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EVALUATING THE HABITABILITY OF A NUCLEAR POWER PLANT CONTROL ROOM DURING A POSTULATED HAZARDOUS CHEMICAL RELEASE

A. INTRODUCTION

Criterion 4, "Environmental and Dynamic Effects Design Bases," of Appendix A, "General Design Criteria for Nuclear Power Plants," to 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities," requires, in part, that structures, systems, and components important to safety be designed to accommodate the effects of and to be compatible with the environmental conditions associated with normal operation, maintenance, testing, and postulated accidents. Criterion 19, "Control Room," requires that a control room be provided from which actions can be taken to operate the nuclear power unit safely under normal conditions and to maintain it in a safe condition under accident conditions.

Releases of hazardous chemicals can result in the control room becoming uninhabitable. This regulatory guide describes assumptions acceptable to the NRC staff for use in assessing the habitability of the control room during and after a postulated external release of hazardous chemicals from mobile or stationary sources, offsite or onsite. This guide also provides guidance acceptable to the NRC staff for the protection of control room operators against an accidental release of such hazardous chemicals, including chlorine. Regulatory Guide 1.95, "Protection of Nuclear Power Plant Control Room Operators Against an Accidental Chlorine Release," provided guidance on storing chlorine onsite, described acceptable design features and procedures for the protection of nuclear power plant control room operators against an accidental onsite chlorine release, and outlined emergency procedures that need to be initiated in the event of a chlorine release.

This Revision 1 of Regulatory Guide 1.78 incorporates and withdraws Regulatory Guide 1.95 since many regulatory positions in these two guides are the same or similar. This revision also updates certain regulatory positions based on more current knowledge of the subject. This guide does not consider the explosion hazard of these chemicals, which is addressed separately in Regulatory Guide 1.91, "Evaluations of Explosions Postulated To Occur on Transportation Routes Near Nuclear Power Plants" (Ref. 1), nor does it address flammability hazards, which are addressed separately in Regulatory Guide 1.189, "Fire Protection for Operating Nuclear Power Plants" (Ref. 2).

The information collections contained in this regulatory guide are covered by the requirements of 10 CFR Part 50, which were approved by the Office of Management and Budget, approval number 3150-0011. If a means used to impose an information collection does not display a currently valid OMB control number, the NRC may not conduct or sponsor, and a person is not required to respond to, the information collection.

B. DISCUSSION

The control room of a nuclear power plant should be appropriately protected from hazardous chemicals that may be discharged as a result of equipment failures, human errors, or events and conditions outside the control of the nuclear power plant. Sources of hazardous chemicals could be mobile or stationary and could include storage tanks, pipelines, fire-fighting equipment, tank trucks, railroad cars, and barges.

This guide has been revised to provide guidance on control room habitability during a postulated hazardous chemical release, including chlorine. The guide describes assumptions and criteria for screening out release events that need not be considered in the evaluation of control room habitability. The guide also provides guidance on performing detailed evaluations of control room habitability and on screening criteria, including the distance between the release source and the control room, the frequency of shipments (to calculate release frequency from a mobile source), the quantity and duration of a release, toxicity of released chemicals, meteorological conditions (for dispersion calculations), and the rate of air infiltration into the control room. The guide covers both toxic and asphyxiating chemicals, but recognizes that the asphyxiating chemicals should only be considered if their release results in displacement of a significant fraction of the control room air. The Occupational Safety and Health Administration (OSHA) provides guidance on what is considered an oxygen-deficient atmosphere.

This revision of Regulatory Guide 1.78 updates specifications of toxicity limits based on more recent data (Regulatory Position 3), brings risk insights into the process, and makes the guidance more performance-based. Consistent with risk-informed regulatory decision-making, this revision encourages licensees to make greater use of risk insights in submitting applications for plant-specific changes to the licensing basis, using the guidance provided in Regulatory Guide 1.174 (Ref. 3). At the same time, the revision continues to provide latitude to the licensees for the use of traditional engineering approaches. Also, consistent with the intent of SECY-00-0191 (Ref. 4) on performance-based initiatives, this revision provides performance-based guidance rather than traditional prescriptive guidance.

The June 1974 version of Regulatory Guide 1.78 specified a 2-minute exposure to given concentration limits of certain toxic chemicals. The 2-minute exposure criterion was based on the time a control room operator is expected to take to don a respirator and protective clothing. The concentration limits were based on outdated and often unverifiable references. Further, only a limited number of chemicals have the toxicity limits specified in the 1974 guide. The National Institute for Occupational Safety and Health (NIOSH) has published updated toxicity limits for many hazardous chemicals, based on the Immediately Dangerous to Life and Health (IDLH) exposure level concept (Ref. 5). The IDLH value or limit, based on a 30-minute exposure level, is defined as one that is likely to cause death or immediate or delayed permanent adverse health effects if no protection is afforded within 30 minutes. The IDLH exposure limits were developed for respirator selection for a large number of chemicals, including those covered in this regulatory guide. The use of IDLH values as toxicity limits is considered appropriate since it provides an adequate margin of safety as long as control room operators use protective measures within 2 minutes after the detection of hazardous chemicals; they therefore would not be subjected to prolonged exposures at the IDLH concentration levels. Therefore, these limits are included in this revision of Regulatory Guide 1.78.

Many of the regulatory positions in the original Regulatory Guides 1.78 and 1.95 are the same or similar. This revision combines these two guides, thereby making the positions applicable to all toxic chemicals, including chlorine, that should be considered in the control room habitability evaluation. Combining the two guides eliminates certain duplication of efforts for licensees in submitting their applications and streamlines the NRC staff review process.

C. REGULATORY POSITION

The following guidance is provided for evaluating the habitability of a nuclear power plant control room during a postulated hazardous chemical release.

1. HAZARD SCREENING

Whether a chemical source (stationary or mobile) constitutes a hazard that requires a control room habitability evaluation depends on the quantity of chemical released, the distance from the plant, prevailing meteorological conditions, the inleakage characteristics of the control room, and the applicable toxicity limits. Licensees are encouraged to conduct periodic surveys of stationary and mobile sources of hazardous chemicals in the vicinity of their plant sites to keep the site-specific inventories up to date. The following screening criteria identify the release events that need not be considered further for control room habitability evaluation.

1.1 Screening Criteria for Stationary Sources

Chemicals stored or situated at distances greater than 5 miles from the plant need not be considered because, if a release occurs at such a distance, atmospheric dispersion will dilute and disperse the incoming plume to such a degree that either toxic limits will never be reached or there would be sufficient time for the control room operators to take appropriate action. In addition, the probability of a plume remaining within a given sector for a long period of time is quite small.

If sources of hazardous chemicals such as those listed in Table 1 are known or projected to be present within a 5-mile radius of the plant, and in quantities less than those shown in the table of examples in Appendix A for a given toxicity limit and stable meteorological conditions, these sources need not be considered in the evaluation of control room habitability. Appendix A to this guide also contains a simplified procedure for adjusting the quantities given in the table to appropriately account for the toxicity limit of a specific chemical, the meteorological conditions of a particular site, and the air exchange rate of a control room. The calculations in Appendix A are included as examples of the guidance.

Any hazardous chemical stored onsite within 0.3 miles of the control room in a quantity greater than 100 pounds should be considered for control room habitability evaluation. Hazardous chemicals should not be stored within the close proximity (generally within 330 feet or less) of a control room or its fresh air inlets, including ventilation system intakes and locations of possible infiltration such as penetrations. Small quantities for laboratory use, 20 pounds or less, are exempt. The maximum allowable inventory in a single container stored at specified distances beyond 330 feet from the control room or its fresh air inlet varies according to the distance and the control room type.

If there are several chemical containers, only the failure of the largest container is normally considered in the evaluation unless the containers are interconnected in such a manner that failure of a single container could cause a release from several containers.

1.2 Screening Criteria for Mobile Sources

If hazardous chemicals such as those listed in Table 1 are known or projected to be shipped by rail, water, or road routes outside a 5-mile radius of a nuclear power plant, the shipments need not be considered further for evaluation for the same reason stated in the screening criteria for stationary sources. If the shipments are within a 5-mile radius of a nuclear power plant, estimates of the frequencies of these shipments should be considered in the evaluation of control room habitability. Shipments are defined as being frequent[1] if there are 10 total shipments per year for truck traffic, 30 per year for rail traffic, or 50 per year for barge traffic. These frequencies are based on transportation accident statistics, conditional spill probability given an accident, and a limiting criterion for the number of spills or releases. These accident rates have remained relatively constant for many years, therefore it is not necessary to revise these frequencies (Ref. 5).

Mobile sources need not be considered further if the total shipment frequency for all hazardous chemicals, i.e., all hazardous chemicals considered as a singular cargo category without further distinction of the nature of these chemicals, does not exceed the specified number by traffic type. Frequent shipments, i.e., shipments exceeding the specified number by traffic type, need not be considered in the analysis if the quantity of hazardous chemicals is less than the quantity shown in the table in Appendix A (adjusted for the appropriate toxicity limit, meteorology, and control room air exchange rate).

[1] For explosive hazards, a lower number of shipments would be considered frequent since the effects of an explosion would be independent of wind direction.

TABLE 1

TOXICITY LIMITS (IDLH LIMITS) FOR SOME HAZARDOUS CHEMICALS

Chemical	*Toxicity Limit*[a] *ppm*[b]	*Toxicity Limit*[a] *mg/m*[3c]	*Chemical*	*Toxicity Limit*[a] *ppm*[b]	*Toxicity Limit*[a] mg/m[3c]
Acetaldehyde	2000	3600	Fluorine	25	50
Acetone	2500	6000	Formaldehyde	20	24
Acrylonitrile	85	149	Halon 1211	20000	
Anhydrous ammonia	300	210	Halon 1301	50000	
Aniline	100	380	Helium		asphyxiant
Benzene	500	1600	Hydrogen cyanide	50	55
Butadiene	2000	4400	Hydrogen sulfide	100	150
Butene		asphyxiant	Methyl alcohol	6000	7800
Carbon dioxide	40000	7360	Nitrogen (compressed or liquified)		asphyxiant
Carbon monoxide	1200	1320	Sodium oxide		2
Chlorine	10	30	Sulfur dioxide	100	520
Ethyl chloride	3800	9880	Sulfuric acid		15
Ethyl ether	1900	5700	Vinyl chloride	1000	2600
Ethylene dichloride	50	200	Xylene	900	3915
Ethylene oxide	800	720			

This table lists commonly encountered chemicals but the list is not all-inclusive. A more complete list of chemicals is in Reference 5.

[a] Adapted from NUREG/CR-6624, "Recommendations for Revision of Regulatory Guide 1.78" (Ref. 5).
[b] Parts of vapor or gas per million parts of air by volume at 25°C and 760 torr (standard temperature and pressure).
[c] Approximate milligrams of particulate per cubic meter of air, at standard temperature and pressure, based on listed ppm values.

For release of hazardous chemicals from stationary sources or from frequently shipped mobile sources in quantities that do not meet the screening criteria, detailed analysis should be performed for control room habitability. Licensees are encouraged to make use of risk information, particularly when requesting related license amendments. The guidance for risk evaluation is provided in Regulatory Position 2. Licensees may continue to use the traditional engineering approach for control room habitability evaluation; the guidance for this approach is provided in Regulatory Position 3.

2. RISK EVALUATION

For releases of hazardous chemicals from stationary sources or from frequently shipped mobile sources in quantities that do not meet the screening criteria in Regulatory Position 1.1 or

1.2, detailed analyses should be performed for control room habitability. Licensees may provide risk information to demonstrate that the radiological risk to the public from such toxic chemical releases is small, consistent with the Commission's Safety Goal Policy Statement. Release of toxic chemicals that have the potential to result in a significant concentration in the control room need not be considered for further detailed evaluation if the releases are of low frequencies (10^{-6} per year or less) because the resultant low levels of radiological risk are considered acceptable. If demonstrated, an acceptable level of risk may be used by licensees to support license amendment requests.

To facilitate risk-informed license amendments, risk information should be provided in accordance with the guidance set forth in Regulatory Guide 1.174 (Ref. 3). One key principle in risk-informed regulation is that the acceptable level of risk (defined in terms of quantitative health objectives of QHOs) is a small fraction ($\leq$0.1%) of other risks to which the public is exposed. Procedures outlined in the "Framework for Risk-Informed Changes to the Technical Requirements of 10 CFR Part 50," an attachment to SECY-00-0198 (Ref. 6), may also be used as guidelines for quantifying risks. If the level of risk associated with the release of a toxic chemical is not acceptable, detailed control room habitability evaluation should be performed. A method acceptable to the NRC staff for evaluating the habitability of a control room is described in Regulatory Position 3.

3. CONTROL ROOM HABITABILITY EVALUATION

When performing a detailed evaluation of control room habitability during a hazardous chemical release using this guidance, the metric to be used for each chemical is the maximum concentration (toxicity limit) that can be tolerated without physical incapacitation of a control room operator. In deriving the toxicity level in the control room, the detailed calculations should take into account several factors: accident type, release characterization (e.g., release rate, duration), atmospheric dispersion characteristics including prevailing meteorological conditions at the site, and the air exchange rate of the control room. Guidance pertaining to the detailed calculations is provided below. Table 2 of this guide lists the chemical and control room data for an evaluation of control room habitability.

3.1 Toxicity Limits

Table 1 gives the toxicity limits (in ppm by volume and mg/m^3) for the chemicals listed; a more complete list of chemicals and their toxicity limits is provided in Reference 5. These limits are based on the immediately dangerous to life and health (IDLH) exposure level concept (Ref. 7) formulated by the National Institute for Occupational Safety and Health (NIOSH). The IDLH value or limit, based on a 30-minute exposure level, is defined as one that is likely to cause death or immediate or delayed permanent adverse health effects if no protection is afforded within 30 minutes. For each chemical considered, the IDLH limit can be tolerated for 2 minutes without physical incapacitation (for example, severe coughing, eye burn, or severe skin irritation) of an average human. Thus, a 2-minute exposure to the IDLH limits provides an adequate margin of safety in protecting control room operators, and these limits are recommended (Ref. 5). It is expected that a control room operator will take protective measures within 2 minutes (adequate time to don a respirator and protective clothing) after the detection and, therefore, will not be subjected to prolonged exposure at the IDLH concentration levels.

If toxicity limits of released chemicals are not available and no detection instruments are available in the control room for the hazardous chemicals under consideration, the human detection threshold, such as the odor threshold, may be used.

3.2 Accident Types and Release Characteristics

Two types of industrial accidents should be considered for each source of hazardous chemicals: maximum concentration accidents and maximum concentration-duration accidents.

A maximum concentration accident is one that results in a short-term puff or instantaneous release of a large quantity of hazardous chemicals. An example of this type accident would be the failure of a manhole cover on the chemical container or the outright failure of the container itself. Such failure could occur during the transportation of a container as a result of a handling mishap, or it could be caused by naturally or accidently produced environments such as earthquakes, flooding, fire, explosive overpressure, or missiles. A significant inventory could be released in this mode while the balance would be released over an extended period of time.

For a maximum concentration accident involving hazardous chemicals, the instantaneous release of the total contents of one of the following should be considered in the analysis: (1) the largest storage container within the guidelines that is located at a nearby stationary facility, (2) the largest shipping container within the guidelines that is frequently transported near the site (for multiple containers of equal size, the failure of only one container unless the failure of that container could lead to successive failures), or (3) the largest container stored onsite (normally the total release from this container unless the containers are interconnected in such a manner that a single failure could cause a release from several containers).

A maximum concentration-duration accident is one that results in a long-term, low-leakage-rate release. The majority of onsite chlorine releases experienced to date have been of this type, involving leakage from valves or fittings and resulting in a long-term release with a leakage rate from near zero to less than one pound of chlorine per second. Given warning, only breathing apparatus is necessary to protect the control room operator from this kind of release. However, because such a release might continue unabated for many hours, self-contained breathing apparatus, a tank source of air with manifold outlets, or equivalent protection capable of operation for an extended period of time should be available.

For a maximum concentration-duration accident, the continuous release of hazardous chemicals from the largest safety relief valve on a stationary, mobile, or onsite source within the guidelines should be considered.

TABLE 2

CHEMICAL AND CONTROL ROOM DATA FOR HABITABILITY EVALUATION

CHEMICAL

1. Name of hazardous chemical
2. Type of source (stationary or mobile)
3. Human detection (odor) threshold, ppm or mg/m^3 (if available)
4. Toxicity limit (IDLH limit), ppm or mg/m^3
5. Maximum quantity of hazardous chemical involved in incident
6. Maximum continuous release rate of hazardous chemical
7. Vapor pressure, torr, of hazardous chemical (at maximum ambient plant temperature)
8. Fraction of chemical flashed and rate of boiloff when spilling occurs
9. Distance of source from control room
10. Meteorological data

CONTROL ROOM

1. Volume of the control room, including the volume of all other areas supplied by the control room emergency ventilation system
2. Normal flow rates in cubic feet per minute for
   - unfiltered inleakage or makeup air
   - filtered[a] makeup air
   - filtered recirculated air
3. Emergency flow rates for the above
4. Time required to isolate the control room

[a] "Filtered air" refers to the air filtered through filters that have an established removal capability for the particular chemical being considered.

For both types of accidents, release of contents during an earthquake, tornado, or flood should be considered for chemical container facilities that are not designed to withstand these natural events. In the evaluation of control room habitability, it may also be appropriate to consider hazardous chemical releases coincident with the radiological consequences (e.g., of a design basis loss-of-coolant accident for plants that are vulnerable to both events simultaneously) and demonstrate that such coincident events do not produce an unacceptable level of risk.

For chemicals that are not gases at 100°F and normal atmospheric pressure but are liquids with vapor pressures in excess of 10 torr, consideration should be given to the rate of flashing and boiloff to determine the rate of release to the atmosphere and the appropriate time duration of the release. For lighter-than-air gases, the buoyancy effect should be considered in determining the dispersion characteristics.

3.3 Atmospheric Dispersion

The atmospheric transport of a released hazardous chemical should be calculated using a dispersion or diffusion model that permits temporal as well as spatial variations in release terms and concentrations. The NRC uses a computer code, HABIT, for control room habitability evaluation. The HABIT code is described in NUREG/CR-6210, "Computer Codes for Evaluation of Control Room Habitability (HABIT)" (Ref. 8). This code has two modules, EXTRAN and CHEM, for calculation of chemical concentration and exposure, respectively. The model in EXTRAN, a Gaussian plume or puff dispersion model, allows longitudinal, lateral, and vertical dispersions. The model also allows for the effect of wakes and for additional dispersion in the vertical direction when the distance between the release point and the control room is small. Other atmospheric dispersion models (e.g., ARCON96) with similar capabilities may be used for dispersion calculations.

Irrespective of the dispersion model or the analysis tool used, the value of the atmospheric dilution factor between the release point and the control room that is used in the analysis should be that value that is exceeded only 5% of the time.

When boiloff or a slow leak is analyzed, the effects of density on vertical diffusion may be considered if adequately substantiated by reference to data from experiments. The density effect of heavier-than-air gases should not be considered for releases of a violent nature or for released material that becomes entrained in the turbulent air near buildings. The density (buoyancy) effect of lighter-than-air gases may be considered if adequately substantiated by reference to data.

3.4 Control Room Air Flow

The air flows for infiltration, makeup, and recirculation should be considered for both normal and accident conditions. The volume of the control room and all other rooms, including the ventilation systems, that share the same ventilating air, during both normal conditions and accident conditions, should be considered.

The control room and emergency ventilation system should have low-leakage construction. Low-leakage dampers or valves should be installed on the upstream side of recirculation fans or other locations where negative system pressure exists and where inleakage from contaminated atmospheric ambient air is possible.

The inleakage characteristics of the control room envelope during a hazardous chemical challenge should be determined by testing. The testing should be conducted to a recognized industry standard and performed to demonstrate control room envelope inleakage with systems and components configured and operating as they would in the event of a hazardous chemical challenge. Any test determining inleakage should ensure that the control room envelope, its associated ventilation systems, and ventilation systems in adjacent areas are all aligned, functioning, and performing in a manner consistent with the licensing bases.

A comprehensive test identifies all inleakage associated with the envelope. It is not necessary to identify all inleakage sources. However, it is imperative that the testing to determine inleakage be based upon the limiting condition for the type of challenge. This limiting condition may change as systems, components, and operating modes are modified. An effective method that has been used and accepted by the staff to perform a test of envelope inleakage is ASTM E741- 95, "Standard Test Method for Determining Air Change in a Single Zone by Means of a Tracer Gas Dilution" (Ref. 9). Additional guidance on control room envelope inleakage determination for control room habitability testing is being developed and will be published as a regulatory guide.

If credit is taken in the evaluation of the removal of hazardous chemicals by filtration, adsorption, or other means, a technical basis for the dynamic removal capability of the removal system considered should be provided.

4. PROTECTION MEASURES

For adequate protection of the control room operators against the types of accidental releases discussed above, features should be included in the plant design to (1) provide capability to detect such releases, (2) isolate the control room if there is a release, (3) make the control room sufficiently leak tight, and (4) provide equipment and procedures for ensuring the use of breathing apparatus by the control room operators. Provisions that are adequate for the large instantaneous release will also provide protection against the low-leakage-rate release. The guidance for Item 3 is provided in Section 3.4. The guidance for other design features is provided below. Licensees may select and implement specific protection measures as long as these measures ensure adequate protection. Implementation of protection measures for a particular chemical species may be excluded if the detailed evaluation of control room habitability shows that the highest concentration predicted in the control room is below the toxicity limit.

4.1 Detection System

The detection system should be able to detect and signal a concentration level that is significantly lower than the IDLH level, for example, a concentration level of 5 ppm for chlorine. The detection system should be qualified for all expected environments, including severe environments. The system should also be designated as Seismic Category I and be qualified as such. The installation of the detectors should ensure that they are protected from adverse temperature effects. The manufacturer's recommendations for maintenance, testing, and calibration, as well as adjustment to such recommendations that are made by licensees, are acceptable provided they follow sound engineering practices and are compatible with the proposed application.

Human detection, i.e., smell, may be appropriate when no detection instruments are available in the control room for given chemical types.

Quick-response detectors should be located in the fresh air inlets (both normal and emergency air intakes). It may also be appropriate, depending on the design, to have separate channels of detectors for fresh air inlets and to have detectors in the control room envelope ventilation system recirculation lines. The system response time, which incorporates the detection response time, the valve closure time, and associated instrument delays, should be less than or equal to the isolation time.

Remote detectors may be located at storage and unloading locations. These detectors may be placed and the detector trip points adjusted to ensure detection of either a leak or a container rupture. A detector trip signal should isolate the control room before the toxic chemical arrives at the isolation dampers. The detector trip signal should also set off an alarm and provide a readout in the control room. An alternative to the installation of remote detectors would be to provide an isolation system that uses local detectors with a very short isolation time.

4.2 Isolation System

The capability to close the air ducts of the control room with dampers and thus isolate the control room should be considered in the evaluation of control room habitability. For onsite storage, the capability to manually isolate the control room should be provided. Upon detection of a toxic chemical, a detector should initiate complete closure of isolation dampers to the control room with minimal delay. The isolation time is a function of the control room design, in particular, the inleakage characteristics. If the detectors are upstream from the isolation dampers, credit will be allowed for the travel time between the detectors and the dampers.

The isolation system and its components, the recirculating filter system, and the air conditioning system should meet IEEE Std 603-1991, "Criteria for Safety Systems for Nuclear Power Generating Stations" (Ref. 10), since these systems are needed to maintain a habitable environment in the control room during design basis radiological events.

For plants that isolate control rooms, steps should be taken to ensure that the isolated exchange rate is not inadvertently increased by design or operating error. Ventilation equipment for the control room and for the adjacent zones should be reviewed to ensure that enhanced air exchange between the isolated control room and the outside will not occur. All doors leading to the control room should be kept closed when not in use.

4.3 Protection System

If the evaluation of possible accidents for any hazardous chemical indicates that the applicable toxicity limits may be exceeded in the control room, measures should be in place to provide adequate protection to control room operators. The use of full-face self-contained pressure-demand-type breathing apparatus (or the equivalent) and protective clothing should be considered. Adequate air capacity for the breathing apparatus (at least 6 hours) should be readily available onsite to ensure that sufficient time is available to transport additional bottled air from offsite locations. This offsite supply should be capable of delivering several hundred hours of bottled air. Sufficient units of breathing apparatus should be provided for the emergency crew.

Storage provisions for breathing apparatus and procedures for its use should be such that operators can begin using the apparatus within 2 minutes after detection of a hazardous release. Breathing apparatus, air supply equipment, and protective clothing should meet the criterion that a single toxic gas event would not render nonfunctional the total inventory of such protective equipment.

5. EMERGENCY PLANNING

The licensee should have written emergency procedures to be initiated in the event of a hazardous chemical release within or near the plant. These procedures should address both maximum concentration accidents and maximum concentration-duration accidents and should identify the most probable chemical releases at the station. Methods of detecting the event by station personnel, both during normal workday operation and during minimum staffing periods (late night and weekend shift staffing), should be discussed. Special instrumentation that has been provided for the detection of hazardous chemical releases should be described; the description should include the action initiated by the detecting instrument and the level at which this action is initiated. The emergency procedures should describe the isolation of the control room, the use of protective breathing apparatus or other protective measures, and maintenance of the plant in a safe condition, including the capability for an orderly shut down or scram. Criteria and procedures for evacuating nonessential personnel from the station should also be described.

The emergency planning should include training emergency planning personnel on the use of instruments. It should also include periodic drills on the procedures.

Arrangements should be made with Federal, State, and local agencies or other cognizant organizations for the prompt notification of the nuclear power plant when accidents involving hazardous chemicals have occurred within 5 miles of the plant.

D. IMPLEMENTATION

The purpose of this section is to provide information to licensees and applicants regarding the NRC staff's plans for using this revised regulatory guide.

Except in those cases in which an applicant or licensee proposes an acceptable alternative method for complying with specified portions of the NRC's regulations, the methods in this guide that reflects public comments will be used in the evaluation of submittals from operating reactor licensees who voluntarily propose modifications requiring a license amendment related to the control room habitability systems with regard to release of toxic chemicals. Licensees may make use of risk information when requesting a related license amendment. This guide will also be used to evaluate submittals in connection with applications for construction permits, operating licenses, and combined licenses, but not for license renewal if the current licensing basis is maintained. Operating reactor licensees may continue to use the traditional engineering approach for control room habitability evaluation.

REFERENCES

1. USNRC, "Evaluations of Explosions Postulated To Occur on Transportation Routes Near Nuclear Power Plants," Regulatory Guide 1.91, Revision 1, February 1978.[1]

2. USNRC, "Fire Protection for Operating Nuclear Power Plants," Regulatory Guide 1.189, April 2001.[1]

3. USNRC, "An Approach for Using Probabilistic Risk Assessment in Risk-Informed Decisions on Plant-Specific Changes to the Licensing Basis," Regulatory Guide 1.174, July 1998.[1]

4. USNRC, "High-Level Guidelines for Performance-Based Activities," SECY-00-0191, September 2000.[2]

5. L.B. Sasser et al., "Recommendations for Revision of Regulatory Guide 1.78," NUREG/CR-6624, USNRC, July 1999.[3]

6. USNRC, *Framework for Risk-Informed Changes to the Technical Requirements of 10 CFR Part 50,* an attachment to "Status Report on Study of Risk-Informed Changes to the Technical Requirements of 10 CFR Part 50 (Option 3) and Recommendations on Risk-Informed Changes to 10 CFR 50.44 (Combustible Gas Control)," SECY-00-0198, September 14, 2000.[2]

7. NIOSH, "NIOSH Pocket Guide to Chemical Hazards," National Institute for Occupational Safety and Health, 1997.

8. J.V. Ramsdell, Jr., and S.A. Stage, "Computer Codes for Evaluation of Control Room Habitability (HABIT V1.1)," NUREG/CR-6210, Supplement 1 (Prepared for the NRC by Pacific Northwest National Laboratory), USNRC, October 1998.[3]

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[1] Single copies of regulatory guides, both active and draft, may be obtained free of charge by writing the Reproduction and Distribution Services Section, OCIO, USNRC, Washington, DC 20555-0001, or by fax to (301)415-2289, or by email to <DISTRIBUTION@NRC.GOV>. Active guides may also be purchased from the National Technical Information Service on a standing order basis. Details on this service may be obtained by writing NTIS, 5285 Port Royal Road, Springfield, VA 22161; telephone (703)487-4650; online <http://www.ntis.gov/ordernow>. Copies of active and draft guides are available for inspection or copying for a fee from the NRC Public Document Room at 11555 Rockville Pike, Rockville, MD; the PDR's mailing address is USNRC PDR, Washington, DC 20555; telephone (301)415-4737 or (800)397-4209; fax (301)415-3548; email <PDR@NRC.GOV>.

[2] May be read or downloaded from NRC's web site, WWW.NRC.GOV, through The Commission's Activities.

[3] Copies are available at current rates from the U.S. Government Printing Office, P.O. Box 37082, Washington, DC 20402-9328 (telephone (202)512-1800); or from the National Technical Information Service by writing NTIS at 5285 Port Royal Road, Springfield, VA 22161; (telephone (703)487-4650; www.ntis.gov/ordernow. Copies are available for inspection or copying for a fee from the NRC Public Document Room at 11555 Rockville Pike, Rockville, MD; the PDR's mailing address is USNRC PDR, Washington, DC 20555; telephone (301)415-4737 or (800)397-4209; fax (301)415-3548; email is PDR@NRC.GOV.

9. ASTM, “Standard Test Method for Determining Air Change in a Single Zone by Means of a Tracer Gas Dilution, ASTM Standard E741-95, American Society for Testing and Materials, 1995.

10. IEEE, “Criteria for Safety Systems for Nuclear Power Generating Stations, “ IEEE Std 603-1991, Institute of Electrical and Electronics Engineers, 1991.[4]

[4] Copies may be obtained from IEEE Service Center, 445 Hoes Lane, Piscataway, New Jersey 08855-1331.

APPENDIX A

A SIMPLIFIED PROCEDURE FOR CALCULATING WEIGHTS OF HAZARDOUS CHEMICALS FOR CONTROL ROOM EVALUATIONS

The weights presented in the following table are based on a toxicity limit of 50 mg/m^3; air exchange rates of 0.015, 0.06, and 1.2 per hour, respectively; and a Pasquill stability category F representing the worst 5% of meteorological conditions observed at a majority of nuclear plant sites.

WEIGHTS OF HAZARDOUS CHEMICALS THAT REQUIRE CONSIDERATION IN CONTROL ROOM EVALUATIONS (FOR A 50 mg/m^3 TOXICITY LIMIT AND STABLE METEOROLOGICAL CONDITIONS)

Distance From Control Room (miles)[a]	*Weight (1000 lb)*		
	Air Exchange Rate 0.015 per hour	*Air Exchange Rate 0.06 per hour*	*Air Exchange Rate 1.2 per hour*
0.3 to 0.5	9	2.25	0.11
0.5 to 0.7	35	8.75	0.43
0.7 to 1.0	120	30	1.5
1 to 2	270	67.5	3.37
2 to 3	1300	325	16.25
3 to 4	3700	925	46.25
4 to 5	8800	2200	110

[a] All hazardous chemicals present in weights greater than 100 lb within 0.3 mile of the control room should be considered in a control room evaluation.

An air exchange rate of 0.015 (i.e., 0.015 of the control room air by volume is replaced by atmospheric ambient air in one hour) is considered representative of a "tight" control room that has very low-leakage construction features and automatic isolation capabilities. An air exchange rate of 0.06 per hour is considered representative of a control room that has normal leakage construction features and automatic isolation capabilities, whereas an air exchange rate of 1.2 per hour is considered representative of a control room with construction features that are not as efficient for leakage control and without automatic isolation capabilities.

If the toxicity limit, air exchange rate, or meteorological conditions are different from the assumptions used in the table, simple calculations using the following procedures can be performed to determine the weights of hazardous chemicals that are to be considered for the control room evaluation. Note that the weights in the table are based on EXTRAN calculations without the wake effect correction.

Toxicity Limit

The weights presented in the table are directly proportional to the toxicity limit. If a particular chemical has a toxicity limit of 500 mg/m^3, the weights from the table (based on 50 mg/m^3) should be increased by a factor of 10.

Air Exchange Rate

The weights in the table are inversely proportional to the air exchange rate. If a control room has an exchange rate of 2.4 per hour, the weights from the table (based on 1.2 per hour) are decreased by a factor of two. In other words, the weights are appropriately adjusted for the actual fresh air exchange rate. The current crop of control rooms with automatic isolation capabilities may have leakage characteristics different from those listed in the Table. Again, appropriate adjustments of weight should be made based on the actual air exchange rate. It should be noted that the use of an air exchange rate of less than 0.06 per hour for an isolated control room requires that the control room leakage rate be verified by periodic field testing.

Pasquill Stability Category

If it is determined that the worst 5th-percentile meteorology is better (Condition E) or worse (Condition G) than Condition F (the condition used in the table) at a given site, the following adjustments should be made to the table:

Pasquill Stability Category	*Weight Multiplication Factor*
E	2.5
F	1.0
G	0.4

The Pasquill Stability Category F represents the worst 5th-percentile meteorology observed at the majority of the nuclear power plant sites.

REGULATORY ANALYSIS

A draft regulatory analysis was published with the draft of this guide when it was published for public comment (DG-1087, February 2001). No changes were necessary, so a separate value/impact statement for Revision 1 of Regulatory Guide 1.78 has not been prepared. A copy of the draft value/impact statement is available for inspection or copying for a fee in the NRC's Public Document Room at 11555 Rockville Pike, Rockville, MD, under DG-1087. An electronic version of DG-1087 is available in the NRC's Electronic Reading Room under accession number ML010440064.