U.S. DEPARTMENT OF ENERGY
OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT

PRESENTATION TO THE NUCLEAR WASTE TECHNICAL REVIEW BOARD

SUBJECT: DEFENSE WASTE PROCESSING FACILITY HIGH-LEVEL WASTE QUALIFICATION ACTIVITIES

PRESENTER: M. J. PLODINEC

PRESENTER'S TITLE AND ORGANIZATION:
MANAGER AND SENIOR ADVISORY SCIENTIST
GLASS TECHNOLOGY
SAVANNAH RIVER LABORATORY
WESTINGHOUSE SAVANNAH RIVER COMPANY
AIKEN, SOUTH CAROLINA

PRESENTER'S TELEPHONE NUMBER: (803) 725-2170

AUGUST 28-29, 1990

U.S. DEPARTMENT OF ENERGY
OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT

PRESENTATION TO THE NUCLEAR WASTE TECHNICAL REVIEW BOARD

SUBJECT: DEFENSE WASTE PROCESSING FACILITY HIGH-LEVEL WASTE QUALIFICATION ACTIVITIES

PRESENTER: M. J. PLODINEC

PRESENTER'S TITLE AND ORGANIZATION:
MANAGER AND SENIOR ADVISORY SCIENTIST
GLASS TECHNOLOGY
SAVANNAH RIVER LABORATORY
WESTINGHOUSE SAVANNAH RIVER COMPANY
AIKEN, SOUTH CAROLINA

PRESENTER'S TELEPHONE NUMBER: (803) 725-2170

AUGUST 28-29, 1990

BACKGROUND

- **GLASS SELECTED AS WASTE FORM FOR DEFENSE WASTE PROCESSING FACILITY (DWPF) - 1982**
  - **GLASS PROCESSING IS WELL-KNOWN AND SAFE**
  - **GLASS IS STABLE TO RADIATION**
  - **GLASS IS DURABLE AND RUGGED**
  - **EPA: "FACILITY BADLY NEEDED ... ENVIRONMENTALLY BENEFICIAL ACTION [LETTER, CAHILL (EPA) to HINDMAN (DOE), dtd 12/3/81]"**
  - **NRC:"GLASS COULD BE AN ACCEPTABLE WASTE FORM IN A SUITABLY ENGINEERED BARRIER SYSTEM;" URGED SITE-SPECIFIC TESTING [LETTER, MARTIN (NRC) to HINDMAN (DOE), dtd 11/4/82]"**
  - **SUBSEQUENT WORK SHOWING THAT EBS CONTAINING DWPF GLASS CAN MEET REGULATORY REQUIREMENTS ***

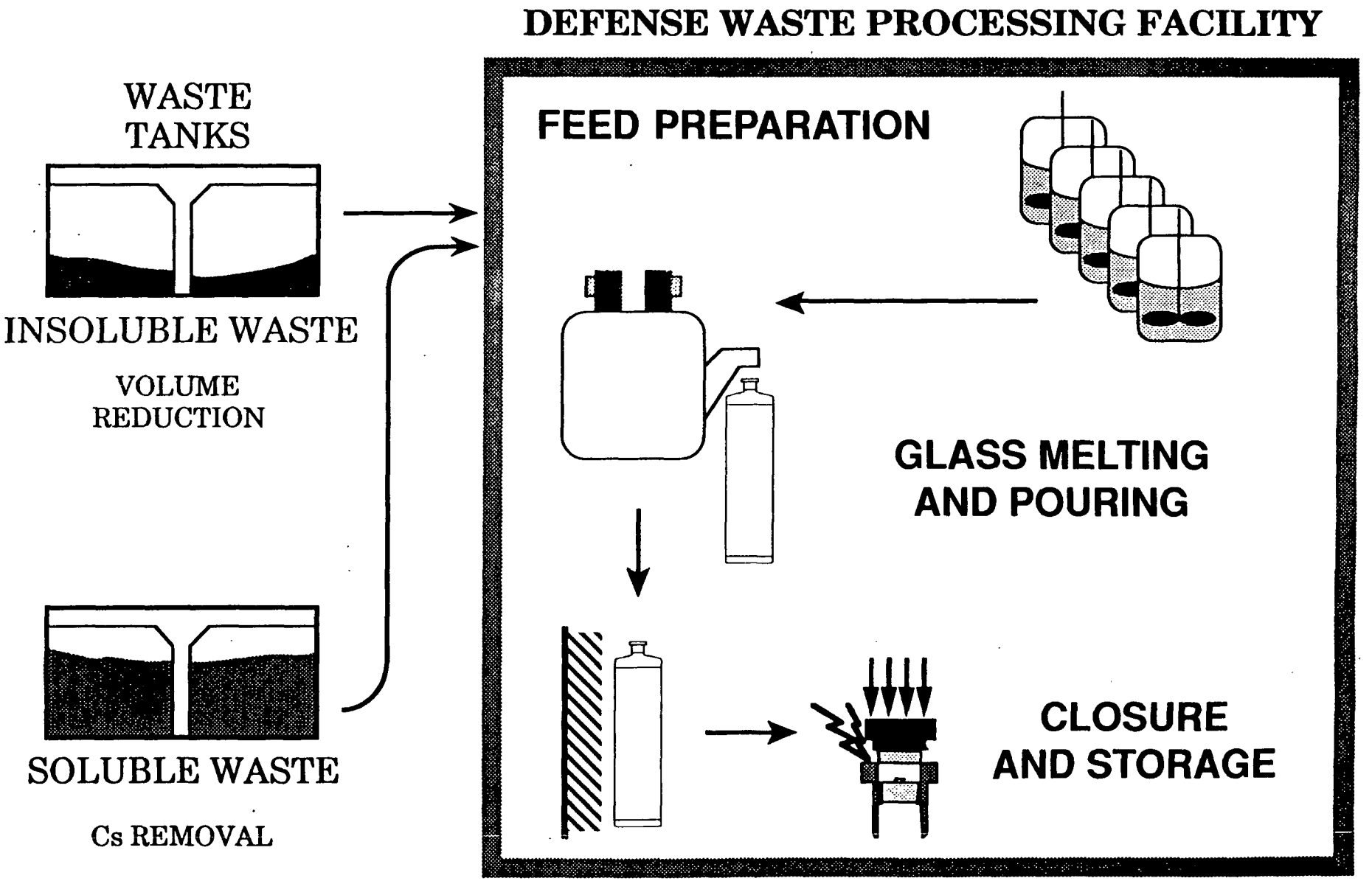
* See N.E. Bibler, G. G. Wicks and V. O. Oversby, "Leaching of SRP Nuclear Waste Glass in a Saturated Tuff Environment," **Scientific Basis for Nuclear Waste Management, VIII,** C. M. Jantzen, J. A. Stone and R. C. Ewing (eds.), 247-56 (1985); and

M. J. Apted and D. W. Engel, "Mass-Transfer Analysis of Waste Packages Containing Defense Waste Processing Facility Glass as a Waste Form," **High-Level Radioactive Waste Management,** Proceedings of the International Topical Meeting, D. B. Shipler (ed.), 388-93 (1990).

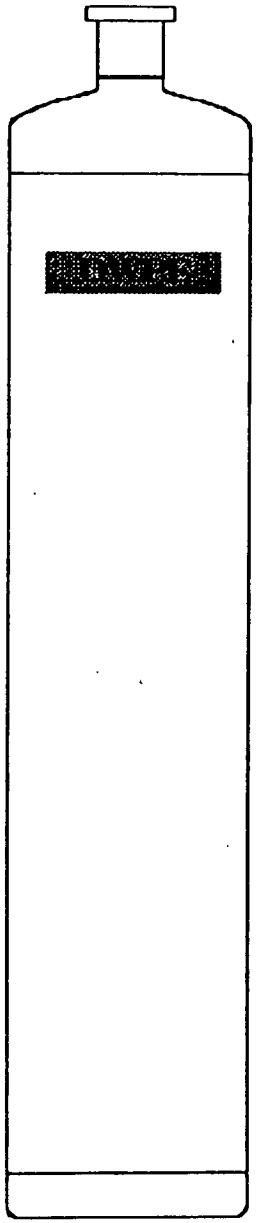
BACKGROUND
(CONTINUED)

- DOE-OCRWM HAS SET SPECIFICATIONS FOR ACCEPTANCE OF THE DWPF PRODUCT
- DWPF WORKING TO ESTABLISH COMPLIANCE THROUGH COMBINATION OF
  - COMPONENT SPECIFICATIONS
  - PRODUCT CONTROL

DWPF PROCESS



DWPF PRODUCT



MATERIALS OF CONSTRUCTION:	AUSTENITIC STAINLESS STEEL (304L)
CANISTER WEIGHT (EMPTY):	450 kg
WEIGHT OF GLASS:	1700 kg (3700 lb)
LENGTH:	300 cm (9 ft 10 in)
DIAMETER:	61 cm (24 in)
WALL THICKNESS:	1.0 cm
AVERAGE FILL HEIGHT:	231 cm
MAXIMUM ACTIVITY:	230 kCi
MAXIMUM RADIATION DOSE:	5500 R/hr
MAXIMUM DECAY HEAT:	670 watts
AVERAGE GLASS DENSITY:	2.73 g/cm^3
AVERAGE TIME OF FILLING:	17 hr
MODE OF FILLING:	CONTINUOUS, DIFFERENTIAL PRESSURE METHOD

PROJECTED DWPF WASTE GLASS COMPOSITIONS

MAJOR GLASS COMPONENTS weight %	CONSTITUENT SLUDGE TYPE						
	Blend[d]	Batch 1	Batch 2	Batch 3	Batch 4	HM	Purex[w]
Al_2O_3	3.98	4.87	4.46	3.25	3.32	7.08	2.89
B_2O_3	8.01	7.69	7.70	7.69	8.11	6.94	10.21
$BaSO_4$	0.27	0.22	0.24	0.26	0.38	0.18	0.29
CaO	0.97	1.17	1.00	0.93	0.83	1.00	1.02
$CaSO_4$	0.077	0.12	0.11	0.10	0.0034	trace	0.12
Cr_2O_3	0.12	0.10	0.12	0.13	0.14	0.086	0.14
CuO	0.44	0.40	0.41	0.40	0.46	0.25	0.42
Fe_2O_3	10.41	12.52	10.61	11.16	11.32	7.38	12.74
Group A[a]	0.14	0.099	0.14	0.10	0.20	0.20	0.078
Group B[b]	0.36	0.22	0.44	0.25	0.60	0.89	0.084
K_2O	3.86	3.49	3.50	3.47	3.99	2.14	3.58
Li_2O	4.40	4.42	4.42	4.42	4.32	4.62	3.12
MgO	1.35	1.36	1.35	1.35	1.38	1.45	1.33
MnO	2.03	2.06	1.62	1.81	3.08	2.07	1.99
Na_2O	8.73	8.62	8.61	8.51	8.88	8.17	12.14
Na_2SO_4	0.10	0.10	0.12	0.096	0.13	0.14	0.12
NaCl	0.19	0.31	0.23	0.22	0.090	0.093	0.26
NiO	0.89	0.75	0.90	1.07	1.09	0.40	1.21
SiO_2	50.20	49.81	50.17	49.98	49.29	54.39	44.56
ThO_2	0.19	0.36	0.63	0.77	0.24	0.55	0.011
TiO_2	0.90	0.66	0.67	0.66	1.02	0.55	0.65
U_3O_8	2.14	0.53	2.30	3.16	0.79	1.01	2.89
Total	99.76	99.88	99.75	99.79	99.66	99.59	99.85

[a] **Group A: semi-volatile radionuclides (Se, Te, Rb, Mo, Tc)**

[b] **Group B: nonvolatile radionuclides (e.g., Sm, Sn, Co, Np, Am, Cm)**

[d] **The "Blend" is the current DWPF design-basis glass**

[w] **The "Purex" glass is a possible "worst-case" composition**

STATUS OF DWPF QUALIFICATION ACTIVITIES

- WASTE FORM COMPLIANCE PLAN (WCP) REVIEWED BY TECHNICAL REVIEW GROUP (TRG), SENT TO NRC

- WASTE FORM QUALIFICATION REPORT (WQR)
  - 16 INITIAL SECTIONS DRAFTED (OUT 0F 24) - PROJECTIONS OF RADIONUCLIDES, HEAT, DOSE; CANISTER-RELATED SPECIFICATIONS; FOREIGN MATERIALS
  - 8 REVIEWED BY TRG, AND COMMENTS RESOLVED
  - 5 ISSUED, WILL BE SENT TO NRC FOR INFORMATION

- FORMALIZED STARTUP TEST PROGRAM IN PLACE
  - QUALIFY TECHNOLOGY DEVELOPED BEFORE WASTE ACCEPTANCE PROCESS
  - DEMONSTRATE ABILITY TO CONTROL PRODUCT
  - PROGRAM DRIVEN BY SPECIFICATION ON RADIONUCLIDE RELEASE

- HAVE DEVELOPED TEST METHOD FOR RADIOACTIVE SAMPLES [PRODUCT CONSISTENCY TEST (PCT)], PROCEEDING THROUGH ASTM

CONTROL AND VERIFICATION OF RADIONUCLIDE RELEASE

- CONTROL PROCESS SO THAT GLASS ABLE TO LIMIT RELEASE TO < 1 $g/m^2 \cdot d$ (28 g/m^2 for 28 d) ON MCC-1 LEACH TEST
- DURING PRODUCTION, VERIFY TO 95% CONFIDENCE LEVEL THAT 95% OF PRODUCT WOULD BE ABLE TO MEET LIMIT
- ANY MEANS (DIRECT OR INDIRECT) ACCEPTABLE, AS LONG AS RELATED TO SPECIFIED METHODS

IMPORTANCE OF GLASS COMPOSITION

- PERFORMANCE OF GLASS IN MCC-1 TEST DEPENDS ON
  - GLASS COMPOSITION
  - WATER COMPOSITION, Eh, pH
  - TEMPERATURE OF INTERACTION
  - FLOW RATE
  - RATIO OF GLASS SURFACE AREA TO SOLUTION VOLUME (SA/V)
  - TIME OF CONTACT BETWEEN GLASS AND WATER
- THE MCC-1 TEST FIXES WATER COMPOSITION (DIW), TEMPERATURE (90°C), FLOW RATE (STATIC), SA/V (10 m^{-1}), AND TIME (28 DAYS)
- THEREFORE, THE DWPF MUST CONTROL THE COMPOSITION OF THE GLASS TO MEET SPECIFICATION

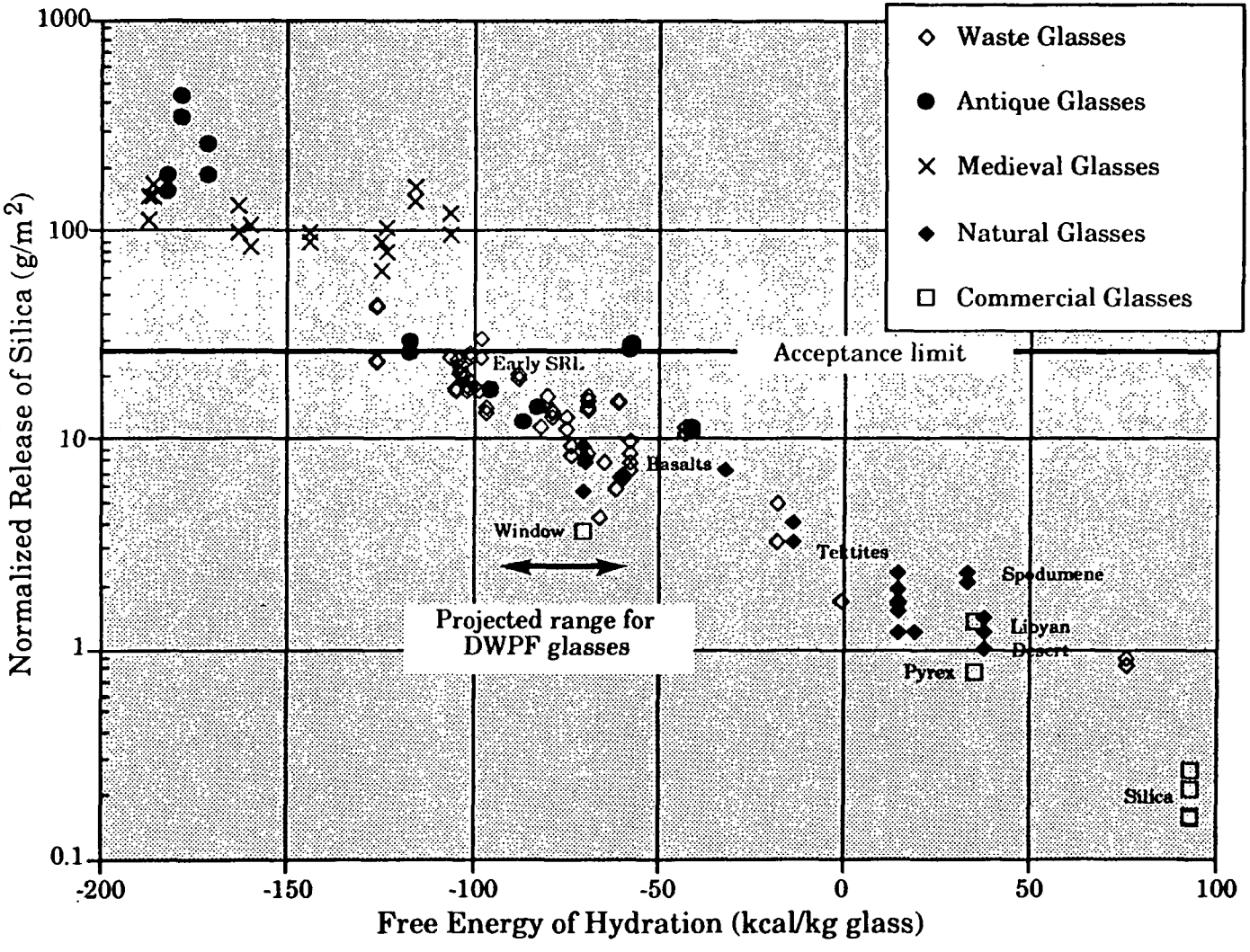
HYDRATION THERMODYNAMICS APPROACH

- ASSUMES GLASS IS A MECHANICAL MIXTURE OF COMPONENTS (SiO_2, B_2O_3, etc.)
- EACH COMPONENT HAS WELL-DEFINED FREE ENERGY OF REACTION WITH WATER
- FREE ENERGY OF HYDRATION OF GLASS = SUM OF THE FREE ENERGIES OF HYDRATION OF INDIVIDUAL COMPONENTS WEIGHTED BY CONCENTRATION OF COMPONENT IN GLASS

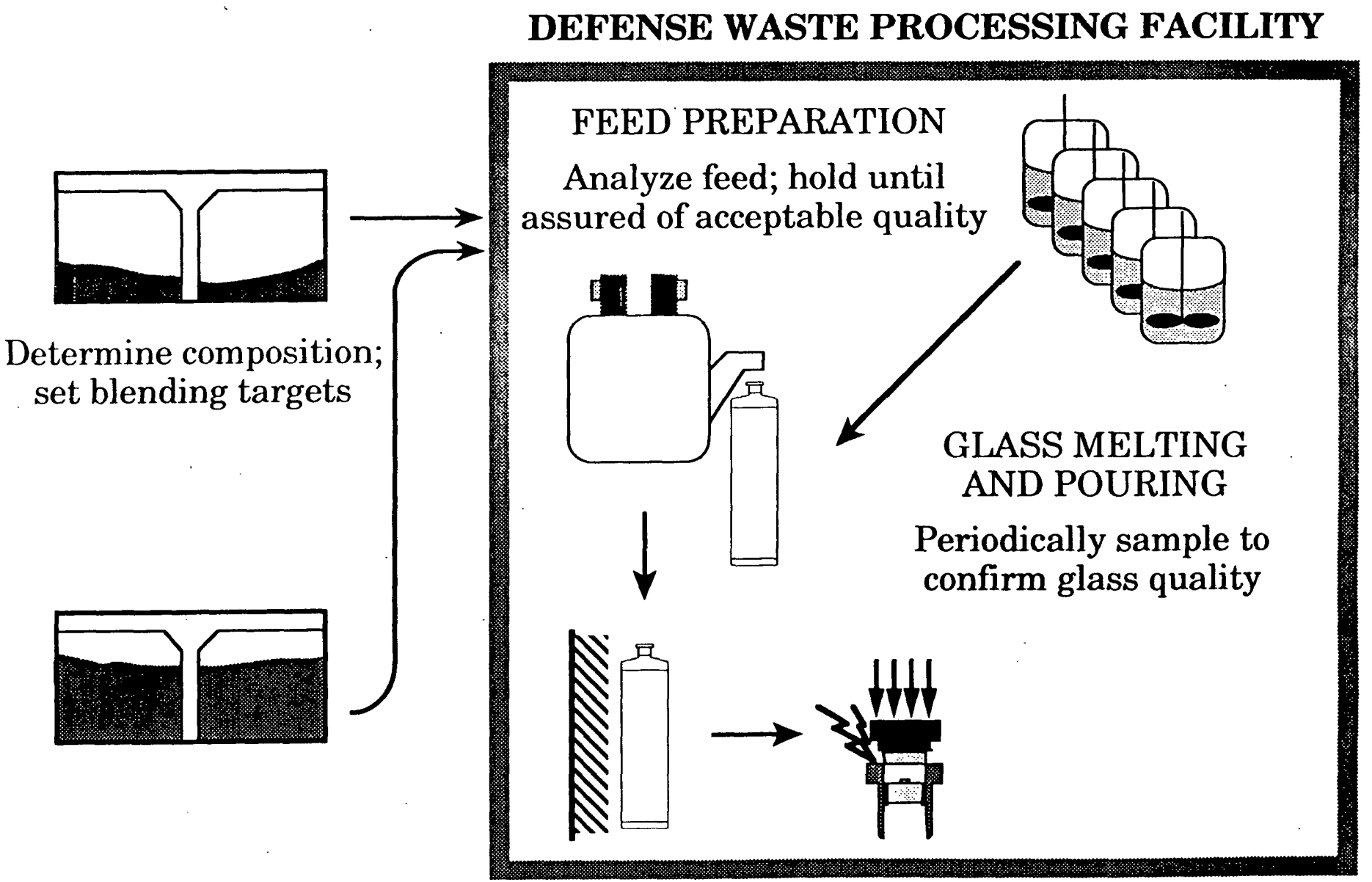
$$\Delta G^{\circ}_{HYDRATION} = \sum_{I} \Delta G^{\circ}_{I,HYDRATION} \cdot m_I$$

ΔG° in kcal/kg glass; ΔG°_I in kcal/mol; m_I in mol/kg glass

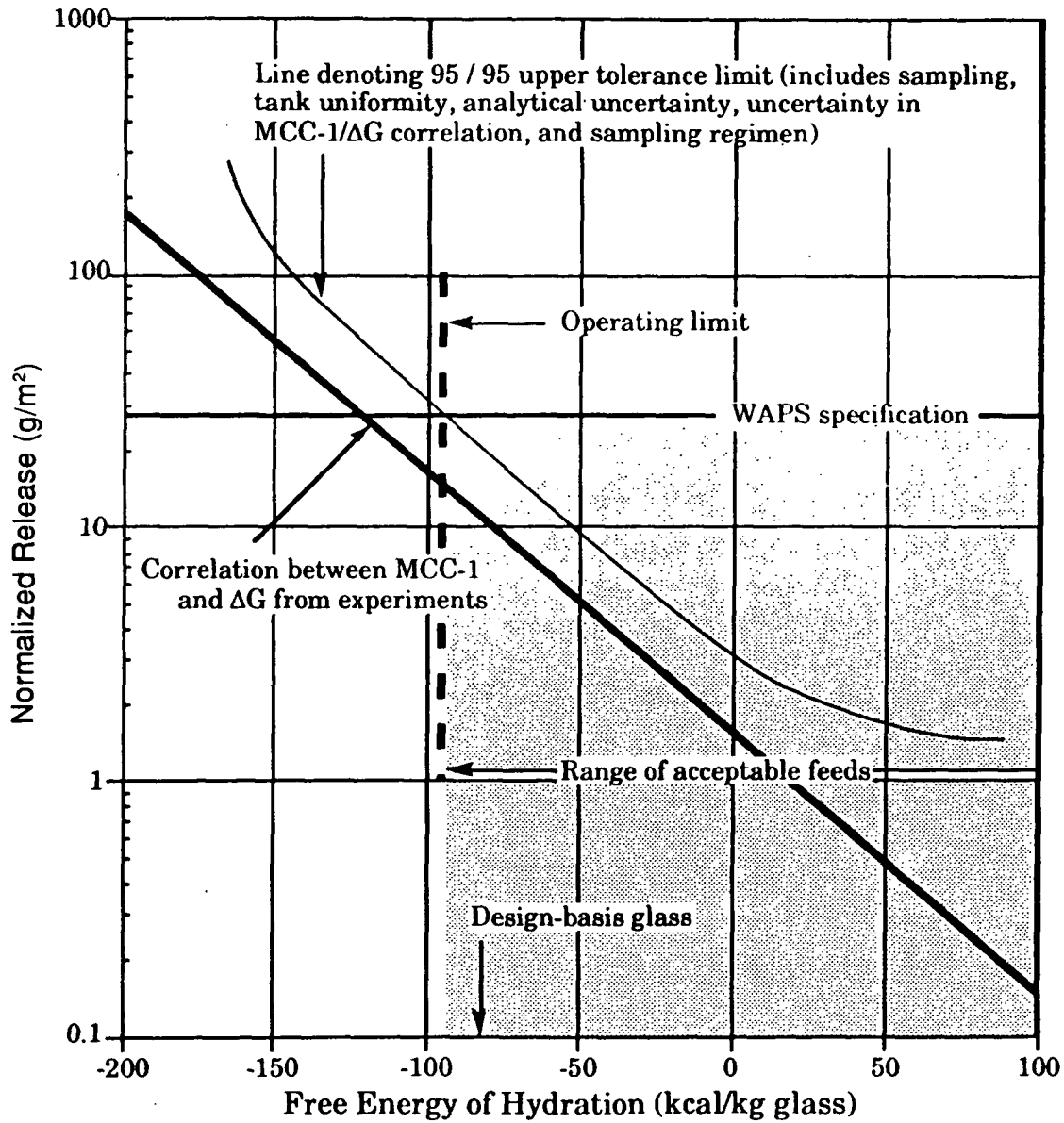
MCC-1 TESTS (28 d, 90°C)



CONTROL OF DWPF GLASS QUALITY



OPERATING LIMIT BASED ON FREE ENERGY



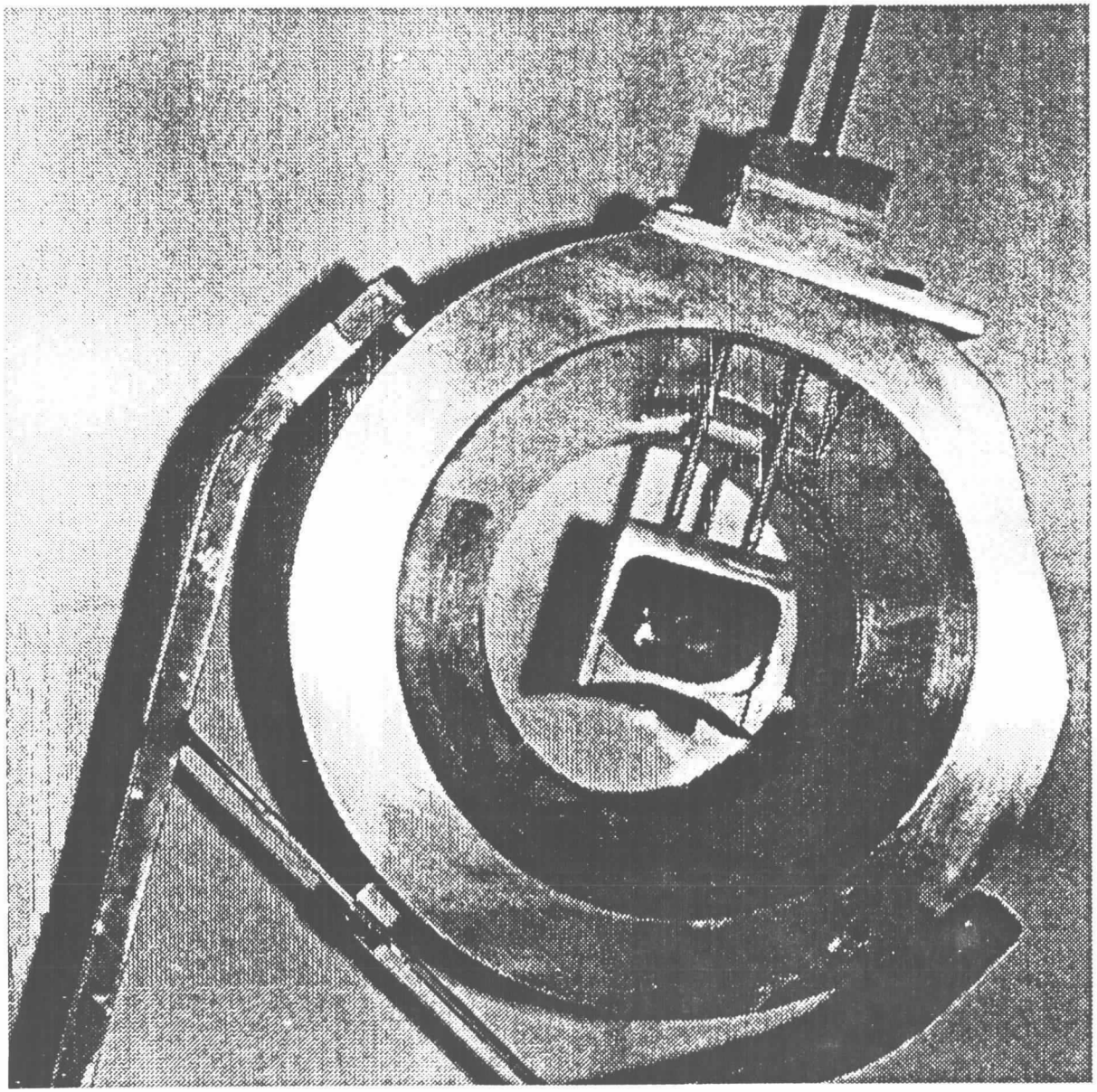
ROLE OF INTEGRATED COLD RUNS

- DWPF PREPARING DETAILED TEST PLANS TO DEMONSTRATE ABILITY TO CONTROL GLASS QUALITY

- WILL USE RESULTS TO VERIFY ABILITY TO CONTROL OVER MOST ADVERSE CREDIBLE CONDITIONS
  - FIRST, VERIFY FOR SMALL CHANGES IN MELTER FEED
  - THEN, STEP CHANGE IN VISCOSITY (LOW), DENSITY (HIGH)
  - NEXT, STEP CHANGE IN VISCOSITY (HIGH), DENSITY (LOW)
  - FINALLY, BACK TO BASELINE CONDITIONS IN PREPARATION FOR FIRST BATCH

- EACH OF 124 CANISTERS WILL BE SAMPLED, MOST DESTRUCTIVELY EXAMINED AS WELL
  - COMPARE GLASS SAMPLE TO CANISTER CONTENTS
  - COMPARE OBSERVED PERFORMANCE TO PREDICTION FROM COMPOSITION

DWPF GLASS SAMPLER



DWPF PRODUCT CONSISTENCY TEST (7 d, 90°C)

- MCC-1 TEST NOT WELL-SUITED TO HOT CELL OPERATIONS BECAUSE IT IS COMPLEX, REQUIRES MONOLITHS AND TEFLON®VESSELS

- HAVE DEVELOPED A PCT WHICH IS SIMPLER, COMPATIBLE WITH PRODUCTION SAMPLES, AND USES STAINLESS STEEL

- TEST CONDITIONS (COMPARED TO MCC-1)
  - DEIONIZED WATER, 90°C, STATIC (ALL THE SAME)
  - GRAINS (MONOLITHS)
  - SA/V = 1950 m^{-1}(10 m^{-1})
  - STANDARD GLASS REQUIRED (NO STANDARDS REQUIRED)
  - STAINLESS STEEL VESSELS (TEFLON® VESSELS)

DWPF PRODUCT CONSISTENCY TEST (7 d, 90°C)

(CONTINUED)

- ROUND ROBIN AND RADIOACTIVE SAMPLE EXCHANGES INDICATE PRECISION FOUR TIMES BETTER
- ASTM COMMITTEE ACCEPTANCE EXPECTED THIS FALL - THEN SUBMIT TO FULL MEMBERSHIP
- EPA INTERESTED IN USE AS REPLACEMENT FOR TOXICITY CHARACTERISTIC LEACHING PROCEDURE (TCLP)

CONCLUSIONS

- DWPF WILL BEGIN NON-RADIOACTIVE TESTING LATER THIS YEAR
- ALTHOUGH VARIABLE IN COMPOSITION, DWPF GLASSES WILL MEET SPECIFICATIONS
- A DETAILED PROGRAM IS BEING IMPLEMENTED TO ENSURE THAT THE DWPF WILL MAKE AN ACCEPTABLE PRODUCT