

What the NWTRB should do about INL's "Steam Reforming" Boondoggle*

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*update of an informal submission, ("**What DEQ should...**") sent 6/27/12 - see "speaker notes" for additional info

Advice for the NWTRB

- Don't don DOE's blinders – challenge nonsensical assumptions
- Don't be lazy – read/GOOGLE everything, make lots of phone calls, use your common(?) sense, & do your own ball park calculations
- Question DOE's "experts", esp. anyone who's either been paid to do something for a DOE contractor or hopes to go to work for one
- Don't be afraid to "rock the boat" – you are supposed to (and can) be independent
- Don't get bogged down by "transscientific" (political) issues* – your job is to concentrate on "technical" stuff

*e.g., pondering the meaning of things like "high", "low", & "consent based"

WHY CARE?

*The World **really** does need a genuinely sustainable “nuclear renaissance”^{note} but...*

- Any such renaissance would require more “reprocessing”
- *“... eventually the anti-nuclear groups found the soft underbelly of the industry. It was something that had remained in the engineering background for decades. It was not nearly as exciting as striving for plutonium breeder reactor configurations or ceramic cores for jet engines, but it was there, and it was a distant bother. It was a nag. It was the long-term disposal of all the radioactive byproducts of nuclear fission”.*
- The institutions collectively responsible for implementing the USA’s reprocessing waste management system (primarily DOE plus its regulators & advisors) have been shirking their responsibilities

*James Mahaffey, “Atomic Awakenings”, p. 304, Pegasus, 2009



Root cause #1 of EM boondoggles is DOE's chronic (mis)management "symptoms"*

1. (EM's) Planning is driven by existing organizational structures rather than problems to be solved
2. Commitments are made without adequately considering technical feasibility, cost, and schedule
3. An inability to look at more than one alternative at a time
4. Priorities driven by narrow interpretations of regulations rather than the regulations' purpose of protecting public health and the environment
5. The production of documents as an end in itself, rather than as a means to achieve a goal
6. A lack of organizational coordination
7. A "not-invented-here" syndrome at individual sites.

**Barriers to Science, Technical Management of the Department of Energy Environmental Remediation Program*", NAP, (1996).



Root cause #2 is DOE's approach to implementing "privatization"^{note}

While "Barriers to Science" was being written, the National Academy's latest concerns included the probable (now realized at both Hanford & INL) consequences of DOE's then-new "privatization initiative": for-profit contractors were to be encouraged to "help" with policy decisions & allowed to operate the Government's national labs in ways that would maximize their profits. The "technical details" of what our government was trying to do and what our tax dollars would be paying for were to (and did) become "proprietary" information.

“High Level” decision making

Characterized by unreasonable and self serving assumptions, phony deadlines, foot dragging, wishful/short term thinking, over-reliance upon in-house “experts” with ties to existing or prospective contractors, **and the passive acquiescence of nominally “independent” oversight/advisory bodies**

Consequently

- The IWTU doesn’t “integrate” – today’s SBW and calcine treatment scenarios are almost totally incompatible
- Fluidized bed “Steam Reforming” (FBSR) is an inappropriate technology – intrinsically problematic (expensive) & if it can ever be made to “work”, will produce an inferior product which will then have to be “fixed”
- Unreasonably high cost projections and overly long time lines (2035 AD?) for treating its own reprocessing wastes are killing INL’s chances of convincing anyone that it (or Idaho) should be leading a “nuclear renaissance”

this could lead to permanent INL Site shut-down

The outcome of twenty years worth of “studying” calcine disposition

2.6.2 Selection Value – Cost

Estimated Range of CDP Treatment and Cost Parameters

Parameters	HIP without RCRA Treatment		HIP with RCRA Treatment		Direct Disposal		Vitrification with Separations		Vitrification without Separations	
Canisters	2,900	3,300	3,700	4,600	6,700	7,300	750	2,200	11,100	13,300
Total Life-Cycle Cost (\$M)	5,503	6,228	6,052	7,119	7,661	8,408	9,556	12,769	11,054	13,074
Cost Ratio	1.00	1.13	1.10	1.29	1.39	1.53	1.74	2.32	2.01	2.38

Calcine Disposition Project, presentation to NWTRB by Ron Ramsey, 29Je10



Breakdown of DOE EM's cost analysis¹

OPTION CHARACTERISTICS	Direct disposal	HIP wo additives	HIP with additives	Sep-VIT	Direct VIT (BSG)
No. of canisters ¹	7300	3300	4600	2200	13300
Total cost, \$M ¹	8410	6230	7120	12800	13100
Disposal/transport cost, \$M ²	4526	2046	2852	1364	8246
Processing cost/m ³ of calcine, \$M ³	0.882	0.950	0.970	2.592	1.097
Processing cost/canister, \$M ⁴	0.532	1.267	0.928	5.184	0.383

1. Slide 2.6.2, Ron Ramsey's NWTRB presentation, 29Je10
2. Cost = 0.6\$M* no. canisters (see p. 25 of DOE/ID-11251, Rev 0 (2007))
3. Process cost/m³ calcine = (total-disposal)/4400 (4400=total vol calcine)
4. Process cost/canister = (total-disposal)/no. canisters



MY OBSERVATIONS

- DOE EM's assertion that the “processing” required to implement the “direct disposal” of a cubic meter of INTEC calcine will cost about the same as HIPing or vitrifying it is unreasonable
- Separating INL's reprocessing radwaste is unreasonable^{note}
- Ridiculously inflated transport/disposal cost assumptions continue to dominate DOE's analyses*
- DOE EM's cost estimates shouldn't be driving decision-making

*e.g., why **should** it cost ~\$0.67 million/m³ to can up & transport several thousand of tonnes of virtually anything to “public land” in a neighboring state (Nevada?) & bury it in already-drilled tunnels?



INL's already-paid-for NWCF could & should have calcined SBW decades ago

- The sole modification required would have been the addition of an inline mixer to its feed line to enable addition of “molasses”***
 - Its “carbonate product” would be superior to that generated by IWTU’s steam reformer – lesser volume/mass & no residual carbon**
 - Sugar calcination would have generated far less toxic/visible NO_x than did INL/NWCF’s traditional purely thermal approach**
 - INL’s EM decision makers “killed” calcination by refusing to implement both this and other straightforward process improvements in a timely manner****
-

* This would have enabled the facile “sugar calcination” of SBW (see note)

** Why? Calcination would be inconsistent with their pet “separations” scheme (see note)



DOE/THOR's FBSR Sales Pitch

“stakeholders” were told that...

- SBW is fundamentally different (e.g., "100's of times less radioactive") than were the already calcined wastes & therefore doesn't require equivalent treatment (in other words, a water soluble, readily dispersible ultimate waste form would be appropriate for SBW)^{note 1}
- FBSR is fundamentally different than INL's calcination process
- FBSR would be cheaper than alternative treatment technologies, esp. vitrification
- The steam reformer's "carbonate product" would be shipped off to WIPP by the end of 2012
- If for some reason, WIPP's stakeholders refused to cooperate, FBSR could make a "better than glass" alternative product suitable for the same repository envisioned for INL's already-calcined radwastes (YM)
- And, of course, they were also led to believe that INL's steam reformer would treat all of its remaining tanked wastes - not just whatever happens to be "easy" to retrieve/process

None of those contentions is true

Misleading Assertions

(Unfortunately, THOR's "customer" wanted to believe)

- Asserting that FBSR would be cheaper^{note} than vitrification is totally unrealistic*
- Asserting that a water soluble, readily dispersible "carbonate" product would be immediately sent off to a repository (a key point to INL's stakeholders) is/was totally unrealistic**
- The results of both HAZEN's & DOE'S pilot plant runs did not support their assertion that that FBSR could convert SBW to a "better than glass" alternative product*** (a key selling point to citizen-stakeholders everywhere)
- The fact that all FBSR pilot plant runs done with both "alternative processes" were plagued with operational difficulties was consistently downplayed: the "executive summaries" of all such reports deemed the test "successful"
- The fact that much (often most) of the product generated consisted of readily dispersible, low bulk density, "fines" accompanied with lots of elemental carbon was consistently downplayed
- The notion that IWTU's "reformer" is any less an "incinerator" than NWCF had been (a key selling point to Idaho's DEQ) is bogus****

* primarily because a melter generates much less of a much less dusty off gas

**DOE's tank wastes were and still are specifically excluded by WIPP's WAP

***HAZEN's "raw" pilot plant run reports to/for THOR are still "proprietary" (secret). My FOIA request unearthed its report of its last "demo" of THOR's "mineralization" process with SBW: THOR/WGI test report 28266-RT-002 rev 0, July '07. THOR's own synopses of HAZEN'S results (see THORTT.com's "library") consistently leave out inconvenient facts & draw unreasonable conclusions.

**** process heat generation via the "in bed" burning of a fuel with oxygen constituted the rationale for labeling NWCF an "incinerator" – FBSR does the same thing with coal instead of kerosene

Some of the Taxdollar-Generated FBSR Sales Pitches^{note}

- Jantzen, C. M. (SRS), “Engineering Study of the Hanford Low Activity Waste (LAW) Steam Reforming Process,” WSRC-TR-2002-00317, Westinghouse Savannah River Company, Aiken, South Carolina, July 12, 2002. (This is probably the DOE Complex’s most influential “technical” contribution to THOR’s financial success. It is a rather simplistic primer on soda-felspathoid mineralogy & doesn’t actually deal with “engineering”- the processing equipment is not described & the physical characteristics of its “product” are not mentioned.)
- Jantzen, C. M. (SRS), “Characterization and Performance of Fluidized Bed Steam Reforming (FBSR) Product as a Final Waste Form (U)”, doc. WSRC-MS-20030-595, Rev 0 (This and succeeding SRS “characterization” reports conclude that a “mineralized” FBSR product is “better than glass” because a prewashed *fraction* of it exhibited area-normalized PCT leach performance superior to that of fine-ground EA glass.)
- McGrail, Pete, et. al., (PNNL), “Initial Suitability Evaluation of Steam Reformed LAW for Direct Land Disposal” PNWD-3288, WTP-RPT-097 Rev 0. (This & similar PNNL reports represent Hanford’s contribution to THOR’s/ DOE’s sales campaign. Its conclusion that a mineralized FBSR calcine is “equivalent to glass” is based upon the bogus assumption that 100% of what’s generated possesses the hydraulic characteristics of coarse sand - the bulk of what’s actually produced from INL SBW (fines) is more clay-like than gravel-like. It also provided SRS’s characterization experts with a rationale for “normalizing” PCT leach test results to BET surface area^{note 2} which, in turn, would allow them to “fairly” conclude that something which totally dissolved during the PCT behaves “better than glass”)
- <http://thortt.com/docs/INEEL-EXT-04-02564.pdf> (p 99 of 171) “The total amount of simulated SBW feed and additives processed was approximately 354 kg and the total solid product mass collected was approximately 88 kg (64 kg of total product solids excluding bed and unreacted carbon solids, consisting of about 28 kg of bed product [22 kg of bed and 6 kg of cyclone samples] and 36kg kg of filter fines)” (in other words: 44 kg fines (not counting carbon) & 23 kg of “bed” granules – consistent with THOR/HAZEN’S “proprietary” 2006 test report)
- <http://thortt.com/docs/INEEL-EXT-04-01493.pdf> (p vi of 164) another of INEEL’s contributions: “Product Consistency Test (PCT) leaches were performed on several bed, cyclone, and filter samples, using a modified PCT procedure developed for INEEL waste calcines. The results are still being evaluated and are not available for inclusion in this report.” (those results were suppressed)

“non proprietary” reports were more candid about fines

For example, *THORsm Bench-Scale Steam*

Reforming Demonstration, Marshall et al, INEEL/EXT-03-00437

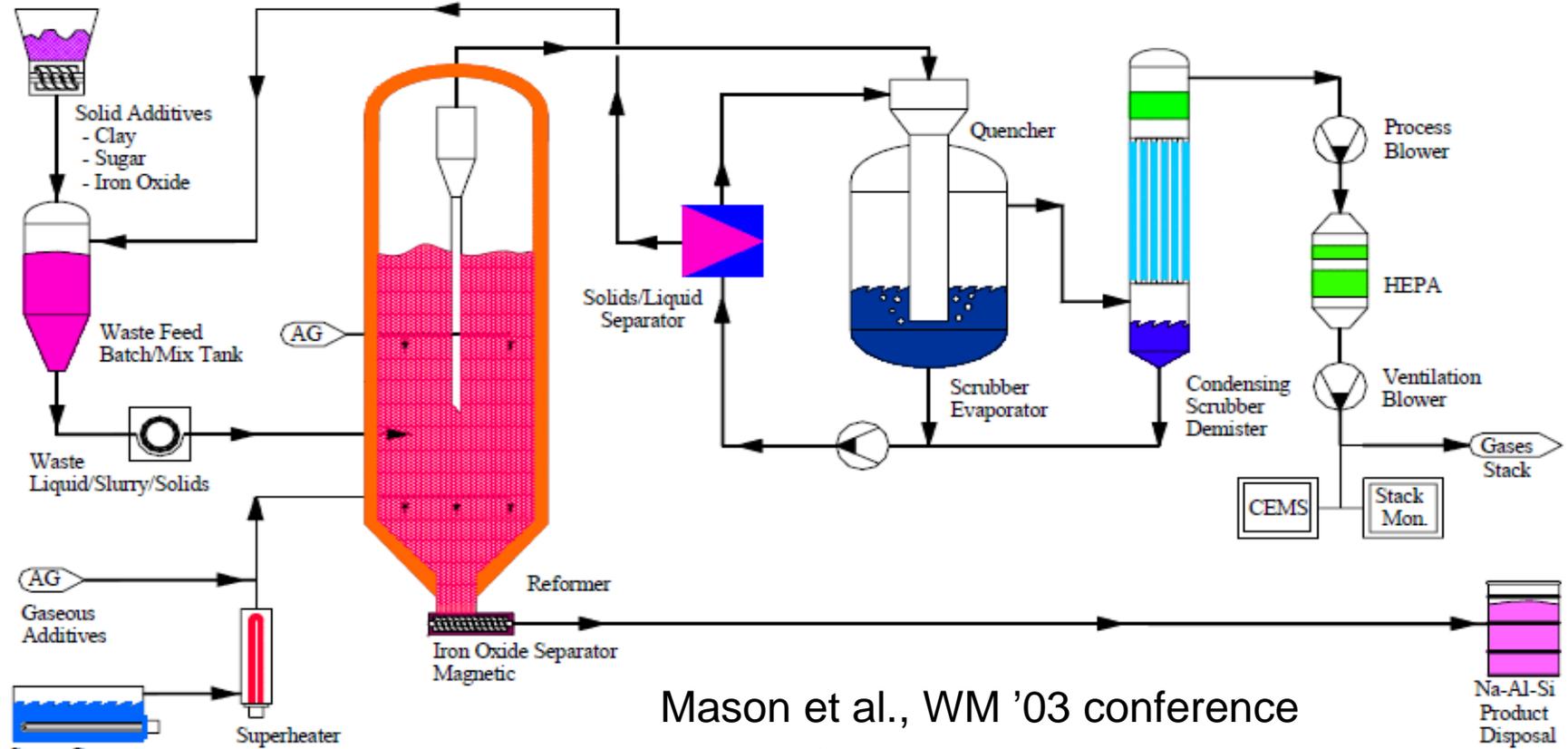
Table 8. Average product densities.

Product	Loose Density	Settled Density	Tamped Density	Particle Density
Bed	1.39 ± 0.09 g/cc	1.43 ± 0.12 g/cc	1.46 ± 0.14 g/cc	2.83 ± 0.15 g/cc
Cyclone	0.24 ± 0.01 g/cc	0.27 ± 0.02 g/cc	0.38 ± 0.02 g/cc	1.50 ± 0.15 g/cc
Filter	0.14 ± 0.02 g/cc	0.16 ± 0.02 g/cc	0.38 ± 0.02 g/cc	1.44 ± 0.17 g/cc

TABLE 9

PRODUCT MASS/SBW MASS		PRODUCT VOLUME/SBW VOLUME	
		Settled Product	Tamped Product
Bed	0.070 kg/kg	0.06 L/L SBW	0.06 L/L SBW
Cyclone	0.135 kg/kg	0.63 L/L SBW	0.45 L/L SBW
Filter	0.052 kg/kg	0.41 L/L SBW	0.17 L/L SBW
Total Product	0.257 kg/kg	1.10 L/L SBW	0.68 L/L SBW
Mass Reduction		Volume Reduction	
74.3%		-10%	32%

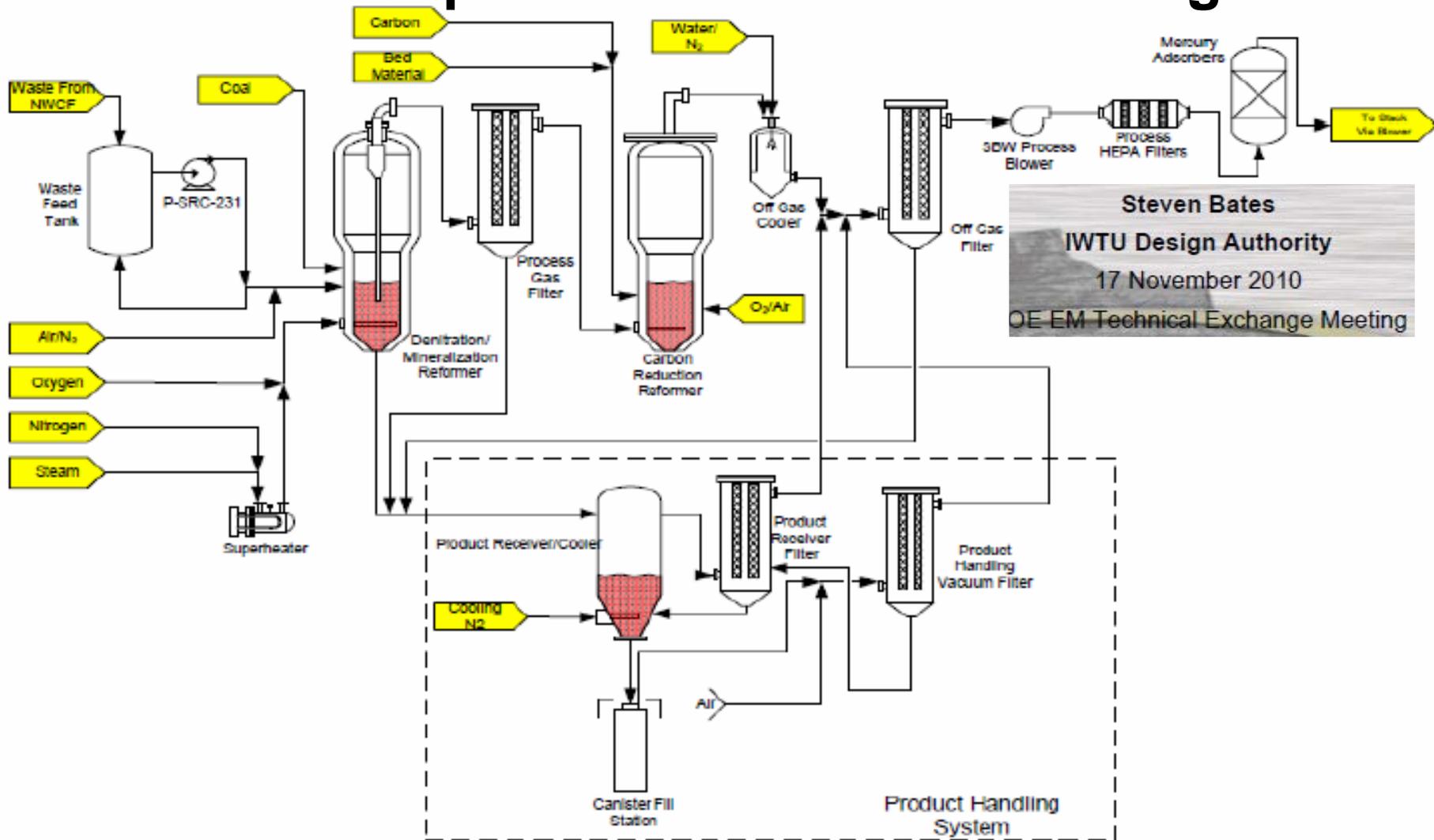
Pre-decisional depiction of “steam reforming”^{note}



Mason et al., WM '03 conference
THORTT.com's "library"

- Note that it didn't produce “fines” (i.e., depicts 100% fines recycle – impossible)
- “It can produce ... silicate, or aluminosilicate products” - not true

Current depiction of “steam reforming”



Steven Bates
IWTU Design Authority
17 November 2010
OE-EM Technical Exchange Meeting

Note that fines are to end up in “product” canisters



Factoids from THOR/HAZEN'S last "carbonate" demo

Summary¹ "The test conditions for CP1 were designed to be representative of the feed and process conditions that would be encountered in the IWTU production facility during actual SBW processing operations" (this reflects the fact that DOE/CWI originally intended to "reform" representative SBW (i.e. both the liquid and solids in the SBW tanks) - they now intend to process only the liquid)

p. 7-88² "The PBF solids produced during both CP1 (done with UDS) and CP2 (no UDS) tests were quite fine with the consistency of talc or flour. They were predominantly carbon..."

p7-82²...average (elemental) carbon content of the CP1 HTF solids was 17.5%

p 7-8²...average carbon content of the CP2 HTF solids was 6.89%

Table 7-20² ..: Bulk densities of CP2 solids (g/cc): DMR granules 0.908, HTF fines 0.595, PBF 0.283

Solid Products

CP1 run (with UDS)	• DMR solids	2704 lb	(57% of the SBW ended up as fines)
	• HTF fines	4614 lb	
	• PBF	287 lb	
CP2 run (no UDS)	• DMR solids	4325 lbs	
	• HTF fines	356 lbs	
	• PBF fines	588 lbs	

-
1. (WM '07 synopsis) "Steam Reforming Application for Treatment of DOE Sodium Bearing Tank Wastes at Idaho National Laboratory for Idaho Cleanup Project" (THORT.com's "library")
 2. (Raw report) "Pilot Plant report...Carbonate flowsheet", RT-ESTD-PMR-001, Oct '06, (334 pp)



In other words...

During their last & most “definitive”(?) demo of THOR’s “carbonate process”, the world’s most experienced team of “steam reformers” (Hazen’s fluidized bed experts) converted a total of ~7900 gallons of SBW simulant into...

- 5645 pounds of fines product (HTF+PBF), 29 wt% of which was elemental C, and...
- 6629 pounds of granular (DMR) product
- The more realistic* “CP1” runs were especially problematic (more breakdowns & more fines)

*more realistic because the “clear liquid” SBW simulant was accompanied by a realistic UDS (undissolved solids) simulant

Consequence #1: IWTU is unlikely to achieve its “volume reduction” goal*

Here's why

- One liter of UDS-free SBW generates ~173 g of “carbonate ash”, and...
 - Average UDS in the INTEC’s SBW tanks is ~26.7 g/liter (80/3)
 - Therefore, total inorganic ash is 6.8E8 g (9E5 gal*3.785 l/gal*(173+26.7 g/l))
 - In HAZEN’s “production” tests inorganic ash was split 64:36 wt-wise between HTF fines & DMR granules and...
 - PBF fines weighed 13% as much as DMR granules
 - Which facts altogether translate to 57 tonnes PBF fines, 262 tonnes HTF fines, and 435 tonnes DMR granules generated from all SBW
- ∑solid product fraction masses divided by their respective densities = 1120m³

1120 m³ > > 623m³

* i.e., all “product” is supposed to fit into 700 canisters compatible with RH-72 B shipping casks; i.e., total volume ≤ 623 m³ (700 * 0.89m³)

Consequence #2

(more important)

It'll be very difficult (expensive) to convert IWTU's "carbonate product" to a genuinely competent* waste form material

*neither "readily dispersible" (dusty) nor water soluble

Why FBSR product would be especially tough (expensive) to “grout”

- Elemental carbon dust (13 wt% of total solid product in Hazen’s last demo) interferes with cementitious binding/hardening reactions (severely limits waste loading)**
- Carbonate ion also interferes with cementitious binding/hardening reactions**

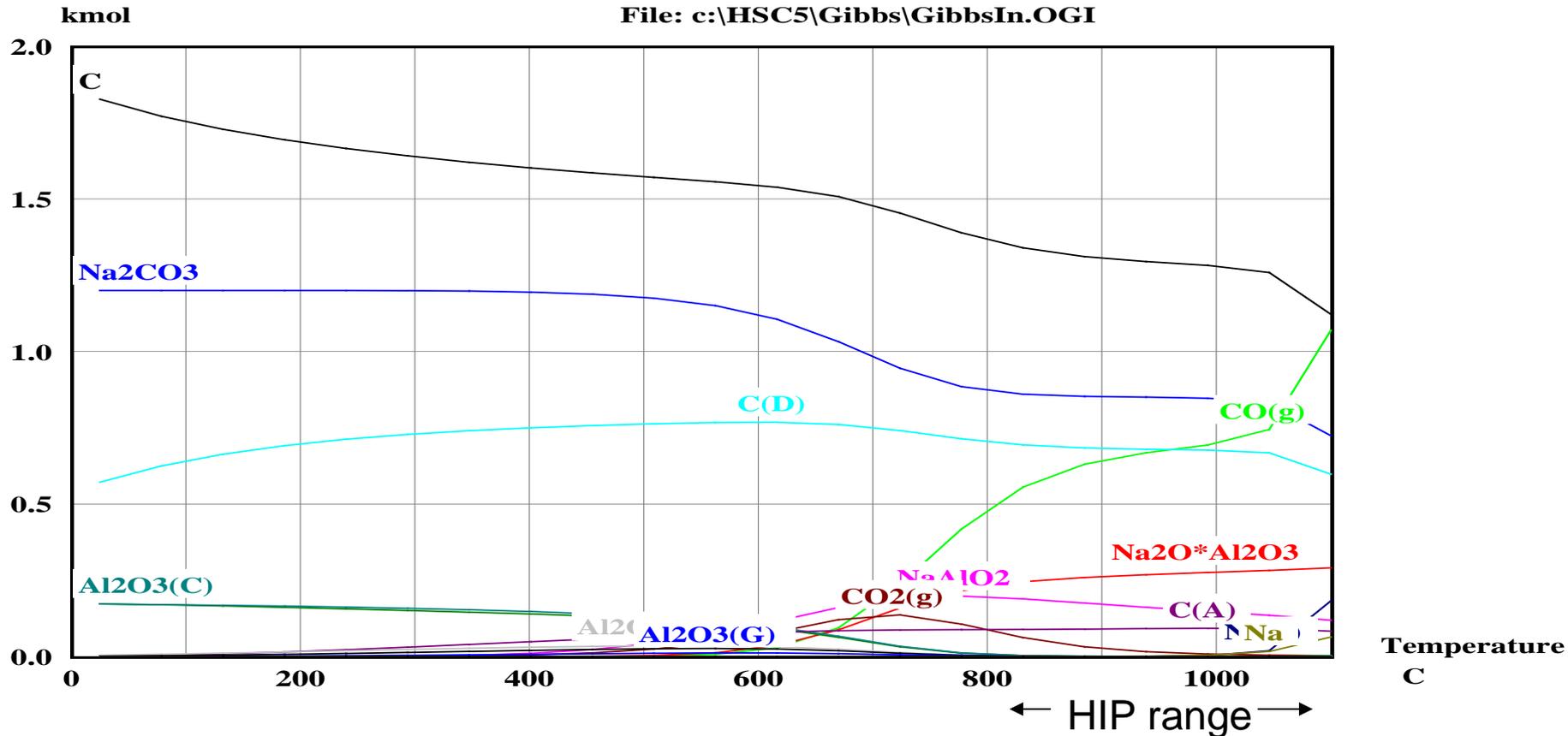


Why FBSR product would be especially tough (expensive) to vitrify

- Its high elemental C content (13 wt%?) would cause severe foaming problems in a melter**
- That carbon would also render melter REDOX control extremely difficult**
- Its physical characteristics (lots of readily levigated dust) would; 1) render it difficult (expensive) to transfer to a melter, and 2) increase that melter's particulate offgas emissions**



Why FBSR product would be especially tough (expensive) to HIP



1. Its elemental C (13wt %?) would generate massive gas pressures (it's oxidized to CO by carbonate & metal oxides under HIPing conditions)
2. It would be extremely difficult to transfer to & tightly pack into HIP cans



EARLY WARNINGS

”DOE-ID should not pursue further steam-reforming initiatives for treatment of SBW to produce waste forms for direct disposal in a federal HLW repository or in WIPP”

**“Technical Review of the Applicability of the Studsvik, Inc./THOR Process to INEEL SBW” , J.A. Gentilucci, J.E. Miller, and W.W. Schultz, TFA 0101, March 2001
(<http://pbadupws.nrc.gov/docs/ML0907/ML090780200.pdf>)**

“A properly designed vitrification system for INEEL’s SBW would be less troublesome to operate than a FBSR, generate a considerably smaller volume of equally easy to clean-up off gas (no fluidizing or “reforming” gas is needed), and produce a waste form much more acceptable to both citizen-stakeholders and independent technical reviewers.”

**D.D. Siemer, “Steam Reformation of Sodium Bearing Waste: Pros and Cons”,
CERAMIC TRANSACTIONS, 2005, VOL 168, pages 81-90**

Whether or not INL's reformer can eventually be made to work, going "hot" will immediately convert both it and IWTU's otherwise useful ancillary equipment* to another fabulously expensive "nuclear facility decommissioning" exercise

*One of the excuses proffered for not modifying NWCF to address its "new" environmental/productivity issues was that doing **anything** to an already crapped up (radioactive) facility is fabulously expensive (e.g., \$50 M)

Conclusion: IWTU should be retrofitted to do something that's more sensible

SOME OPTIONS

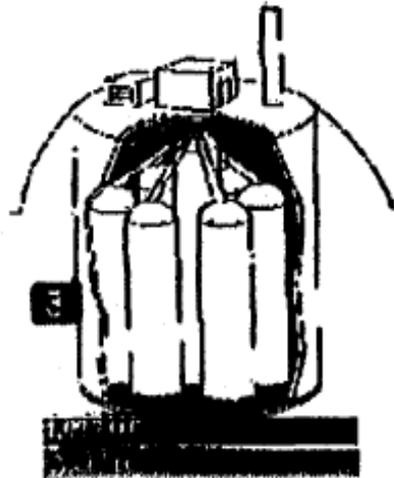
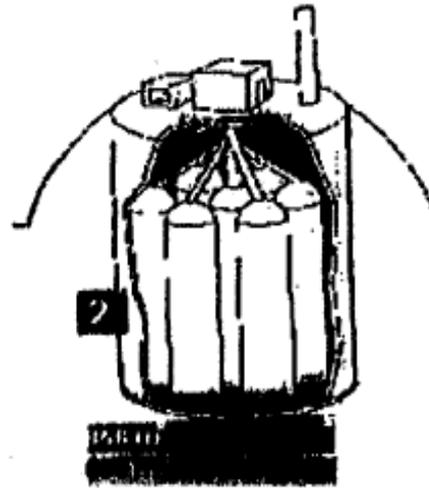
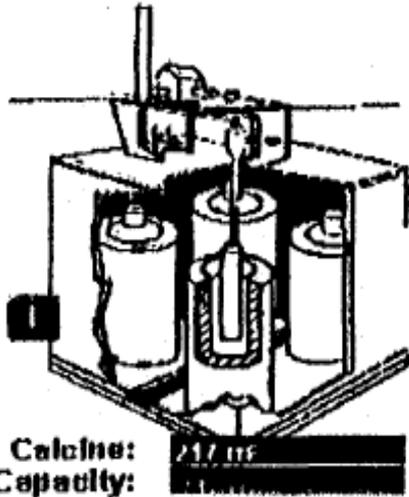
- Retrofit its still “cold” Denitration/Mineralization Reformer (DMR) to do sugar calcination instead – store the calcine in binset #7
- Replace the DMR with a stir melter and use it to covitrify SBW with INL's existing calcines or...
- Vitrify only SBW (first, anyway)



Sugar Calcination Retrofit

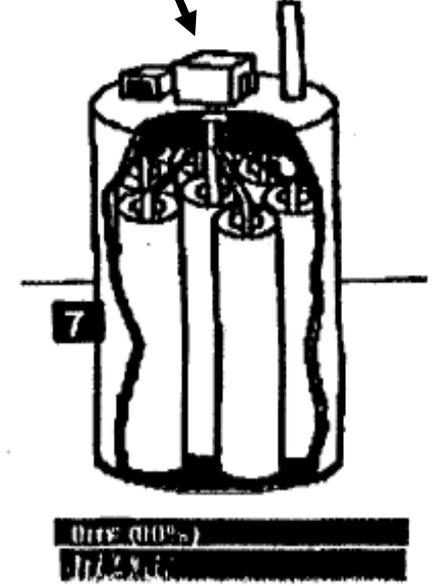
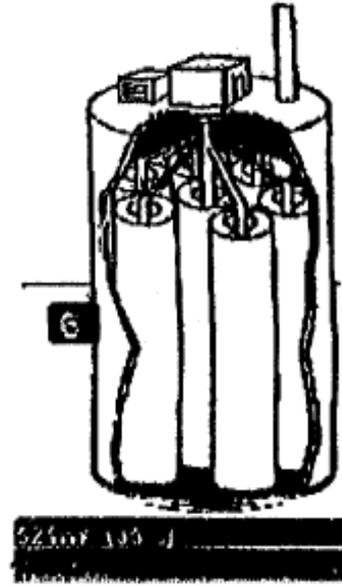
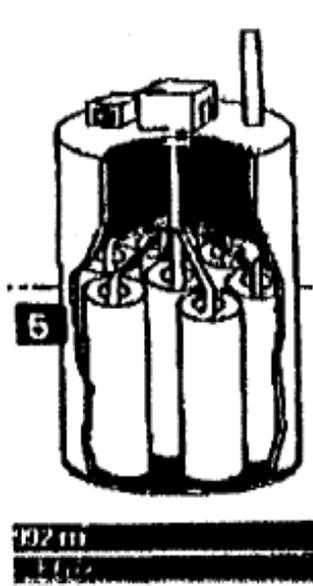
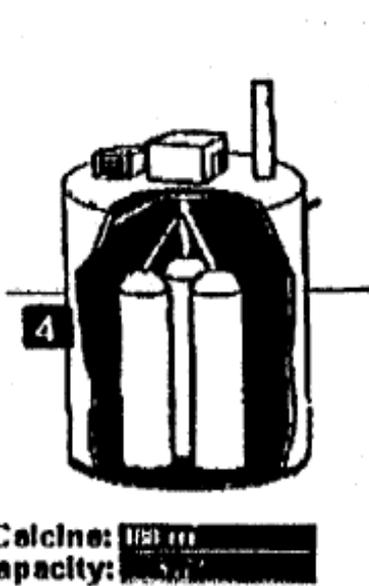
- Relatively quick, simple, and cheap – minimal equipment/process modifications
- Its product would be relatively simple/cheap to subsequently convert to a competent disposal form (no elemental carbon)
- Its storage in INL's already-paid-for binset #7 would be both cheaper and probably safer than doing so in hundreds of small canisters

Calcine Solids Storage Facilities



Total: _____
4166 m³
Calcine Waste
(as of 2/27/99)

Currently empty
~ 1700 m³ bin vol.



- thick-walled stainless bins in thick-walled reinforced concrete "silos"
- Situated in an already crapped-up desert, on Federal land, several hundred feet above water table



Second Option: Co Vitrification

- **Simpler, quicker, and cheaper than EM's current HLRW treatment scenario – minimal product volume and only one process/disposal route required (calcine & SBW chemically complement each other)**
- **Conservative - all of INL's reprocessing waste would be rendered both transportable and “safe” where ever it happens to end up**
- **DOE's “lead NE R&D lab” would finally demonstrate that it could close its own nuclear fuel cycle & thereby improve its chances of survival**

HOW?

- Replace the reformer with a stirrer-equipped* joule heated glass melter
- Install jet-type mixers in the SBW tanks to suspend their ~120,000 kg of UDS
- Install calcine retrieval systems on several binsets at once
- Simultaneously retrieve and mix both wastes with glass formers (the object is to generate one feed stream for one process)
- Feed mixture to the melter & run that glass into RH-72 B compatible storage canisters

* “Stir melters” are more efficient (smaller/cheaper/quicker) than DWPF-style melters (see WSRC.TR-99-00232, Rev. O, p 18)

Third option: “SBW first Vit”

not as efficient as covitrification, but ...

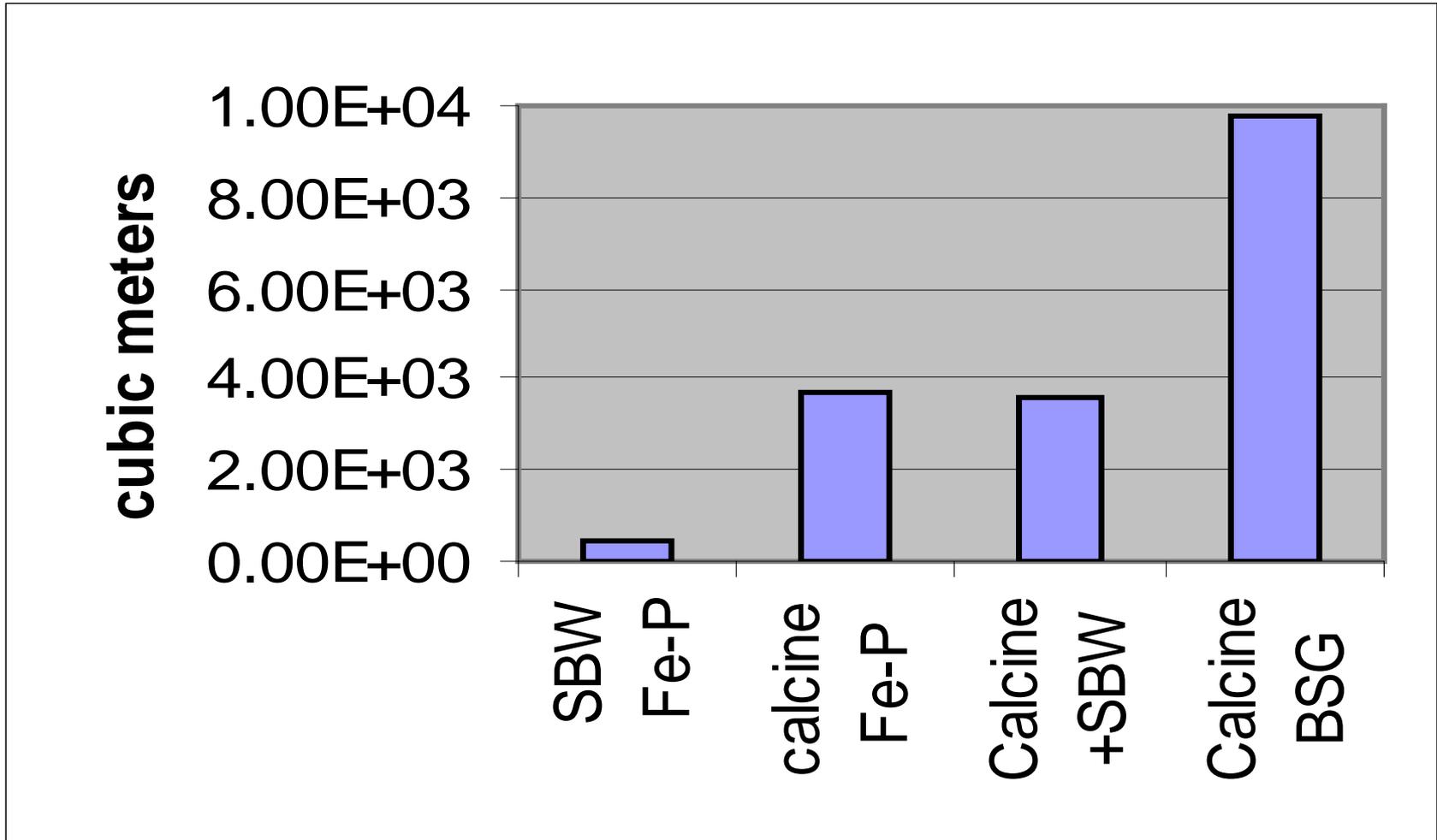
- **Could start sooner**
- **The same equipment could then go on to vitrify the existing calcines along with any other radwastes that the USA’s “Lead NE R&D lab” might eventually generate**

What sort of glass?

Iron/aluminum phosphate (Fe/Al-P) glass is especially suitable because...

- It's easier to make than borosilicate glass (lower melting point/viscosity)
- Permits higher waste loading (a total of ~4000 m³ Fe/Al-P glass vs ~11,000 m³ borosilicate glass)
- Superior leach test performance
- It's main ingredient (phosphoric acid) is “made in Idaho”

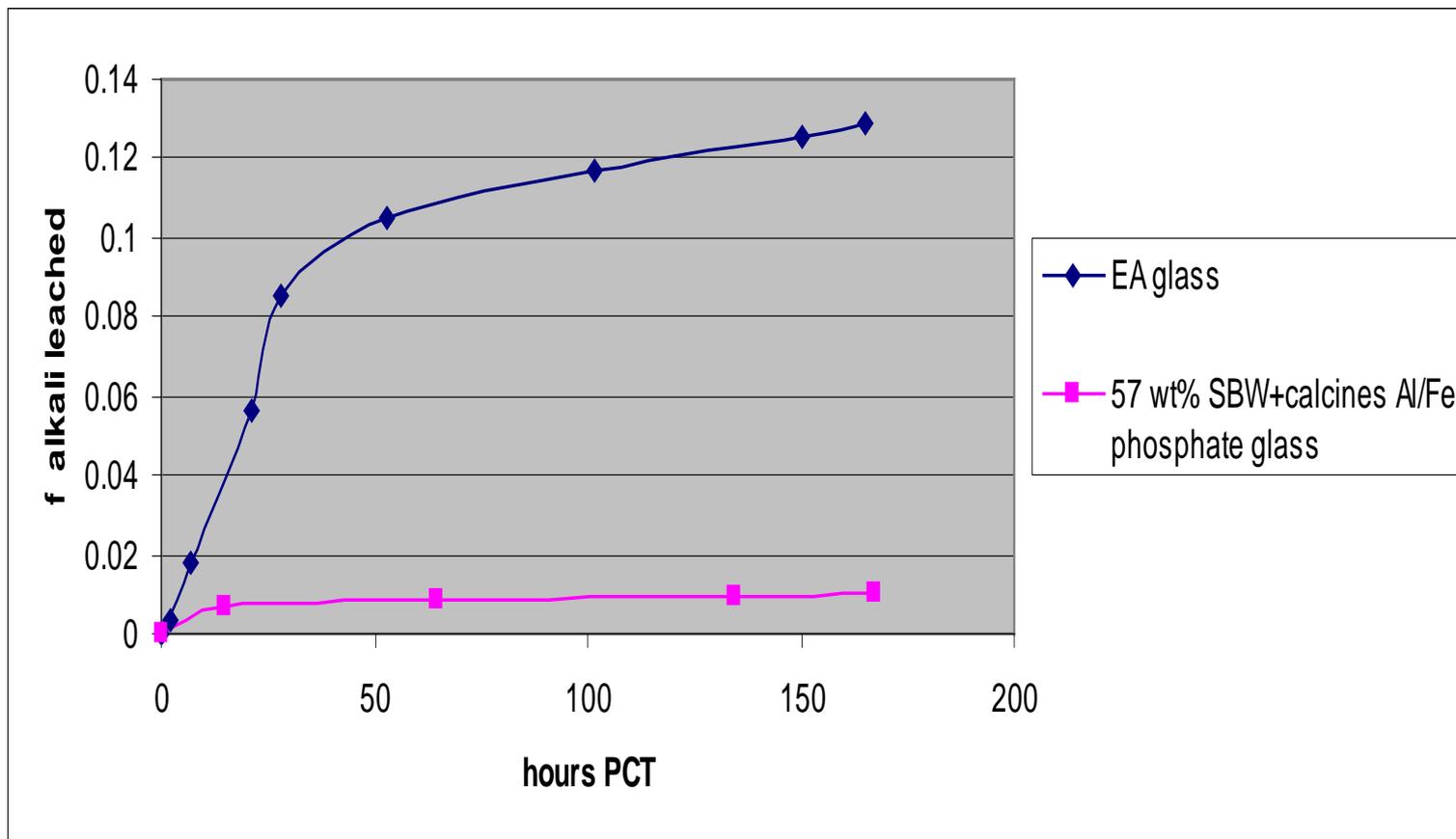
FINAL WASTE FORM VOLUMES *



* Fe/Al-P assumptions include a density of 2.9 g/cc & 35 wt% waste loading for SBW-alone, 53 wt% for “mixed calcines”, and 57 wt% for “all INTEC waste”. “Calcine BSG” assumes the 1999 NAS’s “Alternative High-Level Waste Tr...” report’s glass volume estimate (14,000 canisters x 0.7 m³/canister)

PCT Leach test results note

“all INTEC waste” Fe/Al-P vs EA glasses



*Specimen prepared/sent to me by Prof. Delbert Day (MST/UMR), 18Apr2011

Fe/Al-P glass contains ~57wt% “SBW plus Σ calcines” (oxide basis)



What *should* vitrification cost?

- DOE's current estimated cost of one tonne of glass made with INL's calcine via its hypothetical "direct vit" process is ~\$153,000^{note 1}
- The "mixed" radwaste borosilicate glass "gems" generated by DOE's one & only "Vitrification and Privatization Success" actually cost US taxpayers \$8,433/tonne^{note2}
- "Real world" glass gems/marbles currently cost ~\$2700/tonne (\$1.25/lb) - free shipping! <http://www.mcgillwarehouse.com/c/119/38>
- Fiber glass (FG) also currently costs about \$2700/tonne*
- "Real" glass is too cheap to recycle in much of the USA

*FG is also made with JHMs (<http://www.nrel.gov/docs/fy02osti/32135.pdf>)



A fourth option: The cheapest technically justifiable scenario*

- Install a small rotary kiln-type calciner on the top of calcine binset No 7 (currently empty)
- Feed it with a mix of SBW (jet stir the tanks while retrieving), sugar syrup, and “filter sand”**
- Drop that calcine directly into no. 7’s bins
- When finished, boil off/condense the mercury trapped by the GAC off gas filters, & then burn that carbon in the calciner
- Dump the calciner, etc. into the same binset
- After cool-down, “grout” it (all of the silos?) with a blast furnace slag cement/class F flyash-based concrete & then cast a basalt fiber rebar reinforced concrete pyramid around it (them?)

* & most politically incorrect because it doesn’t assume that the “high” stuff in one state’s reprocessing waste will end up in another’s repository

** this “sand” would include the pelletized silica gel used to filter the calciner’s off gas plus the “bed sand” utilized by its fluidized bed-based off gas burner

Advice for the NWTRB

- Don't don DOE's blinders – challenge nonsensical assumptions
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- Don't get bogged down by "transcientific" (political) issues* –your job is to concentrate on "technical" stuff

*E.g., pondering the meaning of things like "high", "low", & "consent based"