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ENGINEERING SCALE TEST OF AN FFTF FISSION GAS DELAY BED

95,322

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SLIDE 1 - TITLE SLIDE

GOOD AFTERNOON. TODAY I AM GOING TO REPORT THE RESULTS OF ENGINEERING SCALE TESTS OF A CHARCOAL, FISSION GAS DELAY BED FOR THE FAST FLUX TEST FACILITY (FFTF). THE FFTF IS A SODIUM-COOLED, FAST REACTOR BEING BUILT BY WESTINGHOUSE-HANFORD COMPANY FOR THE AEC AT RICHLAND, WASHINGTON. IT EMPLOYS A CLOSED CYCLE ARGON COVER GAS SYSTEM, WHICH PERMITS EXTREMELY LOW RELEASE RATES FOR NOBLE FISSION GASES. INDEED, THE FFTF NOBLE GAS RELEASES ARE SO LOW THAT THE REACTOR DOES NOT EVEN HAVE A STACK.

IN THE FFTF, RADIOACTIVE NOBLE GASES ARE REMOVED FROM THE PRIMARY ARGON COVER GAS BY THE MEANS:

1. DELAY IN A LARGE HOLDUP TANK,
2. DELAY IN CRYOGENIC CHARCOAL ADSORPTION BEDS, AND,
3. SEPARATION BY FRACTIONAL DISTILLATION.

MASTER

DISCLAIMER

IN THE HOLDUP TANK AND CHARCOAL BEDS, REMOVAL OF THE NOBLE GAS ISOTOPES IS ACCOMPLISHED BY DELAYING THE ISOTOPES LONG ENOUGH TO PERMIT THEM TO DECAY TO NON-RADIOACTIVE OR SOLID DAUGHTER PRODUCTS. IN THE FRACTIONAL DISTILLATION STEP, LONG-LIVED ISOTOPES (PRIMARILY ^{85}Kr, ^{133}Xe, AND ^{131m}Xe) ARE PHYSICALLY SEPARATED FROM THE ARGON COVER GAS AND STORED IN STEEL CYLINDERS.

THE PURPOSE OF THE WORK TO BE REPORTED HERE WAS THREE-FOLD:

1. TO VERIFY LABORATORY SCALE MEASUREMENTS OF THE ADSORPTION COEFFICIENTS OF XENON, KRYPTON, AND ARGON USING ENGINEERING SCALE EQUIPMENT,
2. TO EXTEND THE RANGE OF THOSE LABORATORY MEASUREMENTS, AND
3. TO EXAMINE THE EFFECTS OF IMPURITIES IN THE COVER GAS ON THE ADSORPTION OF KRYPTON.

SLIDE 2 - FLOW DIAGRAM

THIS IS A FLOW DIAGRAM OF THE TEST APPARATUS USED FOR THIS WORK.

EXPLAIN:
1. MAIN FLOW PATH
2. INJECTION POINT
3. SAMPLING POINTS
4. COOLING MECHANISM

SLIDE 3 - PHOTO OF TEST RIG

POINT OUT:
1. COLD BOX
2. FLOWMETER
3. IONIZATION CHAMBERS
4. ETC.

SLIDE 4 - PHOTO OF COLD BOX INTERIOR

POINT OUT:
1. BED
2. COOLING COILS

SLIDE 5 - DATA SCHEMATIC

THIS IS A SCHEMATIC OF A TYPICAL DATA TRACE FOR ONE ADSORPTION COEFFICIENT MEASUREMENT. A PULSE INPUT OF RADIOACTIVE

TRACER GAS, ^{85}KR FOR INSTANCE, IS ADDED TO THE INLET ARGON STREAM TO THE CHARCOAL BED. AT SOME TIME LATER, DEPENDING UPON THE DEGREE OF ADSORPTION, THE TRACER GAS ELUDES FROM THE BED. THIS ELUTION CURVE IS THEN USED TO CALCULATE A DYNAMIC ADSORPTION COEFFICIENT.

SLIDE 6 - MEAN HOLDUP TIME

THE FIRST STEP IN THE CALCULATION OF AN ADSORPTION COEFFICIENT FROM THE ELUTION CURVE IS TO OBTAIN THE the ~~FIRST MOMENT OF THE CURVE.~~ mean holdup time of the tracer gas in the charcoal bed. THIS WAS ACCOMPLISHED BY PUTTING THE ELUTION CURVE ON DATA PUNCH CARDS AND PERFORMING THE INDICATED INTEGRATION ON A COMPUTER. This is called the first moment of the elution curve. ~~PHYSICALLY, THE FIRST MOMENT OF THE ELUTION CURVE IS THE MEAN HOLDUP TIME OF THE TRACER GAS IN THE CHARCOAL BED.~~ Utilizing the analysis methods of Underhill at Harvard Air Cleaning Lab.

SLIDE 7 - DYNAMIC ADSORPTION COEFFICIENT

THE DYNAMIC ADSORPTION COEFFICIENT IS CALCULATED FROM THIS EQUATION. THE MEAN HOLDUP TIME IS OBTAINED FROM THE mean ~~FIRST~~

holdup time ~~MOMENT OF THE ELUTION CURVE~~ BY THE METHOD JUST DESCRIBED.

SLIDE 8 - ^{85}KR RESULTS

THESE ARE THE RESULTS OF OUR ^{85}KR ADSORPTION COEFFICIENT MEASUREMENTS. THEY AGREE WELL WITH THE LABORATORY DATA TAKEN FROM THE LITERATURE (RED LINES). "REFERENCE 2" IS FROM THE WORK OF COLLINS, AT THE DRAGON PROJECT IN THE UNITED KINGDOM; "REFERENCE 3" IS FROM UNDERHILL AT THE HARVARD AIR CLEANING LABORATORY.

NOTE THAT THE PRESSURE OF THE COVER GAS HAS A GREATER EFFECT ON THE ADSORPTION COEFFICIENT AT HIGHER TEMPERATURES THAN AT LOWER ONES. UNDERHILL SHOWED THAT THIS IS THE RESULT OF INCREASED ADSORPTION OF Argon COVER GAS AT THE LOWER TEMPERATURES. AS COVER GAS ATOMS FILL MORE OF THE AVAILABLE ADSORPTION SITES, THE EFFECT OF TOTAL PRESSURE ON THE ADSORPTION OF THE TRACER GAS LESSENS. I REFER YOU TO DR. UNDERHILL'S WORK AT HARVARD FOR A MORE COMPLETE EXPLANATION OF THIS PHENOMENON.

SLIDE 9 - ^{133}Xe Results

These are the results of our measurements for ^{133}Xe. Here we extended Collins' work to lower temperatures. Current tests are examining the pressure effect at low bed temperatures.

SLIDE 10 - ^{41}Ar

The third noble fission gas we examined was ^{41}Ar. Measurements were made at 0 and 30 psig over a temperature range from +20 to -160°C. The literature data (red lines) are Underhill's. Note the prominence of the pressure effect and its decrease with decreasing temperatures. Again, I refer you to Dr. Underhill's work for an explanation.

These results satisfied us that the laboratory data could be scaled up for use in the design of the actual FFTF hardware. Next, we examined the effects of some postulated cover gas impurities on the adsorption coefficient of ^{85}Kr.

SLIDE 11 - IMPURITIES

WE INVESTIGATED THE EFFECTS OF NATURAL XENON, NITROGEN, AND METHANE ON THE ADSORPTION OF ^{85}KR. THE AMOUNTS OF GAS SHOWN ON THE SLIDE WERE ADDED TO OUR ARGON SUPPLY STREAM, AND THE ADSORPTION COEFFICIENT OF ^{85}KR WAS MEASURED. FIRST, ONLY XENON WAS PRESENT. THEN NITROGEN WAS ADDED TO THE XENON. LAST, ALL THREE GASES WERE PRESENT.

SLIDE 12 - SIGNIFICANCE TEST FOR ^{85}KR

MEASUREMENTS OF THE ^{85}KR ADSORPTION COEFFICIENT WERE MADE AT -75 AND -125°C. THE ADSORPTION COEFFICIENTS PREVIOUSLY MEASURED FOR ^{85}KR AT THESE TEMPERATURES IN PURE ARGON WERE COMPARED WITH THE COEFFICIENTS MEASURED IN THE PRESENCE OF THE IMPURITIES. THIS COMPARISON WAS ACCOMPLISHED WITH THE T-STATISTIC, WHICH WAS USED IN THE DETERMINATION OF THE SIGNIFICANCE OF THE DIFFERENCES BETWEEN THE MEAN OF THE COEFFICIENTS MEASURED IN PURE ARGON AND THE MEAN OF THE MEASUREMENTS MADE IN THE PRESENCE OF

ONE OR MORE IMPURITIES. AT A CONFIDENCE LEVEL OF 95%, IF THE CALCULATED VALUE OF T WAS LESS THAN THE TABULAR VALUE OF T ($\pm T_{.025}$), THEN THERE WAS NO SIGNIFICANT DIFFERENCE BETWEEN THE MEANS OF THE COEFFICIENTS. IF THE CALCULATED VALUE OF T WAS GREATER THAN THE TABULAR VALUE, THEN THERE WAS A DIFFERENCE WHICH WAS NOT ATTRIBUTABLE TO CHANCE. NOTE THAT AT -75°C NO SIGNIFICANT DIFFERENCES EXIST BETWEEN COEFFICIENTS MEASURED IN PURE ARGON AND THOSE MEASURED IN THE PRESENCE OF IMPURITIES. AT -125°C, THE IMPURITIES CAUSE A DEFINITE DECREASE IN THE ADSORPTION COEFFICIENT. FURTHER, THE DECREASE ONLY OCCURS ONCE, FOR NATURAL XENON. APPARENTLY NITROGEN AND METHANE DID NOT FURTHER DECREASE THE ^{85}KR ADSORPTION COEFFICIENT.

NOTE THAT ALTHOUGH ONLY TWO DATA POINTS WERE AVAILABLE AT -125°C FOR THE MEASUREMENTS IN PURE ARGON, THAT EVEN WITH THIS LARGE STANDARD DEVIATION, A SIGNIFICANT DIFFERENCE STILL EXISTS.

SLIDES OFF

THE LAST WORK THAT I WOULD LIKE TO REPORT ON COVERS THE MEASUREMENT OF THE ^{85}Kr ADSORPTION COEFFICIENT IN A NITROGEN ATMOSPHERE. ALL OF THE INERTED CELLS IN THE FFTF HAVE NITROGEN ATMOSPHERES. IN THE EVENT OF A LEAK OF PRIMARY COVER GAS INTO ONE OF THESE CELLS, THE CELL ATMOSPHERE CAN BE EXHAUSTED THROUGH A CRYOGENIC CHARCOAL BED SYSTEM.

OF CONCERN TO OUR DESIGN CONTRACTOR WAS THE EFFECTS OF OXYGEN AND CARBON DIOXIDE ON THE ADSORPTION OF RADIOISOTOPES OF KRYPTON. THEREFORE WE MEASURED THE DYNAMIC ADSORPTION COEFFICIENT OF ^{85}Kr IN PURE NITROGEN, AND IN NITROGEN WITH OXYGEN AND CARBON DIOXIDE IMPURITIES PRESENT.

SLIDE 13 - N_2 DATA

THE MEASUREMENTS OF THE ^{85}Kr ADSORPTION COEFFICIENT WERE MADE AT -80 AND -120°C, AND AT PRESSURES OF ZERO AND 30 PSIG.

NOTE THAT THERE APPEARS TO BE A PRESSURE EFFECT, THAT IS, INCREASED ADSORPTION WITH INCREASED COVER GAS PRESSURE AT BOTH TEMPERATURES. OF PRIMARY INTEREST THOUGH, IS THAT THE IMPURITIES DID NOT APPEAR TO INTERFERE AT ALL WITH THE ADSORPTION OF KRYPTON.

SLIDE 14 - CONCLUSIONS

WHILE SEVERAL CONCLUSIONS CAN BE DRAWN FROM THE DATA PRODUCED IN THIS PILOT PLANT SCALE TEST PROGRAM, THE THREE LISTED HERE WERE OF MOST INTEREST TO OUR REACTOR DESIGN ENGINEERS:

NO. 1 - MEASUREMENTS OF NOBLE FISSION GAS ADSORPTION COEFFICIENTS IN PILOT PLANT SCALE TEST EQUIPMENT AGREED WELL WITH LABORATORY DATA WHICH WERE USED IN THE PRELIMINARY DESIGN OF THE FFTF UNITS. THUS WE CAN FEEL MORE CONFIDENT THAT THE PREDICTED PERFORMANCE OF THE FFTF HARDWARE WILL BE ACHIEVED.

NO. 2 - SINCE OUR TEST APPARATUS REPRESENTED A SCALEUP OF ABOUT 1000-FOLD OVER THAT USED TO OBTAIN THE LABORATORY-SCALE RESULTS, THE GOOD AGREEMENT OF OUR RESULTS WITH THOSE LABORATORY-SCALE MEASUREMENTS GIVES US CONFIDENCE THAT NO SERIOUS PROBLEMS WILL BE ENCOUNTERED IN USING OUR RESULTS FOR THE DESIGN OF FULL-SCALE EQUIPMENT.

NO. 3 - THE MAXIMUM LEVELS OF IMPURITIES EXPECTED IN THE FFTF COVER GASES WILL HAVE ONLY MINIMAL EFFECTS ON THE ADSORPTION OF KRYPTON RADIOISOTOPES, AND THEN ONLY AT TEMPERATURES BELOW -100°C. SINCE MOST PORTIONS OF THE FOUR CHARCOAL BEDS IN FFTF OPERATE AT AROUND -100°C, THIS IS NOT EXPECTED TO CAUSE ANY PROBLEMS.

SLIDE 15 - REFERENCE

ANYONE WISHING A DETAILED ACCOUNT OF THIS WORK IS REFERRED TO THE TOPICAL REPORT SHOWN ON THE SLIDE. IT IS AVAILABLE FROM THE AEC AT THE ADDRESS SHOWN. I REGRET THAT I HAVE NO MORE COPIES OF IT FOR DISTRIBUTION TO YOU, BUT IT IS AVAILABLE FROM OAK RIDGE.

QUESTIONS?? LEAVE SLIDE 15 ON DURING QUESTIONS.