer. The occurrence of an acute stressor, be it loss of a job or an accidental leakage of Kr-85 from TMI, could therefore have much more serious consequences than if TMI residents were not chronically stressed. Perceived lack of control over events at TMI would also intensify such stress.

4. Effects of the continuing stress at TMI should primarily be restricted to those "at risk" for stress--people more susceptible to the effects of stressors. This portion of the resident population should show symptoms of stress, including chronic arousal, anxiety, emotional upset, concern, depression, and somatic discomfort. Effects could slowly intensify over time.

The extent to which any of these possibilities exists can be partially determined by examining the research that has specifically considered responses to TMI by area residents. By examining this literature, those conclusions that seem appropriate can thus be used to make predictions about alternatives for decontamination procedures at TMI.

IV. RESEARCH ON STRESS AT THREE MILE ISLAND

A. Introduction

No one would doubt that the events at Three Mile Island have produced stress, particularly to persons residing close to the plant. A good number of research efforts have been at least partly concerned with the short-term or long-term effects of that stress. Some of the research has been of considerably quality and has produced data that are acceptable if reviewed by scientific standards. Other research is more preliminary, limited in scope, and of interest anecdotally rather than scientifically. Although the sum total of these studies yield somewhat tentative or preliminary findings, we will here be concerned with the data that is able to withstand at least some scientific scrutiny.

B. Stress Associated With the Accident

The dangers associated with the TMI accident were communicated to the local residents by statements of various officials, by the media and by the threat of an upcoming official evacuation. The majority of the residents were aware of the danger and took it seriously: The various studies appear to agree that about two-thirds (from 66% to 70%) of the local population perceived the TMI situation as a serious threat at the time of the crisis. About the same number

of persons viewed the events as dangerous.* Some groups, however, appear to have been particularly concerned about these dangers; pregnant women, mothers of young children (and to some degree females in general), students, and those with higher educational levels were more sensitive to the threat posed by the accident. Of course, the degree of upset was, in most cases, higher among all groups the nearer to the TMI location they lived.

In part, evacuation may be viewed as an indication of perceived danger, or as a behavioral response to this danger. While evacuation of some residents was suggested by the authorities and consequently cannot serve as an indicator of concern over the TMI events, many of the evacuees left voluntarily. More than two-thirds of those who evacuated voluntarily stated that they did so because they wanted to avoid forced evacuation (Flynn, 1979) while others stayed even though they wanted to evacuate because they could not leave their jobs (64%) or were afraid of looters (34%). Nonetheless, the majority of evacuees appear to have left because they viewed the situation as dangerous (up to 91%). In contrast, 14% of those who did not leave saw no or little danger and 52% wanted to wait for an official evacuation order. Among those who did not leave in great numbers were workers who were employed by TMI. Only 24% of this group appear to have considered the situation dangerous at the time of the accident.

Part of the reason for the stress which the local population experienced at the time of the accident was due to confusion created by the fact that information about the accident was issued by many sources and was often contradictory. Almost three quarters of the local population complained that the information they received was confusing. This proportion was even higher among the evacuees (Flynn, 1979). One consequence of this confusion was increased distrust of the authorities involved. For example, the most distrust was expressed toward Metropolitan Edison: very few residents thought that the information provided by Met Ed was useful, compared to slightly more than half the population who felt that the information provided by the Governor of Pennsylvania and by the NRC was useful. Thirty-one percent thought favorably of the information contained in statements by President Carter.** The most positive feelings towards information sources were found toward local radio and television: about two-thirds of those questioned considered reporting by these media as useful.

Not all groups were positively disposed towards the media. Those closer to TMI were less satisfied with media reporting than those further away. Pregnant

* Since the different questionnaires and interviews used in various studies often used different techniques to assess perceptions of danger, seriousness, etc., we will describe the findings in "general" (summarizing) terms that may not precisely reflect all of the questions asked but should be generally descriptive and applicable. The same summarizing descriptions will be used in later parts of this report.

** Greater trust in government statements was observed in older, less trust in younger persons.

women and students expressed the greatest dissatisfaction with the media. Regardless of these criticisms, the local media were relied on most heavily for what was considered reliable information; more than two-thirds of those affected stated that the information on which their decisions were based was obtained from local media, primarily from radio stations.

As we implied earlier, some sources of information were viewed with distrust, and public confidence in these organizations suffered as a result of the accident. Three quarters of the local population stated that their trust in Met Ed decreased because of the accident. Only two percent ended up with more confidence. Trust in government handling of nuclear power also decreased, but not to the same degree: 43% of those questioned stated that their level of confidence decreased, 4% reported an increase. In one study (Kraybill, 1979) more than half of those questioned indicated that they did not feel they had been told the truth about circumstances surrounding the accident. Nonetheless, (among a limited subpopulation) more than two-thirds approved of government handling of the crisis. The major credit for public confidence in the government seems due to the actions and statements of the Governor of Pennsylvania.

Another source of distress during the accident was confusion surrounding what people should do. It became quite clear to many as the accident unfolded that there was no meaningful and effective emergency plan which would, for example, assure the successful evacuation and care of the local population in the event that an emergency did occur. Further, many residents felt that the scientists involved in the operation, control, and supervision of the TMI project at the time of the accident appeared to disagree with each other, and, consequently, could not be trusted to make the appropriate decisions. Effective control over events at the plant was seen as low or lacking. One result has been a decrease in the previously more or less favorable attitudes toward nuclear power. In one sample (reported by Kraybill, 1979), 43% of the population came away from TMI with less favorable attitudes toward nuclear power (while only 4% felt more favorable after the accident). Nonetheless, 62% of those asked still supported nuclear energy (with 27% opposed). Fifty-eight percent of those asked in a 50-mile radius were in favor of restarting TMI, but more than half of these wanted stricter safety standards imposed first. Thirty-six percent objected to a re-start. In the Houts et al. (1980) sample (stratified by distance) obtained nine months after the accident, it becomes evident that those objecting to re-starting the nuclear energy plant at TMI are those living closest to it: about 60% within the 5-mile concentric circle around TMI objected, about 50% in the 6-15 mile radius, about 40% between 16 and 25 miles, while only about 30% who lived beyond 25 miles had objections. However, only 16% of the population within a 15-mile radius stated that they may consider moving elsewhere if TMI is reopened as a nuclear facility. To summarize: the perceived danger and threat posed by the plant (as perceived), in combination with confusion, distrust, and the stressful effects of evacuation and the uncertainty and potential loss of financial security may be considered as sources of stress that might lead to psychological, psychiatric, or medical problems.

C. Effects of the Stress Experience

Stress experience can result in psychological, social, psychiatric, and physiological-medical outcomes. In all of these areas we may be able to

distinguish between symptoms (complaints by the person that he is not functioning normally or feels ill) and actual malfunctioning and/or disease and physiological damage as an effect of experienced stress.

There is currently no evidence of stress-induced physiological organ damage as a result of TMI stress; however, such damage would typically not become evident in such a short time period and cannot consequently be ruled out. However, more physiological symptoms (complaints of a medical nature) were reported by people living near TMI in comparison to those living further away. These increases average about 10 to 12% without any appreciable effect of time on those reports. The same appears to be true for psychological and psychiatric symptoms, although there is some evidence that increases in such problems were reported in January 1980 (in comparison to July 1979).

The use of psychiatric measurement scales designed to reflect psychiatric problems has resulted in mixed feelings. Some researchers report no differences between persons living near TMI and those living further away. Other researchers did obtain differences in anxiety and depression. Bromet's (1980) findings suggest that during or shortly after the accident about one-third of the local mothers (of small children) showed signs of depression and anxiety compared to only 14% of mothers at a comparable nuclear facility. Only about half of those mothers showing symptoms of anxiety or depression mentioned the facility as the cause or one of the causes for their problems. Generally, however, about one-fifth of the population was affected beyond what might be expected near any nuclear plant. Six months later, Bromet found that differences between the population near TMI and near the comparison plant had largely disappeared. These small and temporary effects seem to suggest that the problems produced by the TMI accident in the areas of anxiety and depression seem to have been limited. Preliminary analysis of items on scales measuring anxiety, depression, etc., appears to suggest that some may well exist, suggesting that living near a nuclear facility and having experienced the crisis may be associated with distress and symptom reporting.

D. Distance from TMI

The closer a person's residence is to TMI, the greater the level of stress that he or she seems to have experienced. The level of stress appears to decrease slightly from 5 to 10 to 15 miles from the plant, shows a major drop after 15 miles and then decreases again from 16 to beyond 40 miles from the plant (Houts et al., 1980).

E. Effects of Time

Several sources have concluded that stress levels returned to "normal" after some months. Recent reports such as the one prepared by Houts and his associates (1980) suggest that these conclusions may have been somewhat premature. While it is true that scores reflecting the perception of danger, the level of upset, the distrust in authority, and the objection to nuclear power all decreased during the months following the accident, these scores did not reach "normal" or baseline levels derived from people living more than 40 miles from TMI (Houts et al., 1980).

Measurements of stress-related symptoms in the vicinity of TMI do, for example, show that those living within 15 miles of the plant were still very concerned about potential radioactive emissions (41%), even though that number had decreased (from 61% during the crisis) since the accident (Flynn, 1979, Houts et al., 1980). About half the local residents still considered the plant "dangerous" after several months (down from two-thirds during the crisis). Similarly, just over 40% considered TMI to be a threat to the safety of their families in July, a figure that decreased to just under 40% in January 1980 (down from about 70% in the same 10-mile radius during the crisis). These values are about 30 percentage points higher than responses obtained beyond 40 miles from the plant. At these times it is little surprise, then, that local residents (within a 15-mile radius) continue to be upset about TMI. During the time of the accident, the percentage of persons upset was 42%-52% higher near the plant than it was beyond 40 miles from TMI. That percentage differential has decreased to 15% during the following months. Nonetheless, there still is a differential.

It appears, then, that persons living near TMI experience higher levels of chronic stress as compared to those living far (more than 40 miles) from the plant. The most obvious explanation would be the accident experience and the continuing threat of potential radioactive releases from TMI. Continuing uncertainty in the absence of any steps to clean up the plant or to stabilize it may gradually intensify residual effects of the accident. Alternatively, the stress experienced at TMI may be similar to the stress experienced by those living near any nuclear plant (particularly after the TMI accident has shown the potential dangers involved) or near any facility that might be hazardous (as suggested by Bromet, 1980). Stress experiences (and their potential consequences) may be shared by persons living near any nuclear facility or near any hazardous operation.

F. Characteristics of the Stressed Individual

Before we deal with some of the potential characteristics of the person experiencing stress, we should emphasize that the incidence of stress experience several months after the TMI accident is not surprisingly great. While some persons were able to reduce the threat of danger or insulate themselves from potential consequences of a disaster by the belief that whatever might happen would be in God's hands (69.6% of those who did not evacuate in the immediate area), most people did (and to some degree still do) perceive danger associated with TMI. Nonetheless, the persons reporting one or more physical or behavioral symptoms are not exceeding the population beyond the 40 miles distance by much more than 10 to 15% and may not be very different from persons living near unproblematic nuclear plants elsewhere. Among mothers--one of the more stressed groups--anxiety and depression at TMI vs. another nuclear plant did exceed the expected value near nuclear plants by 20% but dropped sharply by fall of that year.

It may be of interest to focus--to the degree possible with the limited data we have to date--on the characteristics of the person who did experience stress and displayed stress symptoms. It appears that those who consider TMI dangerous are more likely to experience stress-related symptoms than those who

view the plant as safe or as less dangerous. They are more likely to be those persons who evacuated and traveled potentially further when they did leave. They are most likely not the employees of the nuclear facility itself unless they were employed temporarily at the time of the accident. Without question, these are people who are more sensitive to stress and respond more severely to stressing condition, probably any stressing situation. Nonetheless, we should be careful to avoid labeling these persons as abnormal. These people are typically normal functioning people who have a serious level of concern that is producing limited symptoms.

G. Conclusions

The findings of many studies now available suggest that our hypotheses about possible stress among residents of the TMI area are useful. These studies find limited effects of stress in the TMI area. Residents show more symptoms of stress nearly a year after the accident than one would expect in the absence of a stressor. Stress was more pronounced immediately after the accident, but continues as a low magnitude problem for a small segment of the population. There is some evidence of gradual increases in stress-related symptom reporting as time passed, but for the most part it appears that stress levels are below those of a year ago. Thus, it may be concluded that although not severe, some stress continues as a joint product of the accident and the uncertainty of the succeeding year. It is therefore possible that continued uncertainty in the absence of decontamination procedures or steps to clean up the situation may further tax residents' ability to cope. The question, "How much more of this can we take?" becomes a central one, and it appears that, if steps to reduce uncertainty and stress can be accomplished safely, they should be taken as quickly as is feasible.

Many of the people living near TMI are concerned; some of them are still frightened and angry. If there are dangers associated with any action taken with regard to TMI, people living in the vicinity should be given enough information to make intelligent decisions on how to respond. They should be informed about the progress of the situation and about what expectations are for future events at TMI and future life in the area. They should be given some say (control) about the upcoming events, and they should be able to turn to one single source which provides a reliable, truthful, and authoritative (trustworthy) source of information and reassurance.

The remainder of this report will consider the likelihood of stress change (either increase or decrease) as a function of the alternatives for decontamination of the reactor building atmosphere (NUREG-0662).

V. PSYCHOLOGICAL EFFECTS OF DECONTAMINATION ALTERNATIVE

A. Introduction

To summarize, it appears that major upheavals and stress due to cataclysmic events are relatively short-lived--once the event is over, stress is reduced considerably. There may be some longer lasting consequences of such an occurrence, but for the most part, once the event is over, normal functioning

returns. Acute (short-term) stress is a problem primarily during the occurrence of a stressful event. The TMI accident represented such an event--the two-week emergency period aroused a great deal of stress among residents which should have disappeared, for the most part, within several months. However, aftermath of the accident persists; radioactive Kr-85 remains in the reactor building and the reactor is still in a crippled state. Residents believe that there is still danger. Thus, the TMI accident seems to have engendered an aftermath of low-level chronic (long-term) stress. This is indicated by many of the pro-venting letters received; people are aware of the unstable and potentially dangerous consequences of continued delays in decontamination. Many letters indicated that people would not feel safe until the reactor is decontaminated and the plant shut down.

Thus, it can be concluded that one reason for continued stress among TMI area residents is the fact that decontamination has not yet been accomplished. It is also reasonable to assume that successful decontamination of the reactor, once it is accomplished, will reduce some of the stress experienced by some residents. As the reactor approaches "normalcy" or a stabilized, non-threatening state, stress should abate. Thus, in addition to the stated reasons for decontamination, one could add that it will probably reduce psychological stress once it is completed. By removing the source of continued threat and danger, the harmful effects of living near TMI (in terms of stress) should be lessened. However, during the decontamination period, stress may temporarily increase. This is due to (a) the fact that something is occurring after a year of inactivity and (b) the likelihood that decontamination procedures will present new threats (or perceived threats) that have not been prominent concerns. For example, venting of Kr-85 into the atmosphere will be perceived to present a new source of danger to residents--the possibility that they will be exposed to additional radiation. While the decontamination is being accomplished, these new concerns will be salient. However, these too should disappear once decontamination is accomplished.

B. Reactor Building Purge

As outlined in NUREG-0662, atmospheric purging offers a number of advantages; the system is an existing one and therefore decontamination could be accomplished more rapidly. In addition, the document indicates that accidental dose impacts are small, that such a purge could be controlled, and that release can be maintained within Federal regulations. The primary disadvantage of this alternative may be the impact of residents' interpretation of the effects of releasing radioactive gas into the atmosphere. Psychological stress resulting from this interpretation is very likely.

There is one stress-reducing (or potentially stress-reducing) aspect of this alternative. The decontamination of the reactor will reduce stress and the more rapidly this is accomplished, the more rapidly stress may be reduced. In addition, the longer the delay in decontaminating the reactor, the greater is the likelihood of additional uncontrolled or accidental releases of radiation. The very nature of these accidents, their image of uncontrollability, will probably heighten stress responses to them. Such uncontrolled releases can be interpreted as evidence that those running the reactor cannot control it, that

there has been radiation escaping all along. Whether these interpretations are correct is not an issue. When invoked, they will, in all likelihood, lead to stress. Therefore, minimizing the potential for accidental releases of Kr-85 into the atmosphere should reduce distress or prevent increases in stress.

Despite the fact that the rapid atmospheric decontamination offered by reactor purging would lead to stabilization more rapidly, there are a number of factors that should result in increased stress during purging. People are frightened by the prospect of exposure to radioactivity. The bomb-shelter scares of two decades ago are still relevant to many people, and, for the last 35 years, people have been exposed to horror stories about radiation ranging from reports of birth defects, illness, and death in Nagasaki and Hiroshima to movies and novels about mutants and the end of the world. An entire generation of Americans has now been raised during the "atomic era" and has lived with "the bomb" for their entire lives. Despite the safety records or peaceful purposes of much nuclear technology, some of the fears and doubts people have about the safety of the world from nuclear weapons will generalize to non-military use as well. To some extent, many Americans have doubts about nuclear power and whether it is safe to use.

This is apparent in research on risk perception--nuclear plants are seen by Americans as far riskier than they are (Slovic, Fischhoff and Lichtenstein, in press). The relatively dramatic nature of accidents involving nuclear power and the graphic notions of what nuclear accidents may entail can lead to an exaggerated estimate of danger. People seem to judge the safety of nuclear power by different criteria than they judge the safety of other things. They seem more likely, for example, to make judgments about nuclear plants in terms of the "worst possible accident" while this disaster standard is not used to judge the safety of other activities or technologies. The impact of TMI, then, should be viewed against the backdrop of prevailing fears about the risks of nuclear reactors. It is possible that some amount of stress results simply from living near a reactor, regardless of whether it malfunctions.

The purging of the reactor building atmosphere will be controlled by utility personnel and will be subject to inspection and oversight. However, it is possible that this will not translate into perceptions of control by residents. Distrust of the motives or abilities of relevant companies or agencies, coupled with reported human error during the accident and subsequent accidental radiation release may undermine the confidence of residents in the utility's ability to control the purge. Bad publicity for the nuclear industry and the NRC does not help matters. Letters received in response to the NRC request for comments on NUREG-0662 clearly suggested doubts by residents of the TMI area about the motives or competency of the nuclear industry, utilities, and relevant government agencies. Regardless of the veracity of these claims, they affect residents' perceptions of risk. If the purge of radioactivity is seen as beyond their control and in the hands of people who are either not trusted or seen as unable to effectively control it, it is conceivable that stress would be heightened.

C. Other Alternatives

The other decontamination procedures outlined are charcoal absorption, use of a gas compression system, cryogenic processing system, or a selective absorption system. Unlike the purge alternatives, they are not immediately available for use. Adoption of one of these alternatives would result in delays of a year or more. They also would pose offsite storage problems requiring long-term surveillance. They would result in smaller beta skin dose exposures and total body gamma exposures during normal processing than would a reactor purge, but could involve greater exposure in case of an accident. It is therefore unclear that these alternatives are safer than purging into the atmosphere.

These methods would probably be perceived as safer than a reactor purge because radioactive gas would not be released into the atmosphere. These alternatives involve absorbing or drawing off the radioactive Kr-85 into storage containers or facilities, transporting the radioactive gas (or, in the case of the selective absorption alternative, the radioactive krypton) to another location, and storing or burying it. The radiation is being contained, moved, and stored. No radiation (or very little) will be released into the atmosphere around TMI. As a result, these alternatives may seem safer and less threatening to residents and may therefore cause less acute stress than a purge.

However, there are also aspects of these alternatives that may increase stress. First, the delays involved in construction of the systems would result in continued uncertainty and low-level stress. This continued uncertainty could lead to chronic stress effects far worse than those associated with acute stress. Wear and tear on the body is generated by such chronic stress, punctuated by periodic increases in stress as rumors about the reactor are circulated or radiation is accidentally released. This wear and tear may result in damage to the cardiovascular system. Behavioral problems, decreasing coping ability, and costs to mental health may also be heightened by such chronic uncertainty.

Again, a primary problem with such a plan is the fact that construction and delay could result in a greater possibility of future uncontrolled release of Kr-85. The stress-inducing properties of these releases have already been noted.

VI. CONCLUSIONS

In all likelihood, any procedure that is adopted for the decontamination of the reactor building atmosphere will result in some psychological stress. This stress, however, should abate as contamination is reduced and the instability and uncertainty surrounding the reactor is diminished. It is possible that stress levels after successful completion of venting of Kr-85 will be lower than before the venting is begun. The decontamination of the reactor building atmosphere can thus be justified on psychological grounds as well as technical ones. Any steps taken to neutralize the reactor should have salutary effects on residents. However, the procedures involved in decontamination are likely to result in at least temporary increases in psychological stress which may cause problems.

The primary advantages, in terms of stress, of the purge alternative, are the rapid completion of the decontamination and the consequent elimination of future uncontrolled release. The primary disadvantages are that such purging will be perceived by many as a threat to health and may be viewed with suspicion and distrust. Perceived uncontrollability of such a procedure may also heighten stress. However, severe stress effects are less likely if the duration of stressor exposure is reduced. The long delays, continued uncertainty, and possibility of uncontrolled release that characterize the other alternatives may offset the perception that they are safer. The degree to which chronic stress would result in the event of such delays is unclear. It is our opinion that these could be consequences of long delays.

APPENDIX A

PRINCIPAL PROJECTS AND REPORTS
ON THREE MILE ISLAND USED IN THE REVIEW
OF STRESS EFFECTS AT TMI

- Axelrod, D., Bluestone, M., Denson, P., Fabrikant, J., Fowinkle, E., Johnson, K., Jones, E. and Seltser, R. Report of the task group on public health and epidemiology to the President's Commission on the Accident at Three Mile Island. Washington, D. C., October 1979.
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- Kraybill, D. B. Demographic and attitudinal characteristics of TMI evacuees. Unpublished research supported by Elizabethtown College and Lane Intelligence Journal. Dept. of Sociology, Elizabethtown College, Elizabethtown, PA.

Michell, J. K. Responses of impacted populations to the TMI nuclear reactor accident: An initial assessment. Unpublished research sponsored by Cook College, Rutgers University, Dept. of Environmental Resources, Cook College, Rutgers University, New Brunswick, NJ.

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Walsh, E. J. The organizational development of social movements as the result of the Three Mile Island nuclear accident. Incomplete research supported by the National Science Foundation. Dept. of Sociology, Pennsylvania State University, University Park, PA.

NOTE: More information on these and other research projects on Three Mile Island is contained in list of Mental Health Studies, available from:

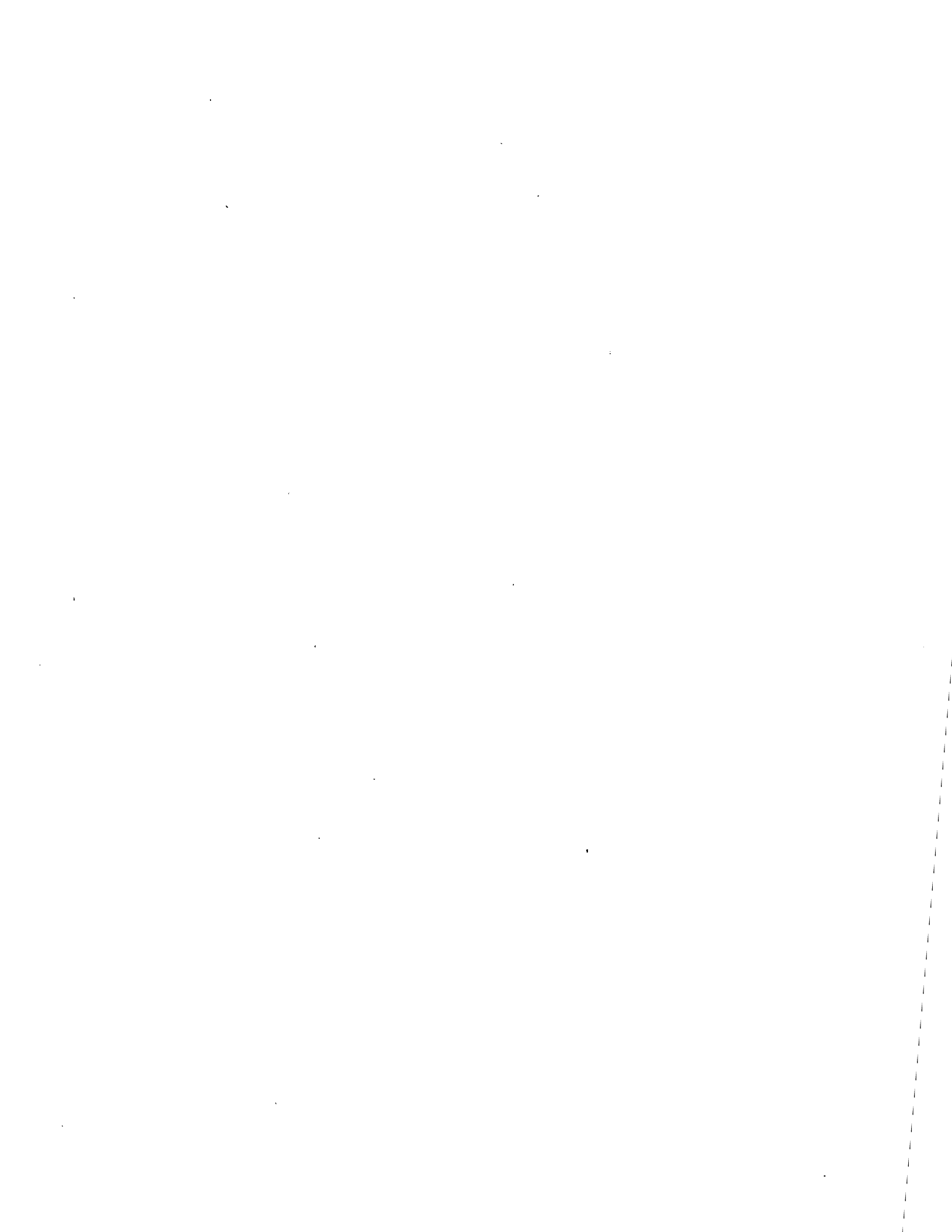
Associate Commissioner
Planning and Evaluation
Bureau of Program Services
Dept. of Public Welfare
P. O. Box 2675
Harrisburg, PA 17120

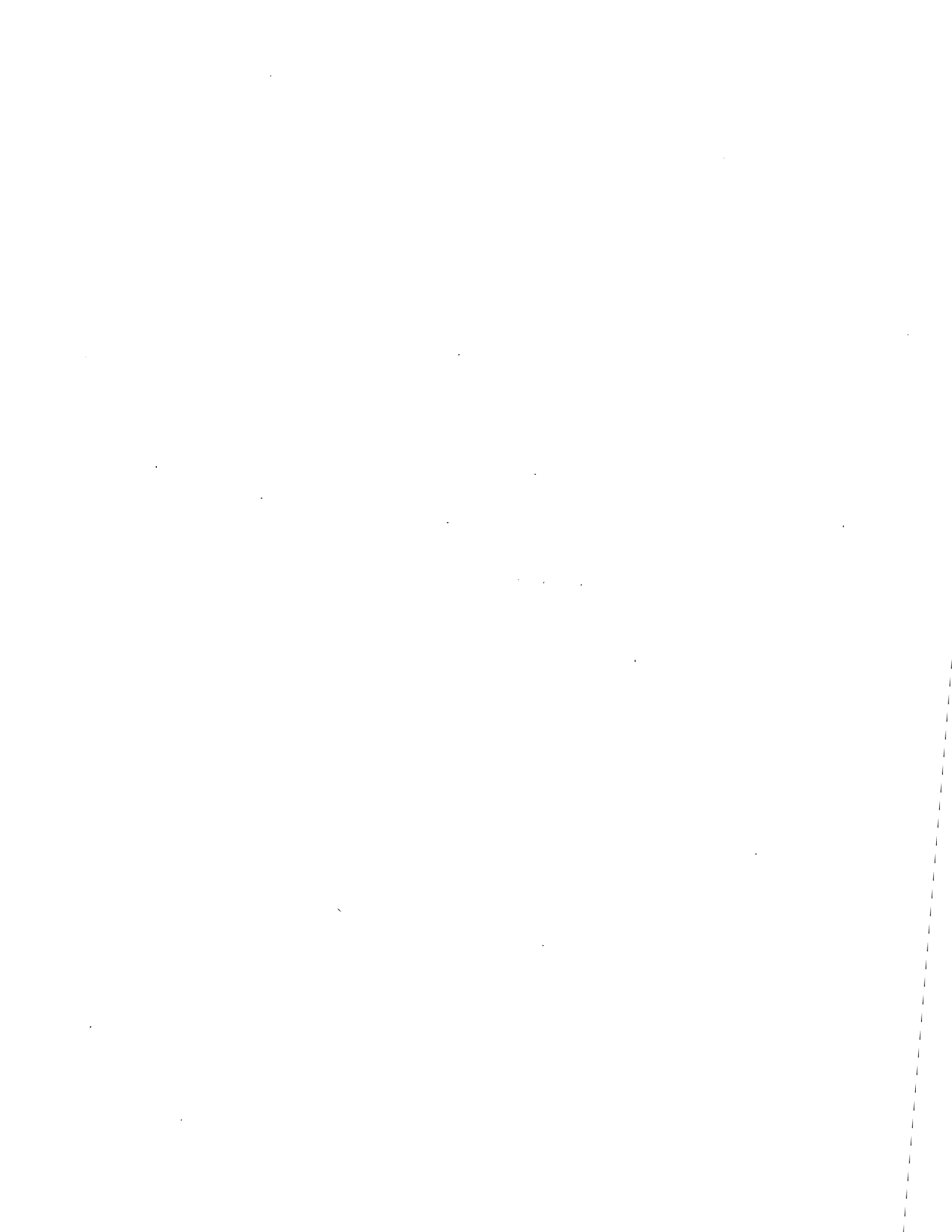
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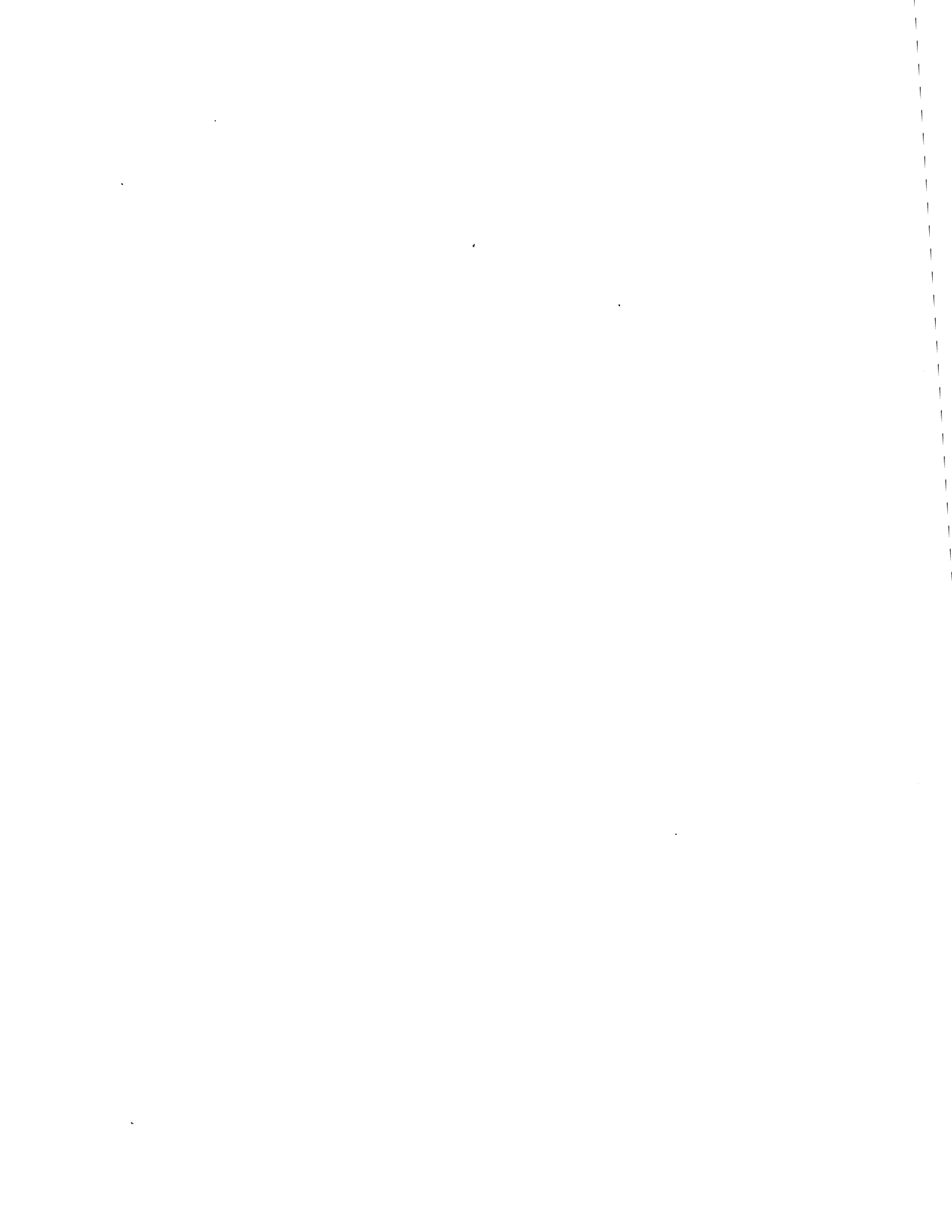
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NRC FORM 335 (7-77)		U.S. NUCLEAR REGULATORY COMMISSION BIBLIOGRAPHIC DATA SHEET		1. REPORT NUMBER <i>(Assigned by DDC)</i> NUREG/CR-1584	
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16. ABSTRACT <i>(200 words or less)</i> <p>The purpose of this report is to consider the nature and level of psychological stress that may be associated with each of several alternatives for decontamination. The report briefly reviews some of the literature on stress, response to major disaster or life stressors, provides opinion on each decontamination alternative, and considers possible mitigative actions to reduce psychological stress.</p> <p>The report concludes that any procedure that is adapted for the decontamination of the reactor building atmosphere will result in some psychological stress. The stress, however, should abate as contamination is reduced and uncertainty is diminished. The advantages of the purge alternative are the rapid completion of the decontamination and the consequent elimination of future uncontrolled release. Severe stress effects are less likely if the duration of stressor exposure is reduced, if the feeling of public control is increased and if the degree of perceived safety is increased.</p> <p>The long delays, continued uncertainty, and possibility of uncontrolled release that characterize the other alternatives may offset the perception that they are safer. In addition, chronic stress could be a consequence of long delays and continued uncertainty.</p>					
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