2. Gaseous RW : mines : Rn; reactors + reprocessing : Kr, Xe, I, release points : fluid leakage, ventilation BWR : air ejector, PWR : gas stripper ,BRW* : condenser, turbine gland seal, vacuum pump, ventilation

Releases from the BWR main condenser air ejector (Ci/y/3400 MWt reactor).

RI	Kr-85m	Kr-85	Kr-87	Kr-88	Xe-133	Xe-135m	Xe-138	I-131	I-133
T	4.5 h	10y	76 m	2.8 h	5.3 d	15 m	14 m	8 d	21 h
FY	1.31	1.31	2.56	3.57	6.7	6.5	6.76	2.89	6.7
BC	8E+4	290	2E+5	3E+5	1E+5	1E+4	4E+5	5	2.1
C	80	290	<1	5	460	<1	<1	<a	<a
CD	22	280	72	76	13	3	90	3E-3	0.01

a = 1E-4, FY = Fission Yield - %, BC = Base case (30 min holdup), C = Charcoal (24 ton system operating at -18 C, -29 C dew point, 850 l/min air leakage, 42 d holdup for Xe and 1.8 d holdup for Kr), CD = Cryogenic Distillation (based on distillation partition factor of 0.0001 for Xe, I and 0.00025 for Kr and holdup time of 90 d for gases collected). PWR* : GALE code 0.12% of FP > primary and secondary

coolant, gaseous stripping 4- 290 l/min residence time, primary - secondary coolant leakage = 43 kg/h

Releases from the PWR waste gas processing system (Ci/y/3400 MWt reactor).

RI	Kr-85 m	Kr-85	Kr-87	Kr-88	Xe-133	Xe-135 m	Xe-138	I-131	I-133
T	4.5 h	10y	76 m	2.8 h	5.3 d	15 m	14 m	8 d	21 h
NT	1E+4	300	8E+3	2E+4	2E+5	1E+4	4900	3	4.4
C	<1	300	<1	<1	18	<1	<1	<a	<a
PS	300	300	72	<1	89	<1	<1	<a	<a

NT = No Treatment, C = Charcoal (72 d holdup for Xe and 4 d holdup for Kr), PS = Pressurized Storage 60 d.

Off-Gas system* : radiolysis, moisture

Compressed gas storage**: recombiner, 10 min decay Kr-89 (3 m), Xe-137 (4 m) + HEPA filter, 90 d, Kr-85 (10 y)

Charcoal : K* adsorption coef. 30 - 10000 cm3/g, Kr, Xe

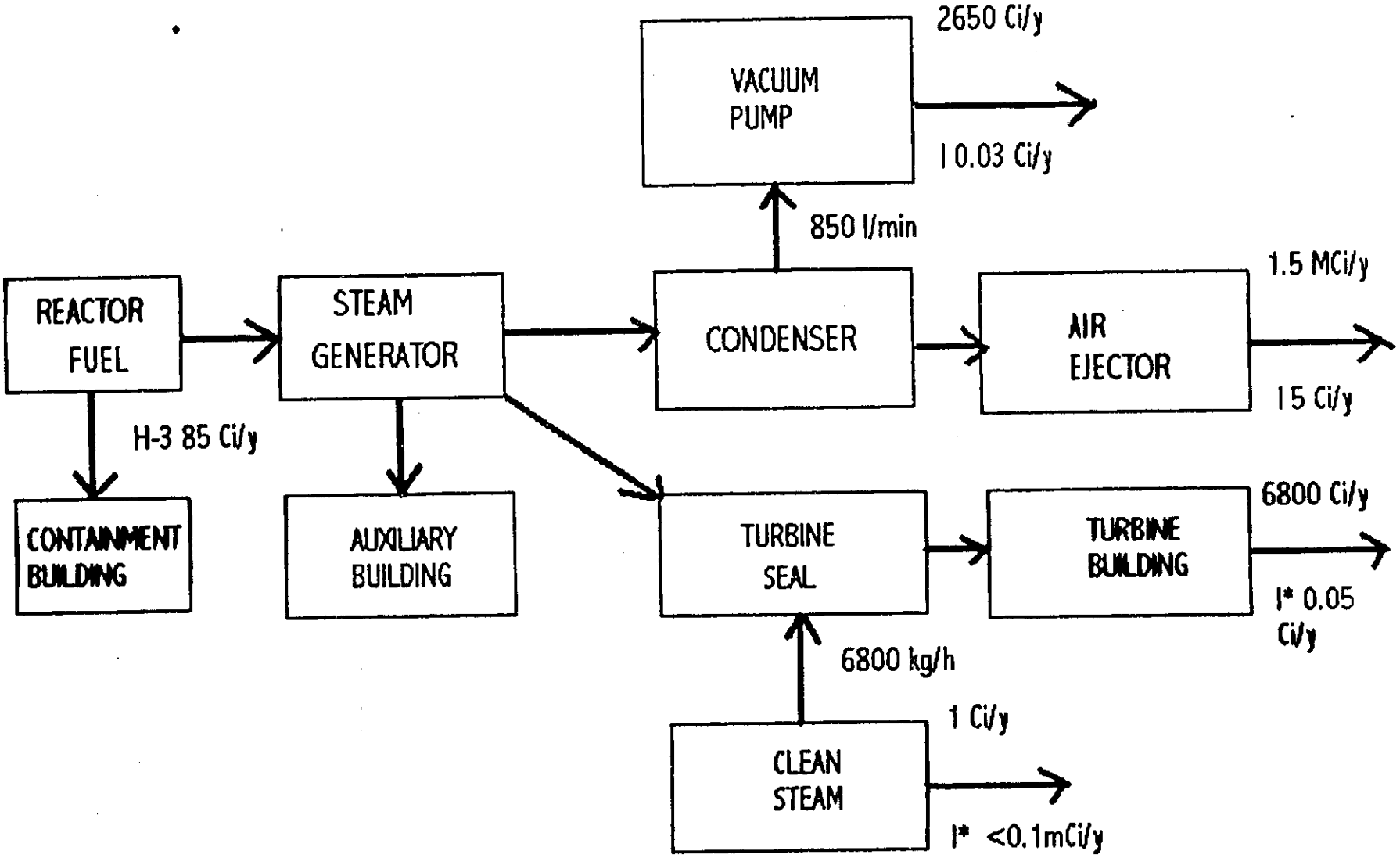
Ambient C** : 1.4 tons > 30 d, moisture removal

Refrigerated C* : 25 to -18 C > K: 3x, $, refrigeration, holdup times Xe/Kr=18

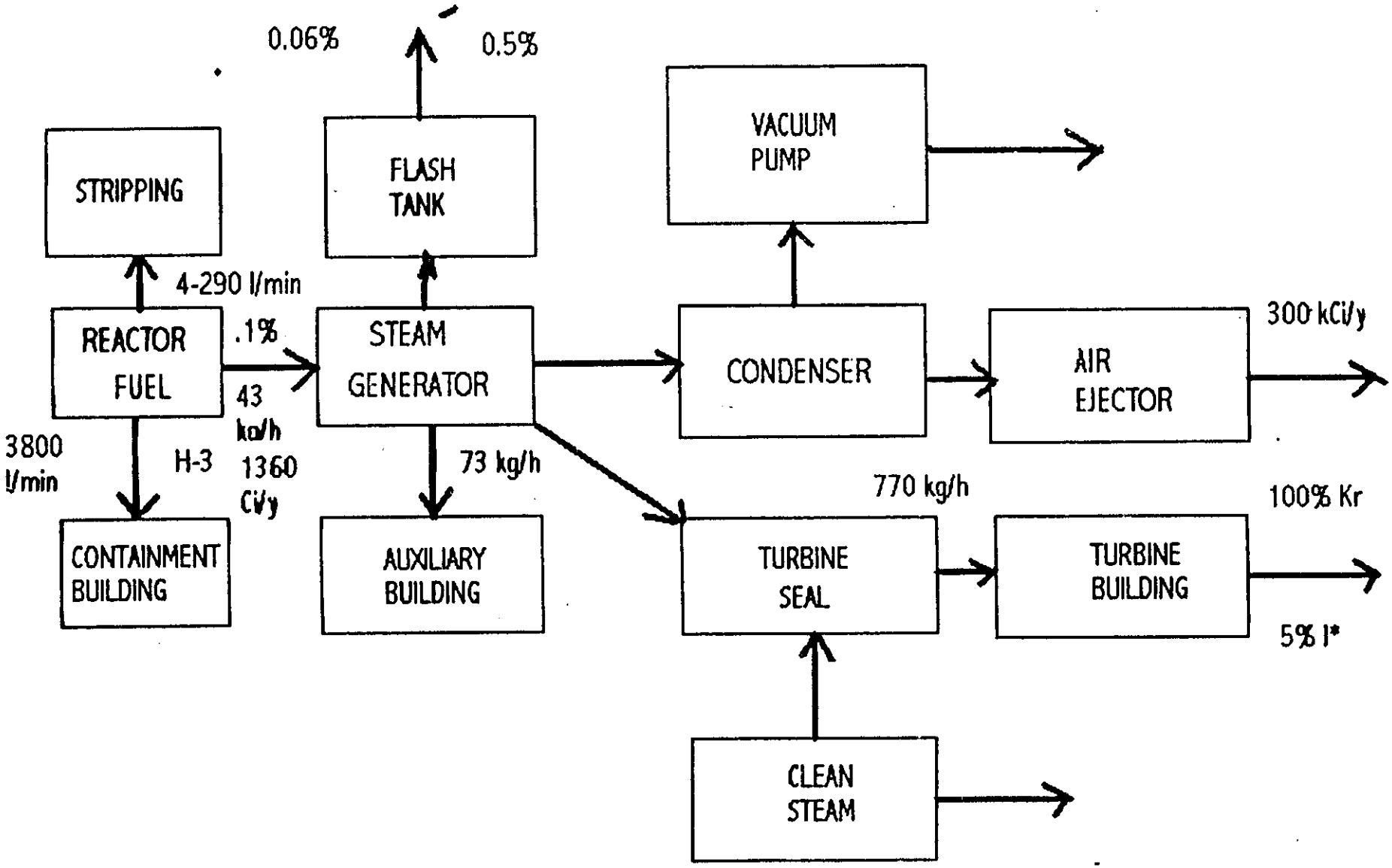
Cryogenic C**: -170 C, cycles : 240 h, ozone, Kr break-through, desorption, desiccant N2

Cryogenic distillation*: O2 + N2 :99% decontamination: Kr

4000, Xe 10000
Boiling points (BP) off-gases:
Gas : H_2 Ne N2 Ar O CH4 Kr Xe CO H_2O
BP-C: -253 -246 -210 -186 -183 -164 -152 -108 -79 100
Filtration: WW 2, HEPA*, glass fibre, resistance, efficiency> 99.97%, prefilters
Radioiodines*: I-131/133, MPC body 0.05 mCi, air 20 nCi/l, TMI 15 Ci I-131, 2.5 Mci Kr, Xe, adsorbents, Ag, C, moisture, CH3I, impregnation KI KI3 HMTA TEDA, aging, weathering, poisoning, guard beds
C bed ignition: zeolite-Ag/Pb, deep beds 15 - 50 cm remote handling
Kr Xe collection: fluorocarbons, C, cryogenic
H-3 removal: oxidation to T2O, reduction to T2
C-14 removal: CO2 + Ca(OH)2
Discharge : no control, irradiation, inhalation, food chain
Effluent plumes: terminal velocity, diffusion, settling
Release form a stack: buoyancy, plume rise, temperature inversions, downwash; Atmospheric diffusion: dry adiabatic lapse rate : 001 C/m, atmosphere: stable neutral unstable; inversion layer. Sutton's equation: virtual diffusion coef., meteorological conditions. Release at a height: reduction 20X effective height. Deposition: terminal velocity, particle size. Adsorption on condensation nuclei: numerous Aitken nuclei D < 1E-7 m, v = 1E-5 m/s negligible settling, RnDP, Sr, Ba . Washout: rainfall 1 mm/h : 50% in 36 min, I-131, Windscale, 1957



BWR Gaseous Release Points



PWR Gaseous Release Points

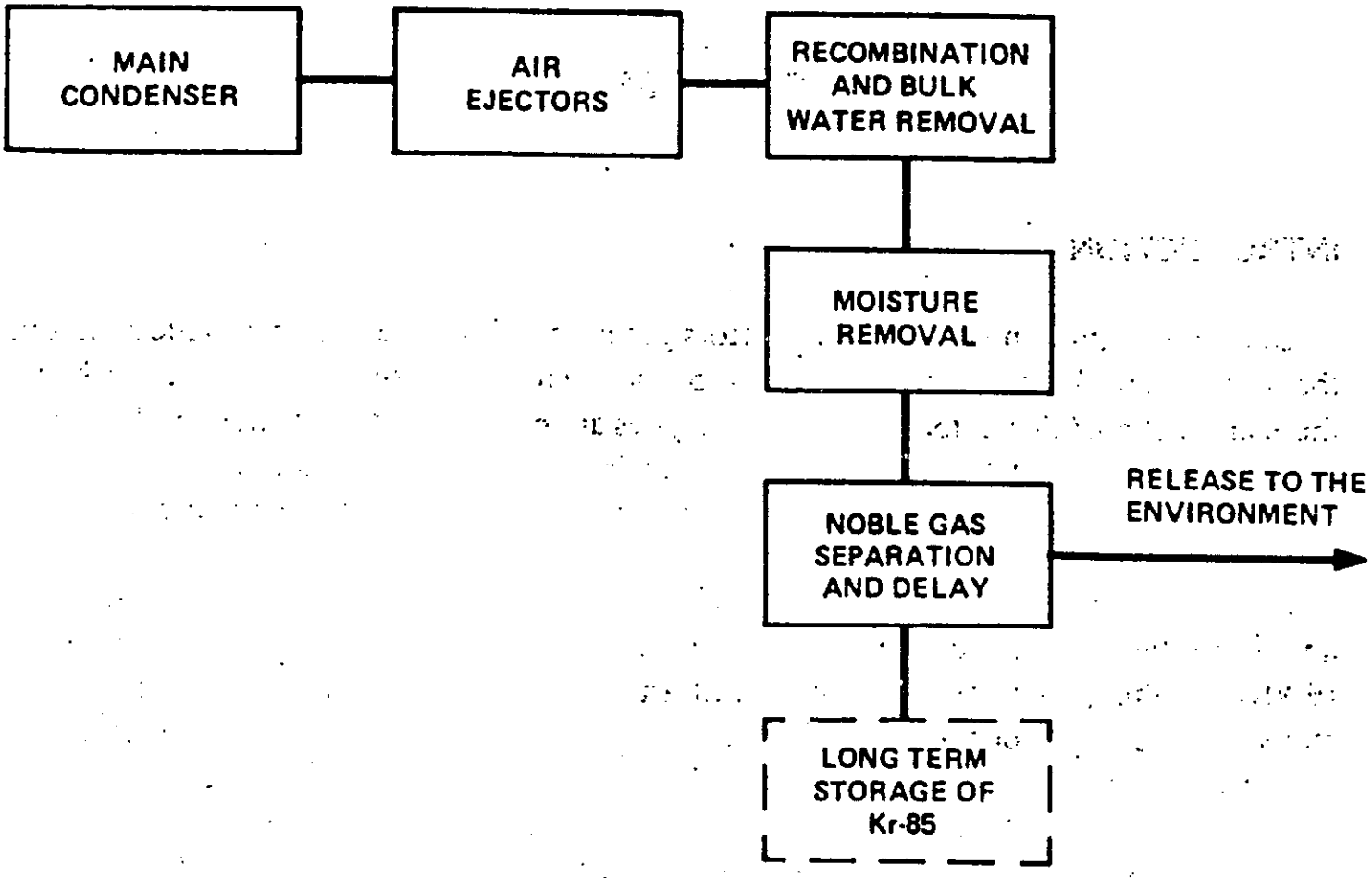
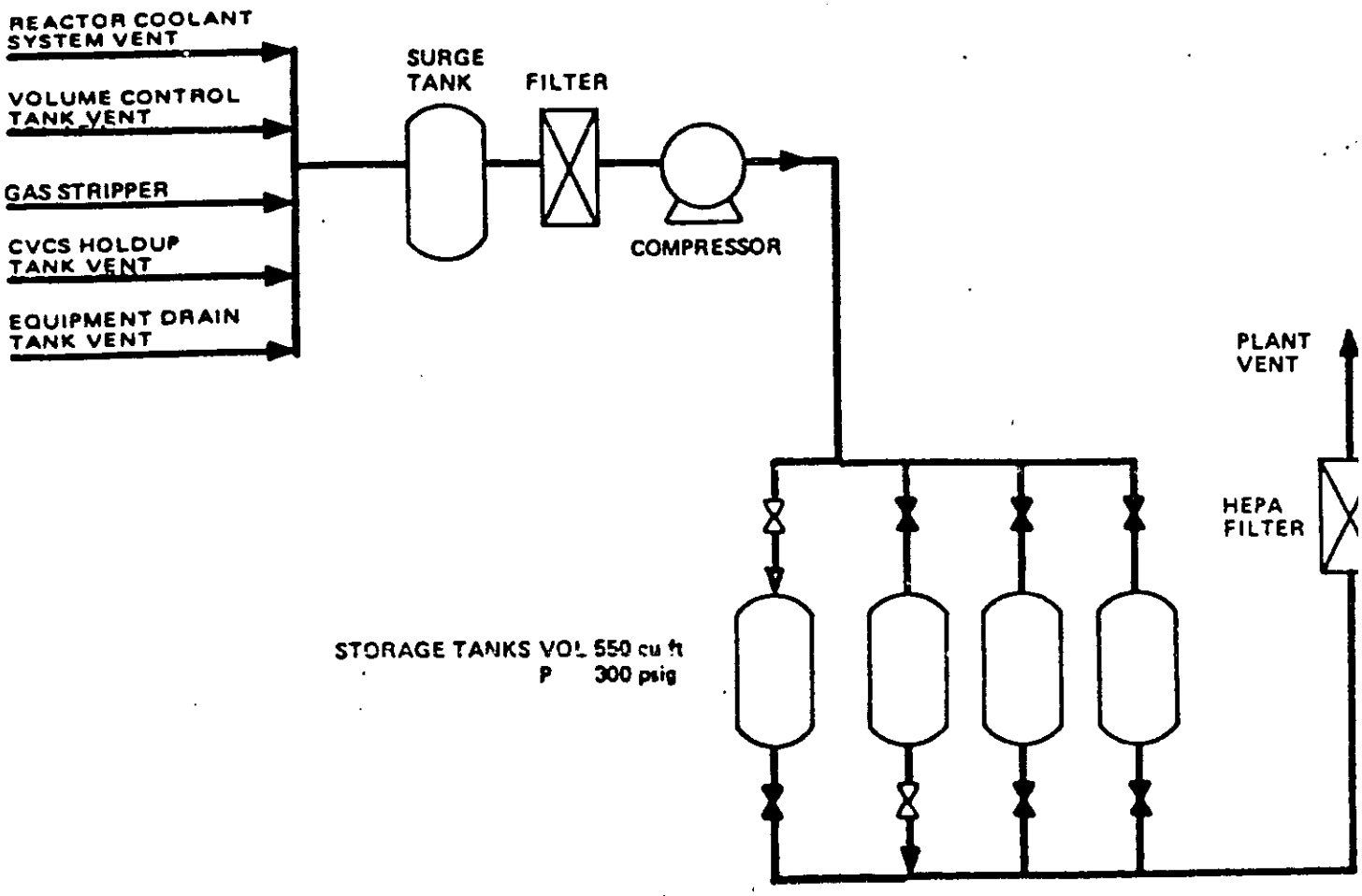
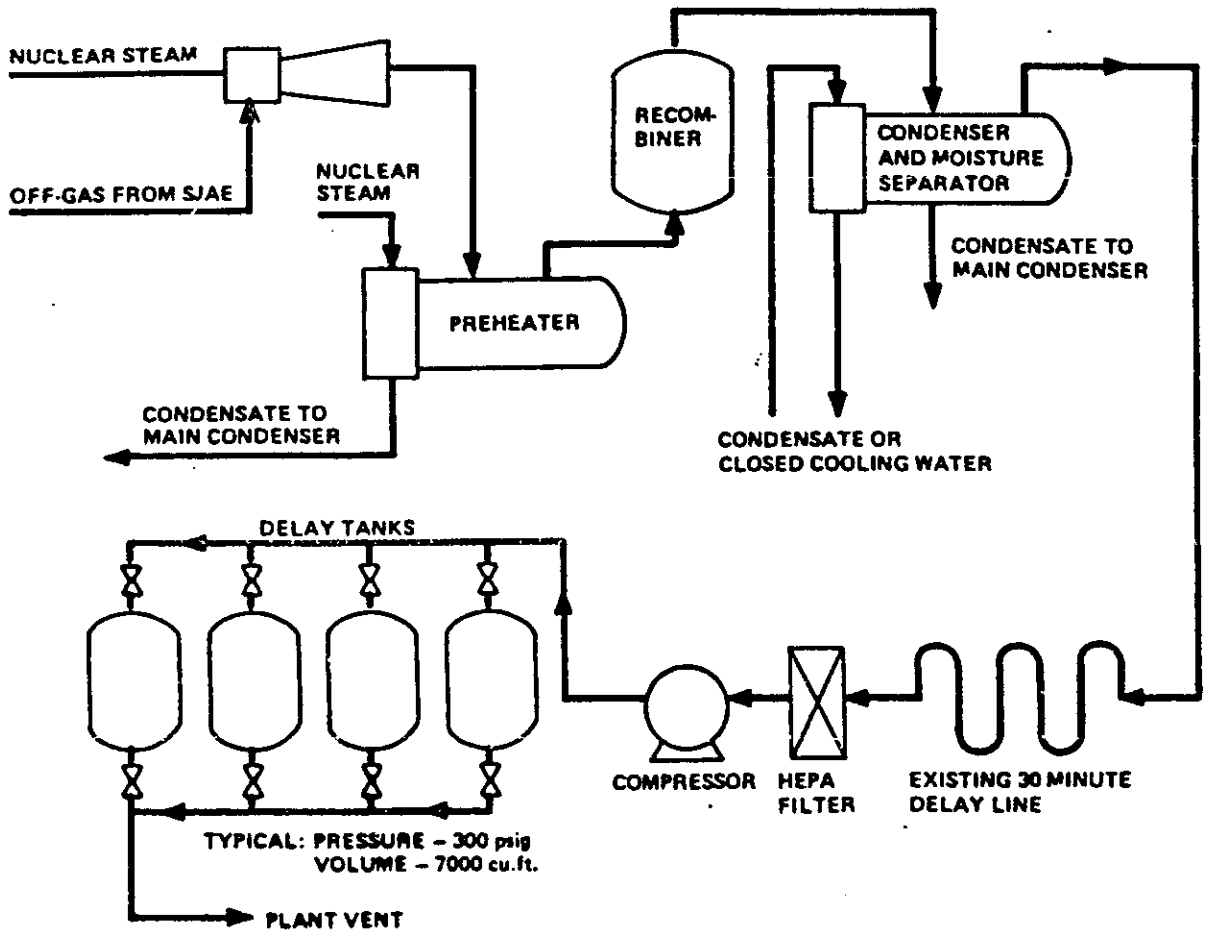


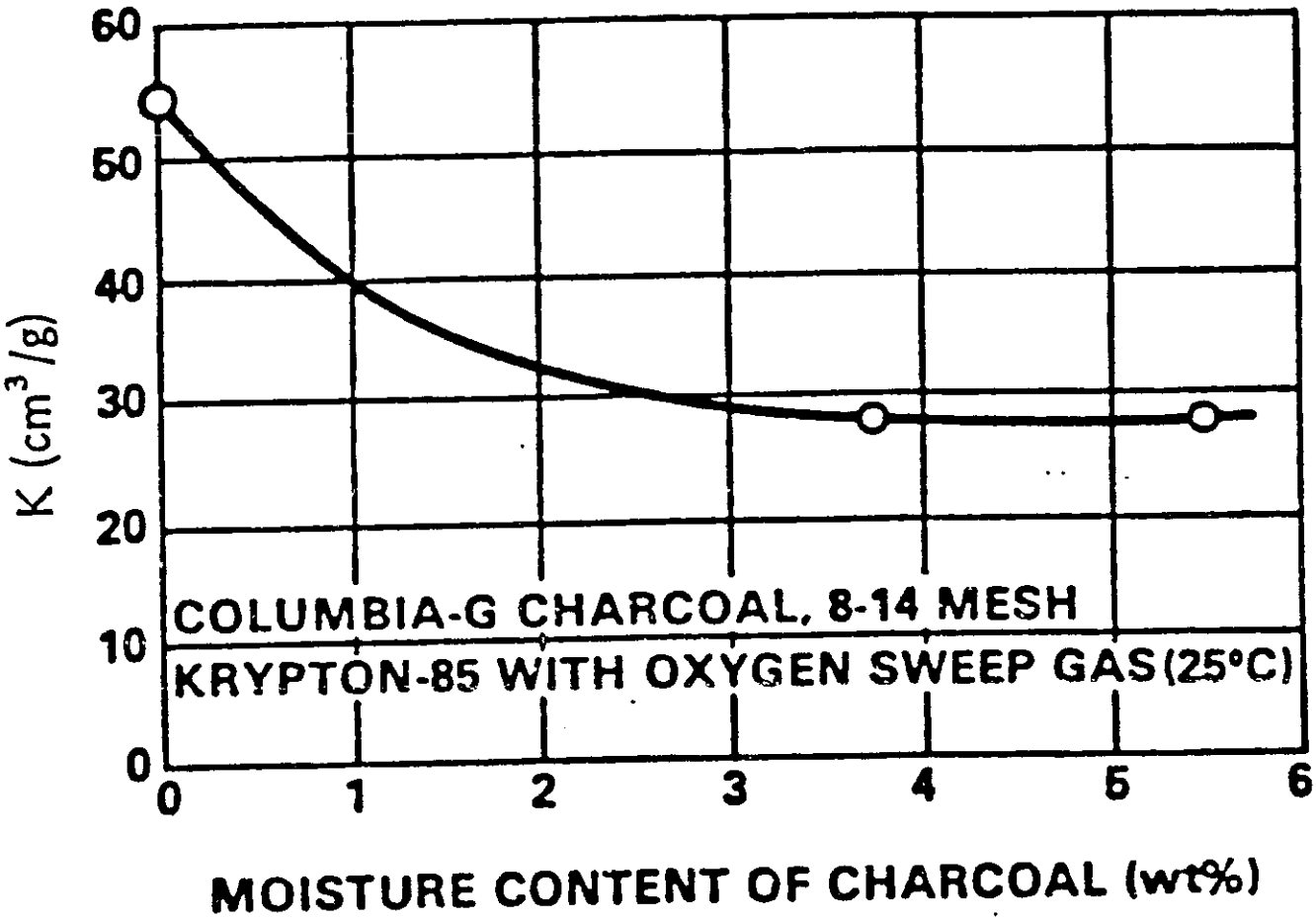
FIG. 1. PRINCIPAL COMPONENTS OF A BWR OFF-GAS SYSTEM



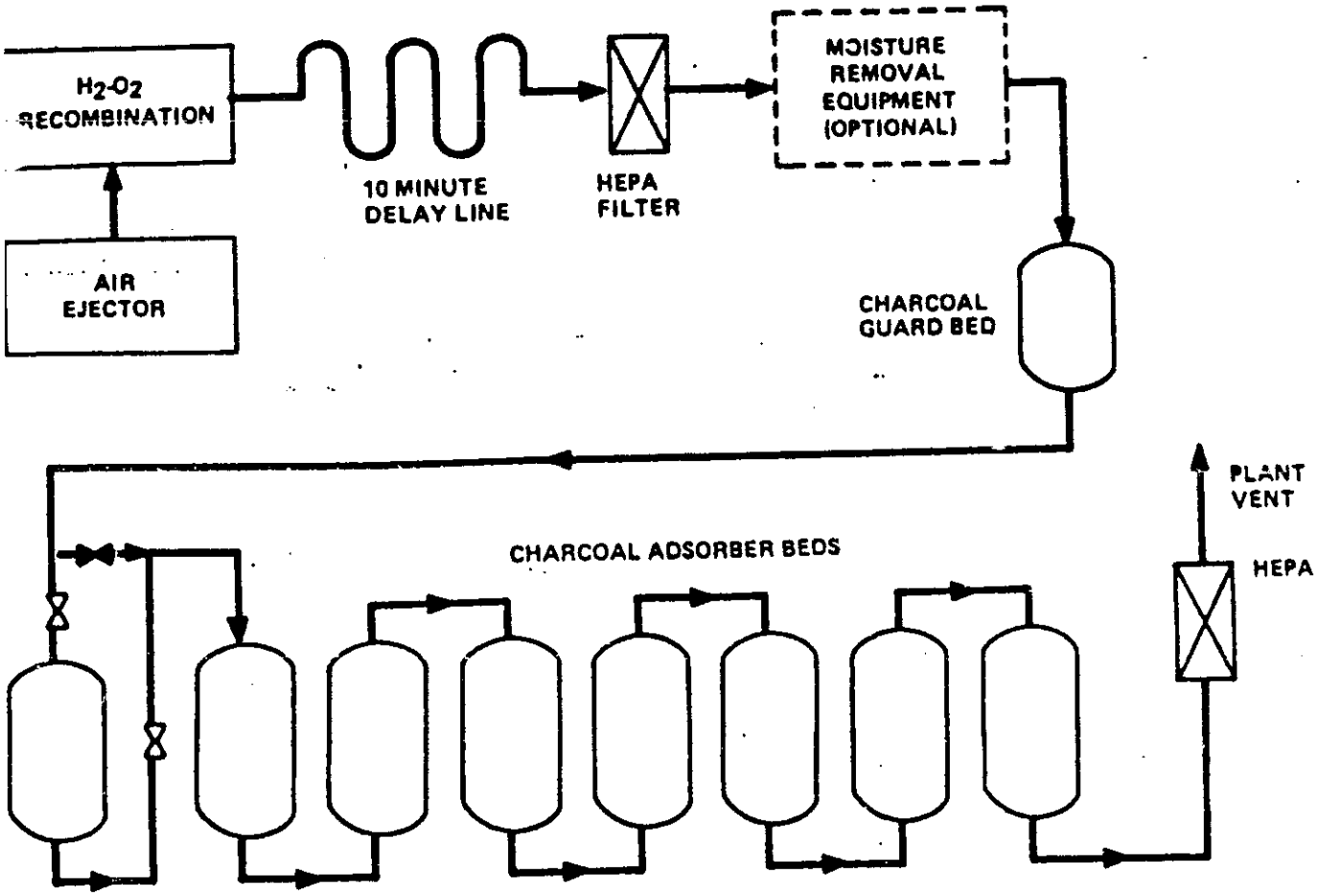
IG. 15. WASTE GAS DECAY SYSTEM FOR TREATING THE OFF-GAS IN A PWR



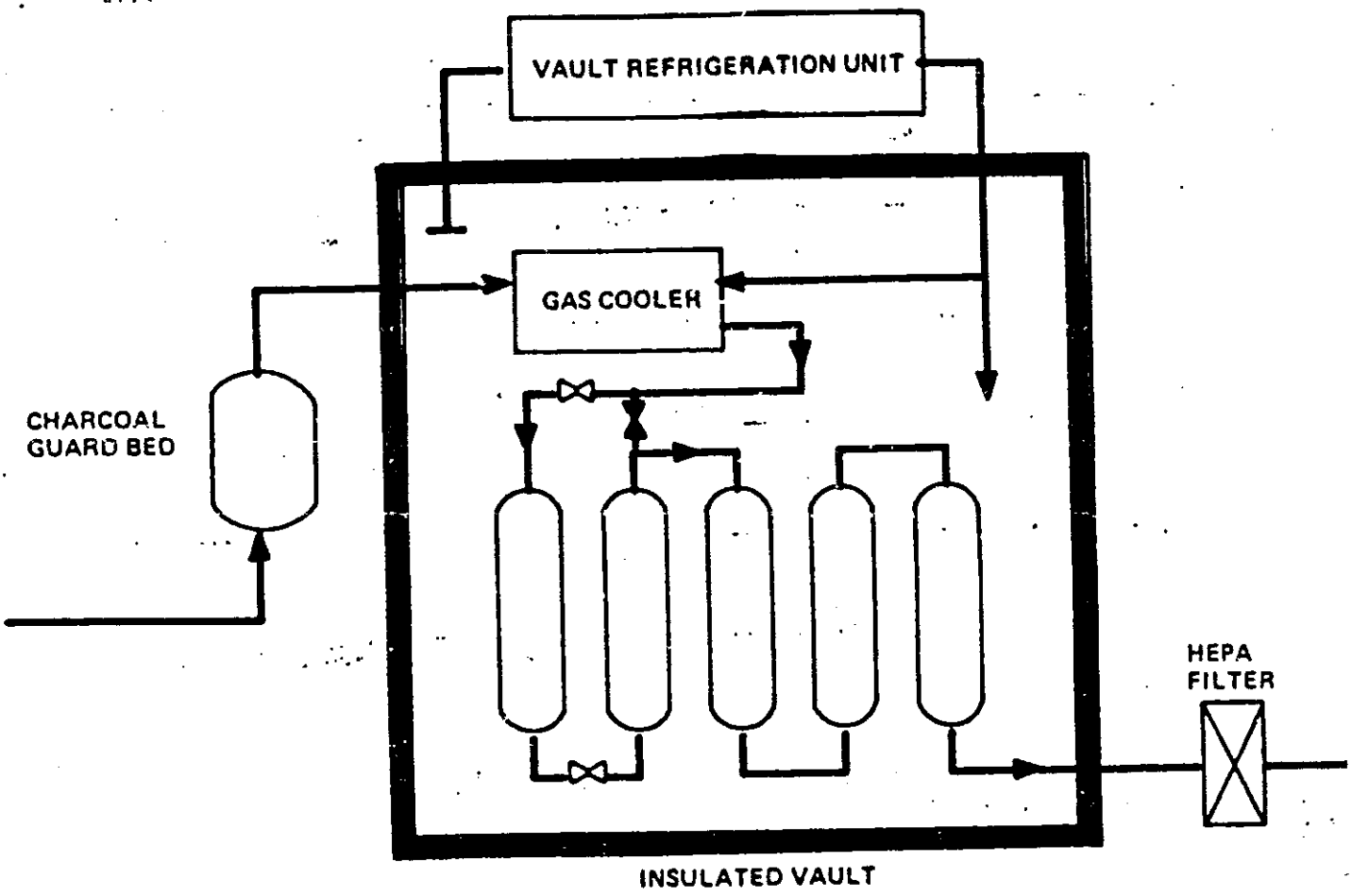
IG. 5. FLOWSHEET FOR A COMPRESSED GAS SYSTEM USED TO TREAT THE OFF-GAS IN A BWR.



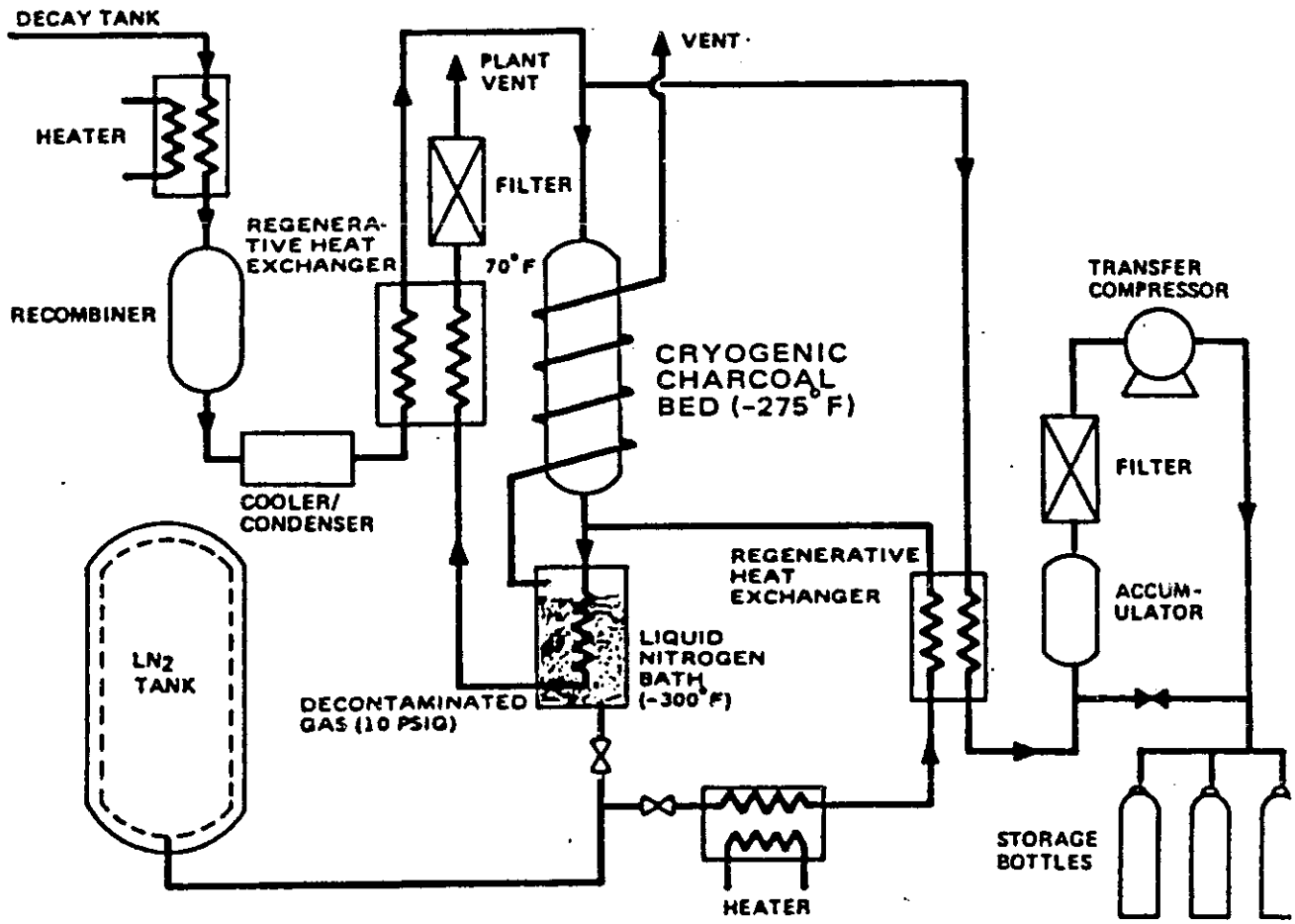
. DYNAMIC ADSORPTION COEFFICIENT FOR KR-85 AS A FUNCTION OI
RELATIVE HUMIDITY



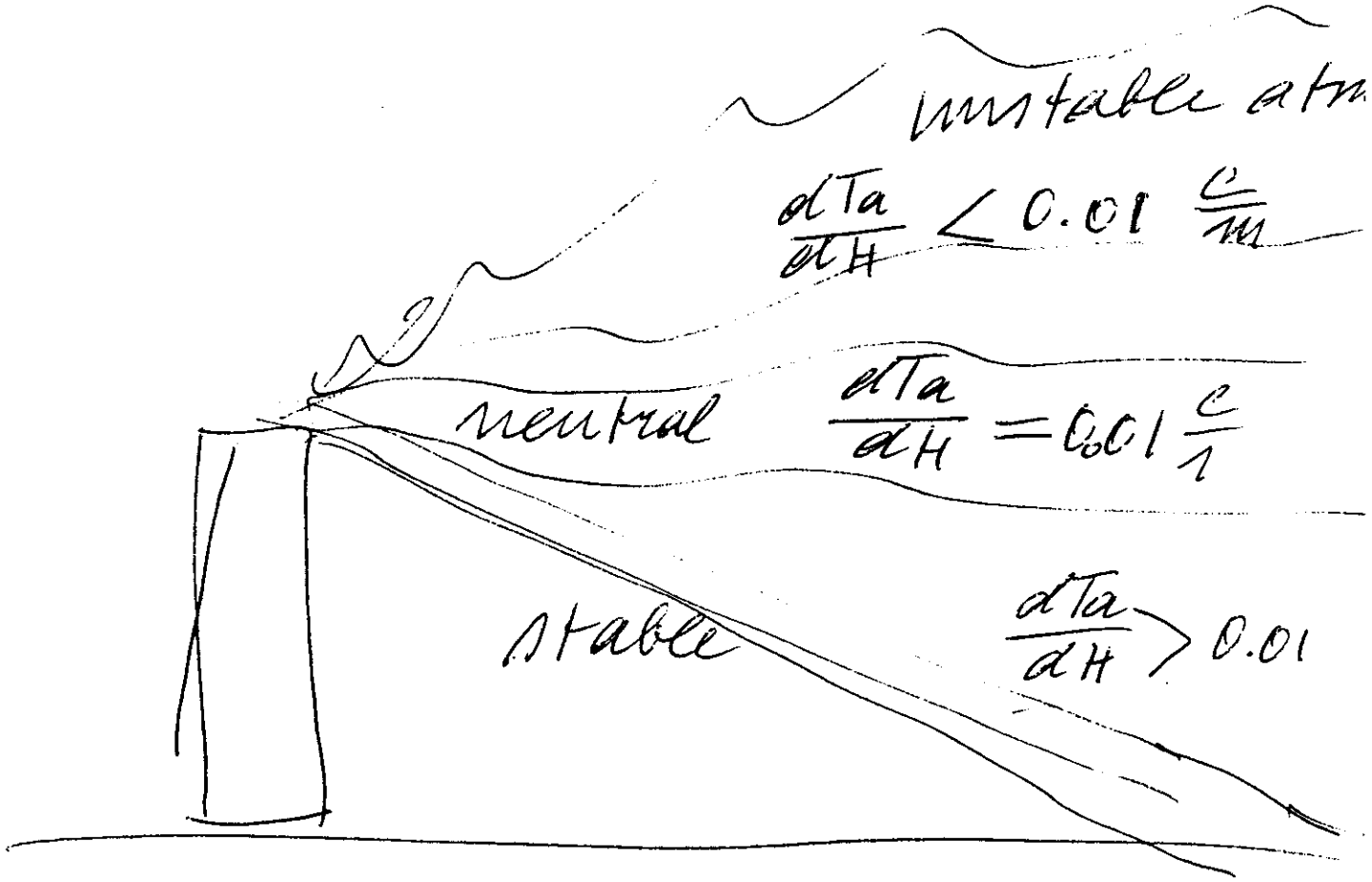
FLOWSHEET FOR AN AMBIENT CHARCOAL SYSTEM USED TO CLEANUP THE OFF-GAS IN A BWR

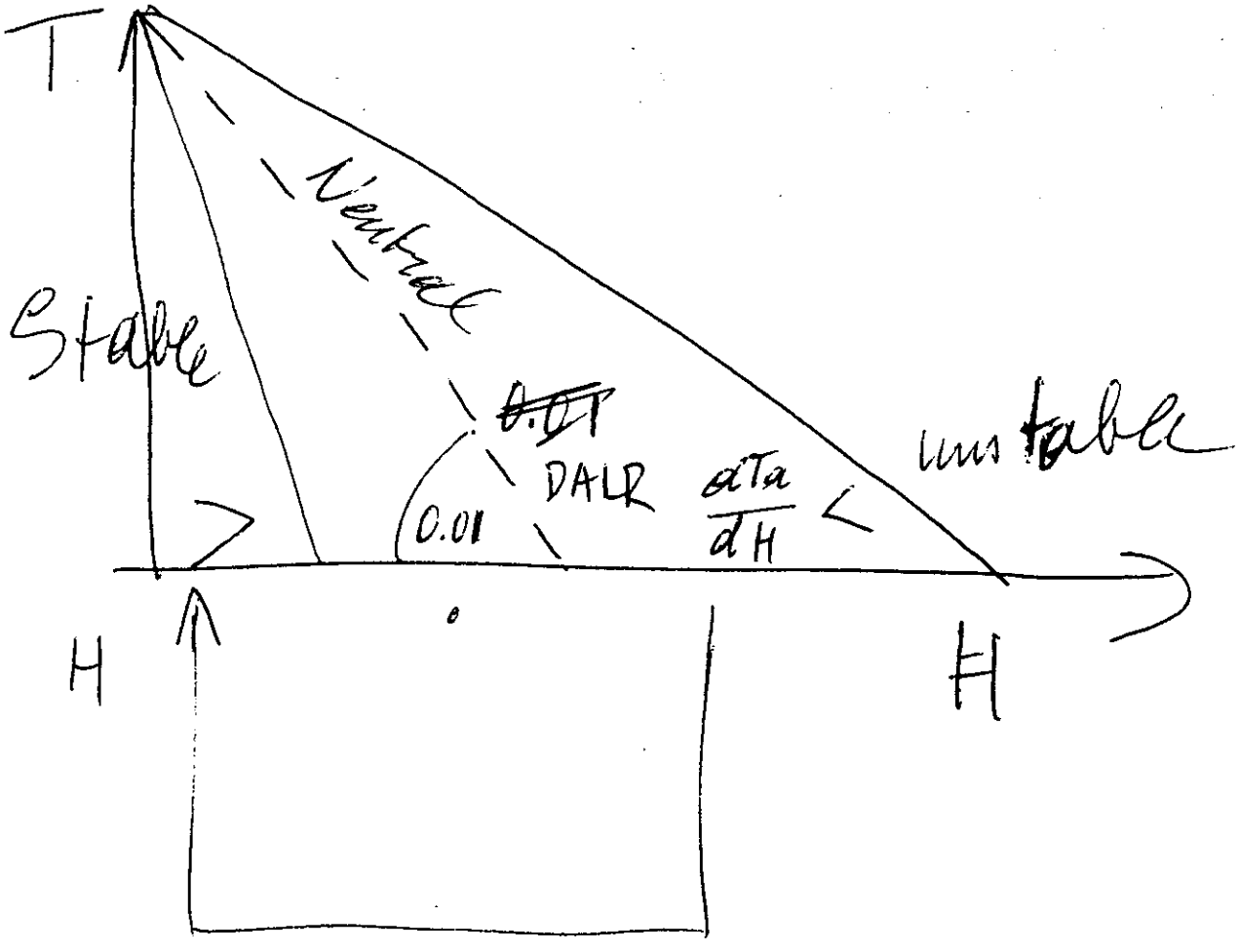


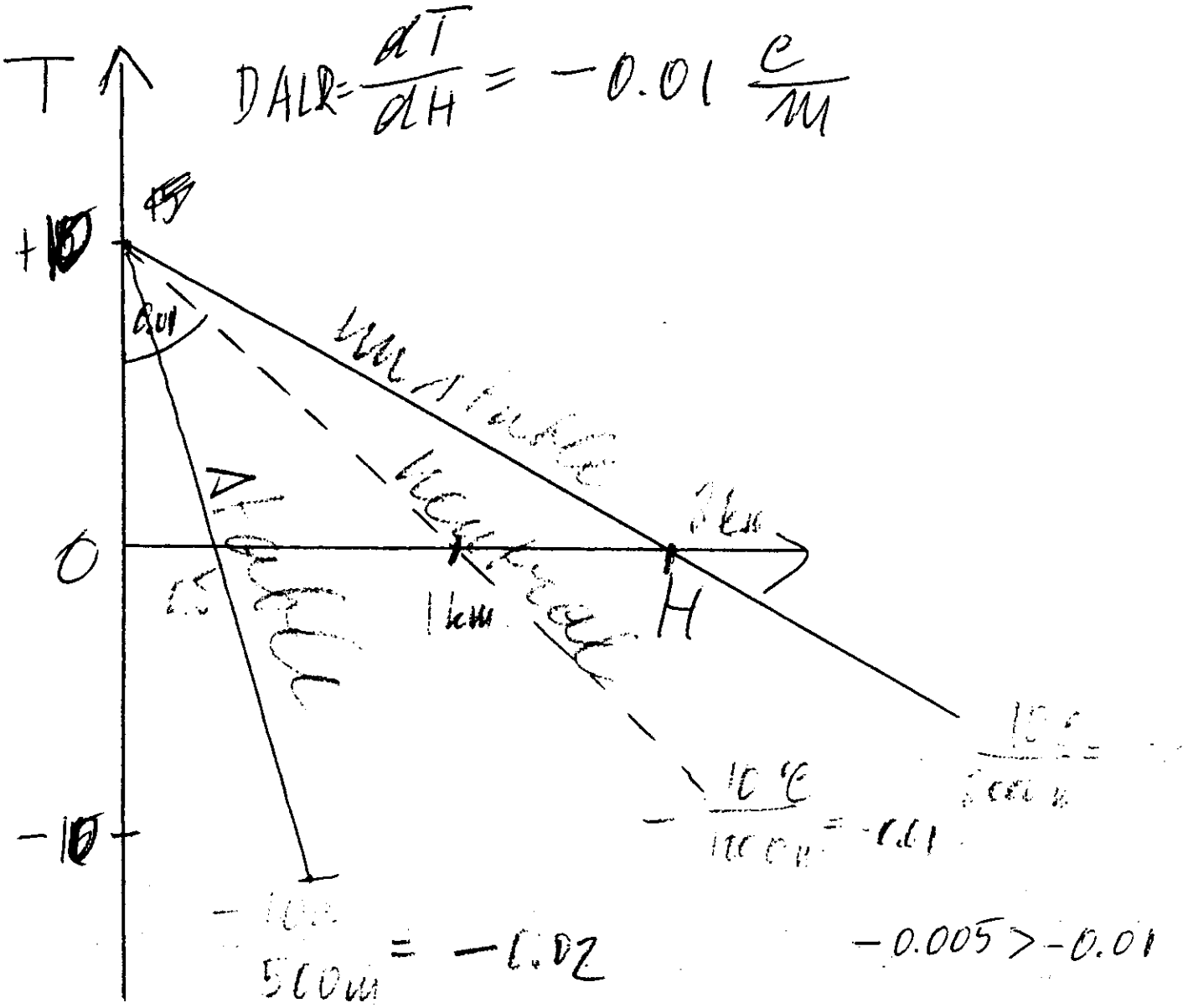
9. REFRIGERATED CHARCOAL SYSTEM FOR CLEANUP OF THE OFF-GAS IN



IG. 18. BATCH OPERATION OF A CRYOGENIC CHARCOAL SYSTEM FOR CLEANUP OF OFF-GAS IN A PWR


unstable atm
$\frac{dTa}{dH} < 0.01 \frac{C}{m}$
neutral
$\frac{dTa}{dH} = 0.01 \frac{C}{1}$
stable
$\frac{dTa}{dH} > 0.01$


T
Neutral
Stable
0.01
DALR
$\frac{dTa}{dH}$
unstable
H
H



$$\frac{dT}{dH} = -0.02 < -0.01$$

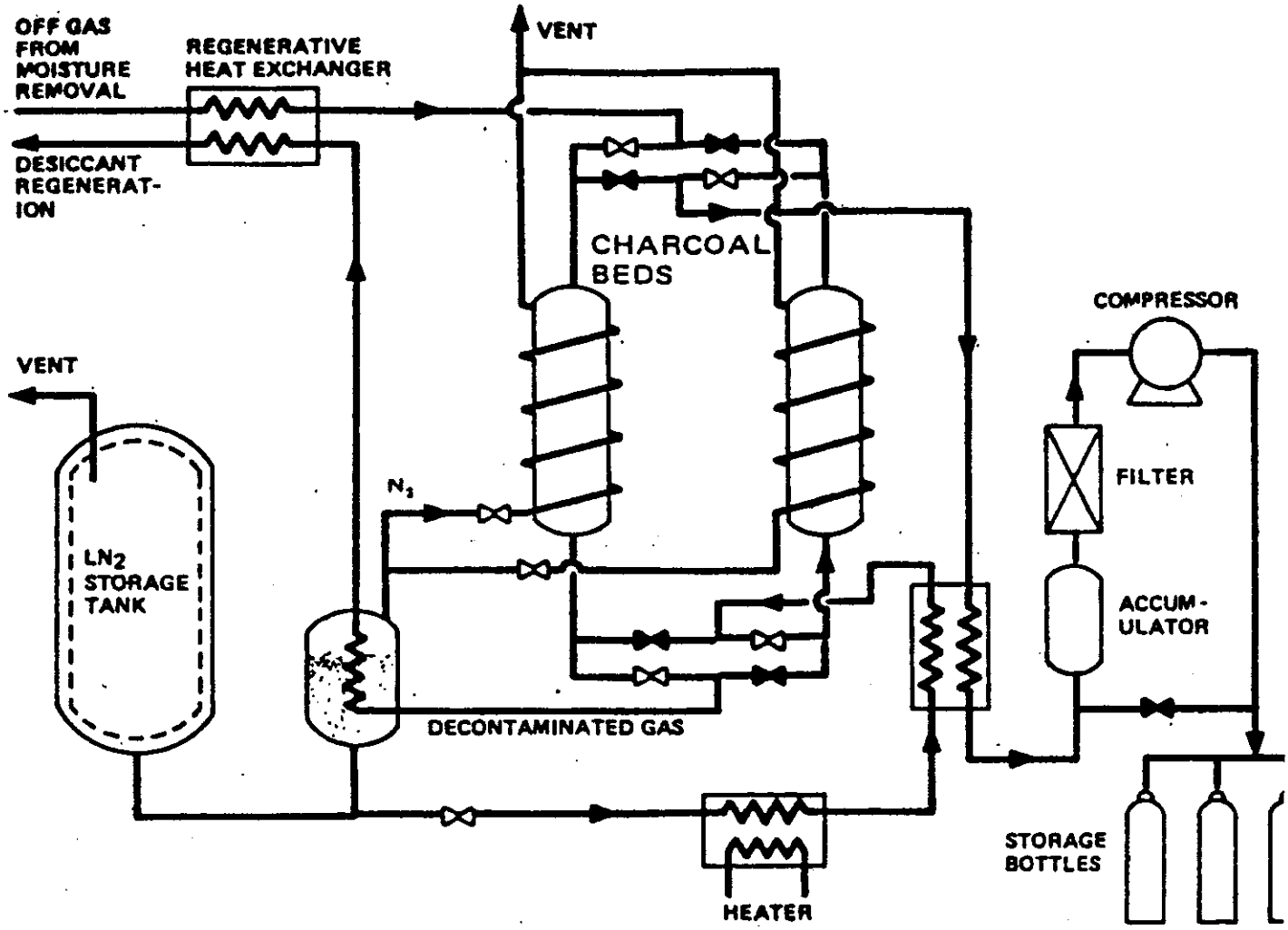


FIG. 13. CRYOGENIC CHARCOAL SYSTEM FOR CLEANUP OF THE OFF-GAS IN A BWR

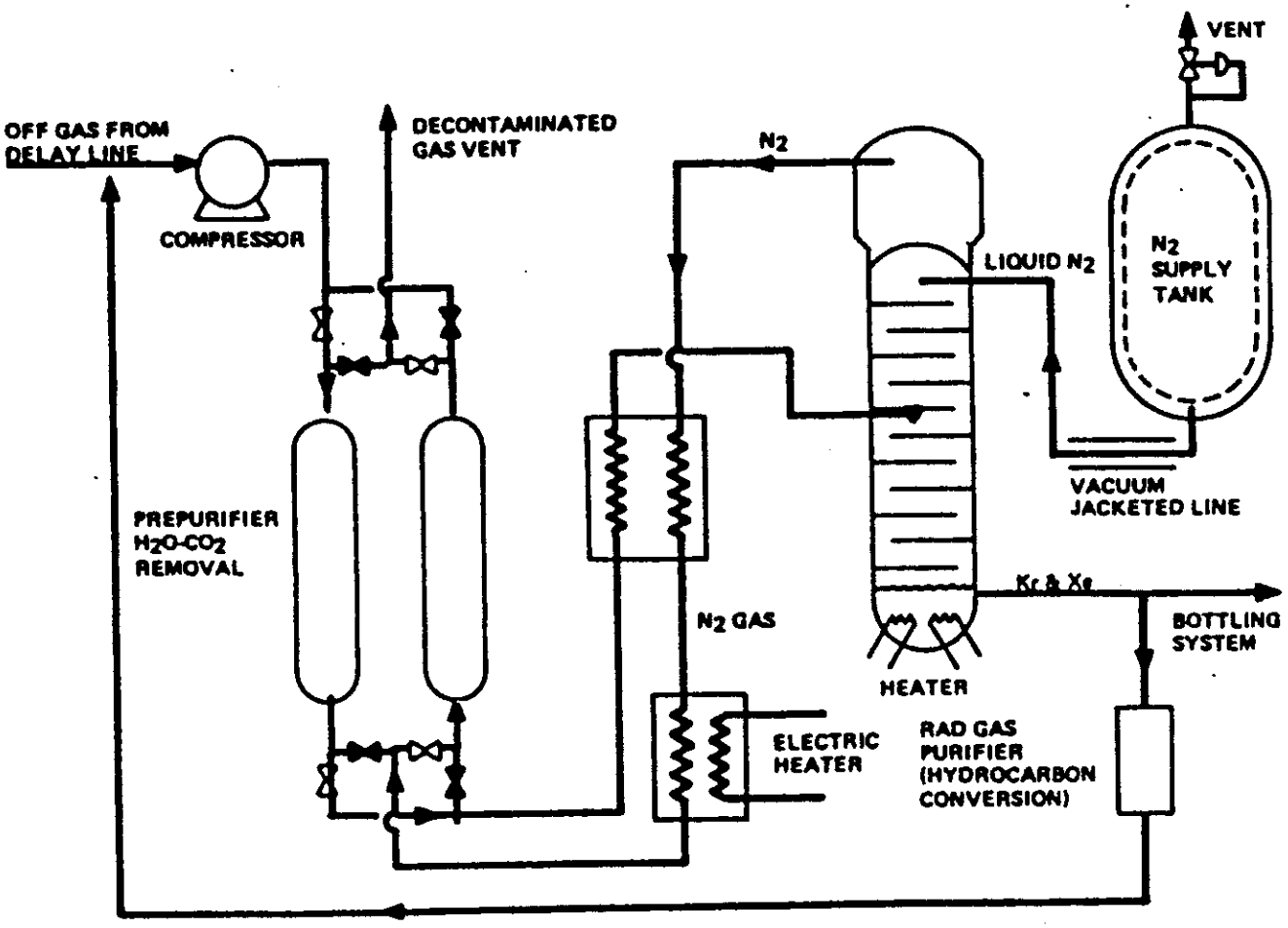


FIG. 11. CRYOGENIC DISTILLATION SYSTEM FOR CLEANUP OF THE OFF-GAS IN A BWR

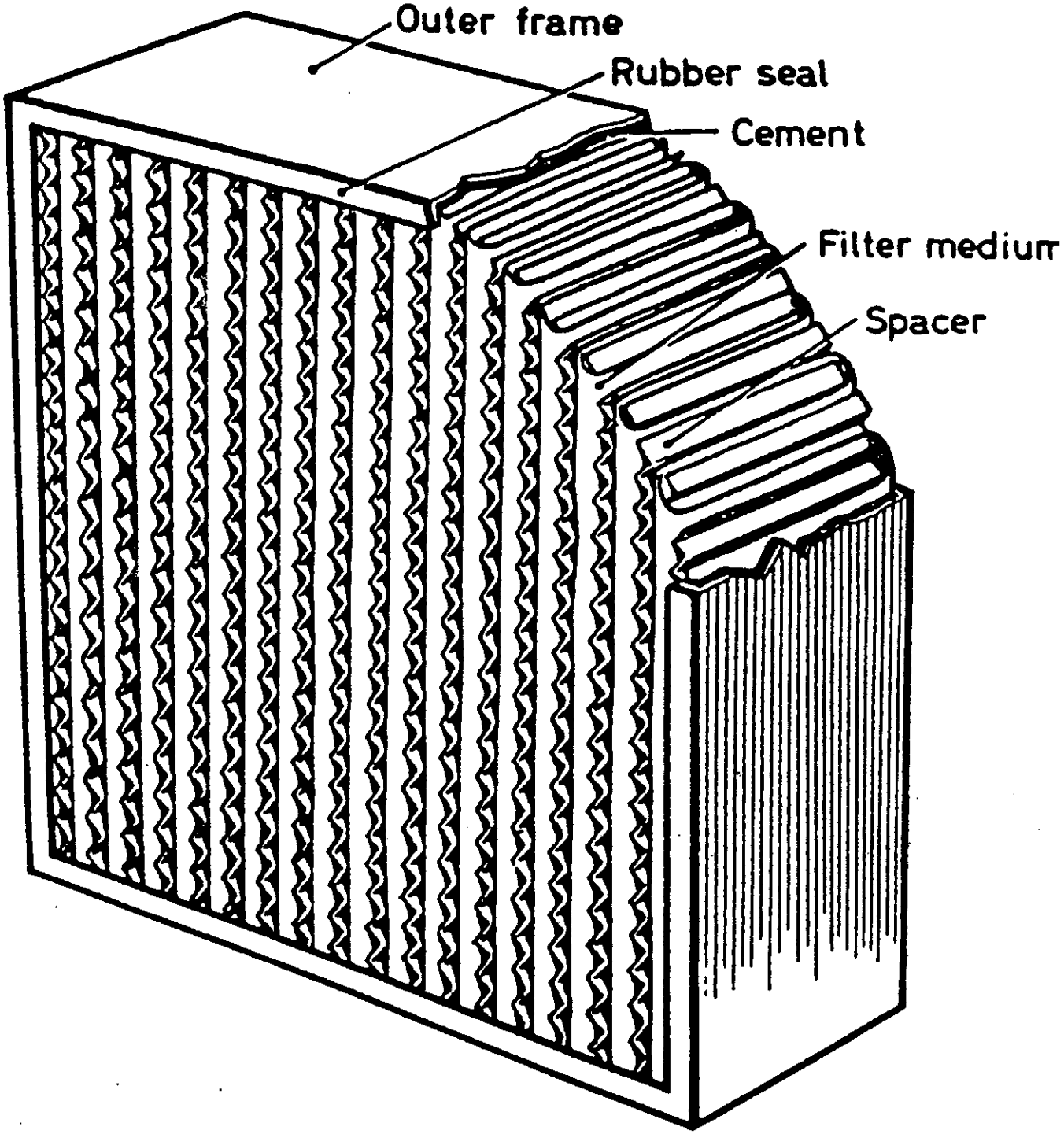
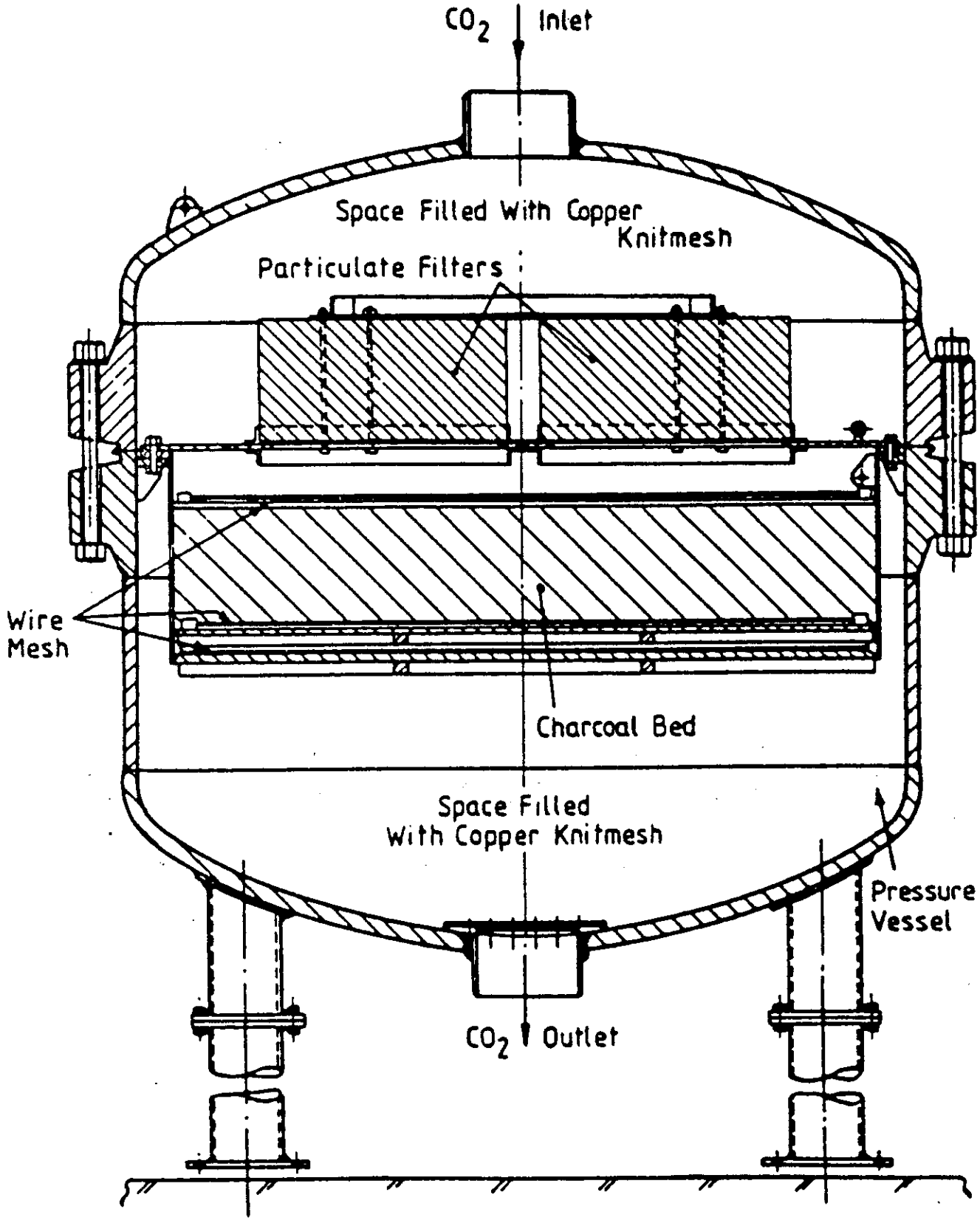


Figure 5.13. Typical high-efficiency particle filter employing paper medium



IG.6. Typical arrangement of iodine sorption plant — Magnox reacto

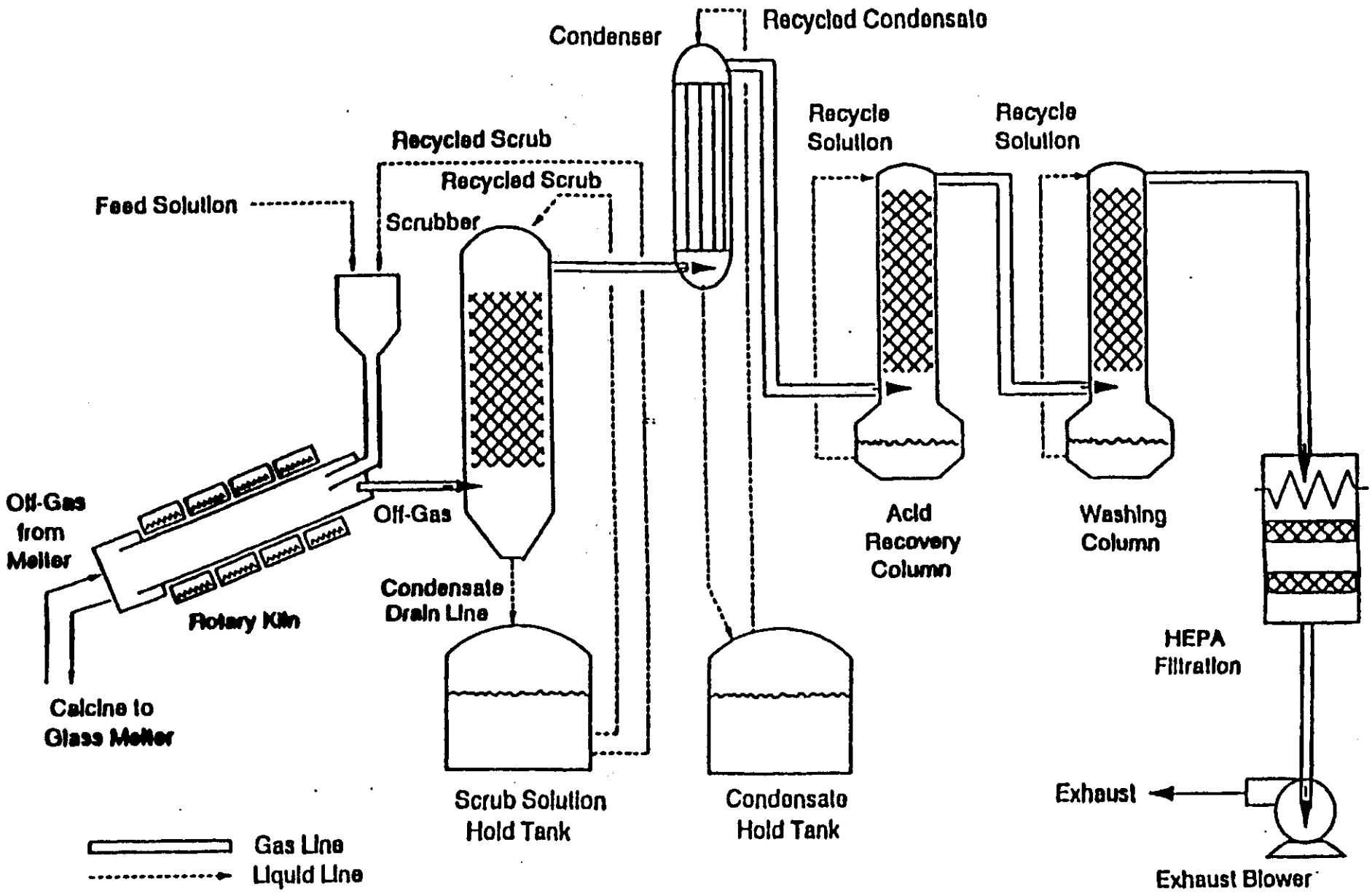
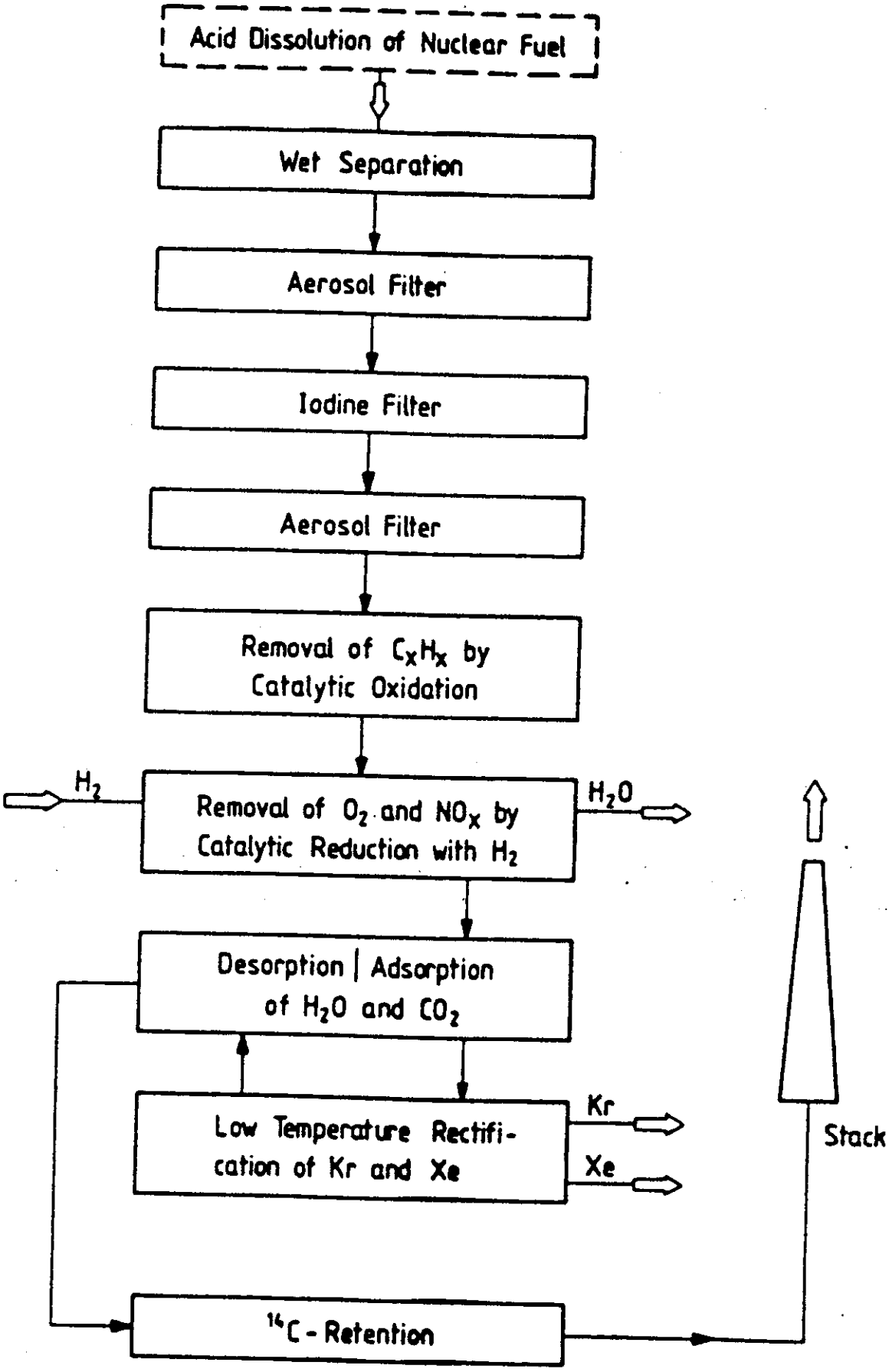
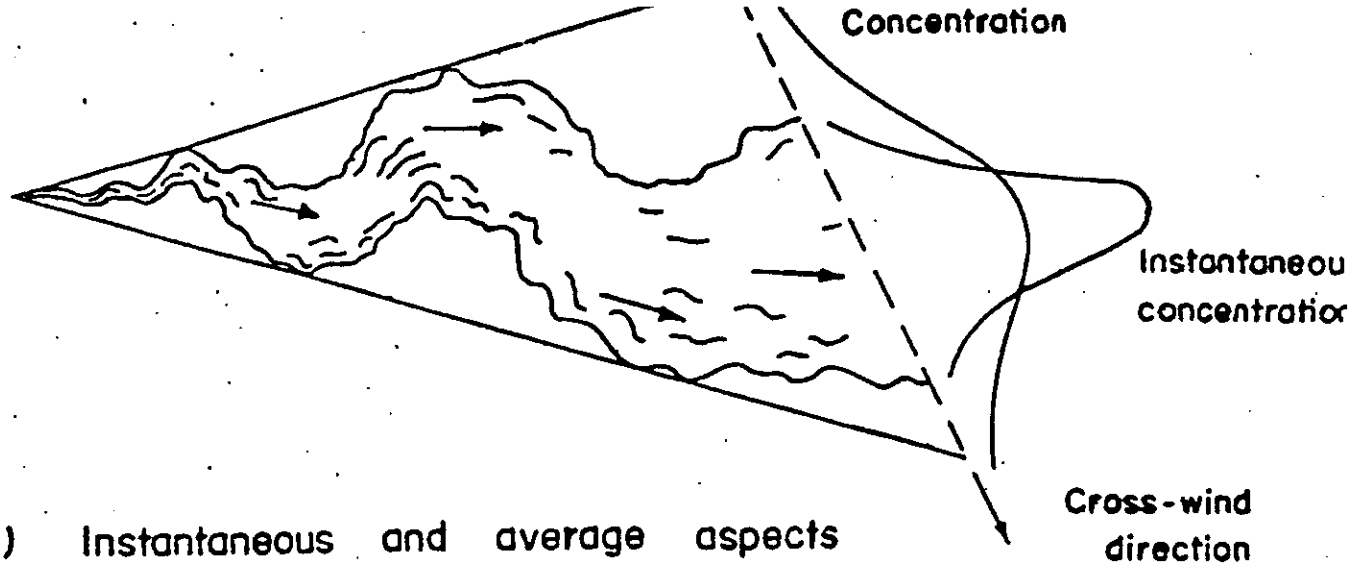


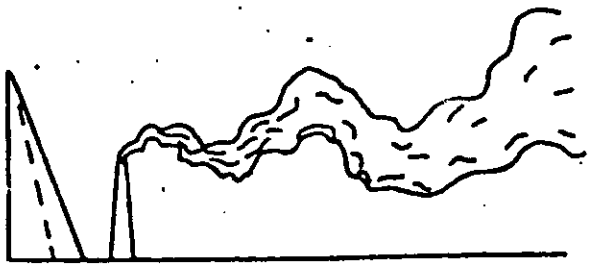
Figure 3 AVM calciner/melter off-gas treatment.



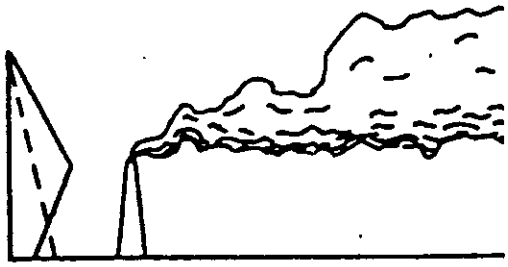
1. Scheme for waste-gas cleaning for a fuel reprocessing plant.



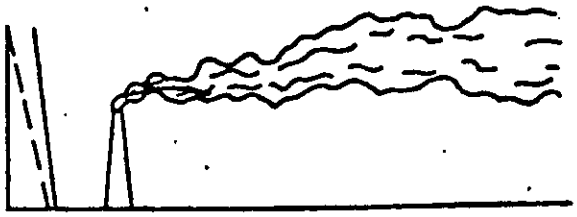
(a) Instantaneous and average aspects of the cross-wind spread of a smoke-plume.



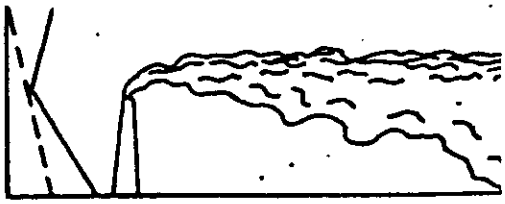
Unstable (looping)



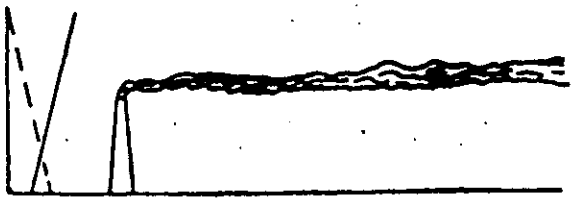
Unstable above
Stable below (lofting



Neutral (coning)



Stable above (fumigatio
Unstable below



Stable (fanning)

--- Dry adiabatic lapse rate

—— Temperature distribution

(b) Characteristic forms of smoke plume from chimneys.

FIGURE 1. Observational features of the spread of smoke plumes.[130,193]

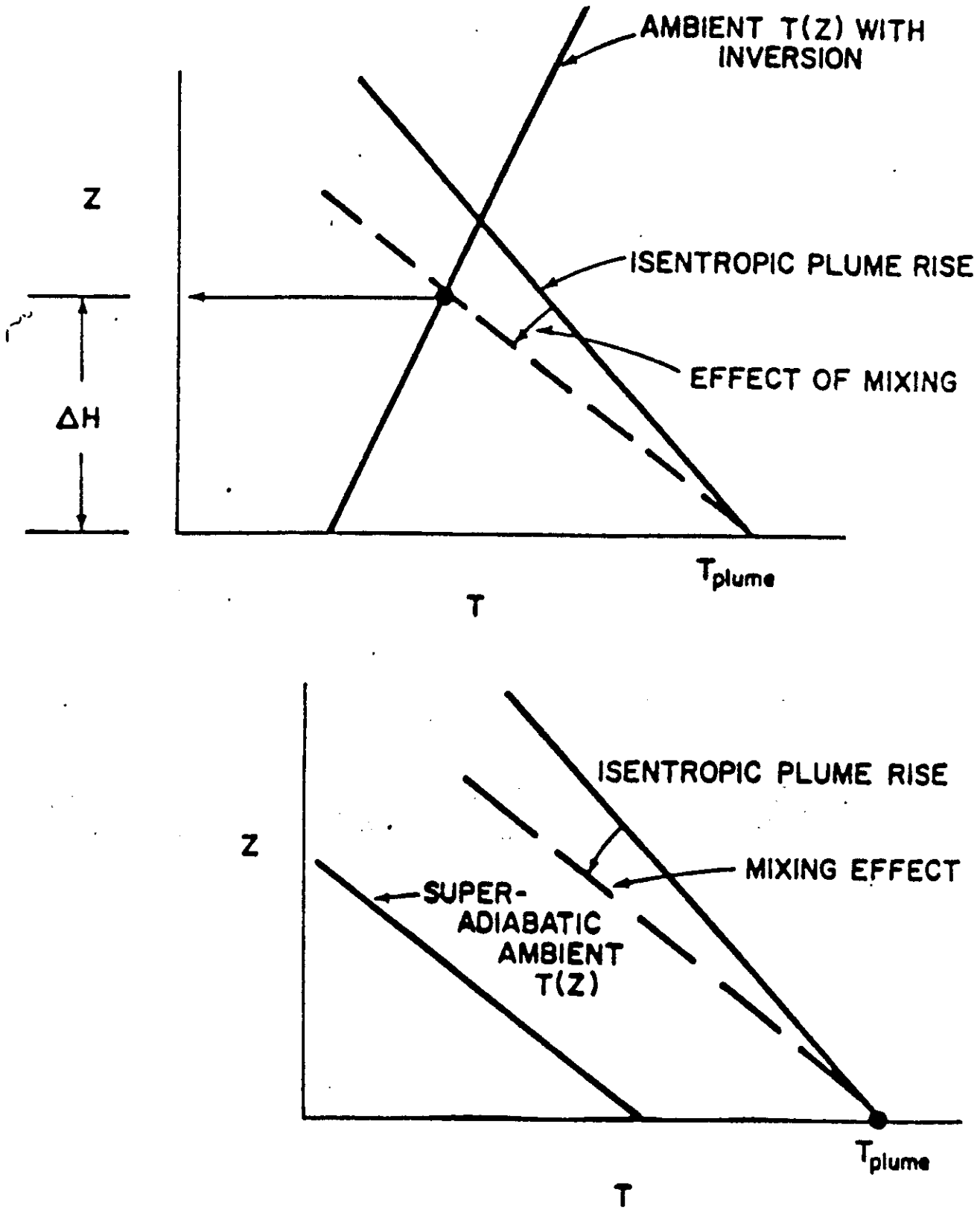


Fig. 9.2 Plume rise in a stable atmosphere (*top*); plume rise in an unstable atmosphere (*bottom*).