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TOXIC CHEMICAL RISK ACCEPTANCE CRITERIA (U)

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TOXIC CHEMICAL RISK ACCEPTANCE CRITERIA

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(Westinghouse M & O Subcommittee on Non-Radiological Risk Acceptance Criteria Development)

ABSTRACT

This paper presents recommendations of a subcommittee of the Westinghouse M & O Nuclear Facility Safety Committee. Two sets of criteria have been developed, one for use in the hazard classification of facilities, and the second for use in comparing risks in DOE non-reactor nuclear facility Safety Analysis Reports.

The Emergency Response Planning Guideline (ERPG) values are intended to provide estimates of concentration ranges for specific chemicals above which exposure would be expected to lead to adverse health effects of increasing severity for ERPG-1, -2, and -3s. The subcommittee recommends that criteria for hazard class or risk range be based on ERPGs for all chemicals. Probability-based Incremental Cancer Risk (ICR) criteria are recommended for additional analyses of risks from all known or suspected human carcinogens. Criteria are given for both on-site and off-site exposure. The subcommittee also recommends that the 5-minute peak concentration be compared with the relevant criterion with no adjustment for exposure time.

Since ERPGs are available for only a limited number of chemicals, the subcommittee has developed a proposed hierarchy of concentration limit parameters for the different criteria. The subcommittee recommends that these parameters be used on the basis of availability in the order presented. This hierarchy was developed from an analysis of the parameters available for 86 chemicals. These include all those for which ERPGs are available or under active development, the additional chemicals for which the National Academy of Sciences has developed Exposure Guidance Levels for military use, and all chemicals on the DOE Emergency Management Advisory Committee priority list for ERPG development.

Scope: The criteria system presented in this document applies to airborne releases of toxic or carcinogenic material evaluated for the purposes of risk assessment and hazard classification. The criteria system does not apply to other nonradiological hazards such as fire, pressure release (including explosions), and reactivity.

Introduction: As prescribed by Department of Energy (DOE) orders, all DOE contractors responsible for the design, construction and operation of DOE non-reactor nuclear facilities must perform hazard assessments and safety analyses for all onsite facilities and operations. It has become evident in fulfilling these requirements per DOE directives that there is a need for the development of scientifically valid criteria to be used in quantitative assessments of the health and environmental risks associated with the accidental release of toxic chemicals. To address this need, the Westinghouse M & O Nuclear Facility Safety Committee formed the Subcommittee on Nonradiological Risk Acceptance Criteria Development. to evaluate criteria currently in use at Westinghouse M & O sites and to develop a uniform approach to the analyses of toxic chemical hazards.

This paper presents the subcommittee's evaluation and recommendations regarding analyses of accidentally released toxic chemicals. The recommendations reported herein are restricted to the airborne pathway because in an accident scenario this typically represents the most immediately significant route of public exposure.

The general definitions of hazards is provided in DOE Order 5481.1B: There is considerable site-to-site variability in the quantitative interpretations of these definitions (see Tables 1 and 2). Other problems associated with the criteria currently used for hazard assessments and risk evaluations include the use of fixed fractions and multiples of exposure parameters. This practice ignores the fact that the slopes of the dose-response curves of individual chemicals vary considerably. A second problem is the use of workplace explosure limits (TLV values, IDLH values) to evaluate consequences of an accidental release of a toxic chemical. These occupational parameters are based upon a very specific risk population and are not intended to be used for evaluating exposure to the general public, particularly to sensitive subgroups such as the young, aged and physiologically impaired. This problem is partially offset by the fact that TLV-TWA values were developed for assessing chronic occupational exposures over an 8-hour day, 40-hour work week and, therefore, their use as exposure limits in consequence analyses of acute exposure to accidental releases of toxic chemicals is conservative. Although IDLH values were established for acute (30 minute) accidental exposure scenarios, their use as a criterion for evaluating accidental releases of chemical hazards is problemmatic since they represent inconsistant estimates of toxicity.

Recommended Criteria: The primary nonradiological criteria recommended for hazard classification and risk assessment are presented in Tables 3 and 4, respectively. Both acute toxic and latent carcinogenic effects are addressed. An analysis of all the concentration limit parameters that could be found for a list

of 86 hazardous chemicals was carried out. Results are summarized in Table 5. Recommended alternate concentration criteria based on this analysis are provided in Table 6 for use when values for the primary concentration criteria have not yet been published. Graphical representations of these risk and hazard classification criteria are presented in Figures 1 and 2, respectively. Concentrations must be calculated as 5-minute peaks using 50% meteorology. No credit may be taken for plume meander or building wake effects. Acute health effects associated with concentration criteria are presented in Table 7.

Application of Criteria: The subcommittee recommends that the hazard classification and risk assessment criteria be applied as follows:

Pathway: The criteria apply to the airborne pathway, i.e. inhalation exposure, only.

Exposure time: Concentrations for comparison with the criteria must be calculated as 5-minute average peak concentrations, using 50% meteorology. No credit may be taken for plume meander or building wake effects.

Carcinogens: For known or suspected human carcinogens, the incremental cancer risk (ICR) is calculated using the EPA's IRIS database values for the chemical-specific slope factor [q_1^* in $(mg/kg/d)^{-1}$ or $(mg/m^3)^{-1}$]. Adjustments between units are made assuming that a person weighing 70 kg breathes 20 m^3 a day. The calculated concentration (in mg/m^3) for the scenario of concern is averaged over a lifetime of 70 years, then adjusted upward by a factor of 5 to account for the additional risk from acute exposures. Both concentration and cancer risk criteria must be met for known or suspected human carcinogens.

Receptor distance: The onsite receptor is assumed to be at a distance of 100 meters from the release in the sector with the least atmospheric dispersion. The offsite receptor is assumed to be at the site boundary location with the least atmospheric dispersion.

Dispersion models: The straight-line Gaussian dispersion model should be used for hazard classification evaluations. Atmospheric models appropriate for the scenario being evaluated should be used in risk assessments (e.g., dense gas model, buoyant plume model, straight-line Gaussian plume model).

parameter hierarchy:

The primary criteria should be used if values for the chemicals of interest have been published. The Table 5 hierarchy of alternative concentration parameters is to be used, in the order presented, on the basis of availability of parameters for the chemicals of interest . Note that even though the concentration limit parameters used as criteria are associated with averaging times other than 5 minutes (such as up to 1 hour for the ERPGs, 15 minutes for the STELs, and 8 hours for the TWAs), the concentrations calculated for comparison must be calculated as the 5-minute average peak concentration and not as the peak concentration for the time period associated with the criterion.

Table 1
Criteria Currently Used at Westinghouse M&O Nuclear Facilities to Classify Nonradiological Chemical Hazards

		M & O FACILITY			
LOCATION	HAZARD CLASS	WHC	WSRC*	WINCO & WWVNC	WEMCO
Onsite	General	N/A	< ERPG-1 < 0.1 x IDLH < 5E-5 ICR	N/A	N/A
	Low	≤ PAG	< ERPG-2 < IDLH < 5E-4 ICR	≤ 5injuries	< IDLH
	Moderate	≤ 2 x PAG	< ERPG-3 < 5 x IDLH < 1E-2 ICR	≤ 10 injuries and/or ≤ 5 fatalities	< 5 x IDLH
	High	> 2 x PAG	≥ ERPG-3 ≥ 5 x IDLH ≥ 1E-2 ICR	> 10 injuries and/or > 5 fatalities	> 5 x IDLH
Offsite	General	N/A	≤ 0.01 x IDLH < 1E-6 ICR	N/A	N/A
	Low	≤ TLV-TWA	< ERPG-1 < 0.1 x IDLH < 5E-5 ICR	< TLV**	< TLV-TWA***
	Moderate	≤ PAG	< ERPG-2 < IDLH < 5E-4 ICR	≤ 5 injuries < TLV**	< IDLH
	High	> PAG	≥ ERPG-2 ≥ IDLH ≥ 5E-4 ICR	> 5 injuries and/or > 1 fatality ≥ IDLH	≥ IDLH

1 PAG ~ 0.5 x IDLH

* WSRC protocol is to use ERPG values first; if ERPG value is not available, then IDLH is used. ICR.is calculated for all known or suspected human carcinogens.

** WWVNSC uses air concentrations averaged over 1 hour to compare to TLV values.

*** WEMCO uses air concentrations averaged over 30 minutes to compare to TLV values.

Table 2
Toxic Chemical Risk Acceptance Criteria Currently In Use at Westinghouse M&O Nuclear Facilities

		M & O NUCLEAR FACILITY			
LOCATION	FREQUENCY RANGE	WHC*	WSRC**	WINCO & WWVNSC	WEMCO
Onsite	1E-6 to 1E-4	2 x PAG IDLH	ERPG-3 5 x IDLH 1E-2 ICR	N/A	N/A
	1E-4 to 1E-2		ERPG-2 IDLH 5E-4 ICR	N/A	N/A
	1E-2 to 1	TLV-C TLV-STEL TLV-TWA	ERPG-1 0.1 x IDLH 5E-4 ICR	N/A	N/A
Offsite	1E-6 to 1E-4	PAG 0.5 x IDLH	ERPG-2 IDLH 5E-4 ICR	N/A	N/A
	1E-4 to 1E-2		ERPG-1 0.1 x IDLH 5E-5 ICR	N/A	N/A
	1E-2 to 1	TLV-TWA	0.01 x IDLH 1E-6 ICR	N/A	N/A

* WHC determines the concentrations acceptable at different risk levels from a linear interpolation between the concentration limits stated above plotted as a function of the annual probability of occurrence (1E-6 or 1, as indicated above) on a log-log plot.

Table 3
Recommended Nonradiological Hazard Classification Criteria

	PRIMARY CONCENTRATION / CANCER RISK CRITERIA	
Hazard Classification	Onsite (at 100 m)	Offsite (at site boundary)
High	≥ ERPG-3 ≥ 1E-2 ICR	≥ ERPG-2 ≥ 5E-4 ICR
Moderate	≥ ERPG-2 ≥ 5E-4 ICR	≥ OSHA STEL ≥ 5E-5 ICR
Low	≥ OSHA STEL ≥ 5E-5 ICR	≥ OSHA TWA ≥ 1E-6 ICR
None	< OSHA STEL < 5E-5 ICR	< OSHA TWA < 1E-6 ICR

Table 4
Recommended Nonradiological Risk Criteria

	PRIMARY CONCENTRATION / CANCER RISK CRITERIA	
Event Frequency (yr^{-1})	Onsite (at 100 m)	Offsite (at site boundary)
$\leq 10^{-6}$ to $<10^{-4}$	≤ ERPG-3 ≤ 1E-2 ICR	≤ ERPG-2 ≤ 5E-4 ICR
$\geq 10^{-4}$ to $<10^{-2}$	≤ ERPG-2 ≤ 5E-4 ICR	≤ OSHA STEL ≤ 5E-5 ICR
$\geq 10^{-2}$ to $<10^{0}$	≤ OSHA STEL ≤ 5E-5 ICR	≤ OSHA TWA ≤ 1E-6 ICR

Table 5: Ratios of Selected Concentration Limit Parameters

No	Parameter	Range	Parameter Ratio			No. of Ratios*	
			Ratio	Mean	Std Dev%	N	n
1	OSHA TWA		1:2	0.97	64	56	54
2	ACGIH TLV	A	1:3	6.33	54	22	20
3	CEGL		2:3	5.78	65	21	19
4	OSHA STEL		4:5	1.85	61	12	8
5	ERPG-1	B	4:6	1.01	27	23	23
6	ACGIH STEL		5:6	0.87	96	12	9
7	ERPG-2		7:8	1.33	67	9	7
8	EEGL(60 min)		7:9	1.98	88	20	17
9	LOC	C	7:10	1.53	109	4	4
10	OSHA C		8:9	1.25	53	12	10
11	ACGIH C		8:10	1.46	93	13	11
			9:10	1.32	68	6	5
12	ERPG-3		12:13	2.58	85	4	3
13	EEGL(30 min)	D	12:14	0.67	74	22	20
14	IDLH		13:14	0.32	72	10	8

* N = Total number of available comparisons
n = Number of comparisons used to calculate means and standard deviations, after exclusion of outlier values.

Table 6: Recommended Alternate Concentration Criteria

PRIMARY CRITERION	ALTERNATE CRITERIA	SOURCE
ERPG-3		AIHA
	EEGL (30 min)	NAS
	IDLH	NIOSH
ERPG-2		AIHA
	EEGL (60 min)	NAS
	LOC	EPA/FEMA/DOT
	PEL-C	OSHA
	TLV-C	ACGIH
PEL-STEL		OSHA
	ERPG-1	AIHA
	TLV-STEL	ACGIH
PEL-TWA		OSHA
	TLV-TWA	ACGIH
	CEGL	NAS

Table 7
Acute Health Effects Associated with Primary Concentration Criteria

Potential life threatening effects

----------ERPG-3----------

Irreversible or other serious health effects or symptoms which could impair an individual's ability to take protective action

----------ERPG-2----------

Irritation
Chronic or irreversible tissue damage
Narcosis (potential prevention of taking protective action)

----------OSHA STEL ----------

No appreciable risk of deleterious effects in the worker population
Potential health effects in sensitive populations of the general public (including children, the aged, and the ill)

----------OSHA TWA----------

No appreciable risk of deleterious effects in the general population (including sensitive individuals such as children, the aged, and the ill)

NOTE: Concentrations are listed in decreasing order.

Figure 1
Graphical Representation of Recommended Nonradiological Hazard Classification Criteria

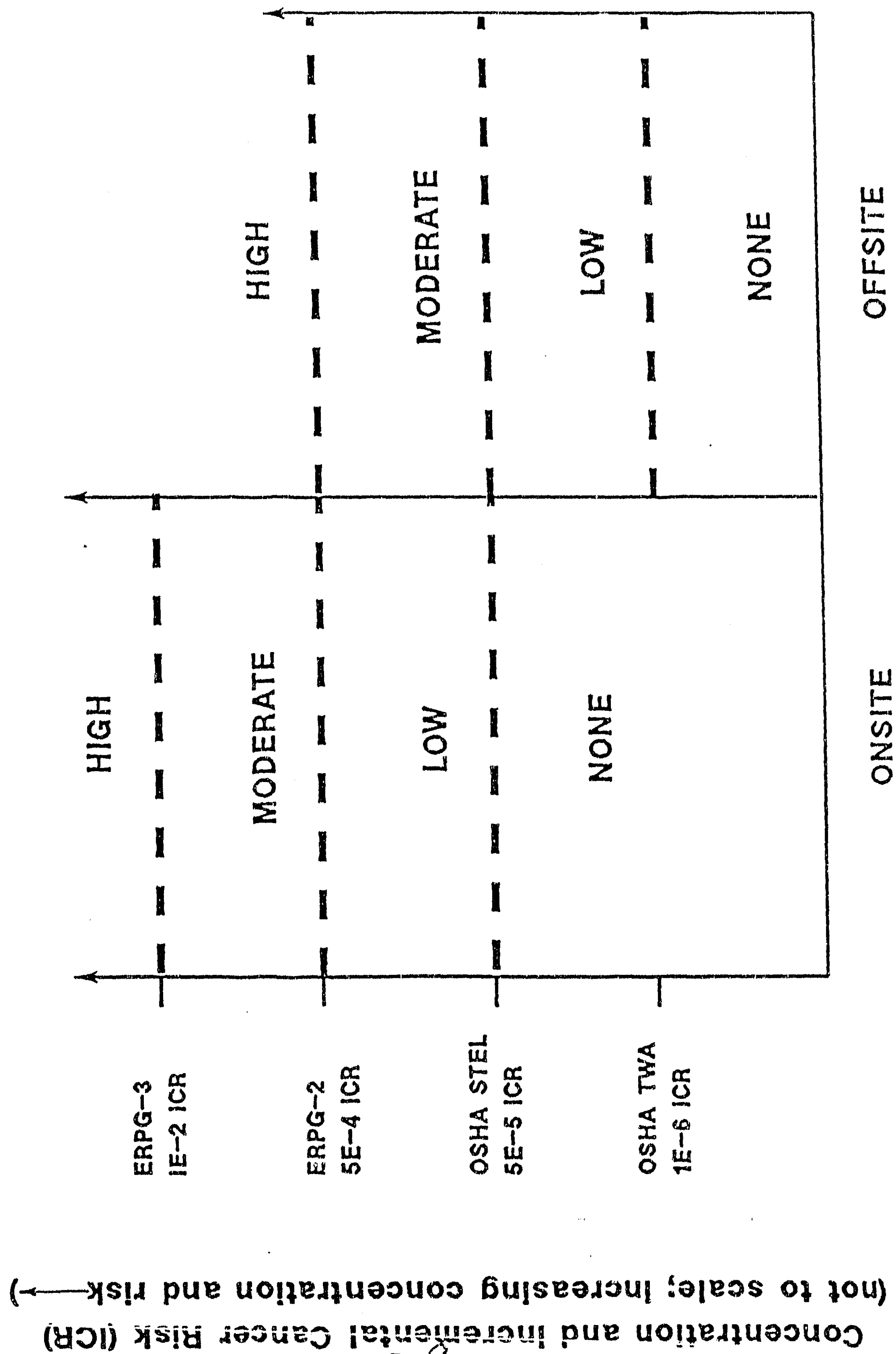


Figure 2
Graphical Presentation of Recommended Nonradiological Risk Criteria

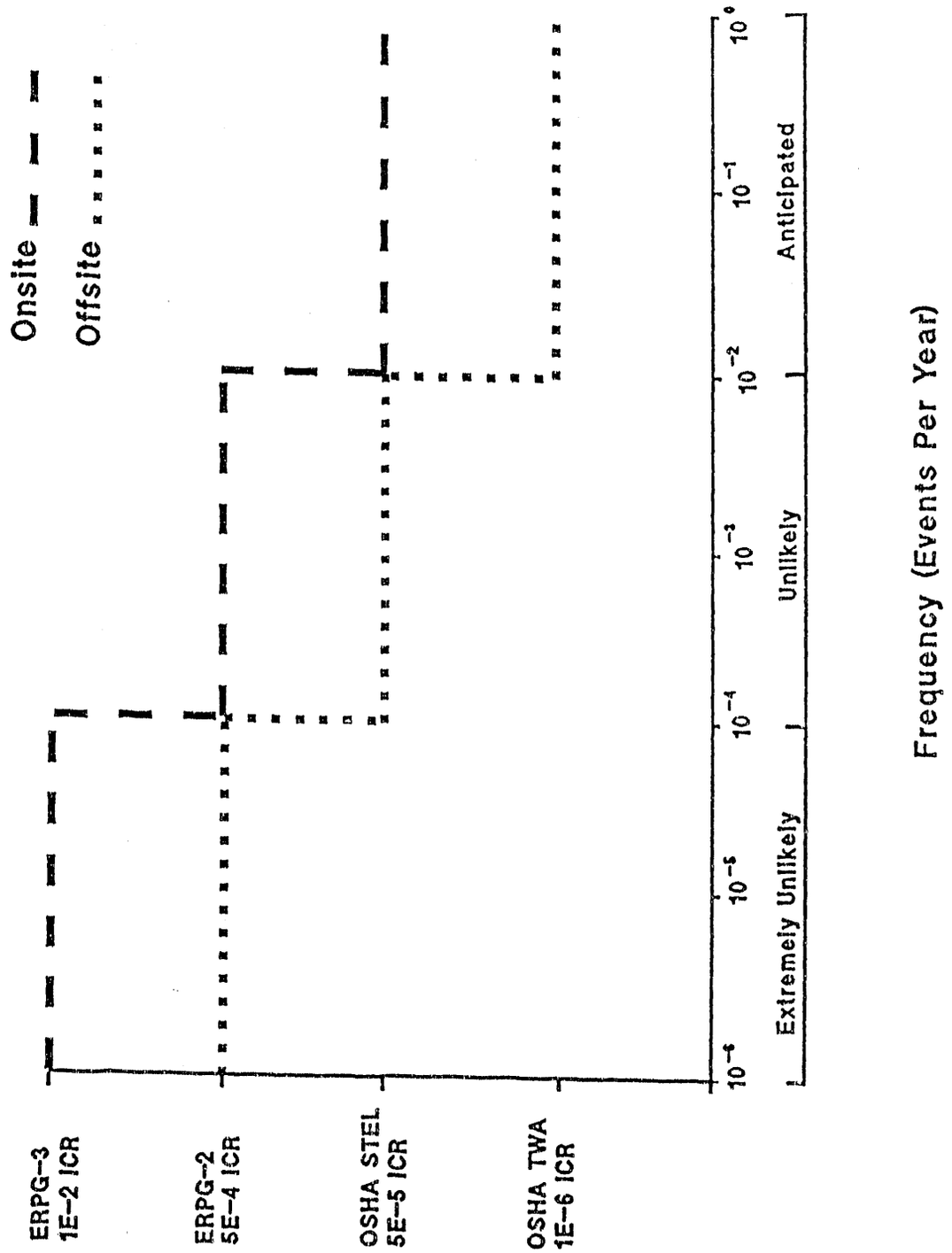


Figure 3: Alternative Conc. Criteria versus PEL-TWA

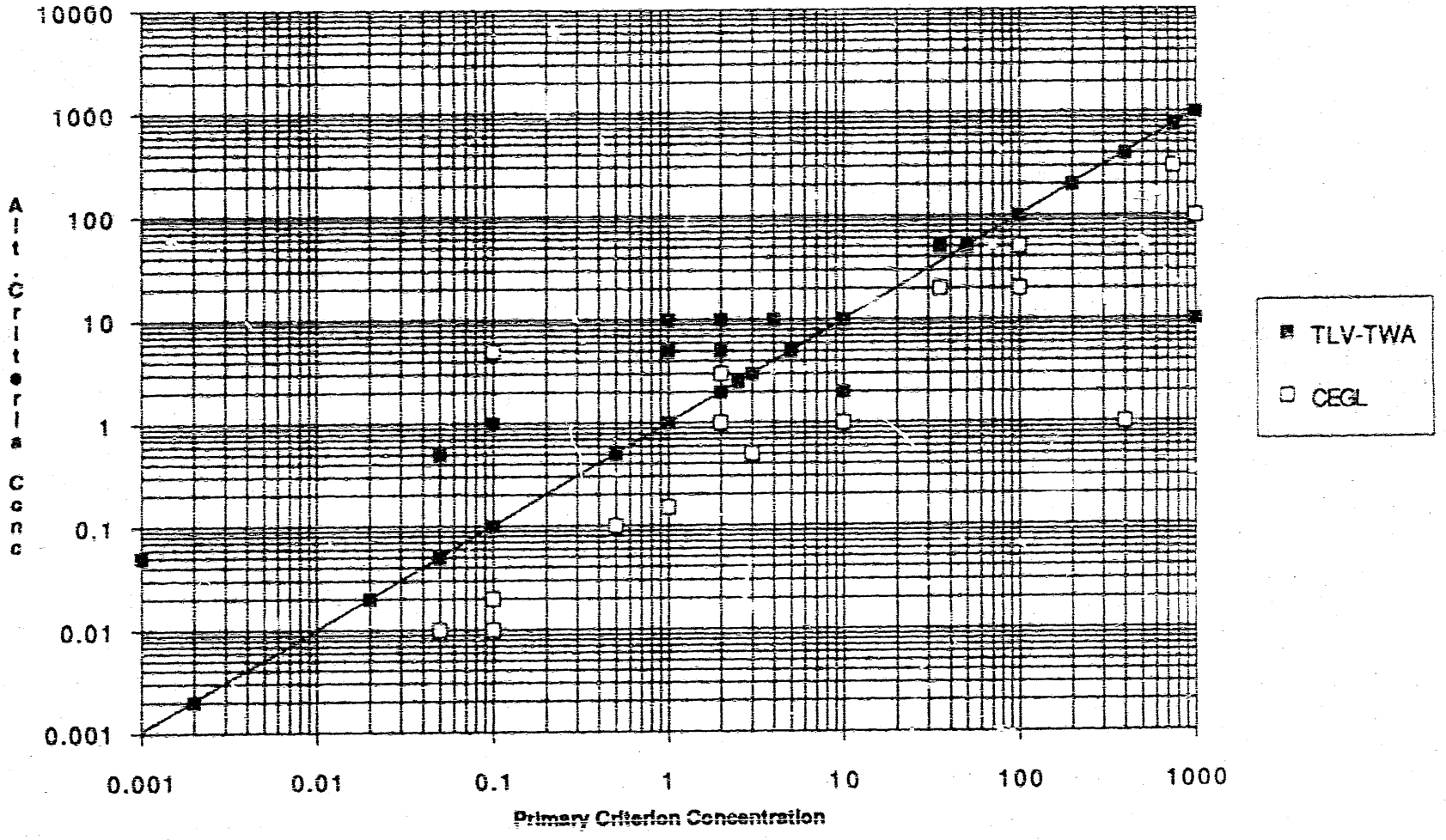


Figure 4: Alternative Conc. Criteria versus PEL-STEL

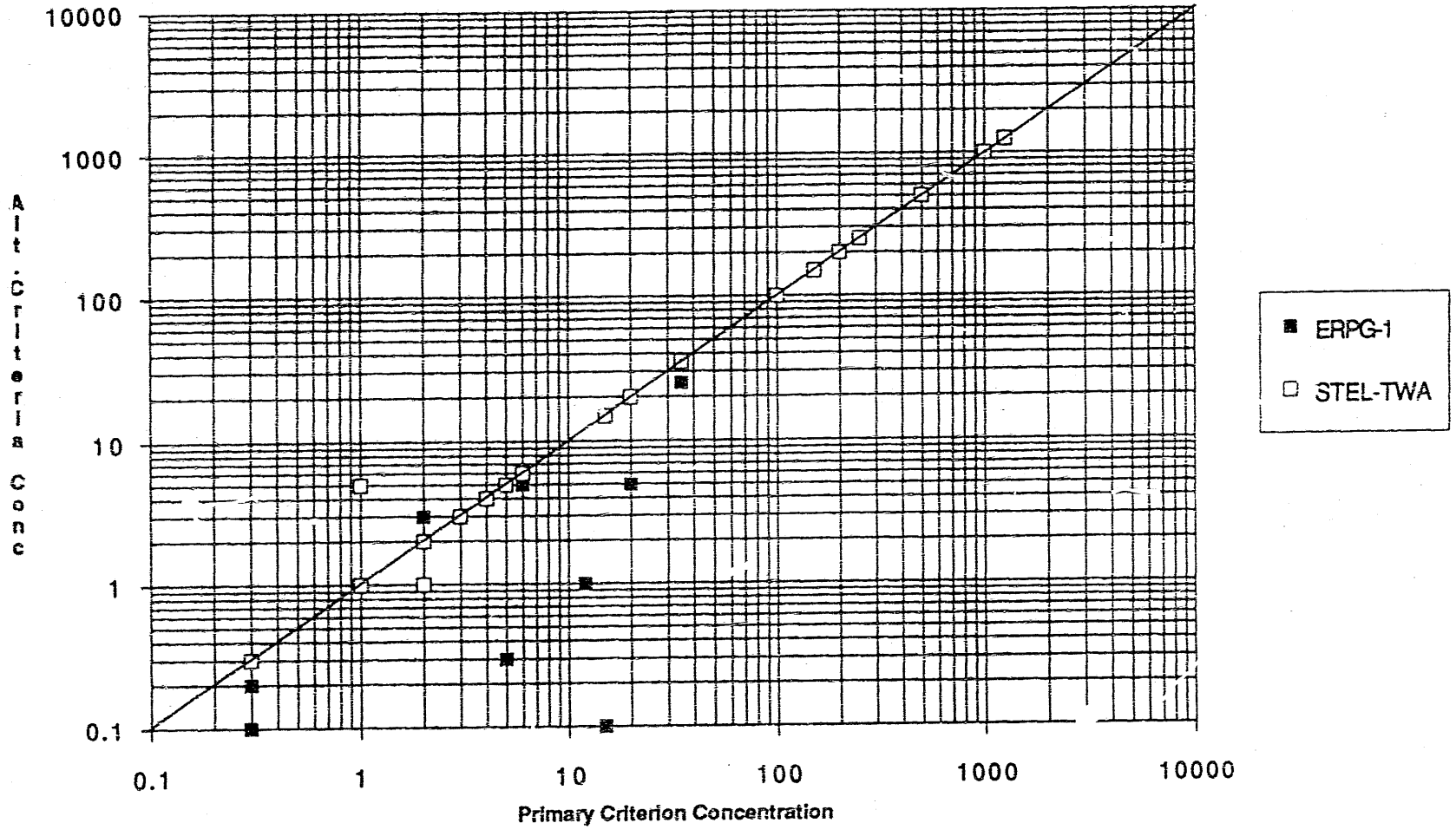


Figure 5: Alternative Conc. Criteria versus ERPG-2

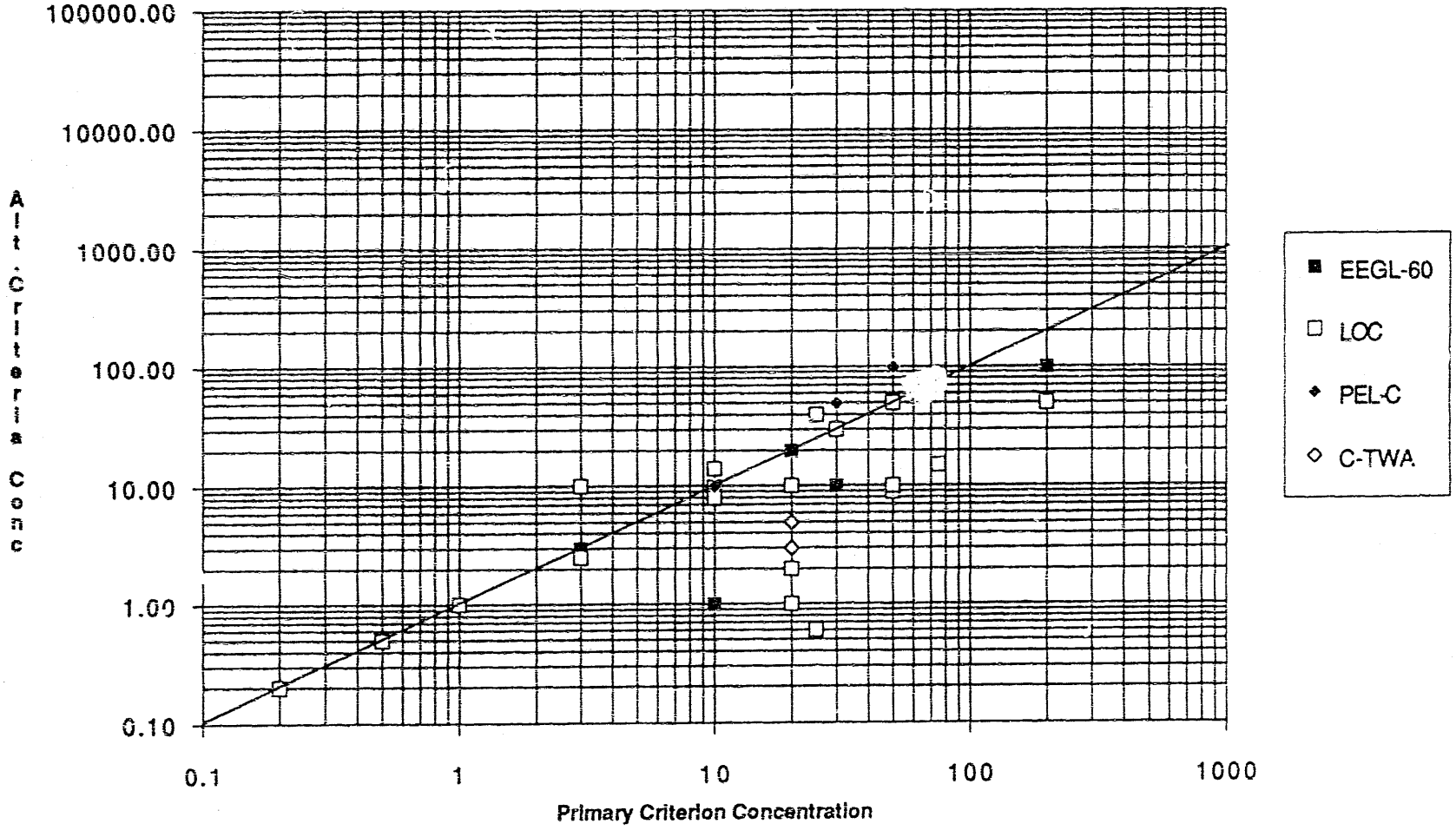
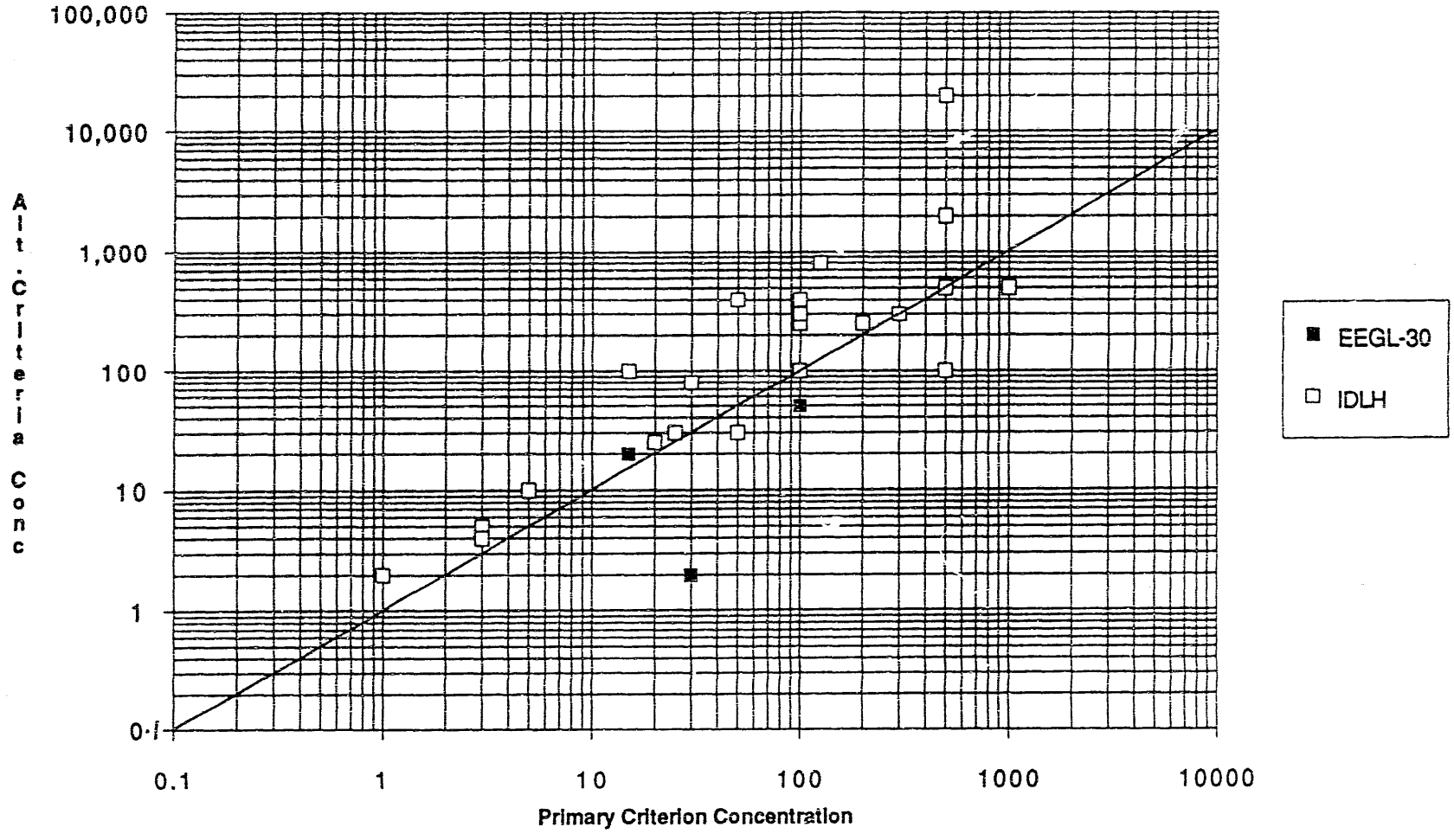


Figure 6: Alternative Conc. Criteria versus ERPG-3



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