



# Evaluation of Vertrel XBW as a Replacement for Freon TDFC in Uranium Chip Cleaning Operations

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## **Freon™ TDFC is currently used as a water displacing agent in the uranium chip cleaning operation.**

- Chip Cleaning
  - cylindrical ultrasonic (20 kHz magnetostrictive) water wash for 3 min to remove coolant consisting of water, propylene glycol, sodium tetraborate, sodium nitrite, and azure blue dye
  - ultrasonic Freon™ TDFC wash for 1 min, soak 5 min and repeat to remove water
  - repeat
- Freon™ TDFC
  - Freon™ 113 (trichlorotrifluoroethane)
  - 150 ppm Surfactant 621 (quaternary ammonium phosphate)

## A replacement for the Freon™ is being evaluated.

- Replacement is necessary
  - Freon™ banned from production as an ozone depleting substance
  - Surfactant 621 is no longer available
- Vertrel™ XBW is possible replacement
  - Vertrel™ XDA (decafluoropentane with 0.05 - 0.2 wt% surfactant) without nitromethane
  - Surfactant is Zonyl 9099 (fluorinated alkyl phosphate, amine salt)

## **Benchtop studies were conducted initially to determine viability of replacement.**

- Water displacement measurements using stainless steel wool pads to simulate chips
- Compatibility with uranium
- Residue analysis using X-ray photoelectron spectroscopy (XPS)
- Thistle tube experiments to evaluate surfactant levels

## **Due to success of benchtop studies, pilot plant level studies were initiated.**

- Used production baskets and production scale ultrasonic cleaner and followed production procedure
- Cleaned depleted uranium chips which were machined from log of known chemistry using enriched uranium coolant (log oiled in between cuts)
- Following cleaning, chips were briquetted and remelted
- Analysis conducted on chips, solutions and new castings
  - Analytical rinse using trichloroethane on chip sample, FTIR
  - Boron analysis of solutions (inductively coupled plasma (ICP))
  - Boron and carbon analysis of chip sample (ICP and Leco)
  - Boron and carbon analysis of new castings (ICP and Leco)

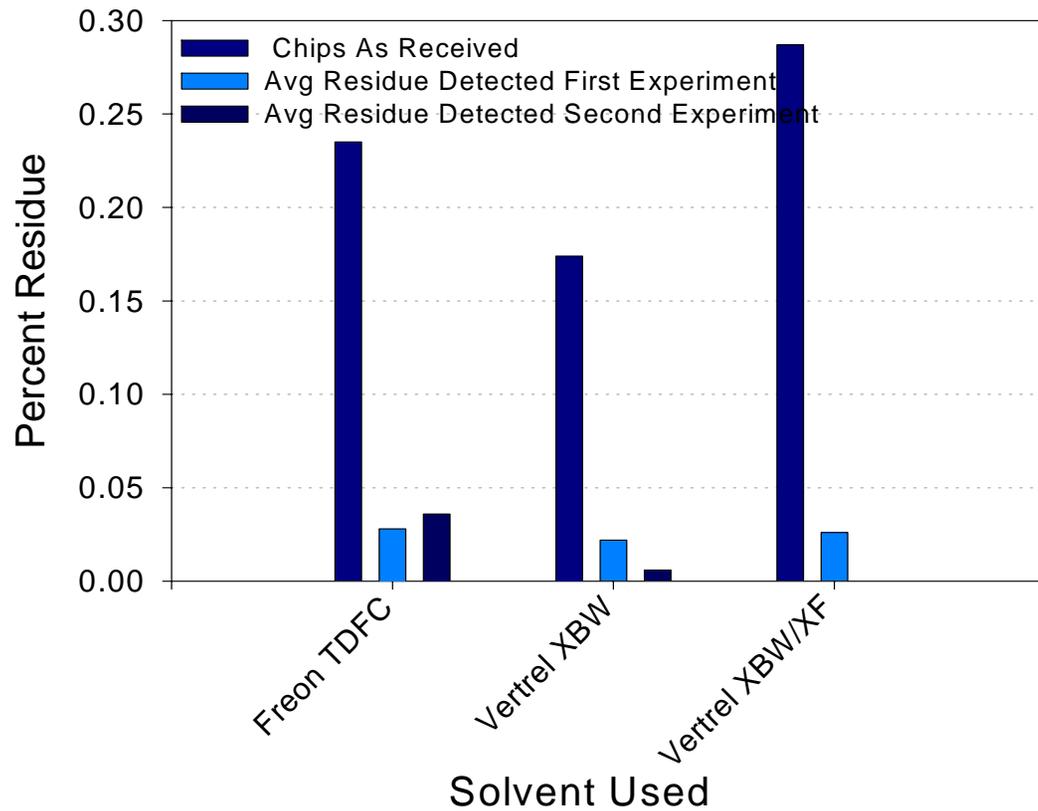
**One basket of chips cleaned using Freon™ TDFC and two baskets were cleaned using Vertrel™ XBW. Some problems were encountered during the first test.**

- Vacuum pump did not work
- Plant lab cleaned chip samples
- Blotter paper throughout chips

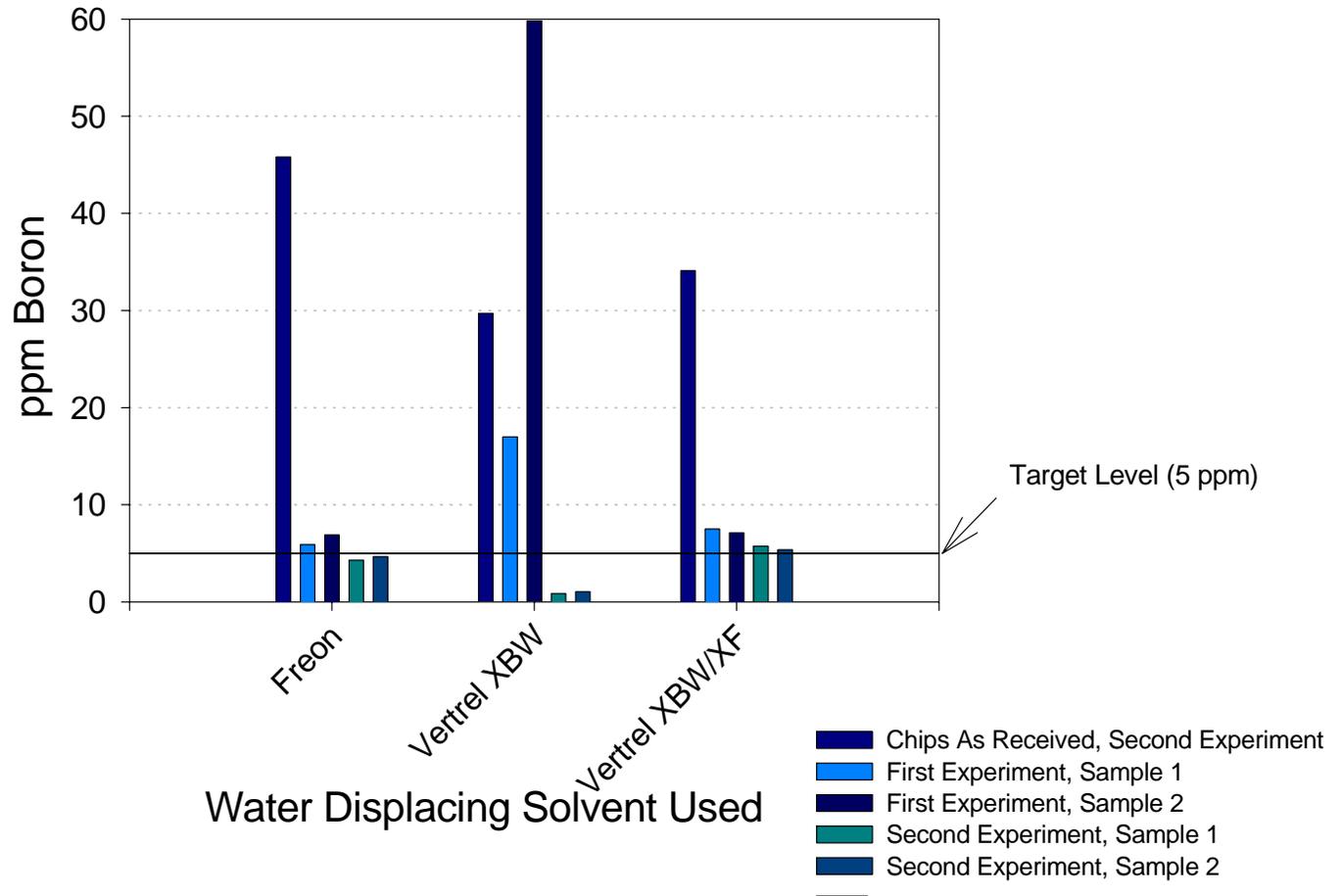
## **The pilot plant study was repeated due to the problems encountered with the initial study.**

- Used same equipment
- One basket cleaned with Freon, one with Vertrel XBW and one with Vertrel XBW/XF
- Used same analytical techniques but have not briquetted and remelted samples
- Initial stock was a piece of high carbon and piece of low carbon material

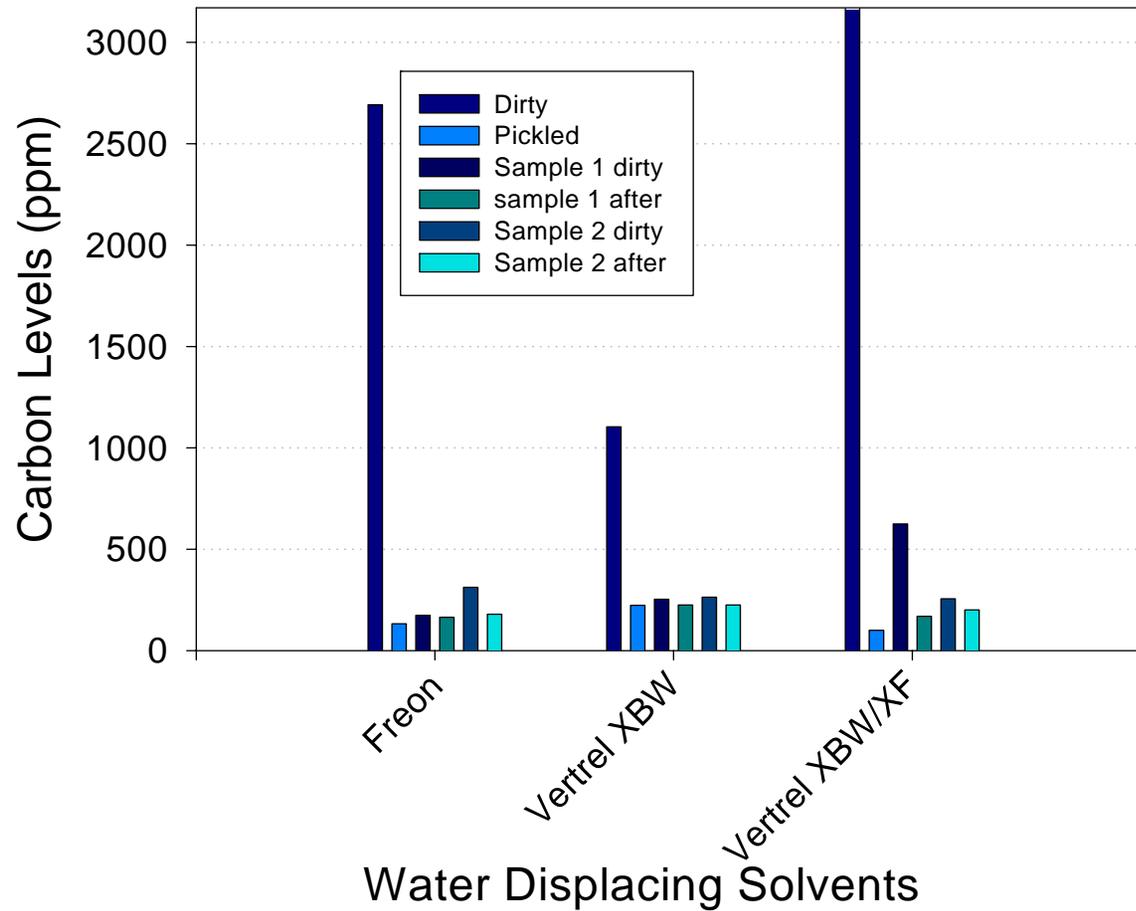
## Amount of Residue on Uranium Chips As Determined Using An Analytical Rinse Technique with Trichloroethane



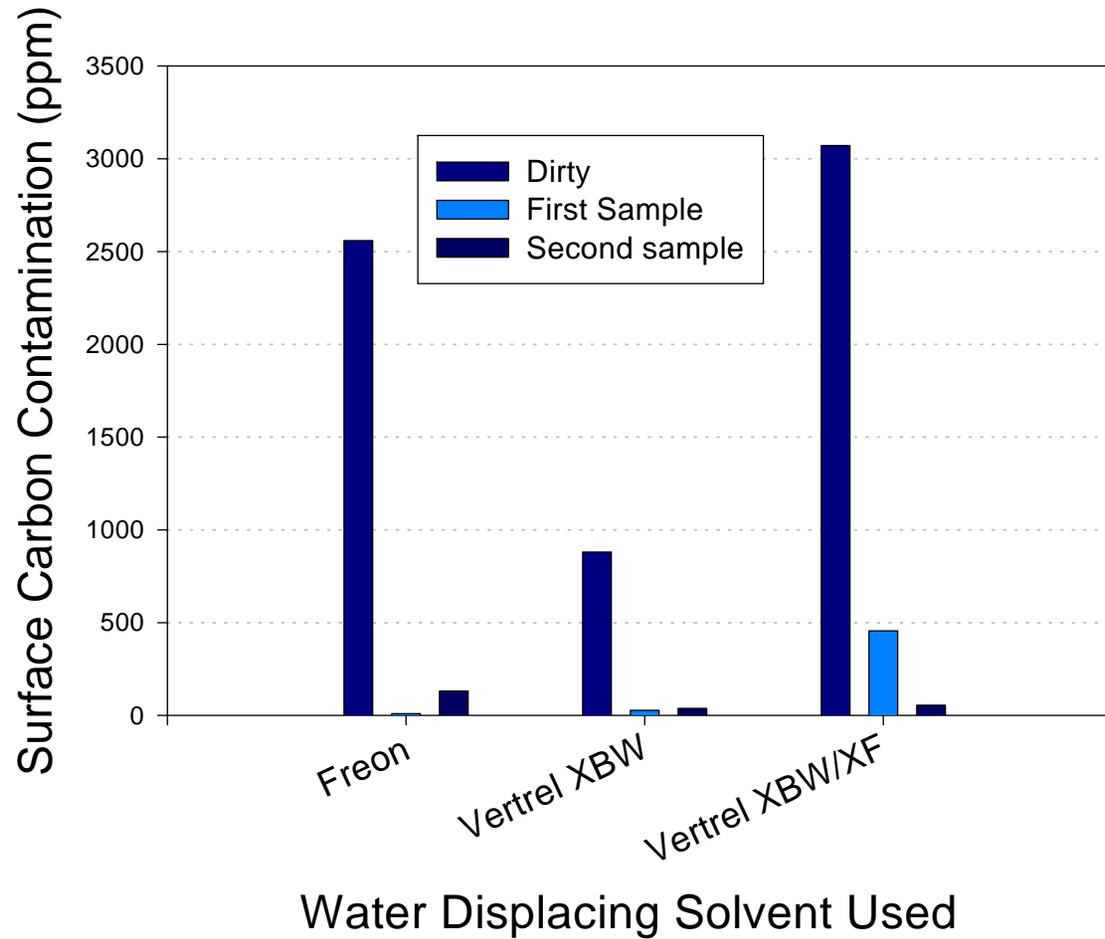
## Amount of Boron Residue Detected Using ICP on Uranium Chips Cleaned Ultrasonically in Water and Water Displacing Solvent



## Level of Carbon For Uranium Chips as a Function of Water Displacing Solvent Used



## Surface Carbon Contamination on Uranium Chip Samples Determined by Difference in Pickled and Non-pickled Chips Using Leco Test



**A recommendation was made to Enriched Uranium Operations to substitute Vertrel XBW for Freon TDFC in the chip cleaning application.**