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**DRAFT REGULATORY GUIDE**

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**DRAFT REGULATORY GUIDE DG-1087**  
(Proposed Revision 1 to Regulatory Guide 1.78)

**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. Regulatory Guide 1.78 (Ref. 1) 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. The 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" (Ref. 2), provides guidance on storing chlorine onsite, describes acceptable design features and procedures for the protection of nuclear power plant control room operators against an accidental onsite chlorine release, and outlines emergency procedures that need to be initiated in the event of a chlorine release.

This proposed Revision 1 of Regulatory Guide 1.78 would incorporate and withdraw Regulatory Guide 1.95 since many regulatory positions in these two guides are the same or

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This regulatory guide is being issued in draft form to involve the public in the early stages of the development of a regulatory position in this area. It has not received complete staff approval and does not represent an official NRC staff position.

Public comments are being solicited on the draft guide (including any implementation schedule) and its associated regulatory analysis or value/impact statement. Comments should be accompanied by appropriate supporting data. Written comments may be submitted to the Rules and Directives Branch, Office of Administration, U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001. Comments may be submitted electronically or downloaded through the NRC's interactive web site at <[WWW.NRC.GOV](http://WWW.NRC.GOV)> through Rulemaking. Copies of comments received may be examined at the NRC Public Document Room, 11555 Rockville Pike, Rockville, MD. Comments will be most helpful if received by **April 10, 2001**.

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similar. The revision would also update 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. 3), nor does it address flammability hazards, which are addressed separately in Regulatory Guide 1.120, "Fire Protection Guidelines for Nuclear Power Plants" (Ref. 4).

Regulatory guides are issued to describe to the public methods acceptable to the NRC staff for implementing specific parts of the NRC's regulations, to explain techniques used by the staff in evaluating specific problems or postulated accidents, and to provide guidance to applicants. Regulatory guides are not substitutes for regulations, and compliance with regulatory guides is not required. Regulatory guides are issued in draft form for public comment to involve the public in developing the regulatory positions. Draft regulatory guides have not received complete staff review; they therefore do not represent official NRC staff positions.

The information collections contained in this draft 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 is being 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. Factors to be considered in the screening process include 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 need be considered only if their release results in displacement of a significant fraction of the control room air.

This proposed revision of Regulatory Guide 1.78 is being developed to update specifications of toxicity limits based on more recent data (Regulatory Position 3), to bring risk insights into the process, and to make the guidance more performance-based. Consistent with risk-informed regulatory decision-making, the proposed 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. 5). At the same time, the revision continues to provide latitude to the

licensees for use of traditional engineering approaches. Also, consistent with the intent of SECY-00-0191 (Ref. 6) on performance-based initiatives, this revision provides performance-based guidance rather than traditional prescriptive guidance.

The June 1974 version of Regulatory Guide 1.78 specifies a 2-minute exposure to given concentration limits of certain toxic chemicals. The 2-minute exposure criterion is based on the time a control room operator is expected to take to don a respirator and protective clothing. The concentration limits are 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. 7). 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 proposed revision combines these two guides, thereby making the positions applicable to all toxic chemicals, including chlorine, that need be considered in the control room habitability evaluation. Combining the two guides will eliminate certain duplication of efforts for licensees in submitting their applications, and will streamline 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 requiring 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. 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 Table 2 for a given toxicity limit and stable meteorological conditions, these sources need not be considered in the evaluation of control room habitability.<sup>1</sup> Appendix A to this guide contains a simplified procedure for adjusting the quantities given in Table 2 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, including chlorine, if 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. Liquified chlorine should not be stored within the close proximity (generally within 330 feet or less) of a control room or its fresh air inlets. Small quantities for laboratory use, 20 pounds or less, are exempt. The maximum allowable chlorine 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. The fresh air inlet is assumed to be at least 15 meters above grade.

If there are several chlorine 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 chlorine 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<sup>2</sup> 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. 7).

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<sup>1</sup> The list of chemicals in Table 1 is not all-inclusive but indicates the more commonly encountered chemicals. A more complete list of chemicals is provided in Reference 7.

<sup>2</sup> 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 FOR SOME HAZARDOUS CHEMICALS**

<i>Chemical</i>	<i>Toxicity Limit<sup>a</sup></i>		<i>Chemical</i>	<i>Toxicity Limit</i>	
	<i>ppm<sup>b</sup></i>	<i>mg/m<sup>3c</sup></i>		<i>ppm</i>	<i>mg/m<sup>3</sup></i>
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		
Carbon monoxide	1200	1320	(compressed or liquified)		asphyxiant
Chlorine	10	30	Sodium oxide	100	520
Ethyl chloride	3800	9880	Sulfur dioxide		15
Ethyl ether	1900	5700	Sulfuric acid	1000	2600
Ethylene dichloride	50	200	Vinyl chloride	900	3915
Ethylene oxide	800	720	Xylene		

<sup>a</sup> Adapted from NUREG/CR-6624, "Recommendations for Revision of Regulatory Guide 1.78" (Ref. 7).

<sup>b</sup> Parts of vapor or gas per million parts of air by volume at 25°C and 760 torr (standard temperature and pressure).

<sup>c</sup> Approximate milligrams of particulate per cubic meter of air, at standard temperature and pressure, based on listed ppm values.

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. For frequent shipments, i.e., shipments exceeding the specified number by traffic type, if the quantity of hazardous chemicals is less than the quantity shown in Table 2 (adjusted for the appropriate toxicity limit, meteorology, and control room air exchange rate), the shipments need not be considered in the analysis.

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 (e.g., technical specifications for toxic gas monitoring system). The guidance for risk

**TABLE 2**

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

<i>Distance From Control Room (miles)<sup>a</sup></i>	<i>Weight (1000 lb)</i>		
	<i>Type A Control Room<sup>b</sup></i>	<i>Type B Control Room</i>	<i>Type C Control Room</i>
0.3 to 0.5	9	2.3	0.1
0.5 to 0.7	35	8.8	0.4
0.7 to 1.0	120	20	1.0
1 to 2	270	52	2.5
2 to 3	1300	280	13
3 to 4	3700	780	33
4 to 5	8800	1400	60

<sup>a</sup> 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.

<sup>b</sup> Control room types: *Type A* - A "tight" control room has low-leakage construction features and the capability to detect at the fresh-air intake those hazardous chemicals stored or transported near the site. Detection of the chemical and automatic isolation of the control room are assumed to have occurred. An air exchange rate of 0.015 per hour is assumed (0.015 of the control room air by volume is replaced with outside air in one hour). The control room volume is defined as the volume of the entire zone serviced by the control room ventilation system.

*Type B* - Same as Type A, but with an air exchange rate of 0.06 per hour. This value is typical of a control room with normal leakage construction features.

*Type C* - A control room that has not been isolated, has no provision for detecting hazardous chemicals, and has an air exchange rate of 1.2 per hour.

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 that do not meet the screening criteria in Regulatory Position 1.1, a licensee may provide risk information to demonstrate that the risk from such releases is small, consistent with the Commission's Safety Goal Policy Statement and with the stated objectives of Criterion 19 of 10 CFR Part 50 for the protection of control room operators. Release events that have low probabilities (10<sup>-6</sup> or less) need not be considered further for detailed evaluation since such events are not likely to result in an unacceptable level of risk. 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. 5) and 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. 8). If the level of risk for a release event 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 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 3 of this guide lists the chemical and control room data needed for an evaluation of control room habitability.

#### **3.1 Toxicity Limits**

Table 1 gives the toxicity limits (in ppm by volume and mg/m<sup>3</sup>) for the chemicals listed; a more complete list of chemicals and their toxicity limits is provided in Reference 7. These limits are based on the immediately dangerous to life and health (IDLH) exposure level concept (Ref. 9) 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 of an average human (for example, severe coughing, eye burn, or severe skin irritation). 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. 7). 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.

The weights presented in Table 2 are directly proportional to the toxicity limit. If a particular chemical has a toxicity limit of 500 mg/m<sup>3</sup>, the weights from the table (based on 50 mg/m<sup>3</sup>) are to be increased by a factor of 10.

If toxicity limits of released chemicals are not available, the values to be used will be determined on a case-by-case basis. The human detection threshold, such as the odor threshold, may be used when no detection instruments are available in the control room for the hazardous chemical under consideration.

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**TABLE 3**

**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<sup>3</sup> (if available)
4. Toxicity limit, ppm or mg/m<sup>3</sup>
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 at cubic feet per minute for
  - unfiltered inleakage or makeup air
  - filtered<sup>a</sup> makeup air
  - filtered recirculated air
3. Emergency flow rates for the above
4. Time required to isolate the control room

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<sup>a</sup> "Filtered air" refers to the air filtered through filters that have an established removal capability for the particular chemical being considered.

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### **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 accidentally 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, the quantity of the hazardous chemical to be considered is the instantaneous release of the total contents of one of the following: (1) the largest storage container within the guidelines of Table 2 that is located at a nearby stationary facility, (2) the largest shipping container within the guidelines of Table 2 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 of Table 2 should be 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 releases coincident with the radiological consequences of a design basis loss-of-coolant accident.

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.

### **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. Such a model is included in the EXTRAN module of the HABIT code described in NUREG/CR-6210, "Computer Codes for Evaluation of Control Room Habitability (HABIT)" (Ref. 10). The model in EXTRAN is a Gaussian plume or puff dispersion model with diffusion coefficients that are functions of time, distance from the release point, and the atmospheric conditions. The 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. The model assumes uniform mixing between the ground and the elevation of the fresh air inlet (a 15-meter elevation from ground level is used).

Other atmospheric dispersion models can be used for dispersion calculations as long as these models have the essential features described above. In other words, the models are to be capable of calculating spatial and temporal variations in release terms and concentrations, simulating wake effect, and simulating near-field effect. Moreover, the models should have a validation data base.

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.

### **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 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 chlorine-contaminated outside air is possible.

In calculating the rate of air infiltration (air leaking into the control room from ducts, doors, or other openings) with the control room isolated and not pressurized, a pressure differential of 1/8-inch water gauge across all leak paths<sup>3</sup> should be used. The use of a higher pressure differential is acceptable provided the flow rate is conservatively adjusted to correspond to 1/8-inch water gauge. Also, the maximum design pressure differential for fresh air dampers on the suction side of recirculation fans should be used.

The use of a calculated infiltration rate is acceptable except when the rate is too low; an equivalent air exchange rate of less than 0.06 per hour when all penetrations are exposed to a 1/8-inch water gauge pressure differential is considered low. For low exchange rates, periodic verification testing should be performed. Testing is also recommended after any major alteration that may affect the control room leakage. To account for the possible increase in air exchange caused by ingress or egress, an additional leakage (10 cfm of unfiltered air is a recommended value) should be assumed for those control rooms without airlock.

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<sup>3</sup> The pressure differential accounts for wind effects, thermal column effects, and barometric pressure changes. It does not account for pressure differences resulting from the operation of ventilation systems supplying zones adjacent to the control room. It should be adjusted appropriately when the ventilation system supplies zones adjacent to the control room.

For onsite chlorine containers with an inventory of more than 150 pounds that are in the proximity of the control room, the normal fresh air makeup rate should be less than one air exchange per hour.

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

#### **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) automatically 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 each of the above design features is provided below. Licensees have the flexibility to select and implement specific protection measures as long as these ensure adequate protection.

##### **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 chlorine, a concentration level of 5 ppm is recommended. 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 are acceptable provided they follow sound engineering practices and are compatible with the proposed application.

Human detection, i.e., smell, may be appropriate if the buildup of the hazardous chemical in the control room is at a slow rate because the air turnover is slow, or when no detection instruments are available in the control room for given chemical types. The use of smell as detection will be considered on a case-by-case basis.

Quick-response detectors should be located in the fresh air inlets. Two separate channels of detectors for each fresh air inlet are recommended. 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 required 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 is to automatically 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 but has a very short isolation time. This can be accomplished by ensuring that the time required for a toxic chemical to travel from the

local detector to the isolation damper, within the inlet ducting, is equal to or greater than the time required to detect the chemical and close the isolation damper.

## **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. 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. For most control rooms, this time should be less than or equal to 10 seconds. 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. 11), 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.

For onsite chlorine storage, the capability to manually isolate the control room should be provided. If there is a chlorine release, exhaust fans should be stopped or isolated from the control room ventilation zone by low-leakage dampers or valves. If there is a chlorine release after control room isolation, the emergency recirculating charcoal filter or equivalent equipment designed to remove or otherwise limit the accumulation of chlorine within the control room should be started up and operated.

## **4.3 Protection System**

If the evaluation of possible accidents for any hazardous chemical, including chlorine, indicates that the applicable toxicity limits may be exceeded, the use of full-face self-contained pressure-demand-type breathing apparatus (or the equivalent) and protective clothing should be considered when developing a hazardous chemical release emergency plan. 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 single-failure criterion, i.e., redundancy and physical separation to accomplish decoupling of the effects of unsafe environmental factors, electric transients, physical accidents, and component failure.

## **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, stating its sensitivity, the action initiated by the detecting instrument and the level at which this action is initiated, technical specification limitations on instrument availability, and instructions for maintenance, calibration, and testing. 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.

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 applicants or licensees regarding the NRC staff's plans for using this revised regulatory guide.

This proposed revision is being released to encourage public participation in its development. 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 method to be described in the revised guide reflecting public comments will be used in the evaluation of applications to renew operating licenses.

## REFERENCES

1. USAEC, "Assumptions for Evaluating the Habitability of a Nuclear Power Plant Control Room During a Postulated Hazardous Chemical Release," Regulatory Guide 1.78, U.S. Atomic Energy Commission, June 1974.<sup>1</sup>
2. USNRC, "Protection of Nuclear Power Plant Control Room Operators Against an Accidental Chlorine Release," Regulatory Guide 1.95, Revision 1, January 1977.<sup>1</sup>
3. USNRC, "Evaluations of Explosions Postulated To Occur on Transportation Routes Near Nuclear Power Plants," Regulatory Guide 1.91, Revision 1, February 1978.<sup>1</sup>
4. USNRC, "Fire Protection Guidelines for Nuclear Power Plants," Regulatory Guide 1.120, Revision 1, November 1977.<sup>1</sup>
5. 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.<sup>1</sup>
6. USNRC, "High-Level Guidelines for Performance-Based Activities," SECY-00-0191, September 2000.<sup>2</sup>
7. L.B. Sasser et al., "Recommendations for Revision of Regulatory Guide 1.78," NUREG/CR-6624, Pacific Northwest National Laboratory, July 1999.<sup>3</sup>
8. 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.<sup>2</sup>
9. NIOSH, "NIOSH Pocket Guide to Chemical Hazards," National Institute for Occupational Safety and Health, 1997.

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<sup>1</sup> Single copies of regulatory guides, both active and draft, and draft NUREG documents 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 Mail Stop LL-6, Washington, DC 20555; telephone (301)415-4737 or (800)397-4209; fax (301)415-3548; email <[PDR@NRC.GOV](mailto:PDR@NRC.GOV)>.

<sup>2</sup> May be read or downloaded from NRC's web site, [WWW.NRC.GOV](http://WWW.NRC.GOV), through The Commission's Activities.

<sup>3</sup> 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](http://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](mailto:PDR@NRC.GOV).

10. S.A. Stage, "Computer Codes for Evaluation of Control Room Habitability (HABIT)," NUREG/CR-6210 (Prepared for the NRC by Pacific Northwest National Laboratory), USNRC, June 1996.<sup>3</sup>
11. Institute of Electrical and Electronics Engineers, "Criteria for Safety Systems for Nuclear Power Generating Stations," IEEE Std 603-1991, 1991.<sup>4</sup>

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<sup>4</sup>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 (a duplicate of Table 2 in DG-1087) are based on a toxicity limit of 50 mg/m<sup>3</sup>; air exchange rates for the three control room types (A, B, and C) 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.

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

<i>Distance From Control Room (miles)<sup>a</sup></i>	<i>Weight (1000 lb)</i>		
	<i>Type A Control Room<sup>b</sup></i>	<i>Type B Control Room</i>	<i>Type C Control Room</i>
0.3 to 0.5	9	2.3	0.1
0.5 to 0.7	35	8.8	0.4
0.7 to 1.0	120	20	1.0
1 to 2	270	52	2.5
2 to 3	1300	280	13
3 to 4	3700	780	33
4 to 5	8800	1400	60

<sup>a</sup> 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.

<sup>b</sup> Control room types: *Type A* - A "tight" control room has low-leakage construction features and the capability to detect at the fresh-air intake those hazardous chemicals stored or transported near the site. Detection of the chemical and automatic isolation of the control room are assumed to have occurred. An air exchange rate of 0.015 per hour is assumed (0.015 of the control room air by volume is replaced with outside air in one hour). The control room volume is defined as the volume of the entire zone serviced by the control room ventilation system.

*Type B* - Same as Type A, but with an air exchange rate of 0.06 per hour. This value is typical of a control room with normal leakage construction features.

*Type C* - A control room that has not been isolated, has no provision for detecting hazardous chemicals, and has an air exchange rate of 1.2 per hour.

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These conditions are generally applicable to toxic gases for most of today's plants. 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.



## 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<sup>3</sup>, the weights from the table (based on 50 mg/m<sup>3</sup>) are to 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 type C 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. When adjustments of this type are made, the control room type (A, B, or C) that has an air exchange rate closest to that of the control room in question should be selected.

For control rooms without automatic isolation capability, the weights for Type C control rooms should be used, appropriately adjusted for the actual fresh air exchange rate. Weights for Type B control rooms should be used when the control room has automatic isolation. Weights for Type A control rooms, appropriately adjusted for the design isolated air exchange rate, should be used only when the control room has been designed specifically for low inleakage. 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 5-percentile meteorology is better (Condition E) or worse (Condition G) than Condition F (the condition used in the table), the following adjustments should be made to the table:

<i>Pasquill Stability Category</i>	<i>Weight Multiplication Factor</i>
E	2.5
F	1.0
G	0.4

## **REGULATORY ANALYSIS FOR REVISING REGULATORY GUIDES 1.78 AND 1.95**

This regulatory analysis evaluates the benefits (values) and the costs (impacts) associated with revising Regulatory Guides 1.78 and 1.95. The values include a potential reduction of public health risk, occupational risk for control room operators, and unnecessary regulatory burden, as well as an increase in regulatory efficiency. The impacts include costs to the industry and to the NRC of implementing the revision.

### **ANALYSIS OF BENEFITS AND COSTS**

#### **Public Health Risk**

A release of a hazardous chemical would not by itself result in a core damage event. For a core damage event to result from the control room operators' inability to function, the hazardous chemical in sufficient quantity would have to be transported from the accident scene to the control room air intake by a credible atmospheric transport mechanism and the control room concentration would have to exceed the specified toxicity limit. This means the wind direction would have to be from the accident scene to the control room. In addition, the weather would have to be relatively calm or the released chemicals would be dispersed quickly and not reach concentrations that could affect an operator's ability to perform required actions.

The baseline public health risk is a measure of contribution to core damage frequency from a hazardous chemical release event and the consequences associated with such an event, i.e., the quantitative health effect. Noting that any changes to a plant's overall core damage frequency that result from the revisions to Regulatory Guides 1.78 and 1.95 would be very small if any (since the baseline contribution is very small to start with), it is reasonable to conclude that an increase in public health risk would not be appreciable in the overall context.

#### **Occupational Health Risk**

The occupational health attribute measures the change in risk to control room operators that would result from changes in accident frequencies and consequences brought about by the proposed revisions. The revisions to Regulatory Guides 1.78 and 1.95 would have minimal, if any, impact on occupational health risk. Incorporation of the immediately dangerous to life and health (IDLH) values as the proposed toxicity limits may be viewed as a relaxation of control room habitability requirements. However, the control room operators are still expected to take protective measures within 2 minutes after detection of a hazardous chemical in the control room atmosphere. Noting that the detection thresholds are significantly lower than the IDLH values and that most chemicals take time to build up concentrations to the IDLH level, it is reasonable to assume that the 2-minute concentrations would be significantly lower than the IDLH values for most chemicals. Thus, occupational health impacts appear to be insignificant.

#### **Offsite/Onsite Property**

This measure of the monetary effect on property, offsite as well as onsite, is calculated as the product of the change in core damage frequency and the property

consequences as a result of a core damage accident (e.g., interdiction, cleanup, and evacuation costs). As with public health risk and occupational health risk, the change in core damage frequency that would result from revising Regulatory Guides 1.78 and 1.95 would be very small, if any. Therefore, the impact of the proposed revisions on offsite or onsite property would be insignificant.

### **Implementation by Industry and the NRC**

The implementation costs for a licensee would consist of labor costs to update the plant's Safety Analysis Report (SAR) as necessary and costs associated with new requirements, if any, to perform routine or recurring activities related to surveillance and maintenance programs, operation of chemical detection systems, operator training, etc. NRC's costs for implementation would be a one-time cost to revise Regulatory Guide 1.78, recurring costs associated with reviewing the required licensee reports, and possibly additional inspection and enforcement activities if necessary to monitor licensee implementation.

New requirements for the existing control room habitability systems are not likely to arise. Relaxation of technical specifications may be anticipated, in particular, if the licensees choose to use a risk-informed and performance-based approach for exemption or modification of toxic gas monitoring system requirements. This may result in some cost savings. Even more significant cost savings could result from reducing plant shutdowns caused by spurious actuation of chemical detection systems and control room emergency ventilation systems.

Periodic reviews and inspections related to Regulatory Guides 1.78 and 1.95 and other recurring activities by NRC staff are anticipated to change little, if any, with respect to the efforts to monitor implementation of the revised guidance. Therefore, the incremental costs would be insignificant with respect to the costs of current activities.

### **Regulatory Burden and Regulatory Efficiency**

The revision of Regulatory Guide 1.78 would include an updated list of chemicals and toxicity limits, which would result in more consistent and comprehensive control room habitability evaluations. Improvements in atmospheric dispersion and control room ventilation flow models will further increase confidence in the evaluation process and in risk assessment. Implementation of the revised guidance would be expected to reduce licensee burden in the form of cost savings that could result from reducing plant shutdowns from the spurious actuation of chemical detection systems and control room emergency ventilation systems. Administratively, combining Regulatory Guide 1.78 with Regulatory Guide 1.95 would eliminate certain duplication of efforts for licensees in submitting their applications. The NRC staff review process would also be streamlined, thus reducing review time and increasing efficiency.

### **DECISION**

The considerations of public health risk, occupational health risk for control room operators, economic impacts, regulatory burden reduction, and regulatory efficiency indicate that Regulatory Guides 1.78 and 1.95 should be combined and revised. Therefore, it is recommended that a proposed revision to Regulatory Guide 1.78, which

incorporates Regulatory Guide 1.95, should be issued. The proposed Revision 1 should be issued first as a draft guide to obtain public comments.