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Development of a Large-scale Iodine-125 Production at UC Davis's MNRC

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INTRODUCTION

The demand for iodine-125 (^{125}I) as a medical radioisotope for use in the treatment of prostate cancer continues to increase. However, due to uncertainties with current commercial production facilities, potential supply issues have emerged prompting several reactors worldwide to consider the development and installation of large-scale ^{125}I production facilities. In order to maximize yields with low MW operating reactors (i.e. MNRC up to 2 MW), the production of ^{125}I is accomplished by activating an enriched xenon-124 (^{124}Xe) gaseous target, a stable target isotope with only 0.1% natural atomic abundance. Xenon-124 (^{124}Xe) gas is then transmuted to 17.1-h ^{125}Xe. Decay of ^{125}Xe by electron capture to 60.1-d ^{125}I and its subsequent decay by electron capture to stable ^{125}Te, is accompanied by very low-energy gamma-ray emissions (0.035 MeV) able to irradiate the prostate while minimizing exposure to surrounding tissue. During the irradiation process, some 13.0-d ^{126}I is produced in the target area through the neutron activation of newly formed ^{125}I, but it decays also by electron capture to stable ^{126}Te. Therefore, ^{126}I radionuclidic impurity levels are kept to a minimum by proper and effective trapping (filtering) ^{126}I near the target while the resulting ^{125}Xe parent is transported and trapped in far away cryogenically-cooled decay containers. In this manner, pure ^{125}I with >99.9% radionuclidic purity is obtained from the decay of the trapped ^{125}Xe.

THE ORIGINAL SYSTEM

In 2002, MNRC installed and operated succesfully for ~ 1.5 years, a closed loop system using Al material for containment of the enriched ^{124}Xe during irradiation. Cryogenic traps were used to store ^{124}Xe and to receive the decaying ^{125}Xe parent. The target was operated in a location not far from the central irradiation facility (CIF) and bombarded with thermal neutron fluxes of about 1.17 x 10^{13} n/cm^{2}s. With 8-h irradiations, ~ 3.5-d decay, and ~ 60% extraction efficiency ^{125}I production averaged 307 GBq (~ 8.3 Ci) per batch. The system was designed by the Sandia National Laboratory in Alburquerque, NM and manufactured by Raytheon on a grant funded by the US Department of Energy. However, problems with design features and restrictions on serviceability and repairs ultimately forced MNRC to abandon it as a first target failure resulted in high contamination levels in the whole system which further restricted personnel accessibility.

THE NEW SYSTEM

Today, a new target and a multi-compartment (modular) transport and decay system with automatic operation and dispensing of high-level batches of ^{125}I and with ready access for maintenance and repairs have been designed to resume ^{125}I production activities. The system is largely based upon the production system for accelerator-produced ^{123}I from its parent ^{123}Xe, developed at UC Davis's Crocker Nuclear Laboratory and operated without incidents from the early 1970's to late 1980's (Lagunas-Solar et al., 1979a; Lagunas-Solar et al., 1979b; Lagunas-Solar, 1985; and Jungerman et al., 1989). Operating at CIF to optimize neutron fluxes, the new target will be a double-contained SS chamber where higher ^{124}Xe gas pressures are to be irradiated resulting in increased ^{125}Xe and ^{125}I yields.

RESULTS

The new operating conditions are summarized in Tables I & II. They provide ample opportunities for increased production

with shorter irradiation times. Figure 1 shows a schematic of the new system indicating the interconnected compartments with the ^{125}Xe decay and the ^{125}I dispensing unit to be located in a new radiochemistry laboratory (RadLab) ~ 70 m (~200 ft) away from the reactor core. These new features and operational modes will be presented in detail together with the design rationale for changes and improvements.

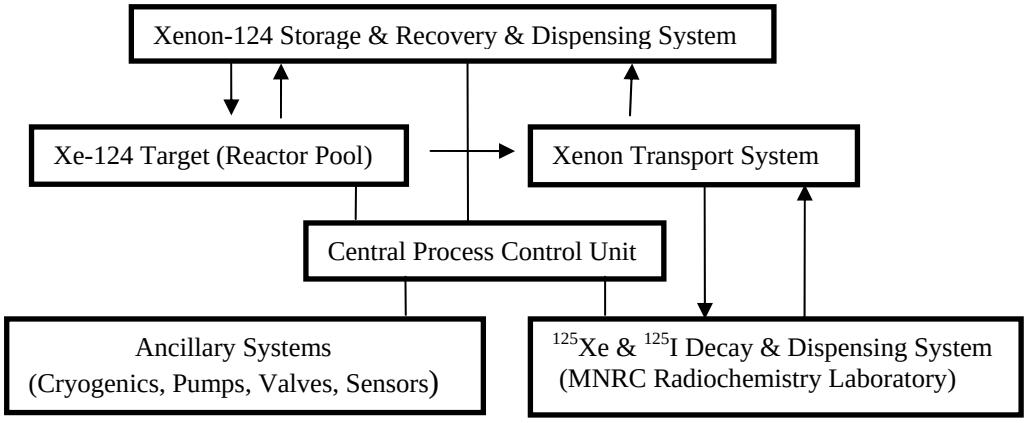
Table I. Physical dimensions of ^{124}Xe targets

Core Location	Wall Material Outer/ Inner	Volume (L)	Pressure kPa (psi)
Old E6	Al/ Al	0.300	827 (120)
New E6	SS/ SS	0.482	1378 (200)
New E6	SS/ SS	0.482	2756 (400)
CIF	SS/ SS	0.922	1378 (200)
CIF	SS/ SS	0.922	2756 (400)

Table II. Estimates of ^{125}I production for an 8-h irradiation cycle at 1.5 MW, 3.5 d decay and ~60% overall extraction efficiency.

Core Location	Excess Reactivity	Neutron Flux (n/cm^2.s)	^{125}I Prod. per Cycle GBq (Ci)
Old E6	- - -	1.17E13	307.1 (8.3)
New E6	– $ 0.47	7.57E12	514.3 (13.9)
New E6	– $ 0.69	6.37E12	869.5 (23.5)
CIF	– $ 0.35	8.02E12	1047.1 (28.3)
CIF	– $ 0.64	6.38E12	1672.4 (45.2)

Figure 1. Schematic of the new MNRC ^{125}I production system.



REFERENCES

1. LAGUNAS-SOLAR, M.C., JOHN A. JUNGERMAN, NEAL F. PEEK, CASEY W. BENNETT, "*Large-Scale Cyclotron Production of High-Purity Carrier-Free Iodine-123.*" (1979a). J. Lab. Compds. & Radiopharmaceuticals 16 (1): pp. 224 - 225, (1979).
2. LAGUNAS-SOLAR, M.C., JOHN A. JUNGERMAN, NEAL F. PEEK, FRANK E. LITTLE (1979b). "*A remote flow system for large-scale high-purity I-123 Production.*" Proc. of 27th Conf. on Remote Systems Technology, San Francisco, California CRSTBJ 27 1-432, pp. 295 - 300 (1979).
3. LAGUNAS-SOLAR, M.C. (1985). "*Cyclotron Production of High-Purity Iodine-123 for Medical Applications via the I-127(p,5n)Xe-123 → I-123 Nuclear Reaction.*" In: The Developing Role of Short-Lived Radionuclides in Nuclear Medical Practice. Peter Paras & J.W. Thiessen (Eds.), Department of Energy Symposium Series 56. CONF - 820523 (DE82008258) pp. 203 - 223 (1985).
4. JUNGERMAN J.A., N.F. PEEK, H.H. HINES, M.C. LAGUNAS-SOLAR (1989). "*Continuous Flow Radioactive Iodine-123 Production*". US Patent # 4,818,868; April 4, 1989.