UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

January 31, 2003

MEMORANDUM TO: Melvyn N. Leach, Chief
Special Projects and Inspection Branch
Division of Fuel Cycle Safety
and Safeguards
Office of Nuclear Material Safety
and Safeguards

THRU: Joseph G. Giitter, Chief
Special Projects Section
Special Projects and Inspection Branch
Division of Fuel Cycle Safety
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FROM: Andrew Persinko, Sr. Nuclear Engineer
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SUBJECT: DECEMBER 10-12, 2002, MEETING SUMMARY: MEETING WITH DUKE COGEMA STONE & WEBSTER TO DISCUSS MIXED OXIDE FUEL FABRICATION FACILITY REVISED CONSTRUCTION AUTHORIZATION REPORT

On December 10-12, 2002, U.S. Nuclear Regulatory Commission (NRC) staff met with Duke Cogema Stone & Webster (DCS), the mixed oxide fuel fabrication facility (MFFF) applicant, to discuss the revised construction authorization request (CAR or revised CAR) submitted to NRC on October 31, 2002. The meeting agenda, summary, handouts, attendance list, and clarifying information provided by DCS are attached (Attachments 1, 2, 3, 4, and 5 respectively).

Docket: 70-3098

Attachments:
1. Meeting Agenda
2. Meeting Summary
3. Meeting Handouts
4. Attendance List
5. Clarifying Information

cc:
P. Hastings, DCS
J. Johnson, DOE
H. Porter, SCDHEC
J. Conway, DNFSB
L. Zeller, BREDL
G. Carroll, GANE

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NAME	APersinko		LGross		DBrown		JGiitter	
DATE	1/ 16 /03		1/ 29 /03		1/ 13 /03		1/ 31 /03	

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MEETING AGENDA
MOX FUEL FABRICATION FACILITY
December 10-12, 2002

<u>December 10, 2002</u>

9:00 AM	Introduction
9:15 AM	Discussions of chemical safety
12:00 NOON	Lunch
1:00 PM	Discussions of chemical safety
4:30	Summary / Actions
5:00	Adjourn

<u>December 11, 2002</u>

9:00 AM	Discussions of chemical safety
12:00 NOON	Lunch
1:00 PM	Discussions of chemical safety
4:30	Summary / Actions
5:00	Adjourn

<u>December 12, 2002</u>

9:00 AM	Discussions of fire protection
12:00 NOON	Lunch
1:00 PM	Discussions of electrical/I&C
4:30	Summary / Actions
5:00	Adjourn

Attachment 1

MEETING SUMMARY
MOX FUEL FABRICATION FACILITY
December 10-12, 2002

Purpose:

The purpose of the meeting was to discuss chemical safety, fire protection, and electrical/instrumentation and control (I&C) issues related to the Mixed Oxide Fuel Fabrication Facility Construction Authorization Request (CAR) submitted by DCS on October 31, 2002, or identified in the NRC staff's Draft Safety Evaluation Report (DSER) dated April 30, 2002.

Summary:

The meeting was a technical, working level meeting that covered, in detail, chemical, fire protection, and electrical/I&C issues. The normal format was for DCS to respond to staff questions, most of which were related to open items identified in the staff's DSER. For issues related to red oil and to hydroxylamine nitrate (HAN), DCS had prepared presentations (DCS slides in Attachment 3).

A summary of the issues discussed is provide below:

Chemical Safety

1. CS-5 Modeling of Hazardous Chemical Releases: NRC staff questioned whether the administrative controls identified in the revised CAR were needed after a chemical event, specifically the administrative controls identified as facility worker actions, chemical safety controls, material handling controls and laboratory material controls. DCS stated that operator actions outside of the control room and chemical events are not coupled and that there is no chemical release that would result in a radiological release. DCS expected that any worker dose increases would be small and would not impact the Part 70.61 performance requirements. DCS stated that the term "Chemical Safety Controls" in the CAR refers to samples and that, in the MOX process, samples are a permissive action. In other words, if there is an event, the process is shutdown and failure to take samples does not put the process at risk since it remains shutdown. Samples are taken automatically or are remotely handled. "Laboratory Material Controls" also refers to sampling and is addressed by the previous DCS statement. DCS provided clarifying information contained in Attachment 5 and will provide revised CAR pages to reflect this information. Staff finds that this information closes this issue. **(CLOSED)**

2. CS-5 Temporary Emergency Exposure Limits (TEELs): NRC staff questioned the use of TEELs as a chemical limit, since TEEL values are subject to change, and the justification for the TEEL values are chosen by DCS. NRC staff noted that several of the TEEL-3 limits in the October 2002 CAR have increased substantially as compared to prior values provided by the applicant and are (numerically) significantly greater than other levels of concern in the literature, such as IDLHs, proposed AEGLs, and STELs. DCS will provide a rationale for the values it has chosen and will denote the actual numerical values as limits rather than TEELs. **(OPEN)**

3. AP-14 New Issue - Plutonium VI oxalate: NRC staff questioned the safety factor (i.e., design basis) to be applied to prevent overpressure of components, such as gloveboxes, and the calcining furnace. DCS noted that the calciner does not clearly fall

into any specific section of the American Society of Mechanical Engineers code. Staff found acceptable that the specific setpoints will be determined as part of final design. DCS provided clarifying information contained in Attachment 5. Staff finds that this information needs to include a qualitative approach that will link the residual plutonium (VI) oxalate introduced into the calciner furnace to the P(max) +10% calculation. DCS will evaluate this and include the calciner in the appropriate table of Section 11.8 for codes and standards that apply to fluid transport system components. **(OPEN)**

4. CS-2 Hydroxylamine nitrate (HAN)/Hydrazine: DCS made a presentation regarding the work it is performing on this subject (DCS slides are provided in Attachment 3). Rather than using an instability index approach, DCS is performing experiments and developing an approach that controls nitrous acid and N2O4 concentrations by the addition and presence of hydrazine. DCS will provide the results of its work along with proposed design bases in January 2003. **(OPEN)**

5. CS-3 Hydrazoic Acid: NRC stated that it believed that DCS would be submitting additional information, beyond that contained in the revised CAR, and therefore, it did not complete its review of this issue. DCS stated that it does not intend to submit any additional information and that it believes that the information contained in the revised CAR on this subject was sufficient. NRC staff questioned whether sampling or neutralization would be used to assure that hydrazoic acid was removed from the system. In response, DCS stated that it intends to use neutralization in all cases and that sampling may be used if it is determined that neutralization alone is insufficient. DCS provided information contained in Attachment 5 to confirm this; NRC staff is continuing its review. **(OPEN)**

6. CS-8 Depleted uranium in the warehouse: NRC staff questioned the damage ratio of 0.1 chosen by DCS. DCS agreed that it would add combustible loading control as a principal structure, system or component (PSSC) in the warehouse and provided the information in Attachment 5. Staff considers this issue closed for fire effects in the warehouse and will review the damage ratio considering seismic effects when the design is completed. **(CLOSED)**

7. CS-10 Emergency control room design bases: NRC staff questioned the design basis values (i.e., the chemical concentration thresholds) for the emergency control room. DCS will provide and justify the design basis values. **(OPEN)**

8. CS-4 Azides: NRC staff asked how DCS intends to prevent dryout and the design bases for U/PuO2 azide concentrations and the specific pH controls for sodium azide. DCS will provide the requested information. **(OPEN)**

9. CS-7 Delivery of chemicals: This issue relates to operator action discussed in issue CS-05. Thus, CS-07 has been subsumed by CS-05. **(CLOSED)**

10. AP-13 Chemical releases: NRC staff questioned the effects of potential chemical releases in the process cells that would be emitted through the stack and potentially recirculated into the building through the building intake. During the meeting, DCS provided a qualitative discussion of why such a release would not exceed the

performance requirements in 10 CFR 70. The discussion included flowrates, volumes, and distance of the stack from the intake. DCS documented this discussion in Attachment 5. **(CLOSED)**

11. CS-1 Red oil: There was significant discussion regarding this subject. Questions posed by the NRC staff and DCS responses are documented in Attachment 5. DCS stated that it is evaluating the effects of impurities on the initiation temperature. Staff will review the results of experiments affecting closed systems when the results are available. DCS identified 135 degrees C as the initiation temperature for a "runaway" reaction. During an Advisory Committee on Reactor Safeguards (ACRS) presentation, DCS indicated that it intended to operate an evaporator at up to 135 C. During the December 2002 public meeting, DCS indicated that the design basis value to prevent a "runaway" reaction for a closed system was 135 C. The staff notes that there is no margin between the two temperatures. In addition, the staff also notes that the presence of organics and other impurities can depress the initiation temperature for the runaway reaction below 135 C. From this, the staff has concluded that: 1)T- operations + enthalpy effects < 135 C-impurity depression-safety margin where: T-operations is the maximum process operating temperature; 2)enthalpy effects is the temperature rise due to impurities (e.g., red oil); 3) impurity depression is the runaway initiation temperature reduction due to impurities; 4)135 C is the initiation temperature for a "runaway" reaction not modified for impurities. Notwithstanding the ACRS presentation where DCS indicated that it intended to operate an evaporator in the system at up to 135 C, please identify the safety margin. **(OPEN)**

12. AP-2 Flammability limits: This issue applies to hydrogen in the electrolyzer and the sintering furnace areas. DCS stated that it intends to use 50% as the lower flammability limit (LFL) never to be exceeded and 25% LFL as the trip setpoint. NRC staff questioned this 25%/50%, considering that DOE Hanford adopted 25% LFL as the design basis never to be exceeded (NRC provided the Hanford reference to DCS) and hydrogen generation considering an overvoltage condition. DCS stated that it plans to monitor acid normality and shutdown the electrolyzer if a certain normality is reached, and that monitoring normality takes into account potential overvoltage conditions. DCS will provide a description of its LFL determination methodology, state that hydrogen monitors are located in the furnace areas, and provide supporting information regarding acid normality effect on hydrogen production. **(OPEN)**

13. AP-3 Titanium fires: DCS will provide the design bases that address titanium fires. NRC staff also questioned embrittlement of titanium in the presence of hydrogen and provided a reference on the subject to DCS Reference: (CEPOD) L.A. Bray, J.L. Ryan, E.J. Wheelwright, and G.H. Bryan, "Catalyzed Electrolytic Plutonium Oxide Dissolution: The Past 17 Years and Future Potential," Chapter 30 in Transuranium Elements: A Half Century, L.R. Morss and J. Fuger ED., American Chemical Society, Washington D.C. (1992). DCS will provide the requested information. **(OPEN)**

14. MP-1 Uranium pyrophoricity: DCS stated that it would address this issue in its soot loading analysis in open item FS-1. The analysis will include heat load, burnback, and hot particle generation. MP-1 will remain open pending NRC staff's review the soot loading analysis. **(OPEN)**

15. MP-2 Plutonium oxide pyrophoricity: DCS will address the hazard posed by storing purified, calcined plutonium oxide in buffer storage which does not meet the DOE-STD-3013-2000 standard. DCS will also address moisture content and storage times as necessary. **(OPEN)**

16. MP-4 Hydrogen leak in the furnace area: Flammability limits provided in AP-2 will also address the MP-4 issue. In addition, DCS noted that potential specific controls for meeting hydrogen flammability limits (such as limiting the hydrogen content in the hydrogen-argon mixture, monitoring for oxygen within the furnace, monitoring for hydrogen outside of the furnace, and crediting dilution air flow associated with the HDE or VHD systems) were already identified as PSSCs in other safety strategies and, thus, there would be little or no impact of the specific control selection upon the design at the Independent Safety Analysis (ISA) stage. This issue has been subsumed by issue AP-2. **(CLOSED)**

Fire Protection

17. FS-1 Soot analysis: Soot analysis to be provided by DCS which will include effects from oxidized UO2 particles. **(OPEN)**

18. FS-2 Fire barriers: NRC staff questioned whether barrier safety margin includes flashover. DCS stated that the barrier analysis methodology will be the same methodology used for all analyses and includes flashover. After the staff reviewed calculations during an in-office review subsequent to the meeting, the staff questioned the barrier margin considering that DCS chose 600^{o} C as the criteria for flashover. Staff provided references that indicate that flashover can occur between 450 - 600^{o}C. DCS calculations resulted in some of the room temperatures that exceed 500^{o} C and research indicates that flashover can occur between 450 - 600 C. These elevated temperatures led staff to question whether the duct work is rated for a deflagration that would occur because of hot unburnt hydrocarbons being exhausted into the C3 system. DCS will revise pages in the revised CAR and justify its severity flashover calculation methodology and assumptions. In addition, staff questioned whether the DCS severity calculation considered location effects. The fuels' location (near the walls or corners) grossly intensifies the heat release rate and thus hastens the fire development such that even though the fuel burn duration may not exceed 80% of the barrier rating, flashover could still occur. **(OPEN)**

19. New Question - reliability of clean agent: NRC staff questioned the reliability for clean agent since the revised CAR did not indicate a 100% reserve. DCS responded that there still will be a 100% reserve but that it will not be connected - the fire brigade must connect it. DCS will provide revised CAR pages to address this. The issue remains open pending receipt of the revised CAR pages. **(OPEN)**

20. New Question - C4 filters: NRC staff questioned an apparent change in strategy in the revised CAR regarding combustible loading controls and the final C4 high efficiency particulate air (HEPA) filter. DCS stated that there is no change in strategy. As discussed in Attachment 5, DCS will provide revised CAR pages that clarify that the C4

filter is a PSSC for a glovebox fire and that combustible loading controls are a PSSC for a fire in the HEPA filter rooms areas, but outside of the HEPA filter ventilation ducts. **(CLOSED)**

21. New Question - isolation valve vs. damper: NRC questioned the differences between isolation valves and fire dampers. Staff stated that the term "fire damper" infers that it meets certain National Fire Protection Association requirements and that it automatically closes. DCS provided clarification in Attachment 5. However, further discussion of this clarification is necessary. **(OPEN)**

Electrical / Instrumentation and Control

22. NRC staff asked if pressure vessel controls in the revised CAR are administrative controls. DCS will clarify Section 11.9.5.2 and will revise Table 5.6-1 to indicate which controls are administrative.

23. DCS stated that the term "engineering features" in Section 5.6.2.1 refers to analytical equipment in the laboratory and remote handling equipment. DCS will provide written information to clarify this term.

24. DCS stated that instrumentation to control overpressure in the sintering furnace (discussed in Section 11.4.11.8) is part of the process safety control subsystem and will revise the revised CAR, including Section 5.5, to reflect this.

25. NRC staff questioned whether the combustible gas detectors are part of the process safety control subsystem as implied in Table 5.6-1 on page 5.6-16 of the revised CAR, and, if so, will they meet all industry standards applicable to the process safety control system. DCS responded that there are 3-4 options to detect combustible gases, all of which are feasible and all of which rely on the process safety control system. If DCS determines that the combustible gas detectors are necessary to meet 10 CFR 70 performance requirements, then they will meet all requirements applicable to the process safety control system.

26. DCS stated that the continuous air monitors (CAMs) are not PSSCs for detecting a confinement failure. Since DCS is obligated to meet Part 20 radiation requirements, the CAMs would be useful in detecting a slow leak. However, a slow leak may not exceed the 10 CFR 70 performance requirements since 10 CFR 70 performance requirements address acute consequences which, in this case, would be addressed by operator action.

27. DCS stated that the entire electrical system will not be tested per Institute of Electrical and Electronics Engineers standards, as may be implied by the wording in Section 11.5.2.5 on page 11.5-7 in the revised CAR. DCS will clarify.

28. With respect to the wording in Section 11.6.3.3.3 on page 11.6-8 of the revised CAR, DCS stated that the phrase "followed by placing the process in a safe condition" means "fail safe." Additionally, DCS stated that if there is a fail safe design, physical separation is not applied in all cases. For example, glovebox safety controllers are separated but

the actual sensors are not physically separated since they must be located in the glovebox. DCS will clarify.

29. With respect to standards for digital computer software in Section 11.6.7 in the revised CAR, DCS stated that it has not committed to meeting: (a) IEEE 829-1983, "Software Test Documentation," (b) IEEE Std 1016-1987, "Recommended Practice for Software Design Descriptions," and (c) NUREG/CR-4640, "Handbook of Software Quality Assurance Techniques Applicable to the Nuclear Industry." Rather, test documentation is based on the ISO 9000 requirement which is used at the MELOX plant. NRC staff stated that ISO 9000 is largely administrative with respect to documenting tests and that IEEE-829 contains more. DCS stated that it will have a plan for documenting its tests if it does not adopt IEEE-829. Further, DCS stated that it will review IEEE-730, "Software Quality Assurance", and incorporate features it feels are needed. DCS will discuss this further in its license application.

30. DCS stated that, as part of its license application, it will review EPRI topical report TR-102323, "Guide to Electromagnetic Interference Susceptibility Testing for Digital Safety Equipment in Nuclear Power Plants," and NRC Information Notice 83-83, "Use of Portable Radio Transmitters Inside Nuclear Power Plants."

31. DCS will make an editorial correction at the top of page 11.5-13 in the revised CAR which states "The emergency control system provides hard-wired control..."

32. DCS will clarify the fourth paragraph on page 11.5-15 of the revised CAR to indicate which emergency control room provides control for which emergency generators.

33. With respect to environmental qualification of the process safety control system, DCS stated that equipment on the process safety control system are qualified for the environment which they may be expected to see. However, the process safety control system is not seismically qualified since the equipment is not needed to operate after an earthquake.

34. DCS will clarify that the seismic monitoring system and the seismic trip system are one and the same system, i.e., the seismic monitoring and trip system, and that this system will meet IEEE 603 requirements. Staff considers this to be an open item. **(OPEN)**

35. With respect to environmental qualification for the emergency control system, DCS stated that no chemically harsh environments have been identified that can affect the emergency control system. DCS further stated that: 1) there is no electrical equipment in the process cells; thus no electrical equipment needs to be qualified for chemical releases in these areas; and 2) if it elects to employ a prevention strategy for release of material that could affect the environment in which equipment must operate, then the equipment will not be required to be environmentally qualified. DCS will clarify how it intends to implement IEEE-323 regarding equipment qualification.

36. Although the current electrical system exceeds that for nuclear power plants, NRC staff noted that the current design calls for paralleling the standby emergency diesels generators prior to connection to the affected bus. NRC staff noted that such an arrangement may increase challenges to PSSCs (and items relied on for safety (IROFS)) and that paralleling the generators needs to be carefully analyzed. NRC staff,

however, stated that it is providing this information for DCS to consider in its detailed design (not at the design basis stage). NRC is not suggesting that DCS remove the standby diesel generators since, even though there may be added challenges to IROFS, overall reliability may actually be increased by including the standby diesel generators. The same discussion was held for the Essential Uninterruptible Power Supplies (UPS) which are also paralleled.

DUKE COGEMA STONE&WEBSTER SLIDES
MOX FUEL FABRICATION FACILITY
December 10-12, 2002

Attachment 3

MOX Fuel Fabrication Facility Chemical Safety

DCS Meeting with NRC Staff
10-12 December 2002
Washington D.C.

Schedule for the Presentations

- Tuesday, Dec 10th : Pu - Oxalate
- Tuesday, Dec 10th : Pu - HAN System
- Wednesday, Dec 11th: Red Oil

Tuesday, Dec 10th
Pu-Oxalate and Pu-HAN Systems

- Team
- DCS Approach to Safety
- Plutonium – Oxalate
- Hydroxylamine
- Hydrazoic Acid

Tuesday, Dec 10th: Pu-Oxalate and Pu-HAN Systems Presentation of the Team

- Marc KLASKY , DCS
- Marc VIAL, DCS/MIT
- Scott BARNEY, Hanford
- Pr Ken CZERWINSKI, MIT
- Pr Jim NAVRATIL, Clemson University

DCS Approach to Safety

- The DCS Safety Strategy is based on a ***fundamental understanding of the system*** through an exhaustive review of the literature, cooperation with world

Plutonium Oxalate System Analysis

Pu-Oxalate – Safety Concern

◆ **Hazard**

$PuO_2C_2O_4.3H_2O$ could thermally decompose at high temperatures causing over-pressurization of vessels/equipment

◆ **Experimental Results**

Subramanian et al. measured the heat of reaction for the decomposition using differential thermal analysis (DTA). DTA curve for $PuO_2C_2O_4.3H_2O$ is presented and shows:

- a broad *endothermic* peak, due to dehydration, with maximum at 142°C and,

- a sharp *exothermic* peak, due to the oxidation of the oxalate, with a maximum at **219°C**. The energy produced is -25 kcal/mole.

Pu-Oxalate – DCS Strategy

- DCS Safety Strategy Control

Sampling for Pu(VI) prior to forming Pu(VI)-Oxalate has been identified as the only SSC principal needed. [1]

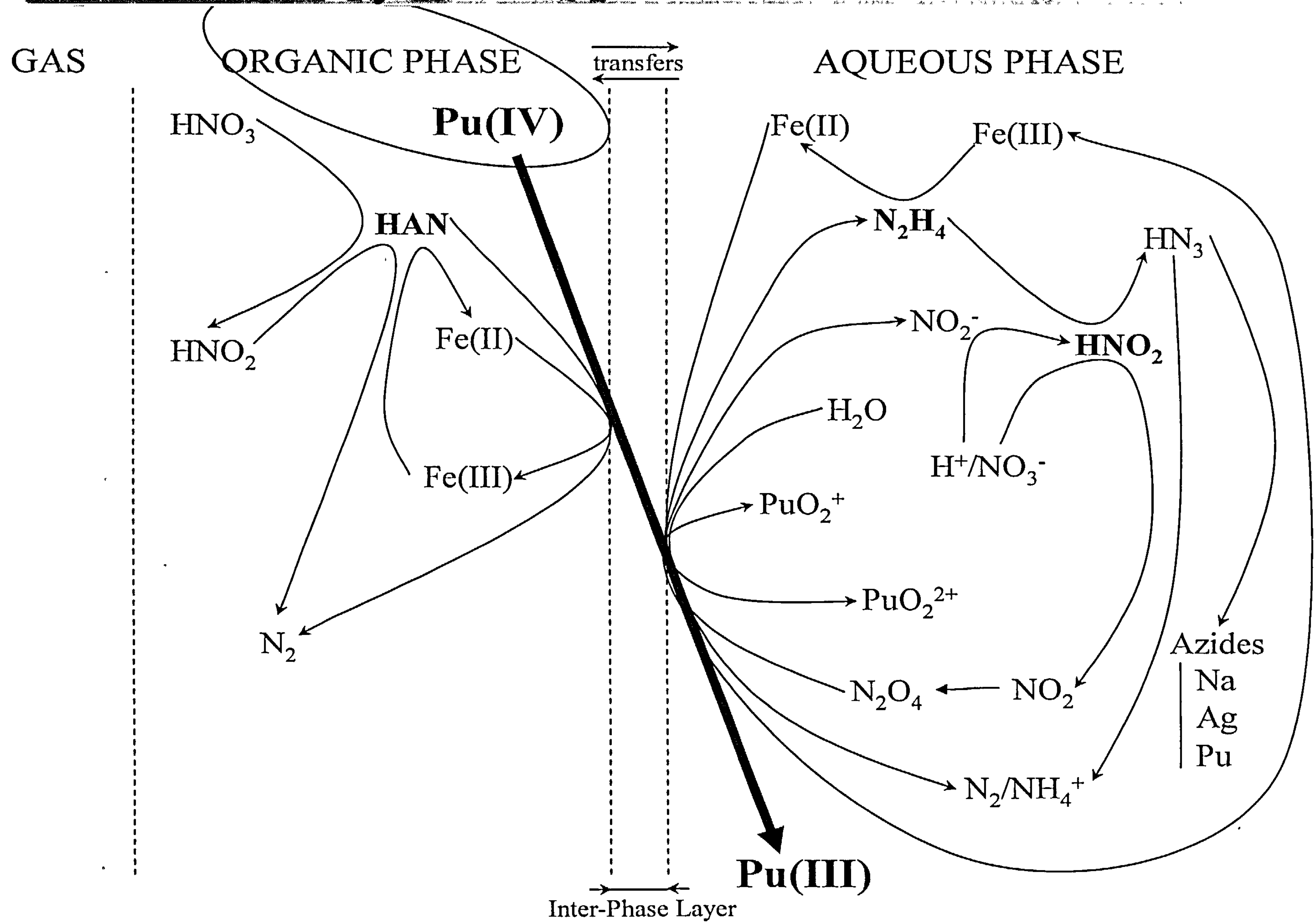
- Other process temperatures within the AP Process are limited to much lower temperatures due to consideration of other phenomena.
- Prevent Pu(VI) oxalate from entering process equipment where temperatures approaches 219°C.

[1] Many means to perform the measurements have been identified and DCS can ensure that the sensitivity will be low enough to detect the maximum quantity required for safety

Plutonium – HAN System

Plutonium – Hydroxylamine – Hydrazine System

Pu – HAN System



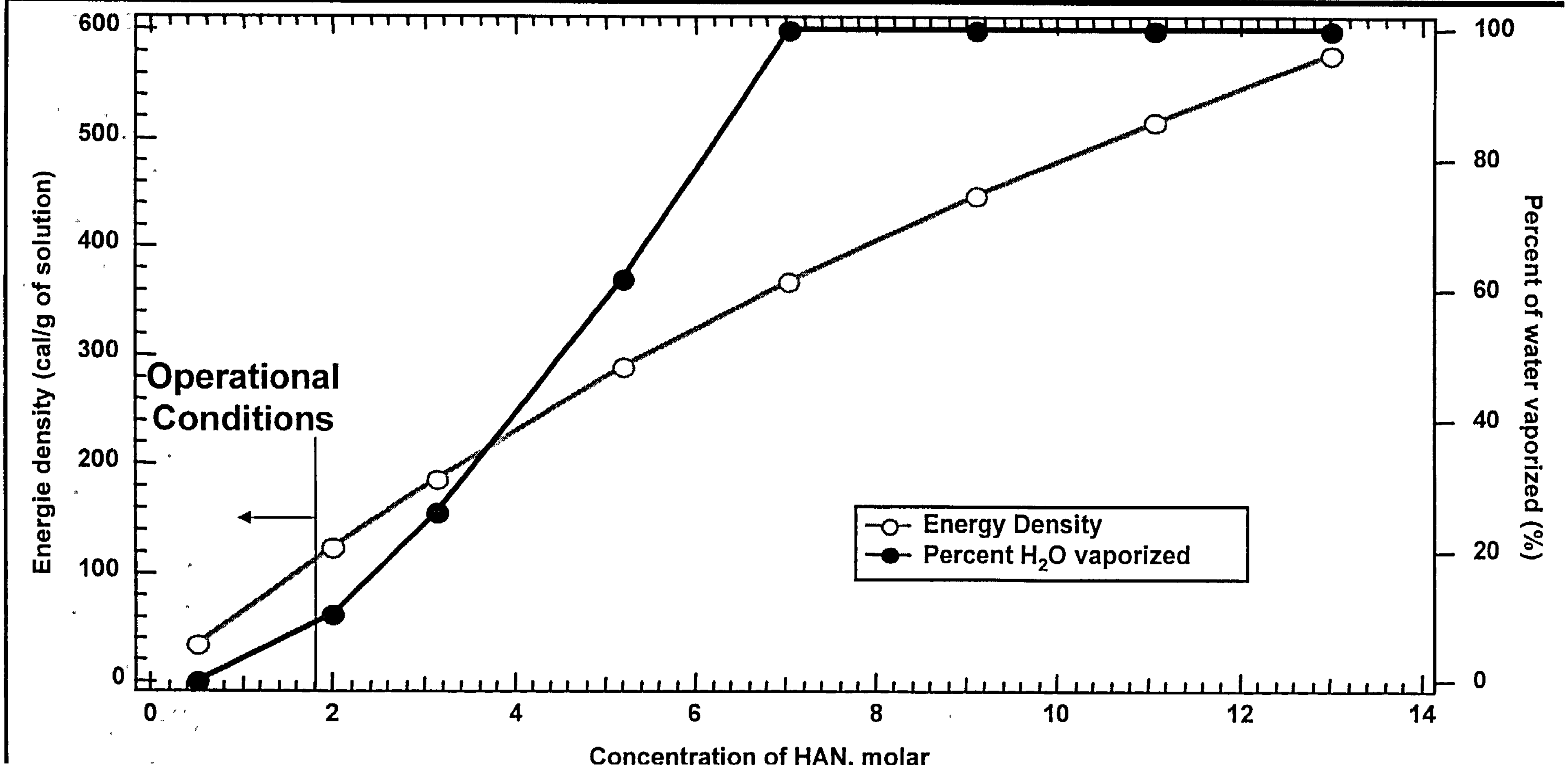
Safety Concerns

- The autocatalytic reaction of the system could lead to **over-pressurization** as a result of the production of nitrogen oxides gaseous products.
- HAN autocatalytic oxidation is strongly **exothermic**.

$$4HAN \rightarrow 3N_2O + 7H_2O + 2HNO_3 \quad \Delta H = -49 kcal/mol$$

$$5HAN \rightarrow 3N_2 + 8H_2O + 4HNO_3 \quad \Delta H = -68 kcal/mol$$

Energy Density and Water Vaporization From Autocatalytic HAN Oxidation



Safety Strategy: Limitation of the Instability Index (DOE/EH-0555) (1)

The Instability Index Model has very narrow applicability for safety.

Limitations:

- Empirical model applicable ***only*** in the limited and restricted conditions of the study.
- Incomplete understanding of the system.

$$I = (1 + [HNO_3])^{1 + Log\frac{[HNO_3]}{[HAN]}} + (1 + [HNO_3])^{1 + Log(100[Fe])}$$

Safety Strategy: Limitation of the Instability Index (DOE/EH-0555) (2)

- Does not take into account the influence of Plutonium, which plays to roles in catalysis and radiolysis
- Problems with the logarithmic function arise at low hydroxylamine concentration when computing
- Impurities restricted to Iron

A Complex System

- Multi-parameters
  - Reagents / products
  - Temperature
  - Normality
  - Ionic Strength
  - Impurities
- Multi-phases
  - Organic
  - Aqueous
  - Gaseous

Properties of Hydroxylamine (HAN)

- Insoluble – only present in the aqueous phase
- Extraction - Reduction of Plutonium [Pu(IV) →Pu(III)]
- Reaction with nitric acid (autocatalytic reaction)
- Reaction with nitrous acid
- Reduction of Iron [Fe(III)→Fe(II)]
- Exothermic Oxidation

Extraction - Reduction of Plutonium

- Reduction of Pu(IV) to Pu(III) by HAN is fast
- Two Reactions are possible:

$$2NH_3OH^+ + 4Pu^{4+} \rightarrow 4Pu^{3+} + N_2O + H_2O + 6H^+$$

$$2NH_3OH^+ + 2Pu^{4+} \rightarrow 2Pu^{3+} + N_2 + 2H_2O + 4H^+$$

- Preferred Reaction depends on the ratio R

$$R = \frac{[Pu(IV)]_0}{[NH_3OH^+]_0}$$

- R>1: reaction 1
- R<1: reaction 2

Ionization Reaction of HAN (NH_2OH)

- In solution Nitric Acid is dissociated as:

$$HNO_3 \rightarrow H^+ + NO_3^-$$

- In Nitric Acid Solution, HAN is thus ionized as:

$$NH_2OH + H^+ \rightarrow NH_3OH^+$$

Mechanism of Pu Reduction (Reaction 2)

Multi-step reactions:

$$PuNO_3^{3+} \xrightarrow{K_d} Pu^{4+} + NO_3^-$$

$$Pu^{4+} + H_2O \xrightarrow{K_h} PuOH^{3+} + H^+$$

$$NH_3OH^+ \xrightarrow{K_a} NH_2OH + H^+$$

$$PuOH^{3+} + NH_2OH \xrightarrow{K_3 = k_3 / k_{-3}} Pu^{3+} + NH_2O + H_2O$$

$$2NH_2O \xrightarrow{k_4} N_2 + 2H_2O$$

Rate Law for the Reduction of Pu via Reaction 2

The kinetic of the reaction can be derived using the steady state approximation applied to NH_2O

$$-\frac{d[Pu(IV)]}{dt} = k\frac{[Pu(IV)]^2[NH_3OH^+]^2}{[Pu(III)]^2[H^+]^4(K_d+[NO_3^-])^2}$$

with:

$$k = k_4K_3^2K_h^2K_d^2K_a^2$$

Arrhenius Equation – Kinetic Rate Constant

Temperature (^oC)	10^2k (M^5sec^{-1})
30	2.9
35	7.4
40	15
45	35

$$rate\ constant = 1 * 10^{23} * \exp(-\frac{15{,}779}{T})$$

$$E_a = 31 kcal / mol$$

NB: Exponential Fit

Reaction of HAN with Nitric Acid also called "Autocatalytic" Reaction

$$H^{+} + HNO_2 + NO_3^{-} \rightleftarrows N_2O_4 + H_2O$$

$$NH_2OH + N_2O_4 \rightarrow N_2O_3 + HNO + H_2O$$

$$N_2O_4 + HNO \rightarrow N_2O_3 + HNO_2$$

$$N_2O_3 + H_2O \rightarrow 2HNO_2$$

$$HAN + HNO_3 \rightleftarrows 3HNO_2 + H_2O$$

N_2O_4 Production Rate

Schmid & Baehr measured the rate constant of formation of dinitrogen tetraoxide and its dependency on temperature and normality

Temperature [°C]	Rate Constant per sec.	
	1.3M HNO_3	2.5M HNO_3
0	0.186	0.87
10	0.6	2.9
20	1.7	8.7

Oxidation of HAN with Nitrous Acid

Electrophilic Nitrosation of the Conjugate Acid of HAN

$$H^{+} + HNO_2 \rightleftarrows H_2NO_2^{+}$$

$$HAN + H_2NO_2^{+} \rightleftarrows N_2O + 2H_2O + H^{+}$$

$$HAN + HNO_2 \rightleftarrows N_2O + 2H_2O$$

Rate Law of the Reaction

$$rate\ constant = k[HAN][HNO_2][H^{+}]$$

Kinetics of Decomposition of HAN in Nitric Acid

The rate law of decomposition of HAN by Nitric and Nitrous Acids can be derived by applying the steady state approximation to N_2O_4, HNO and N_2O_3.

$$-\frac{d[NH_3OH^+]}{dt} = [HNO_2][NH_3OH^+]\left(\frac{k_1[H^+][NO_3^-]}{\frac{k_{-1}}{k_2} + 2[NH_3OH^+]} + k_4\right)$$

Hydrazine

- Not Extractable in the organic phase
- Nitrous Acid Scavenger / Fast Reactant
- Reductant of Plutonium [Pu(IV) to Pu(III)]

Nitrous Acid Scavenger

- Reactivity of Nitrous Acid Scavengers @25°C

Substrate	0.05M [H^+]	0.5M [H^+]	1.3M [H^+]
HAN	0.15	2.1	9.6
Hydrazoic Acid	8	105	680
Hydrazine	31	390	1820

$$H^+ + HNO_2 \rightarrow H_2NO_2^+$$

$$Substrate + H_2NO_2^+ \rightarrow Products$$

Nitrous Acid Scavenger

- Hydrazine impedes Pu leakage by reacting on HNO_2
- The Scavenging reaction is **fast**, Acid, Temperature and Ionic Strength dependent
- The Global Reaction is: $N_2H_4 + HNO_2 \rightarrow HN_3 + 2H_2O$

$$Rate\ Constant = kK_a \frac{[H^+][N_2H_4][HNO_2]}{K_a + [H^+]}$$

Plutonium Stabilizer
Re-oxidation Mechanism

- The Re-Oxidation of Pu(III) has two main side effects:
  - Re-produces Pu(IV) and so deplete HAN
  - Autocatalyzes the production of Nitrous Acid (rate: 1.5 for 1)

$$Pu^{3+} + N_2O_4 \rightarrow Pu^{4+} + NO_2 + NO_2^-$$

$$H^+ + NO_2^- \rightleftarrows HNO_2$$

$$2NO_2 \rightleftarrows N_2O_4$$

Reduction of Plutonium

- In addition to the scavenging of nitrous acid, hydrazine also may reduce Pu(IV) to Pu(III)
  - In excess of Pu

$$4Pu^{4+} + N_2H_4 \rightarrow 4Pu^{3+} + N_2 + 4H^+$$

  - In excess of Hydrazine

$$2Pu^{4+} + 2N_2H_4 \rightarrow 2Pu^{3+} + 2NH_4^+ + N_2$$

  - Global Reaction (assuming a 1:1 ratio)

$$N_2H_5^+ + Pu^{4+} \rightarrow Pu^{3+} + \frac{1}{2}N_2 + NH_4^+ + H^+$$

Rate Constant of Pu Reduction by N_2H_4

- The kinetics of the reduction of Pu by hydrazine can be described by the following reduction rate (@50°C; I=2)

$$-\frac{d[Pu(IV)]}{dt} = k\frac{[Pu(IV)][N_2H_4]}{0.14+[H^+]}$$

- Temperature, Ionic Strength dependent
- This reaction is slower than the HAN reduction

Hydrazine Reduction of Plutonium Mechanism

- The mechanism of reduction of Pu by hydrazine may be described by the following steps:

$$Pu^{4+} + H_2O \xrightarrow{K_h} PuOH^{3+} + H^+$$

$$N_2H_5^+ + PuOH^{3+} \rightarrow Pu^{3+} + N_2H_3 + H_2O + H^+$$

$$N_2H_3 + 3Pu^{4+} \rightarrow 3Pu^{3+} + N_2 + 3H^+$$

$$2N_2H_3 \rightarrow N_4H_6$$

$$N_4H_6 \rightarrow 2NH_3 + N_2$$

Safety Strategy Approach

- Nitrous scavenging properties of Hydrazine prevents the production of dinitrogen tetraoxide, the main intermediate of autocatalytic reaction
- DCS is currently evaluating the use of hydrazine as a potential safety control strategy as well as other means such as a direct HAN approach

Hydrazoic Acid

- Hydrazoic Acid is a product from the reaction between hydrazine and nitrous acid
- It supports hydrazine in its role as being a scavenger (because it is more prevalent in the organic phase)
- It scavenges nitrous acid through a fast reaction

$$HN_3 + HNO_2 \rightarrow N_2O + N_2 + H_2O$$

- Production of gases

Hydrazoic Acid

- Hazard – Properties

  Unstable compound in pure chemical form when heated or shocked
- Threshold partial pressure moving hydrazoic acid into explosive regime experimentally found to be 68 Torr with theoretical partial pressure established to be 19 Torr

Desorption of Hydrazoic Acid

- Critical concentration in aqueous and gaseous phases are given by Henry's Law with experimentally derived Henry's Coefficients

$$H(\mathrm{atm}\cdot M^{-1}) = \frac{P_{HN_3}}{[HN_3]}$$

- Aqueous Phase $H(\mathrm{atm}\cdot M^{-1}) = C\exp(-\frac{E_a}{RT}) = 75{,}475\exp(-\frac{4{,}002}{T})$
- Organic Phase $H(\mathrm{atm}\cdot M^{-1}) = C\exp(-\frac{E_a}{RT}) = 9.5\times10^{9}\exp(-\frac{8038}{T})$

NB: Calculations had been made with a partial pressure of 19 Torr and 0.14M hydrazine

- Critical concentrations calculated to be 0.05M and 0.08M in aqueous and organic phase respectively

Summary
Production of N_2O_4 vs. scavenging HNO_2

- Dinitrogen tetraoxide is the key element in the formation of nitrous acid. The objective is to ensure that its production rate is inhibited by scavenging processes

Temperature [°C]	Rate Constant per sec.in 1.3M HNO3			
	Production (Pr)	Scavenging (Sc)		
		HAN	HN_3	N_2H_4
25	3	10	680	1820
	Ratio Sc/Pr	*3*	***225***	***603***

Design Basis

- Temperature < 60°C
- Partial pressure 19 Torr under investigation
- Hydrazoic Acid concentration <0.055M
- Implement control to ensure that hydrazoic acid is not present in the solvent flow

Plutonium – Oxalate System

Red Oil Phenomena Analysis

Wednesday, Dec 11th
Red-Oil Phenomena

- Team
- DCS Approach to Safety
- TBP Degradation
- Open and Close Systems

ISA Aqueous Polishing Team

Support from both National Laboratories and Academia
Hanford, MIT, Fauske & Associates and Clemson

Support from Oak-Ridge, and Savannah River.

Dr. Marc KLASKY, DCS
Dr. Sven Bader, DCS
Marc Vial, DCS/MIT
Prof. Ken Czerwinski, MIT
Prof. Jim Navatil, Clemson
Dr. Scott BARNEY, Hanford
Dr. Hans Fauske, FAI

DCS Approach to Safety

- Develop ***fundamental understanding*** of phenomena based on **first principles**
- Identify Safety Strategy, necessary and sufficient principle SSCs, and corresponding design basis based on fundamental understanding of phenomena
- Evaluate previous events and controls proposed by others

TBP Degradation (1)

- Basis for the use (or not) of 135°C temperature limit
- The fundamentals of chemical reactions producing energy and basic principles of heat transfer must be understood.
- As stated in the CAR the principle SSCs must be viewed in the aggregate.

TBP Degradation (2)

- Closed System
  - No evaporative cooling because of the equilibration of the system
  - Increase heat that pressurizes the system
- Open System
  - Evaporative Cooling
  - Evaporation of Oxidizing Agents and Decomposed Organics
  - No Pressure Buildup

Experimental Results in a Closed System

- RSST Results showed that the initiation self heating occurs at temperatures in excess of 137°C
- Initiation temperature of self heating is affected by the concentration of nitric acid in the organic

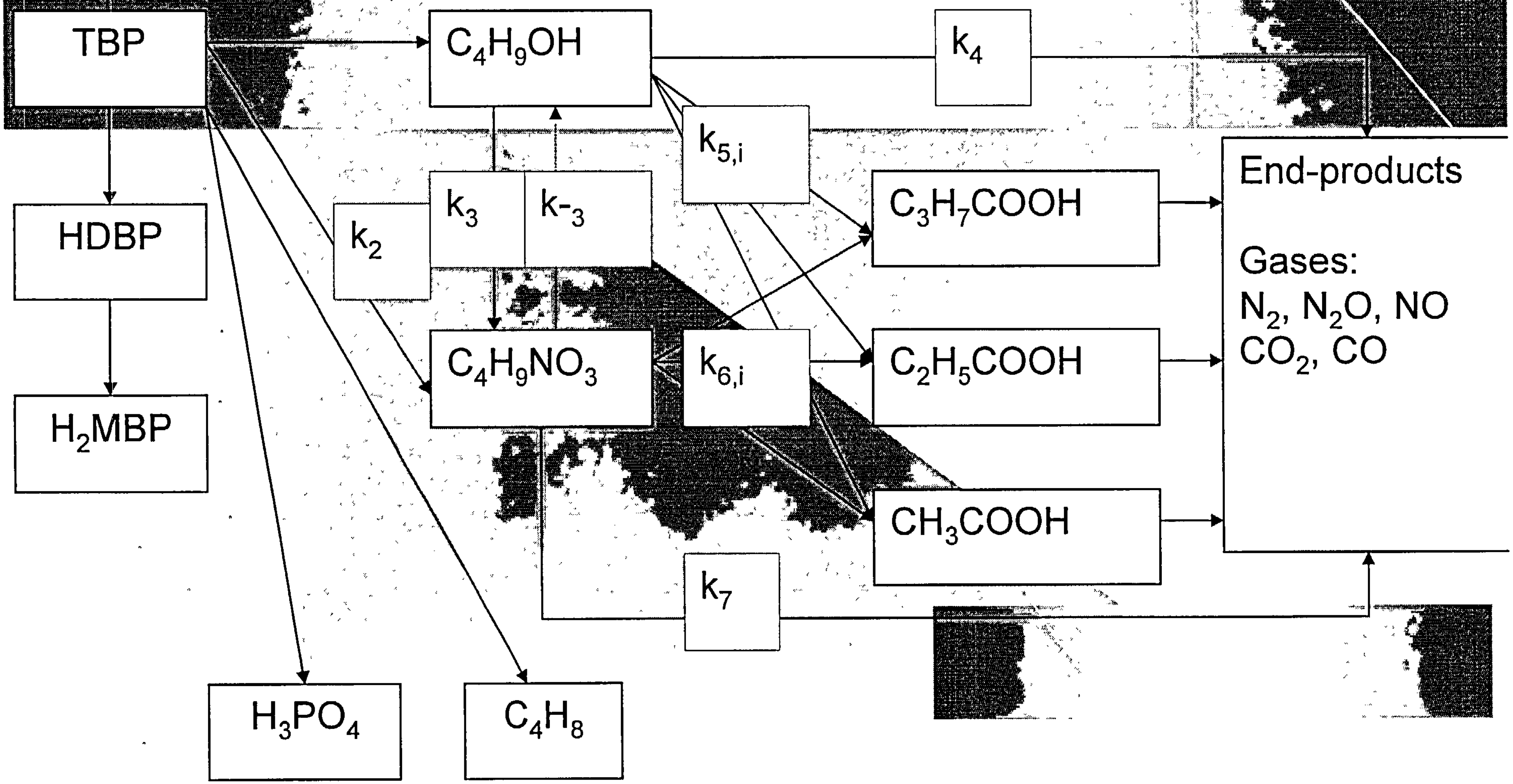
Experimental Results in an Open System

- Evaporative cooling ensures that self-heating does not occur
- Removal of the oxidizing agents reduces the energy content of the system

Principal SSCs for TBP systems

- Selection of Appropriate Diluent ensures that venting is not compromised
- Adequate Venting ensures that the gases produced via TBP degradation reactions are vented
- Venting requirements have been experimentally determined for a TBP/nitric acid/degraded organic system by Fauske

TBP Decomposition Mechanism



DCS Investigation and Analysis

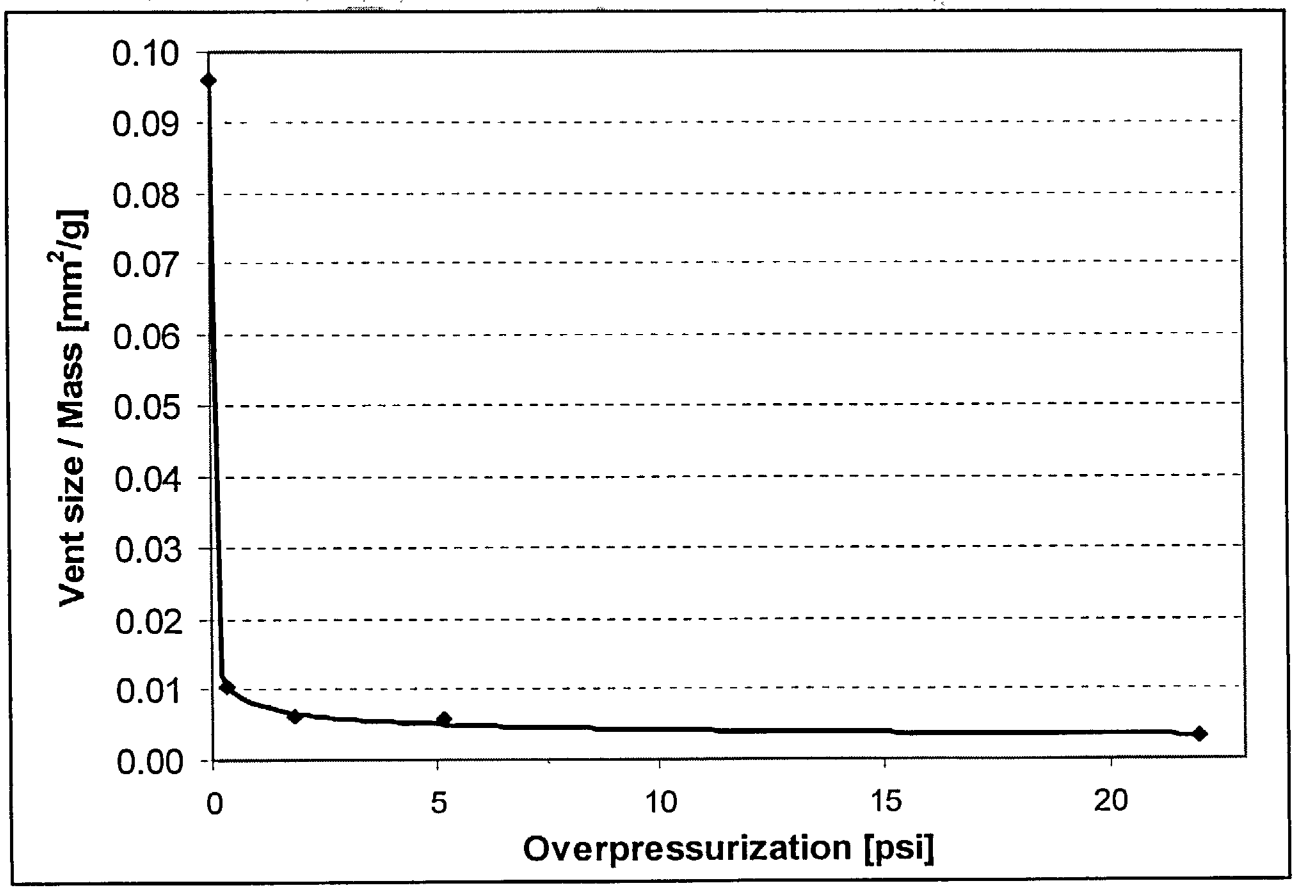
- ISA group has performed confirmatory analytical analysis utilizing kinetic data and the stoichiometric relationship for the quantity of gases generated per mole of TBP reacted, and, confirmed the Fauske relationship for application at the MFFF.
- The Fauske relationship ensures, if satisfied, that over-pressurization events will not occur even in the event that a runaway reaction resulting from TBP/nitric system did occur.

Fauske's Results (1)
Vent Area / Mass ratio vs. Overpressure Relationship

- The relationship between the vent size to mass ratio and the overpressure as described by Fauske may be fit as:

$$\rho = 7.9 * 10^{-3} * \Delta P^{-0.27}$$

Fauske's Results (2)
Vent Area / Mass ratio vs. Overpressure Graph



Confirmation of Fauske's Equation

- Utilizing an Arrhenius equation for the hydrolysis reaction :

$$k_{HNO_3 2TBP} = 4.3 * 10^{10} * \exp(-\frac{112}{RT})$$

where the activation energy is in kJ/g.mol, T in Kelvin and R is equal to $8.314 * 10^{-3}$ kJ/(mol.K).

- And a stochiometry given by:

$$TBP \bullet HNO_3 \rightarrow H_3PO_4 + \frac{3}{2}(N_2 + CO_2 + H_2O + PrCOOH + PrOH)$$

- The mass flow rate of gases produced by the decomposition reactions of TBP at a specified temperature may be calculated.

Fauske's Results – Data

Table 1 – Gas Rates as Function of Reaction Temperature

Temp [°C]	Gas Const R [kJ/g mol K]	k (rate) [s^{-1}]	TBP [M/L]	Gas generated [lb/hr/g]
60	0.008314	1.16E-07	2.6	1.3E-07
135	0.008314	1.9E-04	2.6	2.2E-04
150	0.008314	6.4E-04	2.6	7.2E-2
180	0.008134	5.5E-03	2.6	5.8E-03

Crane's Equation

From Crane's "Flow of Fluids through Valves, Fittings and Pipe" Technical Paper Nº 410 the pressure drop though a nozzle may be determined by use of the following orifice equation:

$$\Delta P = 3.36 * 10^{-4} * \frac{f * W^2}{\rho * d^5}$$

- Where:
  f is the pipe friction factor;
  ΔP is the pressure drop per 100 ft equivalent;
  W is the gas flow in lb/hr;
  d is the pipe/nozzle inside diameter in inches;
  r is the gas density in lb/ft^3;

Using the pressure drop orifice equation with the predicted gas generation rates from Table 1, the pressure though a vessel nozzle may be calculated and compared to the results of Fauske.

DOE Report on Tomsk Event (1993)

"It should be noted that the Team found all facilities that were visited and/or reviewed to be in a safe condition with no "red oil" event imminent or in the offing; however, there were vulnerabilities identified that lessen the apparent safety margin. In essence, the margin was always sufficient, but in several cases it could and should be improved (refer to Recommended Action Items for Specific Sites, below). It is emphasized that while the individual criterion rating may suggest that safety enhancement is desired according to Table 1 (red circles), individually these ratings are generally not an indication of a concern or deficiency, excepting perhaps a vulnerability to inadvertent acid addition. However, taken in their totality for a given facility, there may be indications that special attention should be given to "red oil" concerns, in the continuing effort at DOE sites to improve safety performance."

MEETING ATTENDEES

NAME	AFFILIATION
December 10:	
Andrew Persinko	Nuclear Regulatory Commission (NRC)
Melvyn Leach	NRC
Wilkins Smith	NRC
Alex Murray	NRC
David Brown	NRC
Joel Kramer	NRC
Rex Wescott	NRC
Sharon Steele	NRC
Norma Garcia Santos	NRC
Julia McAnallen	NRC
William Troskoski	NRC
Peter Hastings	Duke Cogema Stone & Webster (DCS)
Gary Kaplan	DCS
Ken Ashe	DCS
Tom St. Louis	DCS
Marc Klasky	DCS
Jean-Francois Weiss	DCS
Marc Vial	DCS/MIT
Faris Badwan	Los Alamos National Laboratory (LANL)
Dan Horner	McGraw-Hill
Geoff Kaiser	SAIC
December 11:	
Andrew Persinko	Nuclear Regulatory Commission (NRC)
Melvyn Leach	NRC
Joe Giitter	NRC
Alex Murray	NRC
David Brown	NRC
Rex Wescott	NRC
Sharon Steele	NRC
Norma Garcia Santos	NRC
William Troskoski	NRC
Peter Hastings	Duke Cogema Stone & Webster (DCS)
Gary Kaplan	DCS
Ken Ashe	DCS
Tom St. Louis	DCS
Marc Klasky	DCS
Jean-Francois Weiss	DCS
Marc Vial	DCS/MIT
Ken Czerwinski	DCS/MIT

Faris Badwan	Los Alamos National Laboratory (LANL)
Geoff Kaiser	SAIC
Steven Dolley	Nuclear Control Institute (NCI)

<u>December 12:</u>

Andrew Persinko	Nuclear Regulatory Commission (NRC)
Melvyn Leach	NRC
Alex Murray	NRC
David Brown	NRC
Rex Wescott	NRC
Sharon Steele	NRC
Norma Garcia Santos	NRC
William Troskoski	NRC
Frederick Burrows	NRC
Paul Loeser	NRC
Peter Hastings	Duke Cogema Stone & Webster (DCS)
Gary Kaplan	DCS
Ken Ashe	DCS
Tom St. Louis	DCS
Marc Klasky	DCS
Jean-Francois Weiss	DCS
Ronald Jackson	DCS
Marc Vial	DCS/MIT
Faris Badwan	Los Alamos National Laboratory (LANL)
Geoff Kaiser	SAIC
Phil Kasik	MPR

CLARIFYING INFORMATION PROVIDED BY DCS

Attachment 5

10-12 December 2002 NRC Public Meeting: Chemical Safety
Summary of Action Items

CS-05 ("Operator Action")

Action: DCS to provide clarification. Text follows:
The MFFF Construction Authorization Request states: "No facility worker or operator actions outside the control room are required to mitigate the consequences to meet the requirements of 10 CFR §70.61 for a chemical release." [31 Oct 2002 CAR, §5.5.2.10.6.1] As amplification of that statement, any adverse impact to an operator occurring during a release of unregulated material (i.e., material that does not constitute "licensed material or chemicals produced from licensed material") will not result in exceeding the performance criteria of 10 CFR §70.61. As indicated in the existing language above, no PSSCs are required to mitigate an unregulated release. Further, the controls that could be impacted by a release of unregulated material are effectively "permissive" in nature (i.e., positive result required before additional processing can continue), and are not required following such a release. These include: chemical safety controls that are administrative and laboratory material controls (i.e., permissive sampling and analysis, etc.); and material handling controls that are either permissive or that fail in a safe state. An appropriate change page for the CAR to reflect this change will be provided.

Language was provided at the conclusion of the meeting and closes this portion of CS-5.

CS-05 (Justification of TEELs, etc.)

Action: DCS to provide clarification that its intent is to commit to specific values, not to TEEL levels that are subject to change. DCS also to provide response to question of adequacy of our committed thresholds, including clarification (if needed) of use of TEEL-2 vs. TEEL-3 values.

Response pending

AP-14: Pu (VI) Oxalate

Action: DCS to provide clarification. Text follows:
The MFFF Construction Authorization Request lists the following design basis pressure criteria for storage tanks, process columns, exchangers, and L/P prime movers (e.g., air lifts, ejectors, siphons, etc.): the greater of Pressure (max) acting at the top of the vessel in normal operating condition + 10% OR Pressure (max) acting at the top of the vessel in accidental or incidental (transient) conditions. (A similar set of criteria is provided for piping and valves as well.) [31 Oct 2002 CAR, Table 11.8-2] DCS also commits to the same criteria for the calciner furnace, and will provide this information in the appropriate location in the CAR accordingly. Applicable codes (cf. Table 11.8-1) have not been identified for the calciner furnace, but owing to the essentially atmospheric pressures anticipated in the calciner furnace, the previously identified 10% safety margin from P(max) during normal operation is judged to be adequate to achieve the performance requirements of 10 CFR §70.61. An appropriate change page for the CAR to reflect this change will be provided.

This language was provided at the conclusion of the meeting and the Staff agreed it would close this new open item. Subsequent to the meeting, however, the Staff retracted their acceptance; they are "essentially happy with the write-up," but want clarification of measurement techniques and thresholds (in qualitative terms) for verifying sufficiently low concentrations of Pu (VI). DCS needs to discuss this with the Staff to clarify what they are looking for.

Open Item CS-02 (HAN)

ACTION: DCS will provide a write-up addressing the issues discussed at the meeting.

Response pending

CS-03 (Hydrazoic Acid)

Action: Staff to determine if DCS needs to clarify design basis values in the CAR. DCS to provide clarification that design basis is not "either/or" between neutralization and sampling. Text follows:

The MFFF Construction Authorization Request states:

"The safety function of chemical safety control is… (2) to ensure that hydrazoic acid is not accumulated in the process or propagated into the acid recovery and oxalic mother liquors recovery units by either taking representative samples in upstream units or by crediting the neutralization process within the solvent recovery unit." [31 Oct 2002 CAR, §5.5.2.4.6.10]

and

"Ensure that hydrazoic acid is not accumulated in the process or propagated to units that might lead to explosive conditions" (Chemical Safety Controls safety function) [31 Oct 2002 CAR, §5.6]

and

"In addition to the previously identified design basis, sampling controls are also implemented to ensure that the process of transforming the hydrazoic acid to sodium azide within the Solvent Recovery Unit is effective to ensure that hydrazoic acid does not accumulate in the process to a limiting concentration due to the continuous injection of hydrazine into the Purification Cycle. This sampling control also ensures that azides are not formed within the extraction and diluent washing pulse columns of the Purification Cycle (i.e., PULS2000 and PULS2200) due to the potential presence of metal impurities within these columns." [31 Oct 2002 CAR, §8.5.1.8]

As clarification, particularly of §5.5.2.4.6.10, sampling has not been determined to be required as a PSSC for confirming neutralization of hydrazoic acid (sampling is employed to assure the proper concentration of hydrazine nitrate is introduced into the system, thereby limiting the quantity of hydrazoic acid produced). The effectiveness of the neutralization process will be demonstrated as part of the ISA. Should it be determined at that time that the effectiveness of the neutralization process cannot be sufficiently demonstrated, a sampling PSSC will be implemented.

In the event sampling is determined to be required, it will be by way of confirming such neutralization, not as a control *in lieu of* neutralization.

An appropriate change page for the CAR to reflect this change will be provided.

This language was presented at the meeting in hopes of closing this item; Staff still not yet prepared to close, according to subsequent discussion with PM; they are evaluating.

Open Item CS-09 (Solvent Temperature)

Item is open – information is scheduled by DCS to be provided in January.

Response pending

Open Item CS-10 (ECR Habitability)

Action: DCS to provide clarification. Text follows:
DCS will include concentration threshold criteria to the existing design basis for the Emergency Control Room HVAC, based on TEEL-3 values, as necessary based on consequence analyses (i.e., results to date show low consequence).

Subsequent discussion with Staff confirmed they are satisfied with this response, subject to TEEL threshold discussion of CS-05 (i.e., acceptability of TEEL-3 values).

Open Item CS-04 (pH Control/Azides)

Staff identified three issues:

- DCS needs to identify administrative controls to avoid dryout and clarify that they are part of the safety strategy at CAR page 5.5-39
- DCS needs to identify the design basis for U-Pu concentrations
- DCS needs to provide a pH value for sodium azide

This issue was not discussed in detail owing to time constraints.

Response pending

Open Item CS-07 (Delivery of Chemicals)

Closed based on closure of "operator action" issue under CS-05.

Staff concurs this item is closed

Open Item AP-13 (Hazardous Chemical Releases in Process Cells)

Action: DCS to provide qualitative discussion of conservatisms in site worker calculation supporting judgment that the site worker consequence bounds that of a facility worker inside the facility subject to unlikely "recirculation" of chemical releases emanating from the stack. Text follows:
With regard to the potential for significant chemical exposure to facility workers from "recirculation" of releases from the stack back into the MFFF, DCS provides the following justification for considering that the calculated consequence for the "site worker" receptor bounds this unlikely scenario. The site worker analysis uses conservative, bounding, deterministic assumptions including: no credit for the stack (i.e., a ground release); conservative dispersion modeling (χ/Q); no immediate evacuation; and no credit for the significant dilution that will occur within the HVAC system prior to release from the stack. Further, the stack itself is provided with standard design features to limit "downwash." There should be ample evidence, therefore, that the conservatively calculated site worker consequence will bound any reasonably realistic "recirculation" consequence to the facility worker by as much as several orders of magnitude. Furthermore, the distance from the point of release to the receptor, considering recirculation through the stack and building intake is expected to be approximately the same as the distance to the site worker.

Staff agrees with this action, which will close this item; submittal of the information above is "new."

Open Item CS-08 (DUO_2 in Warehouse)

Action: DCS to provide additional commitment. Text follows:
As justification for a DR of 0.1, DCS will add "combustible loading controls" as a PSSC in the secured warehouse for the DUO_2 fire to prevent consequence to the site worker. DCS will also include facility worker action (i.e., "worker self-protection") as a PSSC to prevent consequence to the facility worker.

Staff agrees with this action, which will close this item; submittal of the information above is "new."

New Questions: Fire Protection

- CAR §§11.4.11.1.4 & 11.4.2.5.2 discuss isolation valves for C4 and C2 – Staff inquired as to the difference in performance of isolation valves vs. fire dampers.

ACTION: To eliminate a terminology/perception problem, DCS will change the terminology in the CAR from "fire damper" to "fire-rated damper." This change will not occur in detailed design documents.

Staff agrees with this action, which will close this item; submittal of the information above is "new."

- In the original CAR, §5.5 listed the C4 final filter as a PSSC for fire events in the C2 area; this is not the case in the revised CAR; Staff asked for an explanation.

ACTION: DCS committed to provide a change page to add discussion back into glovebox events.

Staff agreed with this action, which will close this item. The change page discussed above has since been submitted.

- CAR §7.2.4.3.3 implies 100% reserve for clean agent is no longer true; Staff asked about the design change and basis.

ACTION: DCS will provide change page(s) to clarify in the CAR; submittal of change page(s) will confirm validity of remainder of RAI response (i.e., seismic, etc.).

Staff agrees with this action, which will close this item; submittal of the information above is "new."

- Staff observed CAR §7.4 discusses FPETool but does not describe the end use of the tool or considerations/inputs;

ACTION: Staff to review methodology in in-office review and identify potential language for addition to CAR.

Open Item CS-01 Red Oil

Open systems

(1) How is mass accumulation of degraded organics addressed?
ACTION: DCS to clarify. Text follows:

> As clarification, the discussion in the CAR indicating "introduction of material" was intended to refer to content of the vessel, including introduction/production, depletion, buildup, etc., as applicable. As indicated in the CAR, controls will be implemented to ensure the vent size is adequate for the total organics concentration.

(2) Why are proposed nitric acid limits different from DOE values?
ACTION: Document response. Text follows:

> As clarification, DCS has not designated nitric acid concentration as a PSSC for preventing TBP/nitric acid reaction overpressure events. The maximum pressurization of a system for a given organic content is based on the bounding conservative assumption of the maximum quantity of nitric acid in the organic phase (i.e., solubility limit of nitric acid in the organic phase).

(3) How does our analysis account for materials other than TBP and nitric acid in terms of energetic potential (mainly concerned about butyl groups)?
ACTION: Document response. Text follows:

> Experimental results have indicated that the inclusion of degraded organics does not result in a discernible difference compared to use of TBP alone. This is attributed to the fact that degraded organics are derived from the degradation of TBP. Thus, the vent size-to-organics ratio is based on total organics.

(4) For vent systems, show two-phase flow will not occur or that vent design will accommodate.
ACTION: Document response. Text follows:

> Experiments have been performed to quantify the required vent area-to-organic mass ratio for a TBP/nitric acid "runaway" reaction. A full range of conditions has been examined in the experiments, the results of which thereby empirically account for foaming, two-phase flow, or other mechanism that may have been present during the experimental conditions. As stated in the 10-12 Dec 2002 public meeting, DCS' approach is to develop a fundamental understanding of the system by evaluating the mechanism and behavior of the chemical system through modeling and experimentation as needed. This fundamental understanding will allow determination of the appropriateness of the relationship of the vent area-to-mass organic ratio.

Closed systems

(1) What is difference in safety strategy between open and closed systems (e.g., temperature)?
ACTION: Document response. Text follows:

> For both open and closed systems, the safety strategy is to prevent over pressurization (i.e., explosion). In an open system, prevention of over pressurization is accomplished by providing a sufficient exhaust path for the removal of gases in process vessels (i.e., venting). For a closed system, prevention of over pressurization is accomplished by maintaining temperature below the initiation temperature for the "runaway" reaction, resulting in a design basis value of 135°C. Notwithstanding the fact that over pressurization in an open system is provided by implementing a sufficient vent area-to-organic mass ratio, limiting temperature at the external heat source to 135°C is conservatively applied to both open and closed systems.

(2) Does 135C value take into account the effects of impurities (e.g., U, Pu, Fe)?
ACTION: Document response. Text follows:

> As clarification, the entire AP system is vented, and DCS' intent is to demonstrate adequate venting to all vessels to the maximum extent practical. DCS is evaluating the effect of impurities on the initiation temperature in closed systems. It is conceivable that analyses and experiments could result in increase or decrease of the temperature at which action is required to remain below the design basis value. Specific set-points will be developed in accordance with the codes and standards described in CAR Section 11.6.7 But the phenomenon is also a function of organics content, nitric acid concentration, system pressure, and extent of venting available. DCS anticipates these parameters can likely be varied as part of detailed design without significant impact to the constructed facility.
>
> Refer also to §8.5.1.5.6 for a discussion of additional controls which provide further confidence that even an unlikely buildup of significant quantities of degraded organics will not result in an unsafe condition. Those controls include limitation of residence time of organics in the presence of oxidizers such as nitric acid and radiation fields, to limit the quantity of degraded organics that may buildup in the system either through hydrolysis and/or radiolysis (e.g., removal of material and/or periodic surveillance/ representative sampling in the unlikely event of an extended facility shutdown).
>
> DCS will advise as to whether adequate venting (i.e., open systems) can be applied as a design basis (i.e., no closed systems) to all AP equipment.

This language was provided at the conclusion of the meeting and will close CS-01.

Open Item AP-2

> **ACTION:** DCS will provide description of LFL determination methodology and provide the report we cited as containing supporting information regarding acid normality effect on H_2 production.

Response pending

Open Item MP-4

> No further action to close

Open Item AP-3 (Ti Fire)

ACTION: Staff to provide citation for reference discussed in meeting

This action is complete.

ACTION: DCS to provide additional information to address open questions.

Open Item MP-1 (UO_2 "pyrophoricity")

ACTION: DCS will commit/confirm that heat load calculation includes effects of burnback, and that soot loading includes effects of oxidizing UO_2.

Staff agrees with this action, which will close this item; submittal of the information above is "new."

Open Item MP-2 (PuO_2 "pyrophoricity")

ACTION: DCS will provide a response evaluating safety controls and providing rational for moisture content after oxidation.

Response pending

New Questions: Electrical/I&C

- CAR pg 11.9-65 under 11.9.5.2 says pressure vessel controls are administrative; Table 5.6-1 indicates otherwise

ACTION: DCS to clarify these are not process controls – essentially administrative controls on placement of gas bottles – and add asterisk to table

Staff agrees with this action, which will close this item; submittal of the information above is "new."

- CAR 5.6.2.1 says chemical safety control program includes administrative and engineered controls - explain conflict with Table 5.6-1

ACTION: Clarify "the principal SSC chemical safety controls is used to implement this sampling process and it utilizes the following ~~engineering and administrative~~ measures…" (i.e., clarify context that sampling is a permissive control for other processes, not a control unto itself)

Staff agrees with this action, which will close this item; submittal of the information above is "new."

- CAR 11.4.11.8 (pg 11.4-34) discusses overpressure control/protection for furnace; are instrumentation channels part of the process safety control system?

ACTION: DCS will move associated Table 5.6 entries to under the process safety control entry. DCS confirms they are part of process safety controls, but it is not clear (as part of detailed design) if they're PLCs or pressure transmitters.

Staff agrees with this action, which will close this item; submittal of the information above is "new."

- CAR 11.4.11.8 says furnace is shut down with no damage to confinement barrier; what is the method to shut down the furnace, and is it the same as equipment used to "shut down process equipment prior to reaching safety limits" in Table 5.6-1 entry on pg 5.6-17 - what's control basis for shutting down furnace?

ACTION: clarification provided in meeting; no additional action required

- CAR pg 11.6-17 says unique standards are applicable to gas detectors; are they part of the process safety control subsystem?

ACTION: clarification provided at meeting; no additional action required (cf. MP-4)

- 5.6.2.6 says continuous air radiation monitors provide additional assurance of response to confinement failure; are they PSSCs?

ACTION: clarification provided at meeting; no additional action required

- CAR 11.5.2.5 says entire electrical system is tested per IEEE standards; verify breadth of commitment

ACTION: DCS to clarify over commitment was not intended

Response pending

- CAR 11.3.3.3 on pg 11.6-8 says loss of safety function followed by placing system in fail-safe condition does not require separation; clarify

ACTION: DCS to provide clarification

Response pending

- CAR 11.6.7 includes new information on digital computer software; discuss planned conformance with or use of IEEE-829-1983, IEEE-1016-1987 and NUREG/CR-4640 (usually used for reactors in conjunction with other standards listed)

ACTION: clarification provided at meeting; no additional action required

- CAR pg 11.6-16 provides new information on standards for EM and radio interference on electrical control systems; discuss EPRI TR-102323 Guide to EM Interference Susceptibility and Info Notice IN-8383 for reactors

ACTION: no additional action required; comment noted for our evaluation

- CAR 11.5-13 contains awkward wording regarding emergency control system; CAR 11.5-15 says emergency control room can be started/stopped from Emergency Control Room – clarify starting generator A from ECR A, generator B from ECR B

ACTION: clarification provided at meeting; DCS to clean up both sections editorially

- CAR 11.6-16 discusses seismic/EQ of emergency control system; is the process safety control system qualified? If latter system is inoperable by environmental conditions or dynamic effects, are other systems needed to ensure safety? Staff noted 10 CFR 70.64(a) provision for EQ for "all PSSCs" (irrespective of function during event).

ACTION: DCS clarified at meeting that safety control system is qualified for anticipated environments during normal, maintenance, and accident conditions, but has no post-seismic function; system stops in fail-safe condition, and process stops via seismic trip; No further action for DCS **ACTION:** Staff to determine if regulatory interpretation required

- CAR 11.6-17 discusses design basis of seismic monitoring system; Jan 2002 letter committed to IEEE 603 for seismic trip system; reaffirm commitment in light of new discussion; discuss relationship between seismic monitoring and seismic trip

ACTION: DCS to clean up paragraph, including clarification of commitment to IEEE 603 for seismic sensors, trip actuation

Response pending

- CAR 11.5-15 discusses EQ of emergency A/C power - IEEE-323-1983 for 1E includes qualification for harsh environments for design bases and post-design bases events; discuss for electrical and mechanical equipment including chemical releases

ACTION: DCS clarified in meeting that PSSCs are qualified to anticipated environments (CAR change page not required); including qualification to environment if related event is not prevented; no further action for DCS