TERA RS220-5

BORD SOLÁTHAIR AN LEICTREACHAIS
Cúirt Stiabhna
18/21 Faiche Stiabhna
Baile Átha Cliath 2

ESB

ELECTRICITY SUPPLY BOARD
Stephen Court
18/21 St. Stephen's Green
Dublin 2

Your ref:

Our ref:

(50) PR-50
45FR65474

20th March, 1981.

E. Gunter Arndt,
Structures and Components Standards Branch,
Division of Engineering Standards,
Office of Standards Development,
U.S. Nuclear Regulatory Commission,
WASHINGTON D.C. 20555,
U.S.A.

DOCKETED USNRC APR 1 1981 Office of the Secretary Docketing & Service Branch

Dear Mr. Arndt,

I was pleased to get your letter of 13th February and to hear that you found my IAEA paper interesting.

I enclose some amendment sheets. The only numerical change concerns the heat dissipation capacity of a natural draught chimney (Fig. 3d) and, while improved calculations have predicted an increase in heat transfer, the change is not significant in the overall context. The remaining changes are of a typographical nature.

I mentioned the plans for an ultra-safe reactor which starts out with safety as the over-riding key design goal. As a result of my paper "Towards a More Forgiving Reactor", and the remarkable similarity of ideas - as also of certain proposed technical solutions - I was privileged to be shown these plans but, since it was on a confidential basis, I do not feel free to give you further particulars without the express permission of the manufacturers.

8104290115
~~8104270279~~

2-4-1 P+50

I will therefore write to the manufacturer to seek such permission or, if they so prefer, they may wish to get in touch with you directly.

Yours sincerely,

C.O'FARRELLY,
Nuclear Safety Engineer.

IAEA - CN-39/58 "Towards a More Forgiving Reactor".

ERRORS IN THE ORIGINAL STOCKHOLM PREPRINT
(discovered since the Meeting of 21 October 1980).

p2,2(2), para.2:
line 1 should read "If αM is positive but numerically less than αF..."
line 4 should read"....greater than αF, ...".

p4,2.2, para.2:
line 1 should read "....inherent engineered shut-down system".

p5,4.3, para.2:
line 5 should read "....12 MW of heat".

p6:
para. 3, line 3 should read ".... 2.4 MW."
para. 4, line 4 should read ".... exceed 16 MW....".

p7, 5.3.1 para.1:
line 1 should read ".....Figs. 4 + 1....."

p7, 5.3.2 para. 2:
line 6 should read "head to permit...."

p9 para.1:
line 4 should read ".... 2½ days (containment breach 3 and 3a)"

p9,6.2, para.1:
line 5 should read ".... design boiling point".

p 11:
para. 3 line 9 should read " in water surface downward trend".
para. 6 line 3 should read "....low-water-level signal......".

p14, 16, 17, 18:
Revised copies of figures attached.

NOTE
F P. sec = Full - power - seconds.

1981-3-9.

SYMBOLS

A	m2	Cross section of chimney
c	J/kg°C	Specific heat
Cf	-	Skin friction coefficient
E	J	Energy
Eo	J	Initial energy of pool
l	s	Mean neutron lifetime
M	kg	Mass
Mc	J/°C	Heat capacity per °C
P	W	Thermal power
Po	W	Full (rated) power of reactor
Pr	-	Prandtl number
p	Pa	Pressure
p_c	Pa	Containment pressure
p_p	Pa	Primary circuit pressure
q	W/m2	Heat transfer rate per unit area
R	-	Temperature-rise-ratio (See 2.1)
Re	-	Reynold's number
S	m2	Surface area of containment
S2 = 2*S	m2	Total heat transfer surface of chimney
St	-	Stanton number
t	s	Time from reactor shutdown
T	°C	Temperature
To	°C	Initial temperature of pool
T1	°C	Inlet temperature
T2	°C	Outlet temperature
TL1	°C	Liner coolant inlet temperature
TL2	°C	Liner coolant outlet temperature
Tp	°C	Mean reactor coolant temperature
Ts	°C	Surface temperature of containment
Tsat	°C	Saturation temperature
W	m	Width between containment and shield building
Yc	m	Width of chimney
Zc	m	Height of chimney
θ	°C	Fuel temperature
θo	°C	Initial fuel temperature
θmax	°C	Maximum fuel temperature
θcr	°C	Critical temperature for fuel damage
ρ	kg/m3	Density

Table I - Graphite Mass & Heat Capacity (Full-power-second/°C)

Parameter	Symbol	MAGNOX		AGR	HTGR
		BRADWELL	WYLFA	HUNT. -B	FULTON
Power(th)	Po	531. E6	1875. E6	1500. E6	3000. E6
Core	M				0.32E6
	Mc/Po				0.19
Reflector	M				0.59E6
	Mc/Po				0.35
Total	Σ M	1.9	3.7 E6	1.0 E6	0.9[illegible]6
	Σ Mc/Po	5.36	2.96	1.13	0.54
Effective *	Mc/Po				0.33

ρ =1800kg/m3 C=1800J/kg°C(@700) * Deduced from heat-up graphs

Table II Energy Requirements for LWR Boil-off & Heat-up

Energy in full-power-seconds	Symbol	PWR (3.5 GW)	SECURE (0.2 GW)
To boil off secondary	E_1	100	-
To raise temp to SV set point	E_2	15	1616
To boil-off water above core	E_3	50	4440
To boil-off water in core etc	E_4	50	1480
Tot. Energy until -FP sec	E_1+E_2	115	1616
SV lifts -time (s)		8.5 E3	3.4E5
Tot. Energy until -FP.sec	$E_1+E_2+E_3$	165	6056
top of fuel is dry -time(s)		1.45E4	2.4E6
Tot. Energy until -FP.sec	ΣE	215	7536
fuel is totally dry-time(s)		2.0 E4	3.5E6

Rev. 80-11

POOR ORIGINAL

SYMBOLS

A	m2	Cross section of chimney
c	J/kg°C	Specific heat
Cf	-	Skin friction coefficient
E	J	Energy
Eo	J	Initial energy of pool
l	s	Mean neutron lifetime
M	kg	Mass
Mc	J/°C	Heat capacity per °C
P	W	Thermal power
Po	W	Full (rated) power of reactor
Pr	-	Prandtl number
p	Pa	Pressure
p_c	Pa	Containment pressure
p_p	Pa	Primary circuit pressure
q	W/m2	Heat transfer rate per unit area
R	-	Temperature-rise-ratio (See 2.1)
Re	-	Reynold's number
S	m2	Surface area of containment
S2 = 2*S	m2	Total heat transfer surface of chimney
St	-	Stanton number
t	s	Time from reactor shutdown
T	°C	Temperature
To	°C	Initial temperature of pool
T1	°C	Inlet temperature
T2	°C	Outlet temperature
TL1	°C	Liner coolant inlet temperature
TL2	°C	Liner coolant outlet temperature
Tp	°C	Mean reactor coolant temperature
Ts	°C	Surface temperature of containment
Tsat	°C	Saturation temperature
W	m	Width between containment and shield building
Yc	m	Width of chimney
Zc	m	Height of chimney
θ	°C	Fuel temperature
θo	°C	Initial fuel temperature
θmax	°C	Maximum fuel temperature
θcr	°C	Critical temperature for fuel damage
ρ	kg/m3	Density

Table I - Graphite Mass & Heat Capacity (Full-power-second/°C)

Parameter	Symbol	MAGNOX		AGR	HTGR
		BRADWELL	WYLFA	HUNT. -B	FULTON
Power(th)	Po	531. E6	1875. E6	1500. E6	3000. E6
Core	M				0.32E6
	Mc/Po				0.19
Reflector	M				0.59E6
	Mc/Po				0.35
Total	Σ M	1.9	3.7 E6	1.0 E6	0.9[illegible]6
	Σ Mc/Po	5.36	2.96	1.13	0.54
Effective *	Mc/Po				0.33

ρ =1800kg/m3 C=1800J/kg°C(@700) * Deduced from heat-up graphs

Table II Energy Requirements for LWR Boil-off & Heat-up

Energy in full-power-seconds	Symbol	PWR (3.5 GW)	SECURE (0.2 GW)
To boil off secondary	E_1	100	-
To raise temp to SV set point	E_2	15	1616
To boil-off water above core	E_3	50	4440
To boil-off water in core etc	E_4	50	1480
Tot. Energy until SV lifts -FP.sec	E_1+E_2	115	1616
-time (s)		8.5 E3	3.4E5
Tot. Energy until top of fuel is dry -FP.sec	$E_1+E_2+E_3$	165	6056
-time(s)		1.45E4	2.4E6
Tot. Energy until fuel is totally dry -FP.sec	ΣE	215	7536
-time(s)		2.0 E4	[illegible].5E6

Rev. 80-11

POOR ORIGINAL

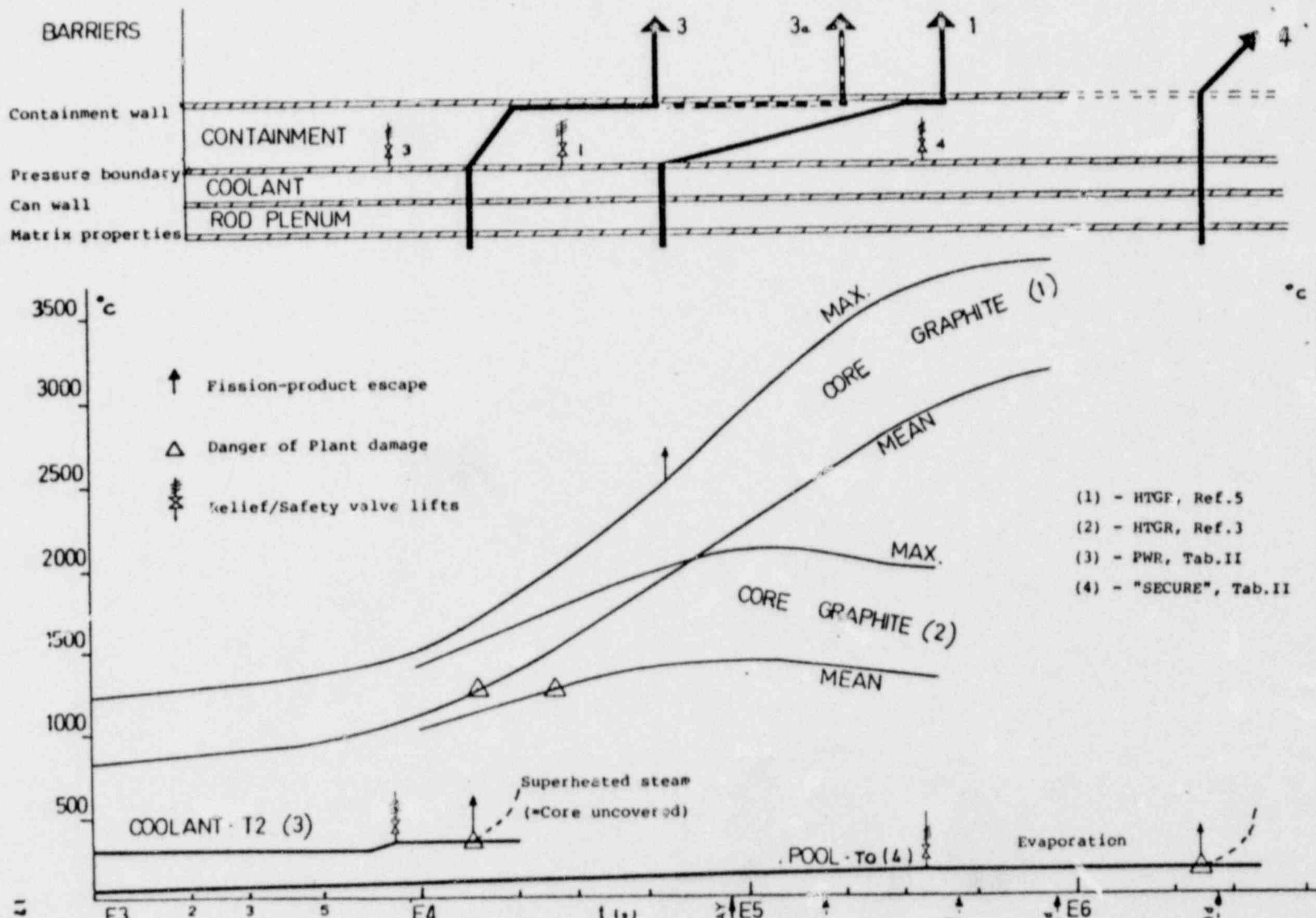
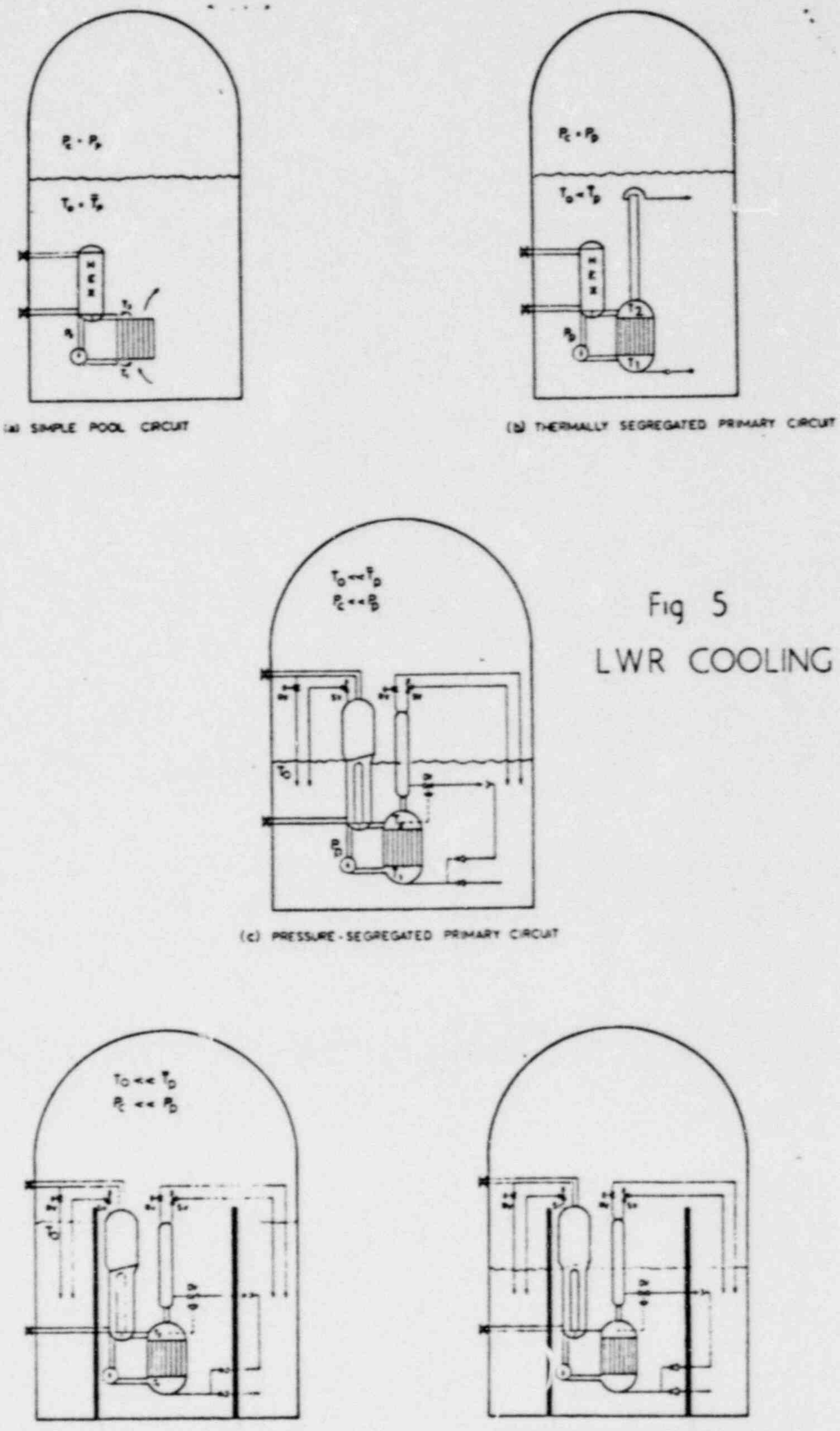


Fig. 4 – UNRESTRICTED CORE HEAT-UP



(a) SIMPLE POOL CIRCUIT

(b) THERMALLY SEGREGATED PRIMARY CIRCUIT

(c) PRESSURE-SEGREGATED PRIMARY CIRCUIT

(d) PRESSURE SEGREGATED PRIMARY IN DRYWELL (Normal Operation)

(e) PRESSURE SEGREGATED PRIMARY IN DRYWELL (Flooded Condition after LOCA)

Fig 5
LWR COOLING