DECAY HEAT

AND

RESIDUAL ACTIVITY

CALCULATIONS

Examples Using Appendix V of the Guidelines document.

Presented by

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USING THE WAKIL RELATION

$$H = 4.95 \sum_{i=1}^{n} t_i^{-0.26}[1 - (1 + T_{oi}/t_i)^{-0.2}]P_{oi}$$

where:

- **h = decay heat in Watts**
- **t_i = decay time since the ith period in days**
- **T_{oi} = operating time for the ith period in days**
- **P_{oi} = operating power for the ith period in KW**
- **n = number of periods**

IF AVERAGE POWER IS KNOWN THEN OPERATING TIME IS GIVEN BY

$$T_{oi} = C_1 \left(\frac{B_i}{P_{oi}}\right) \qquad (6)$$

IF AVERAGE POWER IS NOT KNOWN IT CAN BE CALCULATED FROM

$$P_{oi} = C_1 \left(\frac{B_i}{T_{oi}}\right) \qquad (7)$$

Table AppV-1

B_i units	C_1
MWH	41.7
MWD	1000
grams U-235	769

DECAY HEAT CALCULATIONS FOR SHIPMENT									
SHIPMENT DATE	Ds	22-Feb-97							
Burnup data constant	C1	1000							
ASSEMBLY	BURNUP	OPERATING	END OF	OPERATING	DECAY	A	B	DECAY	DECAY
IDENTIFIER	DATA	POWER	IRRADIATION	TIME	TIME			HEAT	HEAT
	(MWD)	(kW)		(days)	(days)			(kW)	(Watts)
	B	Po	De	To	t			0.00495*A*(1-B)*Po	
				(To=C1*B/Po)	(Ds-De)	t^-.26	(1+To/t)^-.2		
C1	30	30	25-Feb-90	1000	2554	0.130054	0.93605	0.00123	1.2
C2	25	28	02-Jan-95	893	782	0.176916	0.85871	0.00346	3.5
S1	50	65	09-Aug-93	769	1293	0.155233	0.91086	0.00445	4.5
S2	60	61	04-Dec-90	984	2272	0.134071	0.93058	0.00281	2.8
S3	55	75	12-Oct-88	733	3055	0.124136	0.95788	0.00194	1.9
S4	56	40	04-Jan-96	1400	415	0.208597	0.74445	0.01055	10.6

DECAY HEAT CALCULATIONS FOR SHIPMENT — Power Level not known

SHIPMENT DATE	Ds	22-Feb-97
Burnup data constant	C1	1000

ASSEMBLY IDENTIFIER	BURNUP DATA (MWD) B	START OF IRRADIATION Db	END OF IRRADIATION De	OPERATING TIME (days) To = De-Db	OPERATING POWER (kW) Po	DECAY TIME (days) t	a	b	DECAY HEAT (kW) 0.00495*a*(1-b)*Po	DECAY HEAT (Watts)
					(Po=C1*B/To)	(Ds-De)	t^-.26	(1+To/t)^-.2		
C1	30	01-Jun-87	25-Feb-90	1000	30	2554	0.130054	0.99767	0.00005	0.0
C2	25	23-Jul-92	02-Jan-95	893	28	782	0.176916	0.85869	0.00309	3.1
S1	50	02-Jul-91	09-Aug-93	769	65	1293	0.155233	0.91088	0.00342	3.4
S2	60	25-Mar-88	04-Dec-90	984	61	2272	0.134071	0.93056	0.00276	2.8
S3	55	10-Oct-86	12-Oct-88	733	75	3055	0.124136	0.95790	0.00142	1.4
S4	56	05-Mar-92	04-Jan-96	1400	40	415	0.208597	0.74445	0.01478	14.8

Table App V-8 - RESIDUAL CONTENT TABLES

FUEL TYPE	ENRICHMENT %	U-235 CONTENT g	TABLE TO USE
MTR	93	100	App V-2a
		200	App V-2b
		300	App V-2c
		400	App V-2d
	45	200	App V-3a
		300	App V-3b
		400	App V-3c
	20	100	App V-4a
		200	App V-4b
		300	App V-4c
TRIGA (single rod)	70	133	App V-5a
	20	98	App V-5b
		54	App V-5c
		38	App V-5d
TRIGA (25 rod clusters)	93.1	41.4	App V-6a
	19.7	53.6	App V-6b
DIDO	93	150	App V-7a
	80	150	App V-7b
	60	150	App V-7c
	20	200	App V-7d

Table App V-5b. TRIGA Fuel, 20 wt% U, 20% Enrichment, 98 g U-235/Rod

U-235 Burnup, %	0	5	10	15	20	25	30	35
U-235 Burned, g	0	5	10	15	20	25	29	34
U-234	0	0	0	0	0	0	0	0
U-235	98	93	88	83	78	74	89	64
U-236	0	1	2	3	4	4	5	6
U-238	392	391	391	390	389	388	388	387
U	490	485	481	476	471	466	461	457
Np-237	0	0.0	0.0	0.0	0.1	0.1	0.1	0.2
Np	0	0.0	0.0	0.0	0.1	0.1	0.1	0.2
Pu-238	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pu-239	0	0.6	1.1	1.6	2.0	2.4	2.7	2.9
Pu-240	0	0.0	0.1	0.1	0.2	0.3	0.3	0.4
Pu-241	0	0.0	0.0	0.0	0.0	0.1	0.1	0.2
Pu-242	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pu	0	0 6	1.2	1.7	2.3	2.7	3.2	3.6
Am-241	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Am	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

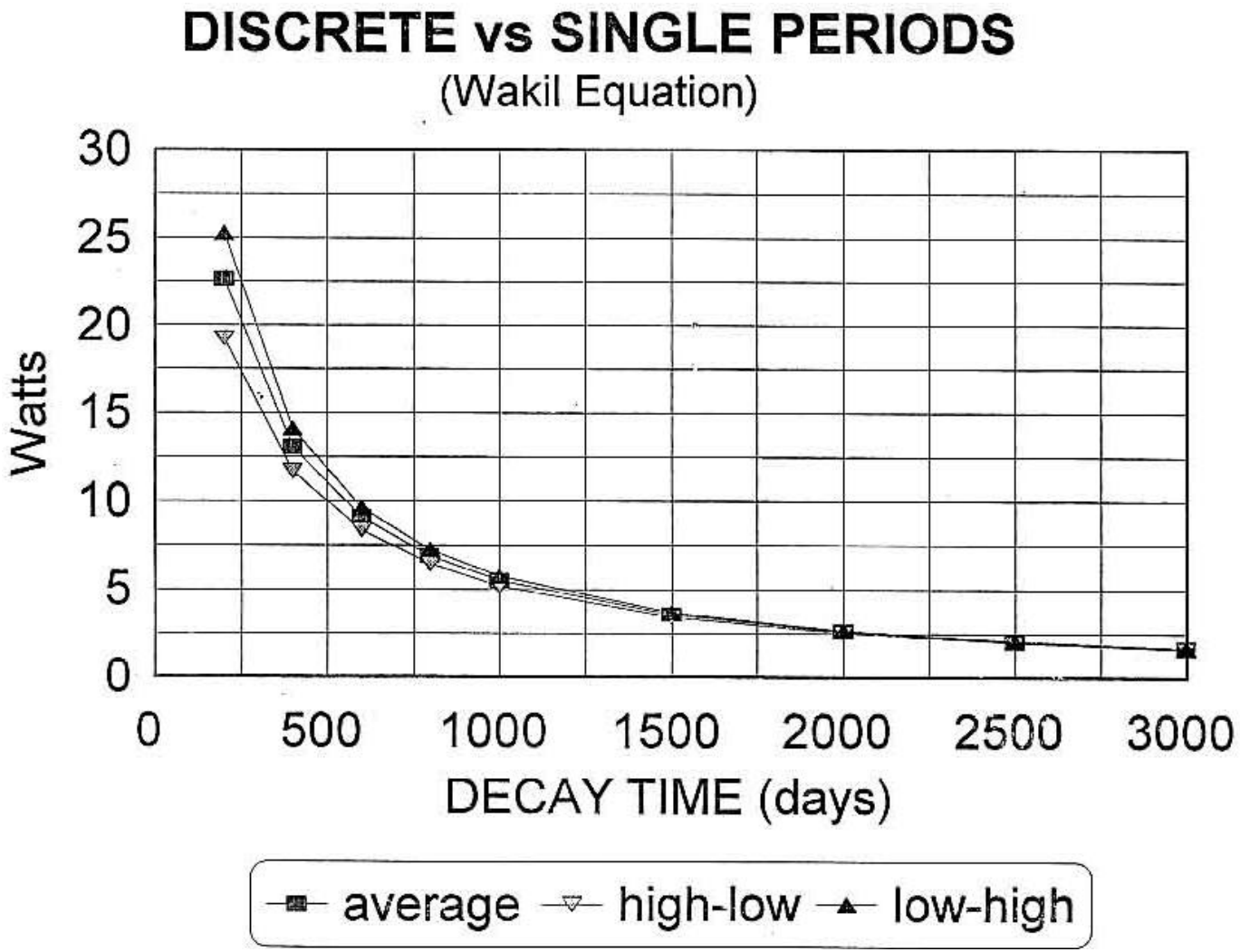
Table App V-2. MTR Fuel, 93% Enrichment

Table App V-2a. MTR Fuel, 93% Enrichment, 100 g U-235/Assembly

U-235 Burnup, %	0	5	10	20	30	40	50	60	70	80
U-235 Burned, g	**0**	**5**	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**
U-234	0	0	0	0	0	0	0	0	0	0
U-235	100	95	90	80	70	60	50	40	30	20
U-236	0	1	2	3	5	6	8	9	11	12
U-238	8	8	8	8	7	7	7	7	7	7
U	108	103	99	91	82	74	65	56	48	39
Np-237	0	0.0	0	0.0	0	0.1	0.1	0 2	0.2	0.3
Np	0	0.0	0.0	0.0	0.0	0.1	0 1	0.2	0.2	0.3
Pu-238	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pu-239	0	0.0	0.0	0	0.1	0.1	0.1	0.1	0.1	0.1
Pu-240	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0
Pu-241	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0.0
Pu-242	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0.0
Pu	0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.2	0.2
Am-241	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0.0
Am	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0

Table App V-2b. MTR Fuel, 93% Enrichment, 200 g U-235/Assembly

U-235 Burnup, %	0	5	10	20	30	40	50	60	70	80
U-235 Burned, g	**0**	**10**	**20**	**40**	**80**	**80**	**100**	**120**	**140**	**150**
U-234	0	0	0	0	0	0	0	0	0	0
U-235	200	190	180	160	140	120	100	80	60	40
U-236	0	2	3	6	10	13	16	19	21	24
U-238	15	15	15	15	15	15	15	15	14	14
U	215	207	198	181	164	147	130	113	96	78
Np-237	0	0.0	0.0	0.0	0.1	0.2	0.3	0 4	0.6	0.8
Np	0	0.0	0.0	0.0	0.1	0.2	0 3	0 4	0.6	0.8
Pu-238	0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1
Pu-239	0	0.0	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.3
Pu-240	0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1
Pu-241	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pu-242	o	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pu	0	0.0	0.1	0 2	0.2	0 3	0.3	0.4	0.5	0 6
Am-241	0	0 0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Am	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0


DISCRETE vs SINGLE PERIODS
(Wakil Equation)
Watts
30
25
20
15
10
5
0
0
500
1000
1500
2000
2500
3000
DECAY TIME (days)
average
high-low
low-high