MEMORANDUM
DECEMBER 19, 2002

TO: Martin J. Virgilio, Director
Office of Nuclear Material Safety and Safeguards

FROM: Alexander P. Murray, Senior Chemical Process Engineer Alexander P. Murray
Special Projects Section
Special Projects and Inspection Branch
Division of Fuel Cycle Safety and Safeguards

SUBJECT: DIFFERING PROFESSIONAL VIEW ON MODELING CHEMICAL CONSEQUENCE EFFECTS FOR DETERMINING SAFETY REQUIREMENTS AT THE PROPOSED MIXED OXIDE (MOX) FUEL FABRICATION FACILITY
DOCKET NUMBER: 070-03098

I apologize for bringing the subject up but this issue has not been adequately reviewed by the MOX management and staff before a conclusion was made. Attached is the subject Differing Professional View (DPV). In summary, the DPV discusses the applicant's use of a code and parameters that do not necessarily meet the "conservative" criteria of the MOX Standard Review Plan nor the standard approach used by the NRC (in the Fuel Cycle Facilities Branch) for existing fuel cycle licensees. The applicant's approach also does not necessarily follow approaches, models, and other guidance for chemical consequence modeling used by the Environmental Protection Agency (EPA). Consequently, safety issues may not be adequately addressed at the proposed facility and appropriate safety measures implemented.

I request that (1) the decision accepting the use of a less conservative code and parameters be over-turned; (2) NMSS establishes a position on the use of codes, estimation techniques, and parameters that is consistent, peer-reviewed, conservative, provides adequate assurances of safety, and defensible [this could be a Branch Technical Position (from the Fuel Cycle Facilities Branch) or a separate guidance document (say, a NUREG document)]; and (3) NMSS addresses the fundamental problem of reconciliation of significantly different results from computer codes, models, and approaches listed in its guidance.

I request that the DPV panel allows me the opportunity to clarify my views and provide additional information on this complex and important subject, as discussed in NRC Management Directive (MD) 10.159. Also, per MD 10.159, I propose Walt Schwink as a qualified individual who can serve on a review panel for this DPV.

Finally, I will continue to monitor the emphasis on the schedule and the issue closure process.

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1. Summary:

Prevailing NMSS Staff/Management Position: This is dichotomous. For the MOX construction application review, MOX management with some support from staff has decided to allow the use of one code (ARCON96) which incorporates additional parameters for dispersion, and, hence, reduces estimated chemical concentrations and consequences. The reduction effect is primarily due to one parameter - plume meander. This approach is not formally documented, is not followed by the NRC Branch (NMSS/FCFB) that regulates chemical consequences at existing fuel cycle facilities, does not address uncertainty concerns in NRC guidance, does not meet the "conservatism" acceptance criteria in the MOX Standard Review Plan (SRP), and is not generally followed by the EPA in its chemical consequence evaluations. NMSS/FCFB and the EPA generally use codes and approaches that result in more conservative (higher) chemical concentrations and consequences.

DPV Position: (1) The MOX Team should use an approach that produces more conservative chemical consequence results and is consistent with NMSS/FCFB and EPA practice. (2) This should be formally documented, say in a Branch Technical Position. (3) NMSS should have a formal approach for reconciling codes and methodologies that produce significantly different estimates of consequences. The DPV notes that other applicable applicant documents have not been reviewed prior to the decision to use the ARCON96 code. Hence, the decision is also premature.

Significance: Without the DPV, chemical consequences to the facility worker, the site worker, the public, and the environment may be significantly under-estimated and approaches for adequate safety measures - and safety controls - may not be implemented. Thus, without safety controls, major injuries and/or fatalities could result to workers and the public from a potential event that the applicant assumes is "not unlikely." Environmental cleanup from commingled chemical and radioactive contamination, and ensuing fires, could be substantial. There would also be significant financial liabilities from actual injuries, insurance payments, likely litigation, repairs, and lost operations. There could also be international repercussions due to the agreements involved in plutonium disposition. This would negatively impact the NRC strategic goals of maintaining safety, improving regulatory effectiveness, and increasing public confidence.

Note: These concerns apply to chemical events and consequences normally regulated by the NRC. These are hazardous chemical effects of radioactive materials, hazardous chemicals produced from radioactive materials, and hazardous chemicals affecting the safe handling of licensed radioactive material.

2. Overview of Documents and Activities

2.1 Construction Application Request (CAR - DCS-NRC-000038) - February 2001:

The applicant submitted the CAR on February 21, 2001. The CAR indicates chemical effects to the public, site worker, and facility worker would be low, using the TEEL consequence limits (pages 8-13 and 8-14). D class stability, a 4.5 m/sec wind speed, a rural terrain, and a leak from the largest container were assumed. In addition, the applicant stated on page 8-14 that principal structures, systems, and components (PSSCs) defined for radiological events may be applicable to process units where chemicals mix with radiological material.

In the applicant's response to a request for additional information (RAI Response 113), the applicant describes plans for chemical consequence modeling using ALOHA for the public (at 5 miles/8 km), with a wind speed of 1.2 m/sec and F stability class, based upon 95% meteorology at the Savannah River Site (SRS). The applicant intended to extrapolate the results out to the site boundary since ALOHA limits the execution time to one hour, which corresponds to about 2.68 miles with a 1.2 m/sec wind speed. For the site worker, the applicant intended to use a 95% chi/q value derived from the ARCON96 code, applied at 100 meters; this value is 4.13E-4 sec/m3 and is approximately a factor of 100 lower than what would be estimated using a "classic" Murphy-Campe calculation. The wind speed was calculated as 1.2 m/sec based upon analyses of 10 years of historical data, at the 95% percentile limit (i.e., lower wind speed and more stability/less dispersion only occur 5% of the time). The applicant states ARCON96 is more applicable because it accounts for building wake and plume meander effects. The applicant intended to use another code for the control room worker, based upon the guidance in R.G.1.78 (June 1974). No results were provided in the RAI response.

2.2 Recent SRS Usage - 1998:

SRS had previously provided recommendations for DOE facility safety analyses for chemicals (WSRC-MS-98-00899). This identified the following dispersion factors (chi/q) used in their analysis:

	F Class, 1 m/sec wind speed	D Class, 4.5 m/sec wind speed
100 meters:	chi/q = 0.024 [s/m3]	0.0014
300 meters:	chi/q = 0.0005 [s/m3]	0.0002

Note that both F and D class dispersion factors at 100 meters are significantly larger than the 100 meter value used by the applicant.

2.3 Argonne National Laboratory (ANL) Analyses on the original Environmental Report - Late 2001:

ANL started evaluating chemical consequence effects from potential chemical releases in late 2001, starting with information supplied by the applicant's Environmental Report. ANL independently decided to use the ALOHA code for estimation of consequences after separately

evaluating chemical release and evaporation rates. The ALOHA code is maintained and updated by NOAA and is funded by the EPA; EPA routinely uses ALOHA for estimating consequences from chemical releases. ANL used F Class meteorology and a wind speed of 1.5 m/sec, as recommended by the EPA (40 CFR 68.22) for the minimum, worst case scenario. The results from using ALOHA showed significant chemical consequences beyond 100 meters for several chemicals, and estimates for nitrogen tetraoxide and hydrazine had the potential to exceed limits at the site boundary. ANL deferred additional work on the chemical consequence modeling until later in 2002 pending receipt of a Revised Environmental Report from the applicant that incorporated changes to the program made by the applicant (and DOE) in February 2002.

2.4 NRC Staff Analyses in the DSER - April 2002:

The staff had to address the apparent contradiction of the CAR analyses indicating no chemical concerns and the preliminary ANL results indicating significant chemical consequences. The staff conducted several parametric analyses using the ALOHA code and obtained similar results to ANL; i.e., indicating the potential for significant chemical consequences. The results are summarized in Section 8 of the staff's Draft Safety Evaluation Report (DSER, NRC, April 2002) and in Table 1 here.

Table 1: Preliminary Analysis of Potential Chemical Impacts - Ambient Temperatures (using TEELs as guidelines; staff does not accept the use of TEELs)

Chemical	Exposure at 100 m, mg/m3	TEEL-1 mg/m3	TEEL-2 mg/m3	TEEL-3 mg/m3	Maximum Distance to TEEL Level, m		
					TEEL-1	TEEL-2	TEEL-3
N_2O_4	140,000	15	15	75	8,000	8,000	4,000
HNO_3	250	2.5	12.5	50	1,800	700	300
HAN	350	10	25	125	600	400	200
$N_2H_4.H_2O$	35	0.006	0.04	0.04	>10,000	5,000	5,000

The staff does not accept the use of TEEL values for chemical consequence limits due to multiple TEEL changes in the past two years, NIOSH and EPA guidance for using lower values, and the NRC use of lower values for chemical consequence categorization for other fuel cycle facilities. The use of lower, more reasonable consequence levels of concern results in receptors at even greater distances being potentially impacted.

2.5 Staff In-Office Review of Applicant Document - August 2002:

The staff reviewed documents during the August 2002 In-Office Review. In one of the documents, chemical consequences are analyzed. Table 2 summarizes the results for the site

worker. The Table 2 results indicate high consequences and this was acknowledged in the document. Table 3 shows the results as a function of distance. The applicant had concluded that nitrogen tetraoxide and hydrazine could exceed the TEEL-2 limit at the SRS boundary (about 5 miles - 8 km - away), the assumed location for the public receptor.

Table 2: Applicant's Results for the Site Worker (the 100 meter receptor)

Compound	Release Rate, kg/hr	Concentration at 100 meters
N2H4*H2O, 35% 477 liters, 47.7 m2 pool	1.487	0.136 mg/m3 (TEEL-3 = 0.02)
HNO3 609 liters, 60.9 m2 pool	5.806	0.266 ppm (TEEL-3 = 20)
N2O4 908 liters, 90.8 m2 pool	2,442	280 mg/m3 (TEEL-3 = 36)
UO2, drum emptying 200 kg	0.120	0.014 mg/m3 (TEEL-3 = 10)
UO2, fire event 37,500 kg	2.25	0.258 mg/m3 (TEEL-3 = 10)

Table 3: Applicant's ALOHA Results as a Function of Distance for Several Chemicals

N2H4*H2O, 35%, 477 liters, TEEL-3 = 0.02 mg/m3

Distance, miles	ALOHA Value	Extrapolation Fit
0.0621 (100 meters)	8.67 mg/m3	7.718 mg/m3
0.1242	2.24	2.248
0.25	0.592	0.647
0.5	0.167	0.189
1	0.0517	0.055
1.5	0.0276	0.027
2	0.0182	0.016

[Staff notes that the power fit is trending below the ALOHA results for 1.5 and 2 mile distances and will likely underestimate the ALOHA prediction at the SRS boundary.]

HNO3, 13.6 N, 609 liters, TEEL-3 = 20 ppm

Distance, miles	ALOHA Value	Extrapolation Fit
0.0621 (100 meters)	26.9 ppm	23.947 ppm
0.1242	6.95	6.972
0.25	1.83	2.007
0.5	0.517	0.584
1	0.16	0.170
1.5	0.0856	0.083
2	0.06	0.05

[Staff notes that the power fit is trending below the ALOHA results for 1.5 and 2 mile distances and will likely underestimate the ALOHA prediction at the SRS boundary.]

N2O4, 100%, 908 liters, TEEL-3 = 36 mg/m3

Distance, miles	ALOHA Value	Extrapolation Fit
0.0621 (100 meters)	29,100 mg/m3	25,944.5 mg/m3
0.1242	7,520	7,552.5
0.25	1,990	2,173.6
0.5	560	632.7
1	173	184.2
1.5	92.7	89.5
2	60.9	53.6

[Staff notes that the power fit is trending below the ALOHA results for 1.5 and 2 mile distances and will likely underestimate the ALOHA prediction at the SRS boundary.]

2.6 Argonne National Laboratory (ANL) Analyses on the Revised Environmental Report - Ongoing:

ANL has resumed work on chemical consequence analysis with the receipt of the Revised Environmental Report from the applicant. Again, they have independently accepted and used the ALOHA code for analyses and have concluded there is the potential for significant chemical consequences to the site worker from several chemicals and to the public from at least one chemical (hydrazine). Their results are essentially the same as in their previous activities (Item 2.3). ANL may be given direction by MOX Management to use the less conservative code and approaches.

2.7 Revised Construction Application Request (RCAR) - October 2002:

Section 8.4 of the RCAR summarizes the chemical accident consequences. The analysis is stated to follow the guidance found in NUREG/CR-6410. The calculations for the site worker are based upon an F stability class using 95% meteorology from 10 years of historic data, and arrived at an air speed of 2.2 m/sec (i.e., different again from the CAR and previous analyses). The chi/q is calculated by the ARCON96 code applied at 100 meters; this value is 6.1E-4 sec/m3 (page 5.4-16). The calculations for the public are based upon a distance of 5 miles (8 km) using the MACCS2; the calculated chi/q is 3.7E-6 sec/m3 (page 5.4-15). The use of ALOHA for the 5 mile receptor is also mentioned.

2.8 NMSS Accident Analysis Guidance - March 1998:

Guidance on estimating consequences is provided in NUREG/CR-6410, "Nuclear Fuel Cycle Facility Accident Analysis Handbook." The Gaussian Model used by ALOHA and other codes is discussed on page 5-6 et seq. ALOHA is listed as a code on page 5-80, in a discussion on EPA guidance on applying refined dispersion models. Page 5-21 et seq discusses building wake effects; ARCON96 is not explicitly mentioned but there is a reference to a revised model developed that incorporates plume meander and may be the precursor to ARCON96. This guidance mentions many models and makes no recommendations or endorsements. On page 5-80, it mentions EPA work that shows "good" models generally perform within a factor of 2 or so based upon chemical release tests. On page 5-81 et seq, model uncertainties are discussed; factors of 3-10 are mentioned.

2.9 Regulatory Guide on Control Room Habitability - December 2001:

The NRC has published Regulatory Guide 1.78, "Evaluating the Habitability of a Nuclear Power Plant Control Room During a Postulated Hazardous Chemical Release," Revision 1, dated December 2001. This mentions the use of the HABIT code for evaluating hazardous chemical concentrations, which is briefly described as a Gaussian plume or puff dispersion model that allows longitudinal, lateral, and vertical dispersions. The model also allows for the effects of wakes and for additional dispersion when the distance between the release point and the control

room is small (small is not defined). The report states other dispersion models with similar capabilities may be used - ARCON96 is listed as an example. There is no endorsement. ALOHA or other models from NUREG/CR-6410 are not mentioned. Model selection criteria are not discussed.

2.10 MOX Standard Review Plan (SRP - NUREG-1718) - August 2000:

NUREG-1718 is the MOX SRP entitled, "Standard Review Plan for the Review of an Application for a Mixed Oxide (MOX) Fuel Fabrication Facility," dated August 2000. On page 8.0-6, paragraph C under the acceptance criteria for "Estimated Concentrations" states, "The applicant provides evidence that the techniques, assumptions, and models used are appropriate for the application and they lead to a conservative estimate of potential consequences. Paragraph A further down the same page similarly states "... and the assumed data input leads to a conservative estimate of potential consequences." Clearly, the applicant's use of ARCON96 and the MOX program acceptance of it are not leading to a conservative estimate.

2.11 Fuel Cycle SRP (NUREG-1520) - March 2002:

NUREG-1520 is the fuel cycle SRP entitled, "Standard Review Plan for the Review of a License Application for a Fuel Cycle Facility," dated March 2002. On page 6-4, paragraph 5 of the acceptance criteria uses a similar phrase "... a conservative estimate of potential consequences."

2.12 "Atmospheric Relative Concentrations in Building Wakes," NUREG/CR-6331 (May 1997):

This report documents the ARCON96 computer code developed for potential use in control room habitability assessments. Figure 27 on page 44 shows a comparison of the classic Murphy-Campe and ARCON96 diffusion models as a function of wind speed for conditions that existed during diffusion experiments at seven reactor sites. At low wind speeds (below about 4.5-5 m/sec), there is a divergence between the models, with ARCON96 generally predicting lower chi/q values (i.e., this would predict lower concentration and consequence estimates). In addition, there is considerable spread in the data comparisons. At 2.2 m/sec, the spread goes from about 0.8 (higher concentrations with ARCON96) to about 12 (lower concentrations with ARCON96); the mode is around 2-3.

2.13 Comparison of ALOHA and Applicant (ARCON96 and MACCS2) Results:

At a distance of 100 meters, with a wind speed of 2.2 m/sec and F class stability, and a 2,000 kg/hr release (approximates the nitrogen tetraoxide situation with a cylinder rupture and release at 20 C):

Applicant (ARCON96): 340 mg/m3 ALOHA: (rural) 13,000 mg/m3, ratio = 40
(Urban) 2,710 mg/m3, ratio = 8

For the facility and site worker receptors, typical levels of concern might be in the 10-40 mg/m3 range (i.e., OSHA and IDLH limits, respectively). Note that such values are clearly exceeded by both modeling approaches but the ALOHA results imply potentially prompt incapacitations and/or fatalities. The ALOHA code does not explicitly output a chi/q value. However, the relative value is inferred by the ratios. Note that the ratio of 40 is above the upper range of ARCON96 ratios and the ratio of 8 is above the mode of Figure 27 in the ARCON96 report (Paragraph 2.12 on the previous page). Thus, the ratios and the numerical values imply ARCON96 is not providing conservative results. Essentially all of the differences are due to one parameter - plume meander.

At the site boundary of approximately 5 miles (essentially the public at the site boundary):

Applicant (MACCS2): 2.1 mg/m3 ALOHA: (rural) 9 mg/m3, ratio = 5

Using the OSHA limit of 9 mg/m3, the ALOHA code indicates potential effects to the public while the applicant's approach does not. Execution of ALOHA with the urban roughness factor indicates the 9 mg/m3 limit would not be exceeded beyond about 1.6 miles. Again, the ratios and the numerical values imply ARCON96 is not providing conservative results.

As an additional indication of non-conservative predictions by the ARCON96 code, the staff ran ALOHA at 4.5 m/sec, Class D stability, and rural conditions. At 100 meters, the result is 882 mg/m3; with urban effects, the concentration becomes 358 mg/m3 (approximately equal to the ARCON96 result with 2.2 m/sec and Class F stability: the evaporation rate was held constant). By comparison to Figure 27, ALOHA and ARCON96 should predict approximately the same value at 4.5 m/sec. Thus, this implies the ARCON96 code results cited by the applicant and accepted by the MOX program are not conservative.

The use of ARCON96 for releases of other chemicals, such as nitric acid and hydrazine, may not identify any consequences requiring safety controls while ALOHA would predict conditions requiring safety controls. Clearly, a defendable rationale is needed for code selection.

3. Staff Discussions:

The staff has had two meetings on the subject of chemical consequence modeling. Both of these meetings and the MOX program decision that use of the ARCON96 code was acceptable (11/25/2002) occurred before the staff had finished its review of the RCAR and before the staff has had the opportunity to conduct another in-office review of chemical consequence calculations. MOX management appeared to act in an arbitrary and capricious manner. It appeared that management had already discussed the issue before the meetings and made a decision, without consideration and discussion of the conservative requirement in the MOX SRP, limitations of ARCON96 and the single parameter effect, the ARCON96 report figure implications, inherent modeling uncertainties (see accident guidance), and FCFB (and EPA) use of ALOHA. FCFB was represented at these meetings and discussed their use of ALOHA, ALOHA's use by the EPA and others, and EPA's viewpoint on reduction parameters like plume meander (it was stated that EPA considered these to be "too manipulative" and not conservative). The issues were not addressed.

The existence of many codes producing different results raises the fundamental question of what to do when codes and assumptions give significantly different results? At the NRC, the staff is required to have adequate assurances of safety and an adequate safety margin. The clear precedence for chemical consequence modeling in NRC/NMSS/FCFB, the CPI (Chemical Process Industries), and the EPA is to use a conservative model/approach like that in ALOHA. As noted in Section 2, ANL also selected ALOHA for chemical consequence modeling for the EIS, and the applicant used ALOHA in the original CAR for modeling releases of gases and vapors. The applicant has also used ALOHA in the revised CAR for concentration estimates at the SRS site boundary. Thus, without an adequate basis, the Agency (and the applicant) gives the appearance of arbitrarily selecting a code. Such an approach seems closer to risk based regulation and does not appear to meet the intent of NRC's risk-informed, performance based (RIPB) regulation and the (revised) Part 70. It would seem that a conservative chemical consequence modeling approach like ALOHA should be used for the EIS analysis and the revised CAR (RCAR) in order to have consistency with precedence, to have reasonable conservatism, to provide adequate safety margins, and to have a defensible position.