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SUMMARY

The H-3 production, transport and environmental release from the 350 MW(t) Modular High Temperature Gas Cooled Reactor was analyzed. The analysis was performed using a modified TRITGO computer code, plant data base from the Preliminary Safety Information Document and materials property data from the Fuel Design Data Manual, Issue F. The analysis indicates that most of the H-3 produced in the reactor is retained by the fuel particles and the structural graphite elements. The single largest source of H-3 is ternary fission in the fuel particles, of which 95% is retained by the particles. The H-3 released from the core and the H-3 produced by He-3 activation are largely removed by the Helium Purification System. Assuming zero leakage of water from the secondary system, the average predicted H-3 activity in the secondary water of 0.35 μCi/g is much greater than the allowable activity of 5 pCi/g for direct discharge into the environment. If any of the secondary water has to be discharged, it must be diluted prior to discharge.

1. INTRODUCTION

This analysis is concerned with the production, retention, transport and release of H-3 during normal operation of the 350 MW(t) Modular High Temperature Gas Cooled Reactor (MHTGR). H-3 is produced in high temperature gas cooled reactors by ternary fission, absorption of neutrons in control materials or burnable poison, neutron capture by He-3 impurity in the helium coolant and reaction of neutrons on lithium impurity in the core graphite materials. Most of the H-3 is produced in solids and the rest (eg., He-3 neutron capture in the coolant channels) is produced directly in the coolant. The H-3 produced in the reactor structural materials from neutron capture in impurities may recoil into the graphite or adsorb in the graphite components or be released to the coolant. The H-3 produced in the coolant and/or H-3 released into the coolant is transported throughout the primary circuit and may also be chemisorbed into the graphite components. A significant fraction of the H-3 in the coolant is removed by the helium purification system. A small fraction of the H-3 is released into the environment due to leakage of the primary coolant helium. Another small fraction of the H-3 in the coolant will permeate through the steam generator tubing into the secondary system

water, where a fraction (due to leakage of water or blowdown of the steam generator) may be released into the environment.

This overall plant mass balance for H-3 was calculated with a modified version of the TRITGO code (Ref. 1). This computer code was originally developed by Oak Ridge National Laboratory (ORNL). Significant modifications have been made to this code to improve its modeling capability. The analysis accounts for all the H-3 production, retention, transport and release mechanisms such that an overall H-3 mass balance is obtained during normal operation of the reactor. The analysis provides information needed for the design of the helium purification system and in the management of radioactive wastes during the operation of the MHTGR.

2. DEFINITION OF THE PROBLEM

The most recent analysis of H-3 production, retention, transport and release from High Temperature Gas Cooled Reactors was performed by Gainey in 1976 (Ref. 2). Most of the earlier analyses efforts were hampered by a lack of a reliable material property data, especially relating to the sorption and/or desorption of H-3 from the graphite structural elements of the HTGR. In addition there has been a lack of experimental measurements on the lithium impurity concentration in reactor core materials. Even this analysis, the lithium impurity level is assumed to be the minimum detectable level for currently available measurement techniques. This lithium impurity provides a significant contribution to the production of H-3 in HTGRs. These two uncertainties introduce significant uncertainties into the subject H-3 analysis.

The definition of the H-3 analysis problem is complete if source or production, retention, transport and release terms are accurately accounted for in the analysis. These terms are listed and are described in detail below.

2.1 Source Terms

The following are the source terms for the production of H-3 in the MHTGR.

1. Ternary fission in the fuel particles
2. He-3(n,p)H-3 reaction in the coolant
3. Li-6(n,α)H-3 reaction in the graphite materials
4. B-10(n,2α)H-3 reaction in the control and burnable poison materials
5. B-10(n,α)Li-7(n,nα)H-3 reaction in the control and burnable poison materials
6. C-12(n,a)Be-9(n,α)Li-6(n,α)H-3 reaction

The largest single contribution for H-3 production is from the ternary fission in the fuel particles. Production by ternary fission is a function of reactor power only. Fractional yield (Ref. 3) for ternary fission varies slightly for different fissile isotopes, but an average is estimated to be 1.0×10^{-4}. Contributions from neutron capture reactions with lithium impurity in the structural materials and He-3 in helium are also significant. All the other reactions play a smaller role in the production of H-3 during normal operation of the MHTGR.

2.2 H-3 Retention in Solids

In the case of fuel, it is known that H-3 is partially retained by intact particles, but completely released from failed particles or those with SiC coating defects. The Fuel Design Data Manual (Ref. 4) provides a correlation for H-3 retention in fuel particles. Using the FDDM correlation and a time averaged fuel temperature of 830 $^{\circ}$ C from Reference 5 an estimate of about 5% release from intact particles can be arrived and was used in the analysis. It must be noted that the contribution from the failed particles (5×10^{-5}) and from SiC defects (5×10^{-5}) is negligible as compared to the diffusive release of ~ 5% from intact particles.

The reaction chains that involve H-3 production in the solids depend on the content and location of impurities such as boron and lithium. A retention factor of 99% is appropriate, since it is known that quite high temperatures (> 1200 °C) are required (Ref. 6) for H-3 desorption from graphite components. To be conservative, no retention of H-3 produced in the impurities in the graphite structures is assumed in the analysis. In addition, no credit is taken for H-3 retention in control materials, since the B_4C operates at high enough temperatures such that essentially complete release is expected based on the correlations from the Fuel Design Data Manual, Issue/F.

H-3 is produced in the helium coolant, ie., in coolant channels and other voids where coolant exists. The pore volume in the graphite elements, both structural elements as well as fuel elements, is large. At a recoil energy of about 0.2 Mev, H-3 has a range of about 500 microns in helium at operating temperature and pressure. Since the pore sizes are equal to or smaller than the recoil range, all H-3 produced by the He-3(n,p)T reaction in the pores is expected to be retained in the graphite elements. However no credit was taken for recoil retention in this analysis, because of the lack of confirmatory data.

Additional retention of H-3 in graphite may take place by chemisorption, which is accounted for by the sorption isotherm (Ref. 6) in the analysis. Chemisorption is expected above a graphite temperature of 650 °C.

2.2 Removal Terms

The following are the removal terms for H-3 from the primary coolant circuit of the MHTGR.

1. Removal by the helium purification system, with a rate constant related to the purification system helium flow rate, the purification system efficiency for hydrogen removal and the core coolant flow rate. This is the dominant removal term.

2. Removal by permeation through the steam generator tubing into the secondary water system. Generally H-3 may permeate through any metallic parts of the system, but contributions from components other than the steam generator are small, because the temperatures are low and thickness of the materials is large, reducing the total permeation loss.

3. Removal or loss due to leakage of primary coolant. During normal operation of the reactor it is expected that a small fraction (10% per year) of the primary coolant helium will leak into the reactor building carrying with it a very small amount of H-3.

4. There are other mechanisms for H-3 removal, but they are processes active during reactor shutdown. Water ingress during shutdown and start up sequences appears to increase release of sorbed H-3 from graphite components to the coolant. Such mechanisms are not included in the analysis.

The pathways for H-3 distribution and release in the MHTGR plant during normal operation are shown in Figure 1.

3. DATA BASE FOR ANALYSIS

The data base for analysis was primarily obtained from the Fuel Design Data Manual, Issue/F (Ref. 4), the Preliminary Safety Information Document (Ref. 7), the Conceptual Design Document (Ref. 8) and the Heat Transport System Design Description, Modular HTGR Plant (Ref. 9). Pertinent data required for the analysis are given in Table 1.

TABLE 1

MHTGR PARAMETERS REQUIRED FOR H-3 ANALYSIS

<u>Reactor</u>

Thermal Power	350 MW(t)
Plant Life Time	40 Years

Capacity Factor	80%
Cycle Length	1.65 Years
Refuelling Scheme	1/2 core/cycle
Core Inlet Temperature	258.0 °C
Core Outlet Temperature	685.0 °C
Weight of Core Elements	1.80×10^5 lbs

Reflectors

Average Temperature of Upper Reflector	300.0 °C
Weight of Upper Reflector	3.66×10^4 lbs
Average Temperature of Lower Reflector	685.0 °C
Weight of the Lower Reflector	4.13×10^4 lbs
Average temperature of Inner Reflector	477.0 °C
Weight of the Inner Reflector	9.40×10^4 lbs
Average Temperature of Side Reflectors	327.0 °C

Steam Generator

Inlet Temperature of Economizer Section	371.4 °C
Outlet Temperature Of Economizer Section	207.4 °C
Economizer Section Surface Area	6.57×10^6 cm^2
Inlet Temperature of Evaporator Section	380.0 °C
Outlet Temperature of Evaporator Section	371.0 °C
Evaporator Section Surface Area	2.03×10^7 cm^2
Inlet Temperature of Superheater 1	435.8 °C
Outlet Temperature of Superheater 1	392.2 °C
Superheater 1 Surface Area	1.77×10^6 cm^2
Inlet Temperature of Superheater 2	595.1 °C
Outlet Temperature of Superheater 2	452.6 °C
Superheater 2 Surface Area	3.10×10^6 cm^2
Tubing Thickness	3.3 mm

Material Properties

Graphite Density	1.74 gm/cc

Lithium Concentration of Graphite (natural lithium is assumed)	0.036 ppm
Boron Concentration in Graphite (other than fuel elements)	2.0 ppm
Boron Concentration in Fuel Elements (Includes Burnable Poison of 7 kgs) (natural boron is assumed)	41.0 ppm

Primary Circuit

Helium Flow Rate	1.24×10^6 lbs/hr
Helium Pressure	63 atms
He-3 Abundance Fraction	2.00×10^{-7}
Helium Makeup Rate of Primary System	10%/year

Secondary Circuit

Mass of Water in the Secondary System	1.34×10^4 lbs
Water Makeup Rate of Secondary System	0.0/day

(This assumption will need to be verified at a later date, but the designers at Combustion Engineering are following this at this time)

Sorption of H-3 on Graphite

$$C_i = \frac{A_o(1 + \beta\gamma_H f)}{1 + e^{a(T - To)}} \cdot P \qquad T > 650\ ^oC$$

$$C_i = 0 \qquad T < 650\ ^oC$$

Where C_i is the sorbate concentration in irradiated graphite,

A_o = 1.38×10^3 $cm^3(STP)/m^2$. torr,

β is a constant = 2.6×10^{-25},

f is the fast fluence (n/m^2),

P is the partial pressure of H_2 and H-3,

γ_H is the annealing factor given by

$\gamma_H = [\ 1 + \exp(0.0439(T - 1423)]^{-1}$

This isotherm developed by Myers, assumes no sorption at temperatures below 650 °C, temperature dependent sorption above 650 °C, fluence dependence of sorption, with sorption increasing with increase in fluence and onset of desorption at about 1500 K. Because of the last assumption no desorption will take place in the MHTGR, since graphite component temperatures will not exceed 1500 K during normal operation. In other words once H-3 is sorbed on to the graphite surface, it will not desorb even if the temperatures change in the graphite components during normal operation of the MHTGR.

4. RESULTS OF THE ANALYSIS

The results of the analysis are shown in Figure 2 thru 8. The total production of H-3 from all processes and the amount bound in solids are shown in Figures 2 and 3. It must be noted that the rate of production by ternary fission is constant throughout the operation of the reactor and is equal to 2035 Ci/cycle, which represents a ternary fission yield of 1.0×10^{-04}. The total production of H-3 as seen in Figure 2 does not grow at the rate of 2035 Ci/cycle, because of a) H-3 decay and b) depletion of impurities such as lithium in the core components. Since most of the reactor graphite components have a life of 40 years and are not replaced, the contribution to H-3 production from neutron activation of impurities in these components reduces to small values due to burnout of the impurities. The overall rate of increase of H-3 in the system reduces with time with the total at the end of life of the reactor reaching a value of about 34,000 Ci.

All of the H-3 produced during the operation is not in the reactor at the end of life, since one half of the core is replaced at the end of each cycle and this refuelling removes H-3 adsorbed or bound in those fuel elements. H-3 retained in the fuel particles is discharged along with the fuel elements and is no longer involved in the transport processes being analyzed in this report.

The production of H-3 from ternary fission as corrected for decay is also shown in Figure 2. At the end of life of the reactor more than half of the H-3 produced originated from ternary fission. The initial rate of production H-3 is about a factor 4 greater than the production from ternary fission

alone. The contribution from neutron capture on impurities in the graphite structural materials is large at the start, but diminishes due to burnout of the impurities.

H-3 bound in solids, ie., in the core graphite components such as fuel, also increases in a similar fashion to about 21,000 Ci at the end of life, which represents about 62% of all the H-3 produced in the reactor.

The H-3 adsorbed in solids as a function of time is shown in Figure 3. Since the isotherm assumes that there is no adsorption below a temperature of 650 °C, the adsorption is limited to a fraction of the core and the lower reflector. During refuelling some of the adsorbed H-3 is removed from the reactor system. Total adsorption corrected for radioactive decay at the end of life of the reactor is about ~ 3500 Ci. This adsorption is entirely due to the sorption isotherms used in this analysis. The uncertainty in the sorption isotherms is expected to be large, since it is based on very meager data base. The total H-3 adsorbed follows the same time dependence as that of H-3 production.

The primary coolant H-3 content as a function of time is shown in Figure 4. It can be seen that the primary coolant content of H-3 increases rapidly in the beginning, reaches a maximum and then decreases to a final steady state value 0.018 Ci. There are three processes involved here. The first one is the burnout of He-3 in the coolant, partially replaced by the primary coolant makeup rate of 10% per year. The second process is the purification rate and the third is the sorption in graphite at temperatures greater than 650 °C. The H-3 levels in the primary coolant reach maximum values rapidly most probably within the first reactor cycle, then reduce to an equilibrium value at about 8 years of operation. This behavior is the result of continuous decrease in the production rate of H-3 during the early stages of reactor operation. The amount of H-3 involved here is quite small and hence any leakage of primary coolant into the containment probably does not add much to the radiation dosage of the plant workers.

Figure 5 shows the time dependence of total H-3 leakage from the primary system. The total loss through this pathway is rather small because the

concentration in the primary coolant is low and the coolant leak rate is only 10%/year. This pathway can be easily ignored under these conditions. Near steady state is reached by the end of life of the reactor for this loss pathway.

The purification plant removes a fraction of about 31% of the total production at the end of life of the reactor. The time integrated H-3 (corrected for decay) removed from the plant by the purification system is shown in Figure 6. During the first cycle out of a total production of about 8780 Ci about 6000 Ci of H-3 is removed by the purification system, assuming that the efficiency for H-3 removal is 100%. This is the largest amount of H-3 removed by the purification system during any cycle of operation of the plant. The load on the purification system reduces for later cycles, since the concentration of H-3 in the primary coolant reduces significantly after the first cycle.

Figure 7 shows the total H-3 inventory of the secondary system. The total is about 3.7 Ci at the end of life of the reactor. This number is somewhat artificial, simply because of the assumption that there is no loss of secondary coolant and thus no makeup water. Operation of the reactor with zero or negligible loss of secondary coolant is assumed here, because Stone & Webster Engineering Company is designing the balance of plant based on this philosophy. The H-3 content of the secondary system is a function of the permeation rate and the H-3 concentration of the primary coolant. The permeation rate constants used here were from Fuel Design Data Manual, Issue F (Ref. 4).

The average activity of the secondary coolant water continues to increase to a final value of about 0.62 μCi/g of water at the end of life as shown in Figure 8. This result is a direct consequence of assuming that the partial pressure of hydrogen and H-3 is zero in the water side of the steam generator or in other words H-3 permeation is a one way process. This number should be compared to allowable activity of 5 pCi/gm (10 CFR 50 Appendix I) of water for discharge into the environment. If any water from the secondary system leaks out it cannot be discharged to the environment without further dilution to meet federal standards for radioactive material discharge.

On the other hand it may be interesting to find the effect of non zero makeup water rate for the secondary system. In the FSV reactor the maximum makeup water rate is about 50 gallons per minute. Since the MHTGR reactor is smaller, assuming a makeup water rate of 20 gallons per minute, the analysis was performed again. The only real change observed from this analysis is the concentration of H-3 in the secondary system. The concentration of H-3 as function of time is shown in Figure 9. This concentration is now lower by a factor of 10^5 as compared to the case where the water makeup rate is zero.

Since the analysis was based on the assumption that the H-3 in the secondary water does not create a back pressure to reduce the permeation, the total H-3 that permeates into the secondary system is independent of the water makeup rate.

Some of the predicted H-3 loadings and concentrations for the first three cycles of operation are given in Table 2. Detailed output for the first three cycles is attached as Appendix A.

Table 2. Results for First Three Cycles

H-3	EOC 1 Curies	EOC 2 Curies	EOC 3 Curies
Total Production	8.78E+03	1.30E+04	1.57E+04
Bound in Solids	2.00E+03	3.81E+03	5.47E+03
Adsorbed on Graphite	7.60E+02	1.17E+03	1.46E+03
In Primary Coolant	7.44E-02	3.65E-02	2.44E-02
Leakage from Primary Coolant	2.00E-02	2.67E-02	2.92E-02
In Purification Plant	6.02E+03	7.99E+03	8.75E+03
In Secondary Water	2.17E+00	2.88E+00	3.16E+00

Average Activity for First Three Cycles

Component	EOC 1	EOC 2	EOC 3
Bound in Graphite (μCi/gm)	3.63E+00	6.95E+00	9.97E+00
Adsorbed in Graphite (μCi/gm)	1.38E+00	2.13E+00	2.65E+00
In Primary Coolant (μCi/scc)	4.51E-06	2.21E-06	1.48E-06
In Secondary Water (μCi/gm)	3.57E-01	4.75E-01	5.19E-01

The analysis for H-3 production and release described above is preliminary in nature. The actual behavior in the MHTGR could be influenced by various other factors. The H-3 production in the reactor will be influenced by the actual lithium impurity levels in the core graphite components. The impurity levels used here were the best estimates from the Graphite Design Data Manual (Ref. 10). These may change depending on possible improvements in the manufacture of graphite blocks and impurity measurement techniques. Simple two group fluxes and approximate neutron cross sections were used in this analysis. More accurate neutron absorption calculations could be used to improve the predictions. This analysis has taken into account refuelling, but does not account for removal and replacement of a part of the inner and outer reflectors. If reflector block replacement is included, H-3 production may increase somewhat.

5. CONCLUSIONS

H-3 permeation through the steam generator tubes is predicted to be less than 4 curies during the life of the plant. Compared to other permeation analysis results, this number appears to be very low and suggests that the permeation data given in the Fuel Design Data Manual which was used in this analysis should be re-evaluated. The analysis was repeated using permeation data from Ref. 1 and approximately 250 curies of tritium permeates through the steam generator tubing into the secondary system during the life time of the plant.

Although the prediction for total H-3 permeation in this analysis is small, this in itself does not invalidate the rest of the conclusions, since permeation is the last step in a series of processes and the total permeation is insignificant as compared to the total production.

This analysis assumes true steady state operation of the reactor, which in real life situation may not be possible. If the reactor experiences many shutdowns during initial stages of the operation and some water ingress events, it is possible to disturb the H-3 distribution in the primary system. It is probable that some of the adsorbed H-3 may isotopically exchange with the hydrogen in the water and thus be removed during reactor shutdowns.

Overall the predictions of this analysis can be used as the tritium source term for system design and radioactive waste management during the operation of the MHTGR.

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Figure 1

350 MW(t) MHTGR TRITIUM PATHWAYS

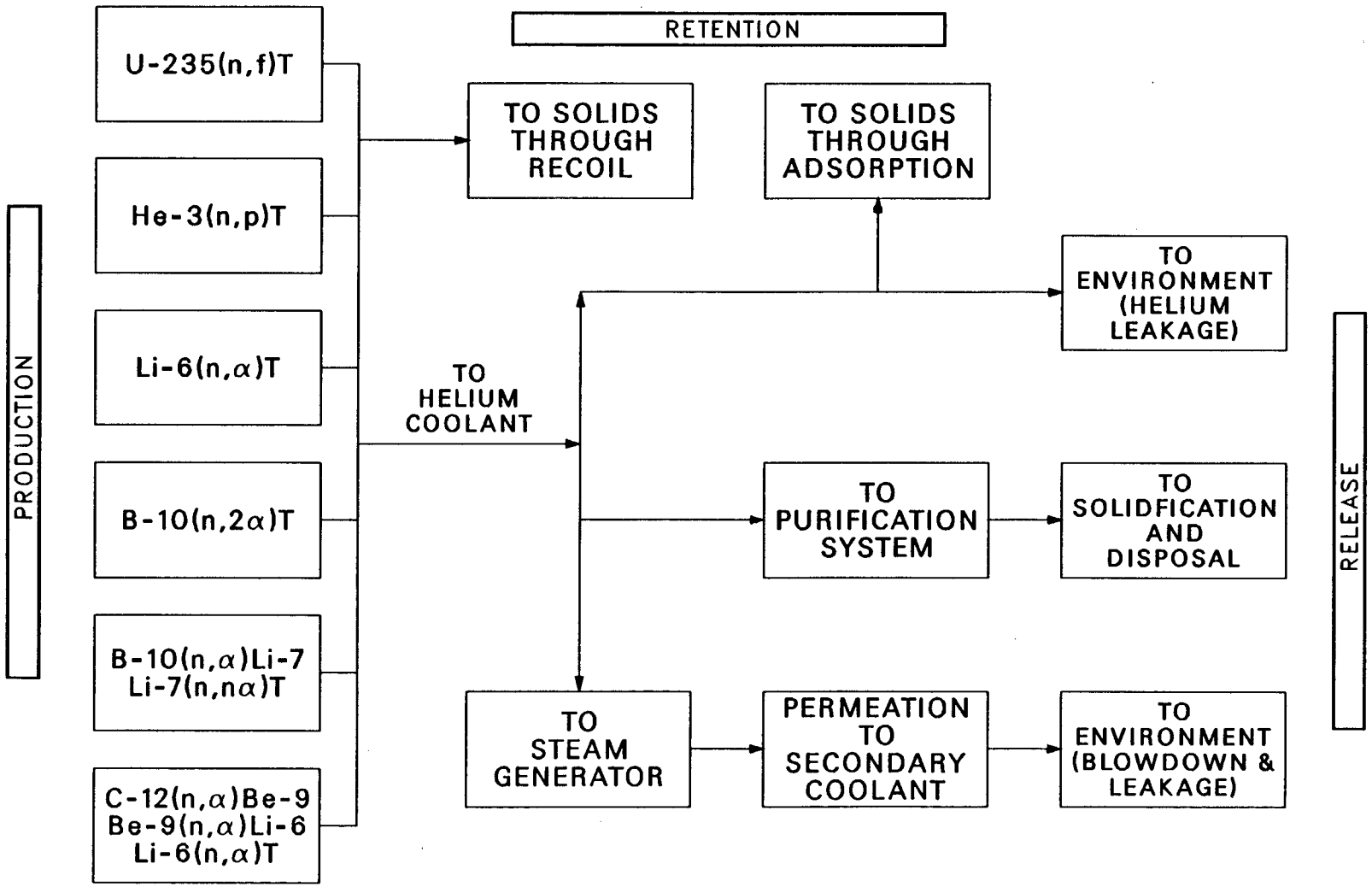


Figure 2.
TRITIUM PRODUCTION & RETENTION IN THE 350 MW(t) MHTGR

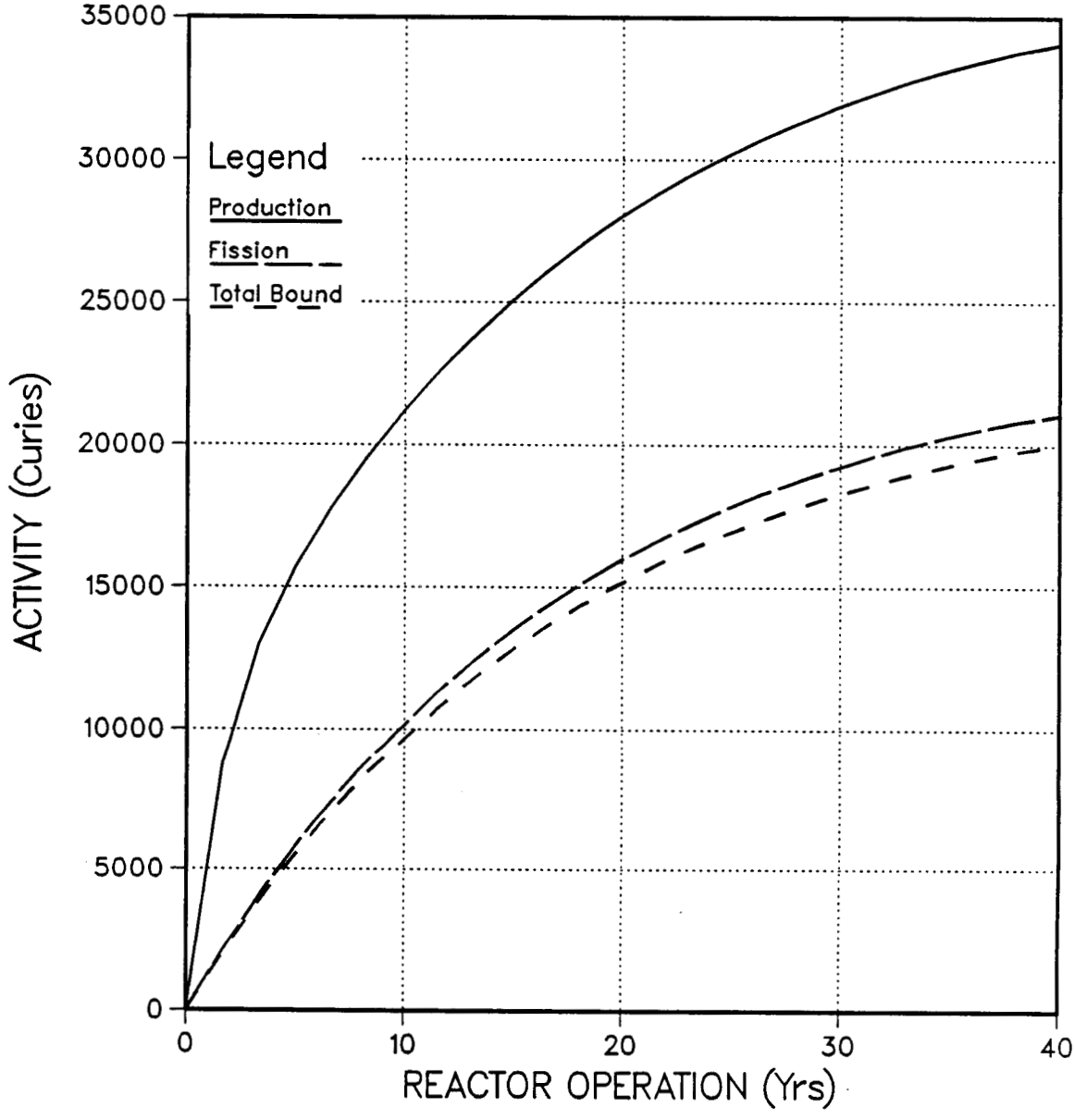


Figure 3.
TOTAL TRITIUM ADSORBED ON GRAPHITE IN THE 350 MW(t) MHTGR

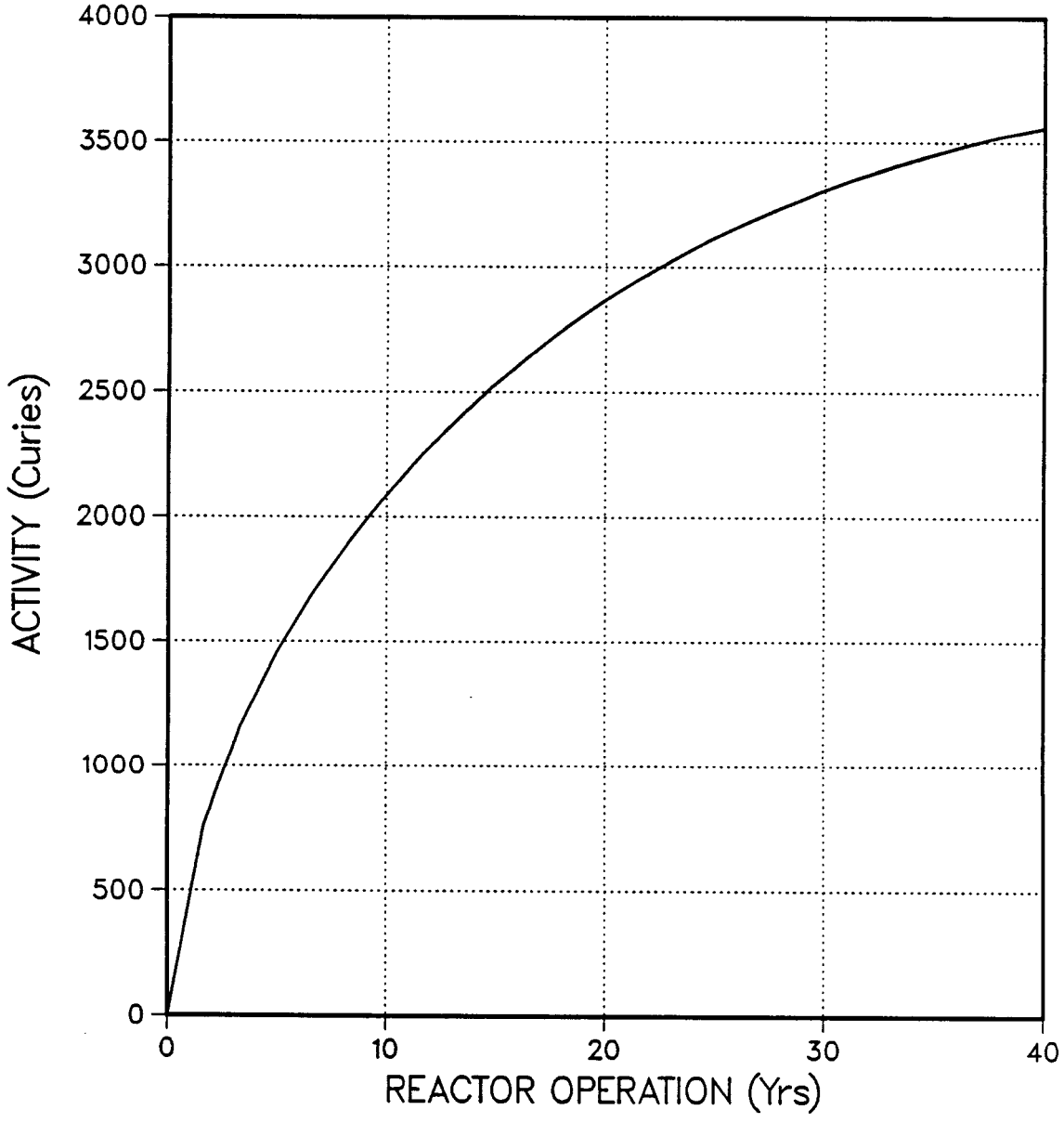


Figure 4.
TOTAL TRITIUM IN PRIMARY COOLANT IN THE 350 MW(t) MHTGR

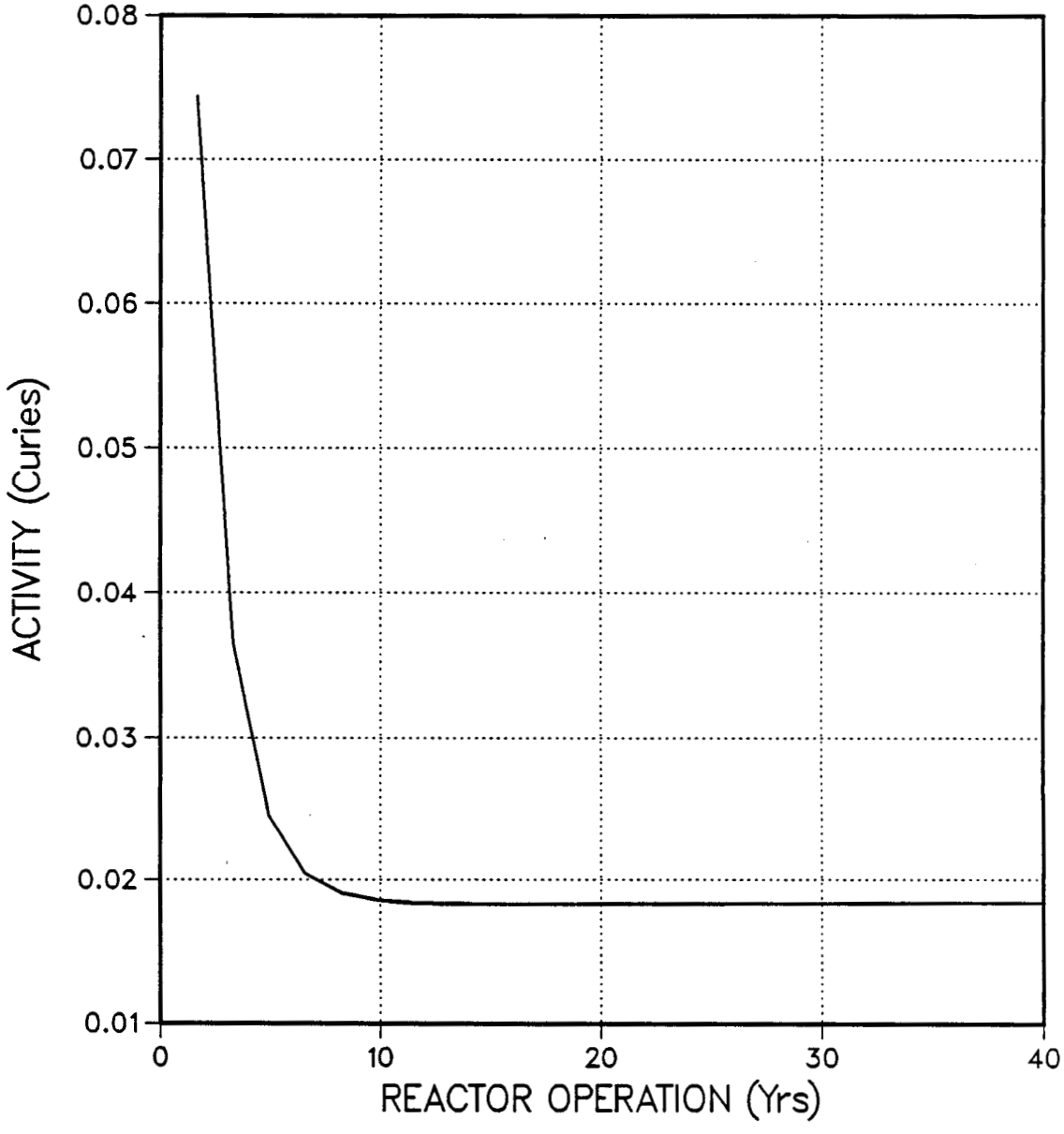


Figure 5.
TOTAL TRITIUM LEAKAGE FROM PRIMARY COOLANT IN THE 350 MW(t) MHTGR

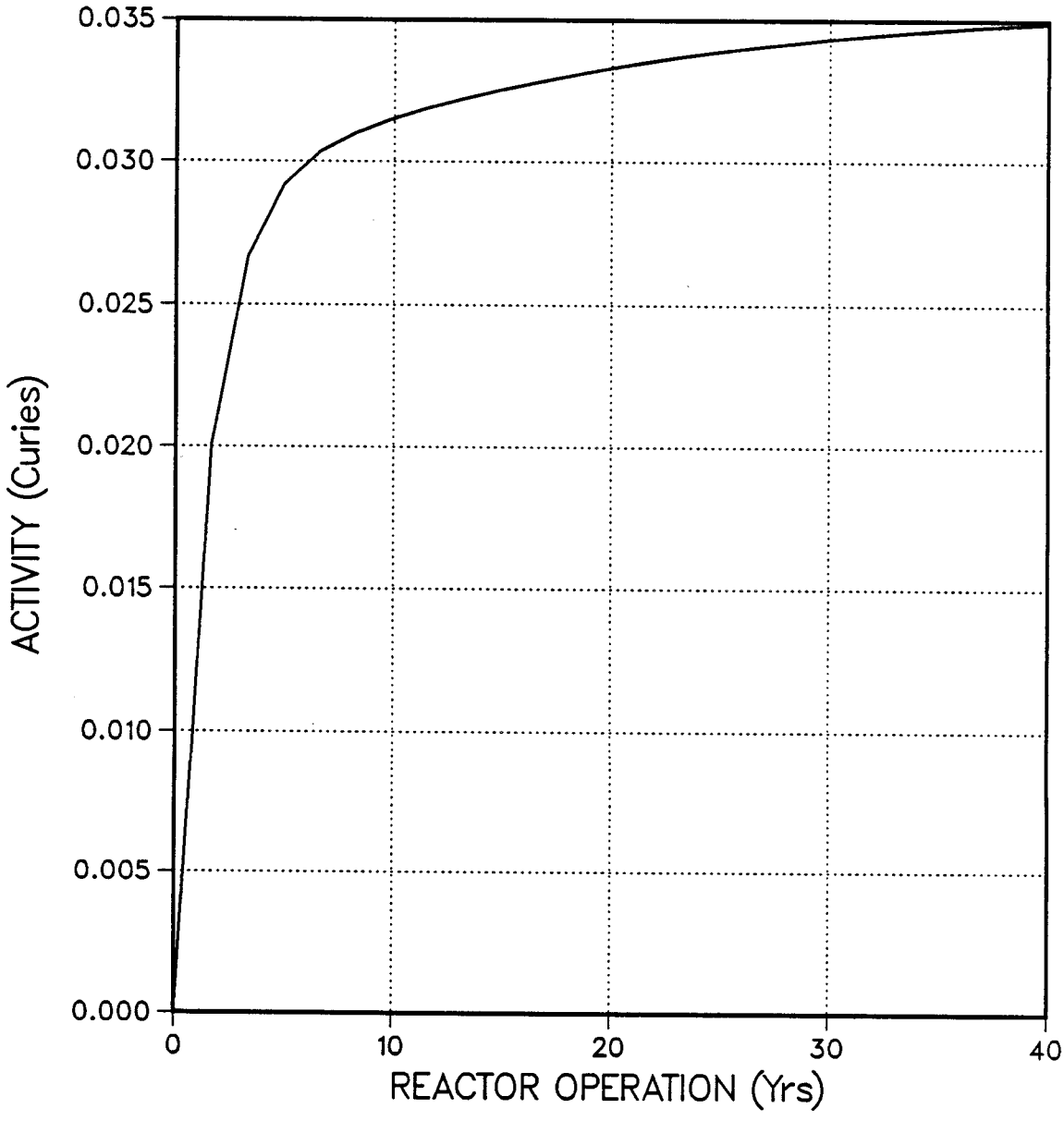


Figure 6.
TOTAL TRITIUM IN PURIFICATION PLANT IN THE 350 MW(t) MHTGR

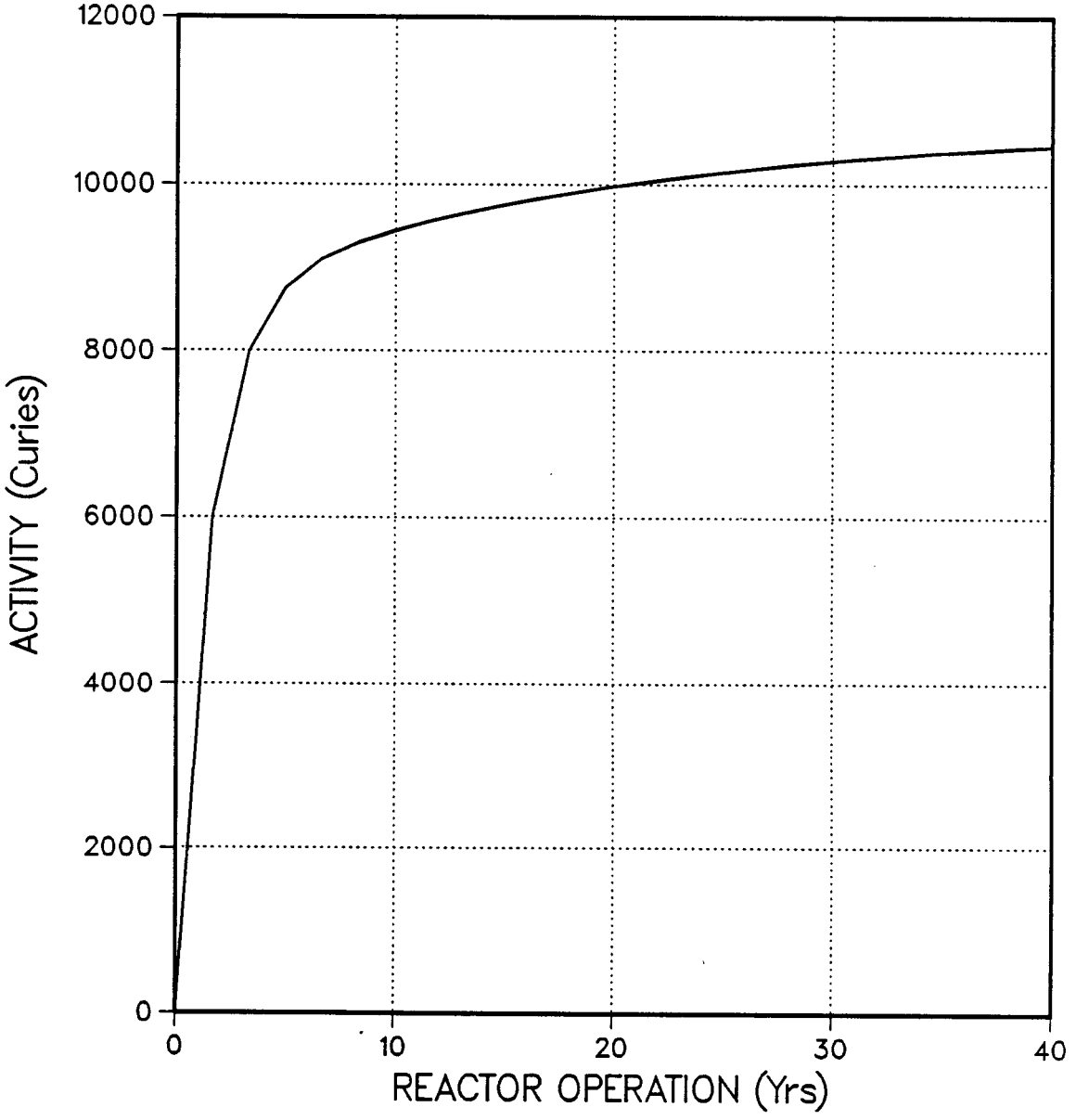


Figure 7.
TOTAL TRITIUM IN SECONDARY WATER IN THE 350 MW(t) MHTGR

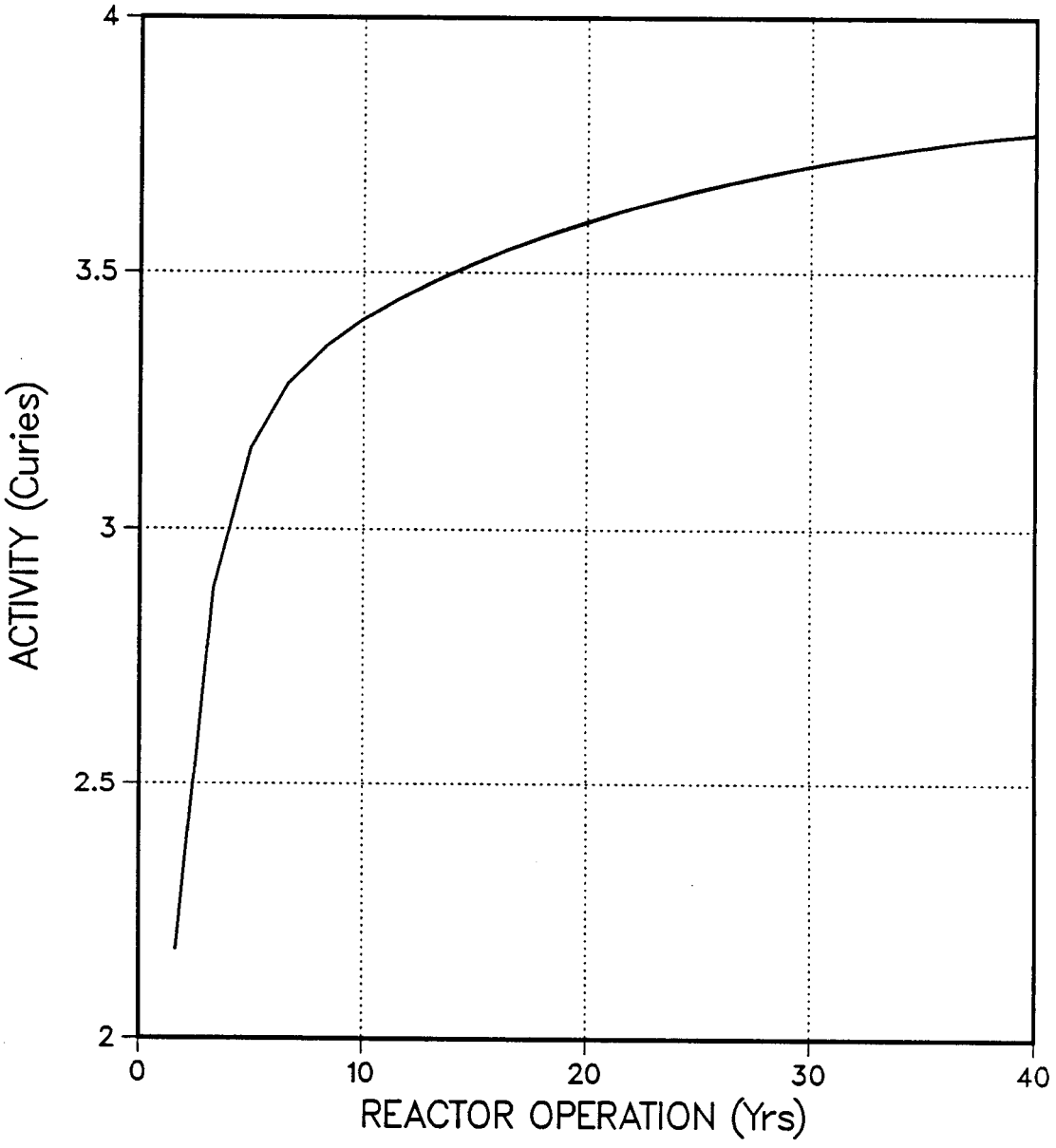


Figure 8.
AVERAGE TRITIUM IN SECONDARY WATER IN THE 350 MW(t) MHTGR

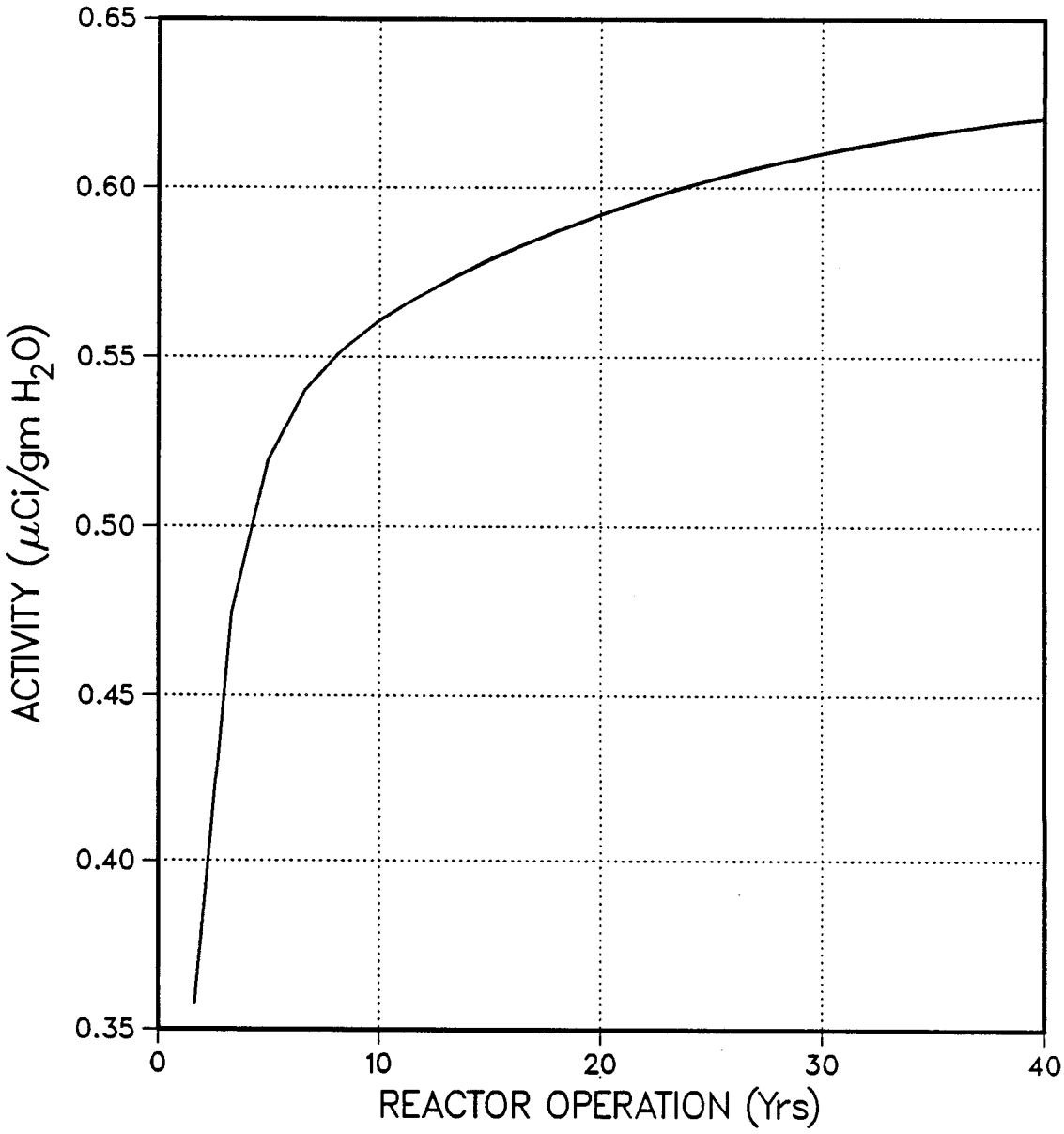
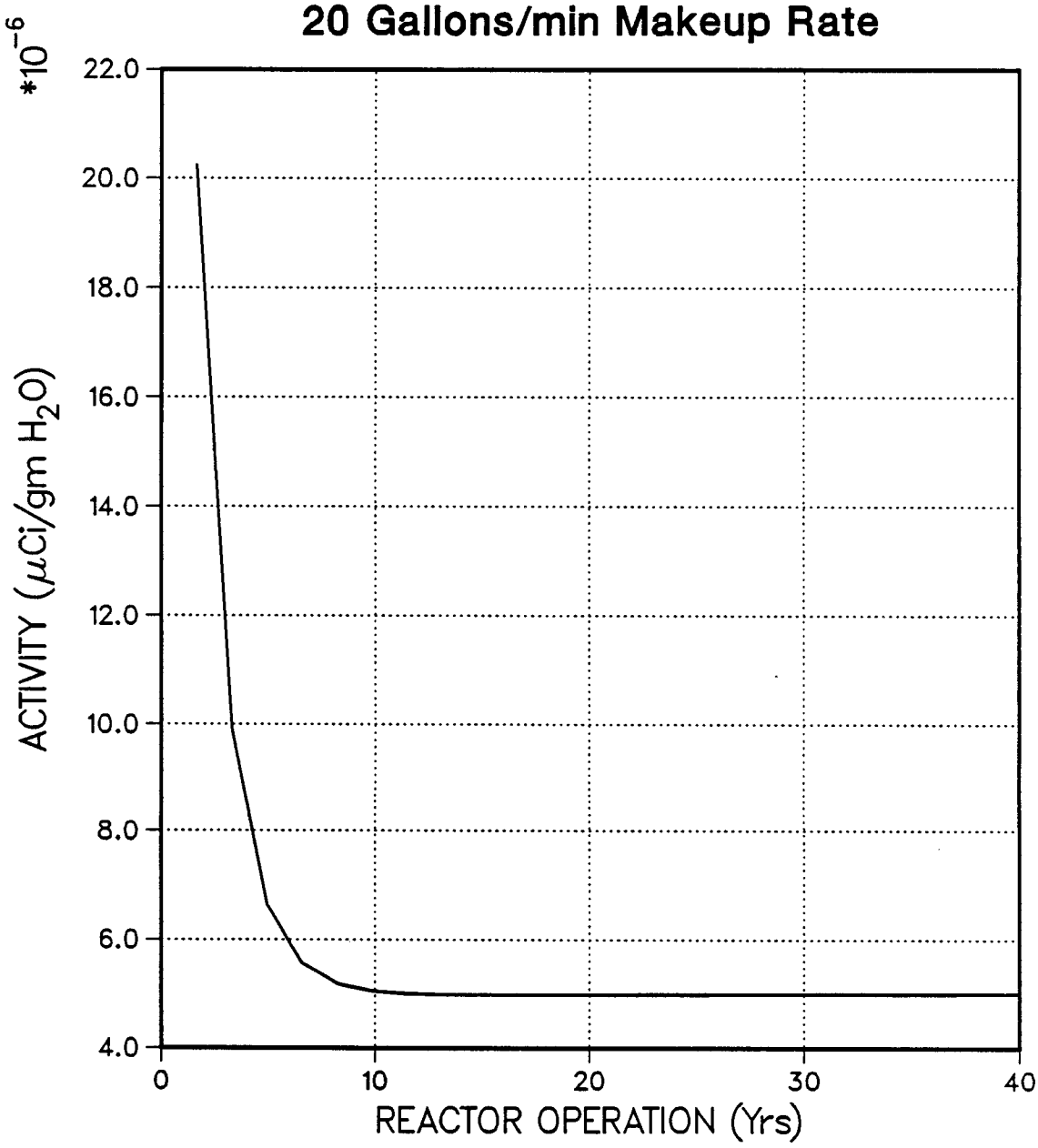


Figure 9.
AVERAGE TRITIUM IN SECONDARY WATER IN THE 350 MW(t) MHTGR 20 Gallons/min Makeup Rate



APPENDIX

DETAILED RESULTS FOR THE FIRST THREE CYCLES OF OPERATION

350 MW(t) MHTGR TRITIUM PRODUCTION AND RELEASE ANALYSIS MYER'S ISOTHERM

13:56:50

24-MAY-88

350 MW(t) MHTGR TRITIUM PRODUCTION AND RELEASE ANALYSIS MYER'S ISOTHERM

Pressure dependence of permeation is linear

Reactor power (MWt)	350.00
Fission density (watts/cm**3)	5.90
Weight of helium (lbs)	6500.00
Helium pressure (atms)	63.00
Average He temperature (C)	471.50
He-3 abundance (fraction)	2.0000E-07
Helium replacement rate(/sec)	3.1700E-09
Helium purification rate(/sec)	9.5000E-04
Mass of water in the secondary system (lbs)	1.3400E+04
Makeup rate of water in the system (lbs/day)	0.0000E+00

909681/0

350 MW(t) MHTGR TRITIUM PRODUCTION AND RELEASE ANALYSIS MYER'S ISOTHERM

	CORE 1	CORE 2	REFLECTOR (TOP)	REFLECTOR (BOTTOM)
Weight (lbs)	7.2000E+04	1.0800E+05	4.4100E+04	4.1300E+04
Density (gm/cm3)	1.7400E+00	1.7400E+00	1.7400E+00	1.7400E+00
Surface Area (sq m/gm)	0.200	0.200	0.200	0.200
Region Temperature (oC)	600.000	704.000	258.000	685.000
Weight Fraction of Region With Channels and Holes	0.6250	0.6250	0.1700	0.1700
Width of Internal Annular Gap Between Rod Matrix and Graphite	0.0050	0.0050	0.0000	0.0000
Width of External Annular Gap Between Region Elements	0.040	0.040	0.040	0.040
He-3 Trapped in Solid (Fraction)	0.000	0.000	0.000	0.000
Fraction of Carbon in Solids	1.000	1.000	1.000	1.000

	REFLECTOR (INNER)	REFLECTOR (SIDE)	CONTROL RODS
Weight (lbs)	9.4000E+04	8.5000E+05	2.7700E+02
Density (gm/cm3)	1.7400E+00	1.7400E+00	1.7400E+00
Surface Area (sq m/gm)	0.200	0.200	0.200
Region Temperature (oC)	477.000	327.000	400.000
Weight Fraction of Region With Channels and Holes	0.0000	0.0000	0.0000
Width of Internal Annular Gap Between Rod Matrix and Graphite	0.0000	0.0000	0.0000
Width of External Annular Gap Between Region Elements	0.040	0.040	0.050
He-3 Trapped in Solid (Fraction)	0.000	0.000	0.000
Fraction of Carbon in Solids	1.000	1.000	1.000

350 MW(t) MHTGR TRITIUM PRODUCTION AND RELEASE ANALYSIS MYER'S ISOTHERM

Name	Surface area Square cms	Thickness mm	Temperature Degrees C	Permeation equation constants Pre exponent cc-H2(stp).mm.atm /Square cm	Act energy Cal/gm mol/deg K
EVAPORATOR	2.03E+07	3.30E+00	2.88E+02	2.510E+02	1.000E+04
ECONOMIZER	6.57E+06	3.30E+00	3.84E+02	2.510E+02	1.000E+04
SUPERHEATER 1	1.77E+06	3.30E+00	4.17E+02	2.510E+02	1.000E+04
SUPERHEATER 2	3.10E+06	3.30E+00	5.26E+02	1.140E+01	1.050E+04

350 MW(t) MHTGR TRITIUM PRODUCTION AND RELEASE ANALYSIS MYER'S ISOTHERM

History lists--value of 1 in first column indicates end of list

Power history list

JX	month	day	year	rel power	start
1	1	1	87	0.800	7306.0

Chemical parameter list(hydrogen conc in ppm, and purification plant efficiency)

IX	month	day	year	H2(ppm)	GAM	start
1	1	1	87	10.000	1.000	7306.0

List of events indicated by code. 0=no printout,1= Printout provided for this point
9 = default value

KX	Month	day	year	code	start
0	1	1	87	1.0	7306.0
0	8	25	88	1.0	7908.0
0	4	19	90	1.0	8510.0
0	12	12	91	1.0	9112.0
0	8	5	93	1.0	9714.0
0	3	30	95	1.0	10316.0
0	11	21	96	1.0	10918.0
0	7	16	98	1.0	11520.0
0	3	9	100	1.0	12122.0
0	11	1	101	1.0	12724.0
0	6	26	103	1.0	13326.0
0	2	17	105	1.0	13928.0
0	10	12	106	1.0	14530.0
0	6	5	108	1.0	15132.0
0	1	28	110	1.0	15734.0
0	9	22	111	1.0	16336.0
0	5	16	113	1.0	16938.0
0	1	8	115	1.0	17540.0
0	9	1	116	1.0	18142.0
0	4	26	118	1.0	18744.0
0	12	19	119	1.0	19346.0
0	8	12	121	1.0	19948.0
0	4	6	123	1.0	20550.0
0	11	28	124	1.0	21152.0
0	7	23	126	1.0	21754.0
0	3	16	128	1.0	22356.0
1	11	8	129	1.0	22958.0

Dates starting and stopping computation span

month	day	year	month	day	year	TBEGIN	TEND

1	1	87	1	11	129	7306.0	22657.0

350 MW(t) MHTGR TRITIUM PRODUCTION AND RELEASE ANALYSIS MYER'S ISOTHERM

Tritium generation and distribution in a high temperature gas cooled reactor

Full reactor power 350. MWth, 5.9Kw/l, Average gas temp 472. deg C, Pressure, 63.0 Atm

Purification rate 82.080000/Day
He amount 6.50E+03 lbs He makeup rate 2.74E-04/Day He-3 abundance 2.00E-07
Water 1.34E+04 lbs water makeup rate 0.00/Day Theo core flux-slow 7.23E+13, fast 2.30E+13

Total Steam Generator Rate constant= 3.4271E-07 Sec-1 was based on 10.00 ppm H2

EVAPORATOR	1.2557E-07 Sec-1,	2.0300D+07 Sqcm,	3.30 mm,	288.3 Deg C,	3.209E-02 STD cc H2,mm/sqcm,hr at 1 atm
ECONOMIZER	1.4961E-07 Sec-1,	6.5700D+06 Sqcm,	3.30 mm,	383.8 Deg C,	1.181E-01 STD cc H2,mm/sqcm,hr at 1 atm
SUPERHEATER 1	5.8393E-08 Sec-1,	1.7700D+06 Sqcm,	3.30 mm,	417.2 Deg C,	1.712E-01 STD cc H2,mm/sqcm,hr at 1 atm
SUPERHEATER 2	9.1328E-09 Sec-1,	3.1000D+06 Sqcm,	3.30 mm,	525.8 Deg C,	1.528E-02 STD cc H2,mm/sqcm,hr at 1 atm

	CORE 1	CORE 2	REFLECTOR (TOP)	REFLECTOR (BOTTOM)
Weight (lbs)	7.2000E+04	1.0800E+05	4.4100E+04	4.1300E+04
Li Concentration (ppm)	0.036	0.036	0.036	0.036
Boron Concentration (ppm)	41.000	41.000	2.000	2.000
Be Concentration (ppm)	0.000	0.000	0.000	0.000
Assigned Fast Flux (n/cm2.s)	1.000E+14	1.000E+14	7.790E+12	4.880E+13
Assigned Fast Flux (n/cm2.s)	5.440E+13	5.440E+13	3.140E+12	3.400E+13
Effective Cross Section Flux Products				
Li-6	2.218E-08	2.218E-08	1.280E-09	1.386E-08
Li-7	7.180E-13	7.180E-13	5.593E-14	3.504E-13
FB-10	1.352E-12	1.352E-12	1.053E-13	6.598E-13
SB-10	8.870E-08	8.870E-08	5.120E-09	5.544E-08
C-12	1.468E-14	1.468E-14	1.144E-15	7.164E-15
Be-9	1.652E-12	1.652E-12	1.287E-13	8.062E-13
He-3	1.240E-07	1.240E-07	7.160E-09	7.753E-08
Fractional Fission Yield	1.000E-04	1.000E-04	1.000E-04	1.000E-04

Original Number of Atoms in Region

Li-6	7.568E+21	1.135E+22	4.636E+21	4.341E+21
Li-7	9.443E+22	1.416E+23	5.784E+22	5.417E+22
FB-10	1.461E+25	2.192E+25	4.366E+23	4.089E+23
SB-10	1.461E+25	2.192E+25	4.366E+23	4.089E+23
C-12	1.619E+30	2.428E+30	9.914E+29	9.285E+29
Be-9	0.000E+00	0.000E+00	0.000E+00	0.000E+00
He-3	5.126E+21	6.871E+21	2.200E+20	1.237E+21

	REFLECTOR (INNER)	REFLECTOR (SIDE)	CONTROL RODS
Weight (lbs)	9.4000E+04	8.5000E+05	2.7700E+02
Li Concentration (ppm)	0.036	0.036	0.270
Boron Concentration (ppm)	2.000	2.000	1000000.000
Be Concentration (ppm)	0.000	0.000	0.000
Assigned Fast Flux (n/cm2.s)	1.650E+13	8.230E+12	8.230E+12
Assigned Fast Flux (n/cm2.s)	1.580E+14	5.750E+13	5.750E+13

Effective Cross Section Flux Products

Li-6	6.441E-08	2.344E-08	2.344E-08
Li-7	1.185E-13	5.909E-14	5.909E-14
FB-10	2.231E-13	1.113E-13	1.113E-13
SB-10	2.576E-07	9.376E-08	9.376E-08
C-12	2.422E-15	1.208E-15	1.208E-15
Be-9	2.726E-13	1.360E-13	1.360E-13
He-3	3.603E-07	1.311E-07	1.311E-07
Fractional Fission Yield	1.000E-04	1.000E-04	1.000E-04

Original Number of Atoms in Region

Li-6	9.881E+21	8.935E+22	2.184E+20
Li-7	1.233E+23	1.115E+24	2.725E+21
FB-10	9.307E+23	8.416E+24	1.371E+27
SB-10	9.307E+23	8.416E+24	1.371E+27
C-12	2.113E+30	1.911E+31	6.227E+27
Be-9	0.000E+00	0.000E+00	0.000E+00
He-3	1.471E+22	6.051E+22	1.925E+19

350 MW(t) MHTGR TRITIUM PRODUCTION AND RELEASE ANALYSIS MYER'S ISOTHERM

During the period from 1 1 1987 to 8 25 1988 The power level was 0.80 and the purification plant efficiency was 1.00
The heat exchanger rate of 3.4271E-07 (sec-1) was based on 10.00 ppm H2

Cumulative tritium inventory in curies as of period end for production, and distribution sinks

Source -atoms		Tritium Production	Bound in Solids	Adsorbed on gr.surface	In primary Coolant	Leakage from Primary	Purif*n Plant	H2O in steam Generator	Blowdown+loss Steam generator
CORE 1			Adsorption Ratio =	0.000E+00	Fraction of He-3(n,p)T recoils bound in solid =			0.00000	
Fuel	1.0000E+00	8.4020E+02	7.9819E+02	0.0000E+00	8.9011E-04	1.4013E-04	4.1994E+01	1.5149E-02	0.0000E+00
He-3	1.8870E+21	1.6335E+02	0.0000E+00	0.0000E+00	2.0777E-03	5.4487E-04	1.6329E+02	5.8906E-02	0.0000E+00
FB-10	3.6457E+23	9.7997E+00	0.0000E+00	0.0000E+00	2.0084E-05	3.2688E-05	9.7961E+00	3.5339E-03	0.0000E+00
SB-10	3.6457E+23	1.4972E+01	0.0000E+00	0.0000E+00	4.1683E-04	4.9940E-05	1.4966E+01	5.3991E-03	0.0000E+00
Li-7	1.4343E+25	1.3038E-01	0.0000E+00	0.0000E+00	2.7624E-06	4.3488E-07	1.3033E-01	4.7014E-05	0.0000E+00
C-12	1.6187E+30	3.9809E-01	0.0000E+00	0.0000E+00	2.3090E-05	1.3278E-06	3.9792E-01	1.4355E-04	0.0000E+00
Be-9	9.8872E+23	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
Li-6	3.0334E+21	2.0927E+02	0.0000E+00	0.0000E+00	2.7177E-03	6.9802E-04	2.0919E+02	7.5464E-02	0.0000E+00
Region totals		1.2381E+03	7.9819E+02	0.0000E+00	6.1483E-03	1.4674E-03	4.3976E+02	1.5864E-01	0.0000E+00
CORE 2			Adsorption Ratio =	1.458E+07	Fraction of He-3(n,p)T recoils bound in solid =			0.00000	
Fuel	1.0000E+00	1.2603E+03	1.1973E+03	6.2910E+01	4.3135E-06	3.5028E-07	1.0497E-01	3.7868E-05	0.0000E+00
He-3	2.5292E+21	2.1894E+02	0.0000E+00	2.1852E+02	1.4983E-05	1.4226E-06	4.2635E-01	1.5380E-04	0.0000E+00
FB-10	5.4685E+23	1.4700E+01	0.0000E+00	1.4662E+01	1.0053E-06	1.2450E-07	3.7310E-02	1.3460E-05	0.0000E+00
SB-10	5.4685E+23	2.2458E+01	0.0000E+00	2.2428E+01	1.5378E-06	1.0211E-07	3.0602E-02	1.1039E-05	0.0000E+00
Li-7	2.1515E+25	1.9556E-01	0.0000E+00	1.9524E-01	1.3387E-08	1.0871E-09	3.2578E-04	1.1752E-07	0.0000E+00
C-12	2.4280E+30	5.9713E-01	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
Be-9	1.4831E+24	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
Li-6	4.5502E+21	3.1390E+02	0.0000E+00	3.1329E+02	2.1481E-05	2.0145E-06	6.0371E-01	2.1778E-04	0.0000E+00
Region totals		1.8311E+03	1.1973E+03	6.3201E+02	4.3334E-05	4.0151E-06	1.2033E+00	4.3407E-04	0.0000E+00
REFLECTOR (TOP)			Adsorption Ratio =	0.000E+00	Fraction of He-3(n,p)T recoils bound in solid =			0.00000	
He-3	8.0984E+19	7.0105E+00	0.0000E+00	0.0000E+00	8.9168E-05	2.3384E-05	7.0078E+00	2.5280E-03	0.0000E+00
FB-10	3.5285E+23	7.9513E-02	0.0000E+00	0.0000E+00	1.5141E-06	2.6522E-07	7.9482E-02	2.8673E-05	0.0000E+00
SB-10	3.5285E+23	4.7353E-03	0.0000E+00	0.0000E+00	1.9092E-07	1.5794E-08	4.7333E-03	1.7075E-06	0.0000E+00
Li-7	1.4162E+23	6.2208E-03	0.0000E+00	0.0000E+00	1.3181E-07	2.0750E-08	6.2184E-03	2.2433E-06	0.0000E+00
C-12	9.9144E+29	1.0465E-04	0.0000E+00	0.0000E+00	6.4717E-09	3.4906E-10	1.0461E-04	3.7737E-08	0.0000E+00
Be-9	4.7177E+22	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
Li-6	4.3953E+21	1.1107E+01	0.0000E+00	0.0000E+00	2.2921E-04	3.7047E-05	1.1102E+01	4.0052E-03	0.0000E+00
Region totals		1.8208E+01	0.0000E+00	0.0000E+00	3.2023E-04	6.0733E-05	1.8201E+01	6.5659E-03	0.0000E+00

350 MW(t) MHTGR TRITIUM PRODUCTION AND RELEASE ANALYSIS MYER'S ISOTHERM

During the period from 1 1 1987 to 8 25 1988 The power level was 0.80 and the purification plant efficiency was 1.00
The heat exchanger rate of 3.4271E-07 (sec-1) was based on 10.00 ppm H2

Cumulative tritium inventory in curies as of period end for production, and distribution sinks

Source -atoms		Tritium Production	Bound in Solids	Adsorbed on gr.surface	In primary Coolant	Leakage from Primary	Purif*n Plant	H2O in steam Generator	Blowdown+loss Steam generator
REFLECTOR (BOTTOM)		Adsorption Ratio = 1.458E+07			Fraction of He-3(n,p)T recoils bound in solid = 0.00000				
He-3	4.5522E+20	3.9407E+01	0.0000E+00	3.9330E+01	2.6967E-06	2.5606E-07	7.6736E-02	2.7682E-05	0.0000E+00
FB-10	4.0716E+22	1.9916E-01	0.0000E+00	1.9871E-01	1.3625E-08	1.5088E-09	4.5216E-04	1.6312E-07	0.0000E+00
SB-10	4.0716E+22	1.6974E-01	0.0000E+00	1.6952E-01	1.1623E-08	7.3017E-10	2.1882E-04	7.8939E-08	0.0000E+00
Li-7	4.2235E+23	3.6495E-02	0.0000E+00	3.6434E-02	2.4982E-09	2.0286E-10	6.0795E-05	2.1932E-08	0.0000E+00
C-12	9.2849E+29	3.6735E-02	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
Be-9	2.7677E+23	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
Li-6	2.4426E+21	8.7534E+01	0.0000E+00	8.7374E+01	5.9909E-06	5.3389E-07	1.6000E-01	5.7719E-05	0.0000E+00
Region totals		1.2738E+02	0.0000E+00	1.2711E+02	8.7153E-06	7.9238E-07	2.3747E-01	8.5665E-05	0.0000E+00
REFLECTOR (INNER)		Adsorption Ratio = 0.000E+00			Fraction of He-3(n,p)T recoils bound in solid = 0.00000				
He-3	5.4146E+21	4.6873E+02	0.0000E+00	0.0000E+00	5.9619E-03	1.5635E-03	4.6855E+02	1.6903E-01	0.0000E+00
FB-10	2.0565E+19	3.5844E-02	0.0000E+00	0.0000E+00	1.8696E-10	1.1956E-07	3.5831E-02	1.2926E-05	0.0000E+00
SB-10	2.0565E+19	1.9299E-01	0.0000E+00	0.0000E+00	4.4922E-06	6.4371E-07	1.9291E-01	6.9592E-05	0.0000E+00
Li-7	1.0540E+24	2.8085E-02	0.0000E+00	0.0000E+00	5.9507E-07	9.3681E-08	2.8075E-02	1.0128E-05	0.0000E+00
C-12	2.1133E+30	2.9239E-02	0.0000E+00	0.0000E+00	1.5433E-06	9.7525E-08	2.9227E-02	1.0543E-05	0.0000E+00
Be-9	2.1299E+23	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
Li-6	6.7804E+20	4.1740E+02	0.0000E+00	0.0000E+00	1.7778E-03	1.3923E-03	4.1725E+02	1.5052E-01	0.0000E+00
Region totals		8.8642E+02	0.0000E+00	0.0000E+00	7.7463E-03	2.9567E-03	8.8608E+02	3.1965E-01	0.0000E+00
REFLECTOR (SIDE)		Adsorption Ratio = 0.000E+00			Fraction of He-3(n,p)T recoils bound in solid = 0.00000				
He-3	2.2272E+22	1.9280E+03	0.0000E+00	0.0000E+00	2.4523E-02	6.4311E-03	1.9273E+03	6.9527E-01	0.0000E+00
FB-10	1.7013E+23	4.4115E-01	0.0000E+00	0.0000E+00	7.7135E-07	1.4715E-06	4.4099E-01	1.5909E-04	0.0000E+00
SB-10	1.7013E+23	7.2200E-01	0.0000E+00	0.0000E+00	1.9852E-05	2.4083E-06	7.2172E-01	2.6036E-04	0.0000E+00
Li-7	9.3605E+24	1.2667E-01	0.0000E+00	0.0000E+00	2.6840E-06	4.2253E-07	1.2663E-01	4.5680E-05	0.0000E+00
C-12	1.9109E+31	3.3263E-02	0.0000E+00	0.0000E+00	1.9226E-06	1.1095E-07	3.3249E-02	1.1994E-05	0.0000E+00
Be-9	9.6066E+23	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
Li-6	3.3693E+22	2.5530E+03	0.0000E+00	0.0000E+00	3.2175E-02	8.5156E-03	2.5520E+03	9.2063E-01	0.0000E+00
Region totals		4.4823E+03	0.0000E+00	0.0000E+00	5.6724E-02	1.4951E-02	4.4806E+03	1.6164E+00	0.0000E+00

350 MW(t) MHTGR TRITIUM PRODUCTION AND RELEASE ANALYSIS MYER'S ISOTHERM

During the period from 1 1 1987 to 8 25 1988 The power level was 0.80 and the purification plant efficiency was 1.00
The heat exchanger rate of 3.4271E-07 (sec-1) was based on 10.00 ppm H2

Cumulative tritium inventory in curies as of period end for production, and distribution sinks

Source -atoms		Tritium Production	Bound in Solids	Adsorbed on gr.surface	In primary Coolant	Leakage from Primary	Purif*n Plant	H2O in steam Generator	Blowdown+loss Steam generator
CONTROL RODS			Adsorption Ratio = 0.000E+00		Fraction of He-3(n,p)T recoils bound in solid = 0.00000				
He-3	7.0847E+18	6.1329E-01	0.0000E+00	0.0000E+00	7.8007E-06	2.0457E-06	6.1306E-01	2.2116E-04	0.0000E+00
FB-10	2.7722E+25	7.1882E+01	0.0000E+00	0.0000E+00	1.2568E-04	2.3977E-04	7.1856E+01	2.5922E-02	0.0000E+00
SB-10	2.7722E+25	1.1764E+02	0.0000E+00	0.0000E+00	3.2347E-03	3.9240E-04	1.1760E+02	4.2423E-02	0.0000E+00
Li-7	1.3436E+27	3.0961E-04	0.0000E+00	0.0000E+00	6.5599E-09	1.0327E-09	3.0949E-04	1.1165E-07	0.0000E+00
C-12	6.2274E+27	1.0840E-05	0.0000E+00	0.0000E+00	6.2656E-10	3.6155E-11	1.0835E-05	3.9088E-09	0.0000E+00
Be-9	3.1306E+20	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
Li-6	8.2345E+19	6.2397E+00	0.0000E+00	0.0000E+00	7.8640E-05	2.0813E-05	6.2374E+00	2.2501E-03	0.0000E+00
Region totals		1.9638E+02	0.0000E+00	0.0000E+00	3.4468E-03	6.5504E-04	1.9630E+02	7.0816E-02	0.0000E+00
Total curies		8.7799E+03	1.9955E+03	7.5912E+02	7.4437E-02	2.0096E-02	6.0224E+03	2.1726E+00	0.0000E+00
Average activity of given region			3.6367E+00 microcuries /gm graphit	1.3835E+00 microcuries /gm graphit	4.5093E-06 microcuries per scc He			3.5743E-01 microcuries per gram H2O	

350 MW(t) MHTGR TRITIUM PRODUCTION AND RELEASE ANALYSIS MYER'S ISOTHERM

During the period from 8 25 1988 to 4 19 1990 The power level was 0.80 and the purification plant efficiency was 1.00
The heat exchanger rate of 3.4271E-07 (sec-1) was based on 10.00 ppm H2

Cumulative tritium inventory in curies as of period end for production, and distribution sinks

Source	-atoms	Tritium Production	Bound in Solids	Adsorbed on gr.surface	In primary Coolant	Leakage from Primary	Purif*n Plant	H2O in steam Generator	Blowdown+loss Steam generator
CORE 1			Adsorption Ratio =	0.000E+00	Fraction of He-3(n,p)T recoils bound in solid =			0.00000	
Fuel	1.0000E+00	1.6056E+03	1.5254E+03	0.0000E+00	8.9011E-04	2.6779E-04	8.0252E+01	2.8951E-02	0.0000E+00
He-3	9.9474E+20	2.1849E+02	0.0000E+00	0.0000E+00	1.0953E-03	7.2879E-04	2.1841E+02	7.8790E-02	0.0000E+00
FB-10	1.8683E+23	1.3950E+01	0.0000E+00	0.0000E+00	1.0292E-05	4.6531E-05	1.3945E+01	5.0305E-03	0.0000E+00
SB-10	1.8683E+23	2.1313E+01	0.0000E+00	0.0000E+00	2.1361E-04	7.1090E-05	2.1305E+01	7.6856E-03	0.0000E+00
Li-7	1.4521E+25	1.0085E+01	0.0000E+00	0.0000E+00	2.1117E-04	3.3640E-05	1.0082E+01	3.6369E-03	0.0000E+00
C-12	1.6187E+30	7.6075E-01	0.0000E+00	0.0000E+00	2.3090E-05	2.5375E-06	7.6045E-01	2.7433E-04	0.0000E+00
Be-9	1.4830E+24	5.5212E-01	0.0000E+00	0.0000E+00	2.0049E-05	1.8416E-06	5.5191E-01	1.9910E-04	0.0000E+00
Li-6	2.1545E+21	3.3721E+02	0.0000E+00	0.0000E+00	1.9035E-03	1.1248E-03	3.3709E+02	1.2160E-01	0.0000E+00
Region totals		2.2080E+03	1.5254E+03	0.0000E+00	4.3671E-03	2.2770E-03	6.8239E+02	2.4617E-01	0.0000E+00
CORE 2			Adsorption Ratio =	1.458E+07	Fraction of He-3(n,p)T recoils bound in solid =			0.00000	
Fuel	1.0000E+00	2.4085E+03	2.2880E+03	1.2003E+02	8.2299E-06	1.3162E-06	3.9445E-01	1.4230E-04	0.0000E+00
He-3	1.3333E+21	2.9285E+02	0.0000E+00	2.9162E+02	1.9995E-05	4.1185E-06	1.2343E+00	4.4526E-04	0.0000E+00
FB-10	2.8025E+23	2.0924E+01	0.0000E+00	2.0826E+01	1.4280E-06	3.2797E-07	9.8289E-02	3.5457E-05	0.0000E+00
SB-10	2.8025E+23	3.1969E+01	0.0000E+00	3.1856E+01	2.1843E-06	3.7595E-07	1.1267E-01	4.0644E-05	0.0000E+00
Li-7	2.1781E+25	1.5128E+01	0.0000E+00	1.5102E+01	1.0355E-06	8.6099E-08	2.5802E-02	9.3081E-06	0.0000E+00
C-12	2.4280E+30	1.1411E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
Be-9	2.2246E+24	8.2818E-01	0.0000E+00	8.2719E-01	5.6717E-08	3.2915E-09	9.8643E-04	3.5585E-07	0.0000E+00
Li-6	3.2317E+21	5.0582E+02	0.0000E+00	5.0388E+02	3.4549E-05	6.4673E-06	1.9382E+00	6.9918E-04	0.0000E+00
Region totals		3.2771E+03	2.2880E+03	9.8413E+02	6.7478E-05	1.2695E-05	3.8046E+00	1.3725E-03	0.0000E+00
REFLECTOR (TOP)			Adsorption Ratio =	0.000E+00	Fraction of He-3(n,p)T recoils bound in solid =			0.00000	
He-3	4.2691E+19	9.3769E+00	0.0000E+00	0.0000E+00	4.7005E-05	3.1278E-05	9.3734E+00	3.3814E-03	0.0000E+00
FB-10	2.8515E+23	1.3669E-01	0.0000E+00	0.0000E+00	1.2236E-06	4.5595E-07	1.3664E-01	4.9293E-05	0.0000E+00
SB-10	2.8515E+23	8.1405E-03	0.0000E+00	0.0000E+00	1.5429E-07	2.7153E-08	8.1374E-03	2.9355E-06	0.0000E+00
Li-7	2.0932E+23	2.0899E-02	0.0000E+00	0.0000E+00	3.2273E-07	6.9710E-08	2.0891E-02	7.5364E-06	0.0000E+00
C-12	9.9144E+29	1.9999E-04	0.0000E+00	0.0000E+00	6.4717E-09	6.6707E-10	1.9991E-04	7.2117E-08	0.0000E+00
Be-9	9.4353E+22	3.1015E-04	0.0000E+00	0.0000E+00	1.2830E-08	1.0345E-09	3.1003E-04	1.1184E-07	0.0000E+00
Li-6	4.1677E+21	2.0649E+01	0.0000E+00	0.0000E+00	2.1733E-04	6.8878E-05	2.0642E+01	7.4464E-03	0.0000E+00
Region totals		3.0192E+01	0.0000E+00	0.0000E+00	2.6606E-04	1.0071E-04	3.0181E+01	1.0888E-02	0.0000E+00

350 MW(t) MHTGR TRITIUM PRODUCTION AND RELEASE ANALYSIS MYER'S ISOTHERM

During the period from 8 25 1988 to 4 19 1990 The power level was 0.80 and the purification plant efficiency was 1.00
The heat exchanger rate of 3.4271E-07 (sec-1) was based on 10.00 ppm H2

Cumulative tritium inventory in curies as of period end for production, and distribution sinks

Source -atoms		Tritium Production	Bound in Solids	Adsorbed on gr.surface	In primary Coolant	Leakage from Primary	Purif*n Plant	H2O in steam Generator	Blowdown+loss Steam generator
REFLECTOR (BOTTOM)			Adsorption Ratio =	1.458E+07	Fraction of He-3(n,p)T recoils bound in solid =			0.00000	
He-3	2.3997E+20	5.2709E+01	0.0000E+00	5.2487E+01	3.5988E-06	7.4128E-07	2.2215E-01	8.0140E-05	0.0000E+00
FB-10	4.0542E+21	2.0127E-01	0.0000E+00	2.0020E-01	1.3727E-08	3.5678E-09	1.0692E-03	3.8572E-07	0.0000E+00
SB-10	4.0542E+21	1.7153E-01	0.0000E+00	1.7079E-01	1.1710E-08	2.4808E-09	7.4347E-04	2.6820E-07	0.0000E+00
Li-7	4.5901E+23	3.1781E-01	0.0000E+00	3.1717E-01	2.1747E-08	2.1412E-09	6.4168E-04	2.3149E-07	0.0000E+00
C-12	9.2849E+29	7.0202E-02	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
Be-9	5.5353E+23	1.0445E-01	0.0000E+00	1.0433E-01	7.1537E-09	4.0514E-10	1.2142E-04	4.3800E-08	0.0000E+00
Li-6	1.3830E+21	1.2899E+02	0.0000E+00	1.2849E+02	8.8099E-06	1.6851E-06	5.0500E-01	1.8218E-04	0.0000E+00
Region totals		1.8257E+02	0.0000E+00	1.8177E+02	1.2463E-05	2.4350E-06	7.2972E-01	2.6325E-04	0.0000E+00
REFLECTOR (INNER)			Adsorption Ratio =	0.000E+00	Fraction of He-3(n,p)T recoils bound in solid =			0.00000	
He-3	2.8544E+21	6.2694E+02	0.0000E+00	0.0000E+00	3.1428E-03	2.0912E-03	6.2671E+02	2.2608E-01	0.0000E+00
FB-10	4.5443E+14	3.2655E-02	0.0000E+00	0.0000E+00	4.1312E-15	1.0893E-07	3.2643E-02	1.1776E-05	0.0000E+00
SB-10	4.5443E+14	1.7581E-01	0.0000E+00	0.0000E+00	9.9263E-11	5.8645E-07	1.7575E-01	6.3402E-05	0.0000E+00
Li-7	1.0540E+24	2.6569E-01	0.0000E+00	0.0000E+00	5.0872E-06	8.8621E-07	2.6558E-01	9.5809E-05	0.0000E+00
C-12	2.1133E+30	5.5876E-02	0.0000E+00	0.0000E+00	1.5433E-06	1.8638E-07	5.5854E-02	2.0149E-05	0.0000E+00
Be-9	4.2598E+23	7.3561E-02	0.0000E+00	0.0000E+00	2.2032E-06	2.4537E-07	7.3533E-02	2.6527E-05	0.0000E+00
Li-6	4.7916E+19	4.0890E+02	0.0000E+00	0.0000E+00	1.2200E-04	1.3639E-03	4.0875E+02	1.4746E-01	0.0000E+00
Region totals		1.0364E+03	0.0000E+00	0.0000E+00	3.2736E-03	3.4572E-03	1.0361E+03	3.7376E-01	0.0000E+00
REFLECTOR (SIDE)			Adsorption Ratio =	0.000E+00	Fraction of He-3(n,p)T recoils bound in solid =			0.00000	
He-3	1.1741E+22	2.5789E+03	0.0000E+00	0.0000E+00	1.2928E-02	8.6020E-03	2.5779E+03	9.2997E-01	0.0000E+00
FB-10	3.4394E+21	4.1081E-01	0.0000E+00	0.0000E+00	1.5593E-08	1.3703E-06	4.1066E-01	1.4814E-04	0.0000E+00
SB-10	3.4394E+21	6.7234E-01	0.0000E+00	0.0000E+00	4.0132E-07	2.2427E-06	6.7210E-01	2.4246E-04	0.0000E+00
Li-7	9.5272E+24	1.1790E+00	0.0000E+00	0.0000E+00	2.2536E-05	3.9327E-06	1.1786E+00	4.2517E-04	0.0000E+00
C-12	1.9109E+31	6.3566E-02	0.0000E+00	0.0000E+00	1.9226E-06	2.1203E-07	6.3541E-02	2.2922E-05	0.0000E+00
Be-9	1.9213E+24	9.1939E-02	0.0000E+00	0.0000E+00	3.3149E-06	3.0667E-07	9.1903E-02	3.3154E-05	0.0000E+00
Li-6	1.2710E+22	3.2885E+03	0.0000E+00	0.0000E+00	1.2133E-02	1.0969E-02	3.2873E+03	1.1859E+00	0.0000E+00
Region totals		5.8697E+03	0.0000E+00	0.0000E+00	2.5089E-02	1.9579E-02	5.8676E+03	2.1167E+00	0.0000E+00

350 MW(t) MHTGR TRITIUM PRODUCTION AND RELEASE ANALYSIS MYER'S ISOTHERM

During the period from 8 25 1988 to 4 19 1990 The power level was 0.80 and the purification plant efficiency was 1.00
The heat exchanger rate of 3.4271E-07 (sec-1) was based on 10.00 ppm H2

Cumulative tritium inventory in curies as of period end for production, and distribution sinks

Source -atoms		Tritium Production	Bound in Solids	Adsorbed on gr.surface	In primary Coolant	Leakage from Primary	Purif*n Plant	H2O in steam Generator	Blowdown+loss Steam generator
CONTROL RODS			Adsorption Ratio = 0.000E+00		Fraction of He-3(n,p)T recoils bound in solid = 0.00000				
He-3	3.7347E+18	8.2031E-01	0.0000E+00	0.0000E+00	4.1121E-06	2.7362E-06	8.2001E-01	2.9582E-04	0.0000E+00
FB-10	2.7722E+25	1.3737E+02	0.0000E+00	0.0000E+00	1.2568E-04	4.5820E-04	1.3732E+02	4.9537E-02	0.0000E+00
SB-10	2.7722E+25	2.2482E+02	0.0000E+00	0.0000E+00	3.2347E-03	7.4990E-04	2.2473E+02	8.1072E-02	0.0000E+00
Li-7	1.3436E+27	5.9166E-04	0.0000E+00	0.0000E+00	6.5599E-09	1.9735E-09	5.9144E-04	2.1336E-07	0.0000E+00
C-12	6.2274E+27	2.0715E-05	0.0000E+00	0.0000E+00	6.2656E-10	6.9095E-11	2.0707E-05	7.4699E-09	0.0000E+00
Be-9	3.1306E+20	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
Li-6	8.2345E+19	1.1924E+01	0.0000E+00	0.0000E+00	7.8640E-05	3.9774E-05	1.1920E+01	4.3000E-03	0.0000E+00
Region totals		3.7493E+02	0.0000E+00	0.0000E+00	3.4432E-03	1.2506E-03	3.7479E+02	1.3520E-01	0.0000E+00
Total curies		1.2979E+04	3.8134E+03	1.1659E+03	3.6519E-02	2.6680E-02	7.9955E+03	2.8844E+00	0.0000E+00
Average activity of given region			6.9497E+00 microcuries /gm graphit	2.1248E+00 microcuries /gm graphit	2.2122E-06 microcuries per scc He			4.7454E-01 microcuries per gram H2O	

350 MW(t) MHTGR TRITIUM PRODUCTION AND RELEASE ANALYSIS MYER'S ISOTHERM

During the period from 4 19 1990 to 12 12 1991 The power level was 0.80 and the purification plant efficiency was 1.00
The heat exchanger rate of 3.4271E-07 (sec-1) was based on 10.00 ppm H2

Cumulative tritium inventory in curies as of period end for production, and distribution sinks

Source	-atoms	Tritium Production	Bound in Solids	Adsorbed on gr.surface	In primary Coolant	Leakage from Primary	Purif*n Plant	H2O in steam Generator	Blowdown+loss Steam generator
CORE 1			Adsorption Ratio =	0.000E+00	Fraction of He-3(n,p)T recoils bound in solid =			0.00000	
Fuel	1.0000E+00	2.3029E+03	2.1878E+03	0.0000E+00	8.9011E-04	3.8409E-04	1.1510E+02	4.1524E-02	0.0000E+00
He-3	7.4897E+20	2.4292E+02	0.0000E+00	0.0000E+00	8.2465E-04	8.1028E-04	2.4283E+02	8.7600E-02	0.0000E+00
FB-10	1.8461E+23	1.7671E+01	0.0000E+00	0.0000E+00	1.0170E-05	5.8943E-05	1.7664E+01	6.3723E-03	0.0000E+00
SB-10	1.8461E+23	2.6998E+01	0.0000E+00	0.0000E+00	2.1108E-04	9.0053E-05	2.6988E+01	9.7357E-03	0.0000E+00
Li-7	1.4523E+25	1.9277E+01	0.0000E+00	0.0000E+00	2.1377E-04	6.4300E-05	1.9270E+01	6.9515E-03	0.0000E+00
C-12	1.6187E+30	1.0911E+00	0.0000E+00	0.0000E+00	2.3090E-05	3.6396E-06	1.0907E+00	3.9347E-04	0.0000E+00
Be-9	1.7302E+24	1.3311E+00	0.0000E+00	0.0000E+00	3.0073E-05	4.4402E-06	1.3306E+00	4.8003E-04	0.0000E+00
Li-6	1.9909E+21	4.4162E+02	0.0000E+00	0.0000E+00	1.7457E-03	1.4731E-03	4.4146E+02	1.5925E-01	0.0000E+00
Region totals		3.0539E+03	2.1878E+03	0.0000E+00	3.9486E-03	2.8888E-03	8.6574E+02	3.1231E-01	0.0000E+00
CORE 2			Adsorption Ratio =	1.458E+07	Fraction of He-3(n,p)T recoils bound in solid =			0.00000	
Fuel	1.0000E+00	3.4544E+03	3.2817E+03	1.7189E+02	1.1786E-05	2.7834E-06	8.3415E-01	3.0092E-04	0.0000E+00
He-3	1.0039E+21	3.2559E+02	0.0000E+00	3.2347E+02	2.2179E-05	7.0928E-06	2.1256E+00	7.6680E-04	0.0000E+00
FB-10	2.7692E+23	2.6506E+01	0.0000E+00	2.6333E+01	1.8056E-06	5.7596E-07	1.7261E-01	6.2267E-05	0.0000E+00
SB-10	2.7692E+23	4.0497E+01	0.0000E+00	4.0280E+01	2.7619E-06	7.2174E-07	2.1629E-01	7.8027E-05	0.0000E+00
Li-7	2.1784E+25	2.8916E+01	0.0000E+00	2.8820E+01	1.9761E-06	3.1784E-07	9.5251E-02	3.4361E-05	0.0000E+00
C-12	2.4280E+30	1.6367E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
Be-9	2.5953E+24	1.9967E+00	0.0000E+00	1.9918E+00	1.3657E-07	1.6441E-08	4.9270E-03	1.7774E-06	0.0000E+00
Li-6	2.9864E+21	6.6243E+02	0.0000E+00	6.5872E+02	4.5166E-05	1.2366E-05	3.7060E+00	1.3369E-03	0.0000E+00
Region totals		4.5420E+03	3.2817E+03	1.2515E+03	8.5811E-05	2.3875E-05	7.1549E+00	2.5811E-03	0.0000E+00
REFLECTOR (TOP)			Adsorption Ratio =	0.000E+00	Fraction of He-3(n,p)T recoils bound in solid =			0.00000	
He-3	3.2143E+19	1.0425E+01	0.0000E+00	0.0000E+00	3.5391E-05	3.4775E-05	1.0421E+01	3.7595E-03	0.0000E+00
FB-10	2.3043E+23	1.7645E-01	0.0000E+00	0.0000E+00	9.8880E-07	5.8858E-07	1.7639E-01	6.3631E-05	0.0000E+00
SB-10	2.3043E+23	1.0508E-02	0.0000E+00	0.0000E+00	1.2468E-07	3.5052E-08	1.0504E-02	3.7894E-06	0.0000E+00
Li-7	2.6404E+23	4.1553E-02	0.0000E+00	0.0000E+00	4.7702E-07	1.3860E-07	4.1537E-02	1.4984E-05	0.0000E+00
C-12	9.9144E+29	2.8684E-04	0.0000E+00	0.0000E+00	6.4717E-09	9.5678E-10	2.8673E-04	1.0344E-07	0.0000E+00
Be-9	1.4153E+23	9.0286E-04	0.0000E+00	0.0000E+00	2.5659E-08	3.0115E-09	9.0250E-04	3.2558E-07	0.0000E+00
Li-6	3.9522E+21	2.8797E+01	0.0000E+00	0.0000E+00	2.0608E-04	9.6056E-05	2.8787E+01	1.0385E-02	0.0000E+00
Region totals		3.9452E+01	0.0000E+00	0.0000E+00	2.4309E-04	1.3160E-04	3.9438E+01	1.4227E-02	0.0000E+00

350 MW(t) MHTGR TRITIUM PRODUCTION AND RELEASE ANALYSIS MYER'S ISOTHERM

During the period from 4 19 1990 to 12 12 1991 The power level was 0.80 and the purification plant efficiency was 1.00
The heat exchanger rate of 3.4271E-07 (sec-1) was based on 10.00 ppm H2

Cumulative tritium inventory in curies as of period end for production, and distribution sinks

Source -atoms		Tritium Production	Bound in Solids	Adsorbed on gr.surface	In primary Coolant	Leakage from Primary	Purif*n Plant	H2O in steam Generator	Blowdown+loss Steam generator
REFLECTOR (BOTTOM)			Adsorption Ratio =	1.458E+07	Fraction of He-3(n,p)T recoils bound in solid = 0.00000				
He-3	1.8068E+20	5.8602E+01	0.0000E+00	5.8220E+01	3.9919E-06	1.2766E-06	3.8258E-01	1.3801E-04	0.0000E+00
FB-10	4.0368E+20	1.8533E-01	0.0000E+00	1.8374E-01	1.2598E-08	5.3237E-09	1.5954E-03	5.7555E-07	0.0000E+00
SB-10	4.0368E+20	1.5795E-01	0.0000E+00	1.5674E-01	1.0747E-08	4.0233E-09	1.2057E-03	4.3496E-07	0.0000E+00
Li-7	4.6265E+23	5.9879E-01	0.0000E+00	5.9671E-01	4.0914E-08	6.9307E-09	2.0770E-03	7.4929E-07	0.0000E+00
C-12	9.2849E+29	1.0069E-01	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
Be-9	8.3028E+23	3.0406E-01	0.0000E+00	3.0339E-01	2.0802E-08	2.2521E-09	6.7491E-04	2.4347E-07	0.0000E+00
Li-6	7.9487E+20	1.4540E+02	0.0000E+00	1.4449E+02	9.9072E-06	3.0263E-06	9.0693E-01	3.2717E-04	0.0000E+00
Region totals		2.0535E+02	0.0000E+00	2.0395E+02	1.3984E-05	4.3214E-06	1.2951E+00	4.6719E-04	0.0000E+00
REFLECTOR (INNER)			Adsorption Ratio =	0.000E+00	Fraction of He-3(n,p)T recoils bound in solid = 0.00000				
He-3	2.1491E+21	6.9704E+02	0.0000E+00	0.0000E+00	2.3663E-03	2.3251E-03	6.9679E+02	2.5136E-01	0.0000E+00
FB-10	1.0041E+10	2.9749E-02	0.0000E+00	0.0000E+00	9.1286E-20	9.9231E-08	2.9738E-02	1.0728E-05	0.0000E+00
SB-10	1.0041E+10	1.6017E-01	0.0000E+00	0.0000E+00	2.1934E-15	5.3426E-07	1.6011E-01	5.7759E-05	0.0000E+00
Li-7	1.0540E+24	4.8215E-01	0.0000E+00	0.0000E+00	5.0873E-06	1.6082E-06	4.8196E-01	1.7387E-04	0.0000E+00
C-12	2.1133E+30	8.0142E-02	0.0000E+00	0.0000E+00	1.5433E-06	2.6732E-07	8.0111E-02	2.8900E-05	0.0000E+00
Be-9	6.3897E+23	2.1414E-01	0.0000E+00	0.0000E+00	4.4064E-06	7.1427E-07	2.1406E-01	7.7220E-05	0.0000E+00
Li-6	5.5525E+18	3.7453E+02	0.0000E+00	0.0000E+00	8.6213E-06	1.2493E-03	3.7440E+02	1.3506E-01	0.0000E+00
Region totals		1.0725E+03	0.0000E+00	0.0000E+00	2.3860E-03	3.5776E-03	1.0722E+03	3.8678E-01	0.0000E+00
REFLECTOR (SIDE)			Adsorption Ratio =	0.000E+00	Fraction of He-3(n,p)T recoils bound in solid = 0.00000				
He-3	8.8402E+21	2.8672E+03	0.0000E+00	0.0000E+00	9.7335E-03	9.5639E-03	2.8661E+03	1.0340E+00	0.0000E+00
FB-10	6.9529E+19	3.7443E-01	0.0000E+00	0.0000E+00	3.1523E-10	1.2490E-06	3.7429E-01	1.3503E-04	0.0000E+00
SB-10	6.9529E+19	6.1280E-01	0.0000E+00	0.0000E+00	8.1130E-09	2.0441E-06	6.1258E-01	2.2099E-04	0.0000E+00
Li-7	9.5305E+24	2.1567E+00	0.0000E+00	0.0000E+00	2.2937E-05	7.1937E-06	2.1558E+00	7.7772E-04	0.0000E+00
C-12	1.9109E+31	9.1172E-02	0.0000E+00	0.0000E+00	1.9226E-06	3.0411E-07	9.1137E-02	3.2877E-05	0.0000E+00
Be-9	2.8820E+24	2.6764E-01	0.0000E+00	0.0000E+00	6.6297E-06	8.9271E-07	2.6753E-01	9.6511E-05	0.0000E+00
Li-6	4.8015E+21	3.3590E+03	0.0000E+00	0.0000E+00	4.5770E-03	1.1204E-02	3.3577E+03	1.2113E+00	0.0000E+00
Region totals		6.2297E+03	0.0000E+00	0.0000E+00	1.4342E-02	2.0780E-02	6.2274E+03	2.2465E+00	0.0000E+00

350 MW(t) MHTGR TRITIUM PRODUCTION AND RELEASE ANALYSIS MYER'S ISOTHERM

During the period from 4 19 1990 to 12 12 1991 The power level was 0.80 and the purification plant efficiency was 1.00
The heat exchanger rate of 3.4271E-07 (sec-1) was based on 10.00 ppm H2

Cumulative tritium inventory in curies as of period end for production, and distribution sinks

Source -atoms		Tritium Production	Bound in Solids	Adsorbed on gr.surface	In primary Coolant	Leakage from Primary	Purif*n Plant	H2O in steam Generator	Blowdown+loss Steam generator
CONTROL RODS		Adsorption Ratio = 0.000E+00			Fraction of He-3(n,p)T recoils bound in solid = 0.00000				
He-3	2.8120E+18	9.1203E-01	0.0000E+00	0.0000E+00	3.0961E-06	3.0422E-06	9.1170E-01	3.2889E-04	0.0000E+00
FB-10	2.7722E+25	1.9702E+02	0.0000E+00	0.0000E+00	1.2568E-04	6.5720E-04	1.9695E+02	7.1050E-02	0.0000E+00
SB-10	2.7722E+25	3.2245E+02	0.0000E+00	0.0000E+00	3.2347E-03	1.0756E-03	3.2233E+02	1.1628E-01	0.0000E+00
Li-7	1.3436E+27	8.4861E-04	0.0000E+00	0.0000E+00	6.5599E-09	2.8306E-09	8.4830E-04	3.0602E-07	0.0000E+00
C-12	6.2274E+27	2.9711E-05	0.0000E+00	0.0000E+00	6.2656E-10	9.9104E-11	2.9700E-05	1.0714E-08	0.0000E+00
Be-9	3.1306E+20	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
Li-6	8.2345E+19	1.7103E+01	0.0000E+00	0.0000E+00	7.8640E-05	5.7048E-05	1.7096E+01	6.1675E-03	0.0000E+00
Region totals		5.3749E+02	0.0000E+00	0.0000E+00	3.4421E-03	1.7929E-03	5.3729E+02	1.9383E-01	0.0000E+00
Total curies		1.5680E+04	5.4695E+03	1.4555E+03	2.4462E-02	2.9199E-02	8.7505E+03	3.1567E+00	0.0000E+00
Average activity of given region			9.9679E+00 microcuries /gm graphit	2.6525E+00 microcuries /gm graphit	1.4818E-06 microcuries per scc He			5.1934E-01 microcuries per gram H2O	