JUN 23 1971

J. P. O'Reilly, Chief, Reactor Testing and
Operations Branch, Divison of Compliance, HQ

JERSEY CENTRAL POWER AND LIGHT COMPANY (OYSTER CREEK)
DOCKET NO. 50-219

The attached report of inspections conducted at the subject facility on April 6 - 8, 12 and 13, 1971 is forwarded for action.

These inspections included an in-depth review of the licensee's management of radwaste, similar to those recently performed at Ginna, Nine Mile Point and Dresden. As you are aware, similar results were obtained and added up to several safety/noncompliance items warrenting formal enforcement action. You have our proposed enforcement letter which was forwarded in advance of this report.

The findings pertaining to radwaste management were a disappointment to us especially in light of the positive signs received during our recent audit of management systems. All the more reason to go the formal enforcement route. With regard to the specific deficiencies noted, subsequent telecons with the site indicate that proper corrective action has been or is being implemented. An inspection is currently underway (June 22 - 25, 1971) and will include followup in these areas.

McDermott's inspection included followup on several of the deficiencies identified in our management systems audit. More will be covered during the current inspection including a visit to Parsippany, tentatively set for the week of June 28. One of the areas reviewed during the April inspection was the surveillance testing program. Although JC is still not completely on top of this, they are in a much better position than before, especially with a full time coordinator of surveillance testing activities.

This report documents early information on the core spray system water hammer problem. Keppler/Nolan have been kept informed of subsequent developments. The significance of the problem (possible

B/415

OFFICE ▶	CO					
SURNAME ▶	Carlson:smg					
DATE ▶	6/23/71					

overstressing of system piping) makes this a reportable (10 day) event for which they are overdue. Communications with McCluskey in this regard have been unfruitful. This was impressed upon Finfrock in a call to him on this matter by McDermott on June 22. It is now our understanding that a report will be submitted in the very near future.

The turbine stop valve closure scrams (Nos. 14 and 15) highlight the possibility of an event which may border on a situation like "turbine trip without bypass valve opening". The mode of turbine stop valve closure, i.e., momentary loss of oil pressure, was reported to have resulted in some delay of bypass valve opening. McDermott has discussed the delay aspects of this event with Bill Farmer, Technical Support Branch, who indicated that he intended to pursue this with GE during a meeting scheduled for May 19, 1971. Our review of the transients for the two scrams in question did not disclose any concerns.

The station staff has been augmented further. Although not all are destined for Oyster Creek (some to go to Forked River 1) this facility should benefit during the interim.

JC has experienced a number (13 at time of inspection) of LPRM failures. Nine Mile Point has a similar problem. The cause, moisture via connectors outside vessel but inside drywell, apparently is the same in each case.

You will note that GE's metallurgical analysis of the previously reported failure of a push-pull rod in the turbine bypass valve control system showed that the material was not in accordance with design specifications. JC has been unsuccessful thus far in getting more details from GE. All four affected rods at OC-1 have been replaced.

The following matters are also spoken to in the report:

1. Scram history data (your memorandum dated 2/8/71).

2. Aircraft overflights (your memorandum dated 2/1/71).

3. Leak detection equipment and procedures (you memorandum dated 3/2/71).

It should be noted that Mr. G. Fredrickson, GAO, accompanied the inspectors on all dates as part of their audit of Region I.

R. T. Carlson
Sr. Reactor Inspector

Enclosure:
CO Report No. 219/71-1

U. S. ATOMIC ENERGY COMMISSION
DIVISION OF COMPLIANCE
REGION I

Field Notes for:

CO Inspection Report No. 50-219/71-02

Subject: Jersey Central Power & Light Co.

Oyster Creek 1 License No. DPR-16

Location: Forked River, N. J. Priority

Category C

Type of Licensee: BWR

Type of Inspection: Routine, Announced

Dates of Inspection: June 22-25 & July 2, 1971

Dates of Previous Inspection: April 6-8, 12, 13, 1971

Principal Inspector: R. J. McDermott 8/2/71
Date

Accompanying Inspectors: L. B. Higginbotham; F. S. Cantrell
Date

T. Young; R. T. Carlson
Date

Other Accompanying Personnel: None
Date

Reviewed By: R. T. Carlson 8/23/71
Date

Proprietary Information: None

8/4/6

OYSTER CREEK - 1 Inspection

22, 23, 24 June 71

Higginbotham

B/419

SECTION I

Enforcement Action

None

Licensee Action on Previously Identified Enforcement Matters

A. Due to a procedural error in counting and analysis of liquid waste effluent it appeared that total radioactivity released had been underestimated for the year 1970. Corrective action to preclude recurrence of this error was verified during the inspection. OC-1 plans to report corrected values for total activity released in their next semiannual report to the AEC.

B. The procedural error in counting and analysis of wastes also caused OC-1 to exceed the technical specification limit for total activity in outside waste storage tanks. Corrective action to prevent recurrence was verified during the inspection.

C.

Unresolved Items

? none from me.

Status of Previously Reported Unresolved Items

A. A review of records and discussions with plant personnel during the last inspection disclosed that OC-1 had apparently not utilized the waste treatment system in a manner to limit or maintain the release of radioactive liquid effluents as low as practicable during a major portion of 1970. Examination of records disclosed that effective use of the waste treatment system had begun in November 1970 and the volumes and total activity had decreased since that time. This inspection disclosed an apparent further reduction in volumes and total activity. OC-1 had instituted a program to control and further limit releases of waste to the environment.

B.

SECTION II

Additional Subjects Inspection, Not Identified in Section I, Where No Deficiencies Or Unresolved Items Were Found

1. Radiation Protection

   a. Personnel monitoring records January 1970 to March 1971.

   b. Survey records January to April 1971.

2. Radioactive Waste Systems

   a. Logs and records January 1970 to May 1971.

   b. Procedures for counting and analysis.

3. Environmental Monitoring

   a. Records for January 1970 to December 1970.

OYSTER CREEK - 1 Field Notes

22, 23, 24, June 71

Higginbotham

FIELD NOTES

Details of Subjects Discussed In Section I (and in last inspection report.)

Liquid Waste System Description (Figure 1) (discussion from FSAR)

1. Low Conductivity Wastes. Low conductivity (high purity) liquid waste from piping and equipment drains are collected in: (a) the drywell equipment drain sump, (b) the reactor building equipment drain tank, and (c) the turbine building equipment drain sumps. Such wastes from piping and equipment drains are transferred to the waste collector tank in the radwaste building. This tank will also collect wastes from the fuel pool, reactor cleanup system, absorption chamber, spent resin and filter sludge dewatering, and low conductivity condensate demineralizer backwash water.

   Low conductivity wastes collected in the waste collector tank and waste surge tank are processed through a pressure precoat filter (waste filter) and a mixed bed demineralizer (waste demineralizer) and then collected as a batch in one of two waste sample tanks. After these wastes are sampled and analyzed, they are normally transferred to the condensate storage tank Processed water may be returned to the waste collector tank for recycle through the system.

2. High Conductivity Wastes. High conductivity (low purity) liquid waste (primarily from floor drains) is collected in: (a) the radwaste building floor drain sumps; (b) the reactor building floor drain sumps; (c) the turbine building floor drain sumps; and (d) the drywell floor drain sump. Such high conductivity waste is transferred to the floor drain collector tank in the radwaste building.

High conductivity wastes are processed through a pressure precoat filter (floor drain filter) and then collected as a batch in one of two floor drain sample tanks. After these wastes are sampled and analyzed, they are normally discharged to the circulating water discharge canal.

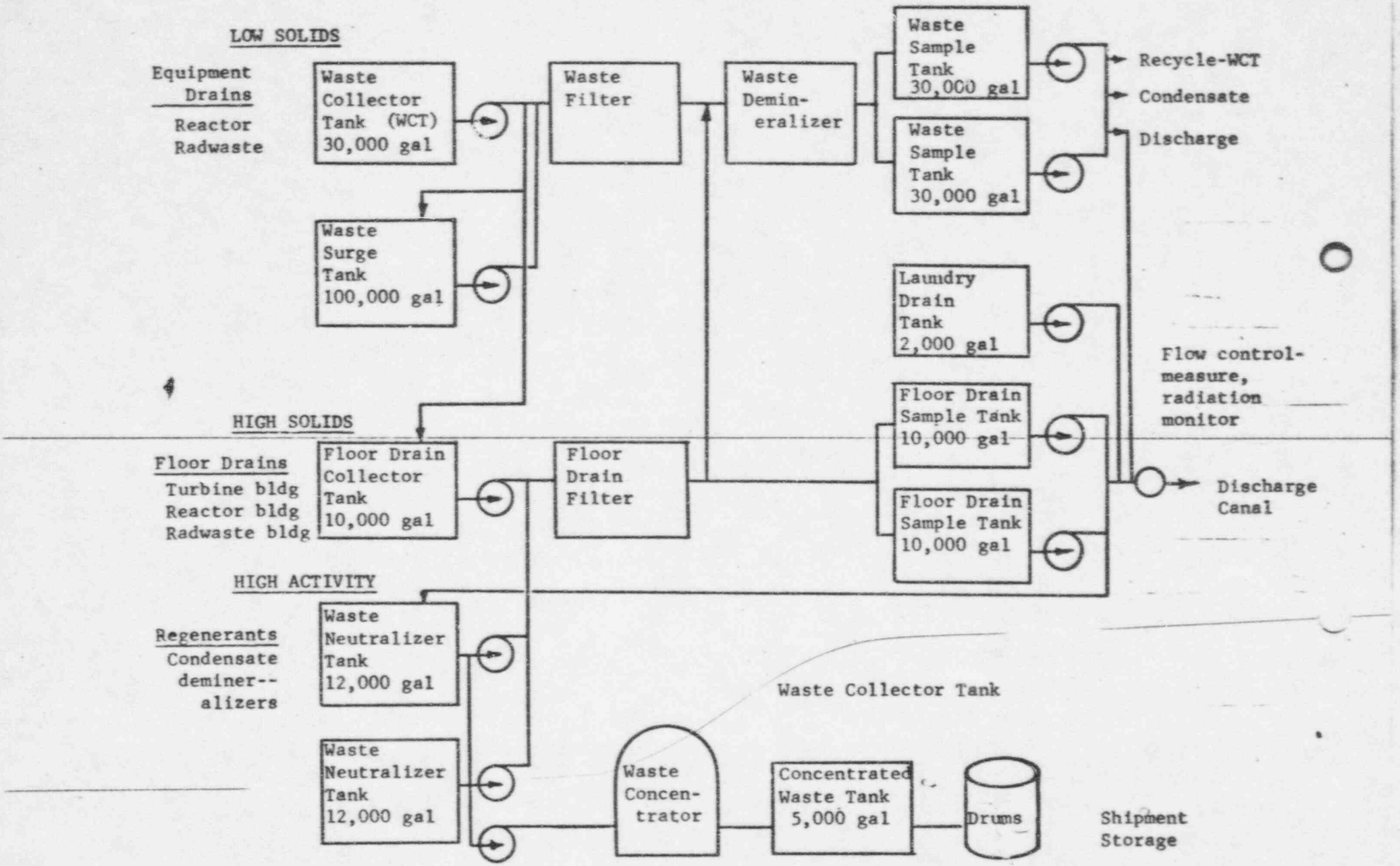
3. Chemical Waste. High conductivity chemical wastes such as laboratory drains and condensate demineralizer regeneration solutions are collected and pumped to the waste neutralizer tank in the radwaste building.

Chemical wastes collected in the neutralizer tank are sampled and neutralized as required. Those batches having sufficiently low concentrations of radioactive material for off-site discharge will be filtered and received in the floor drain sample tank.

After sampling and analysis, this waste will be discharged to the circulating water discharge canal. Those batches which are too high in concentration for off-site discharge are concentrated in the waste concentrator and the condensate liquid is sent to the waste collector tank.

4. Miscellaneous Liquid Waste. Primary system water resulting from refueling and startup operation is discharged through the fuel pool filter and demineralizer and reactor cleanup system to the condenser hotwell and returned to condensate storage.

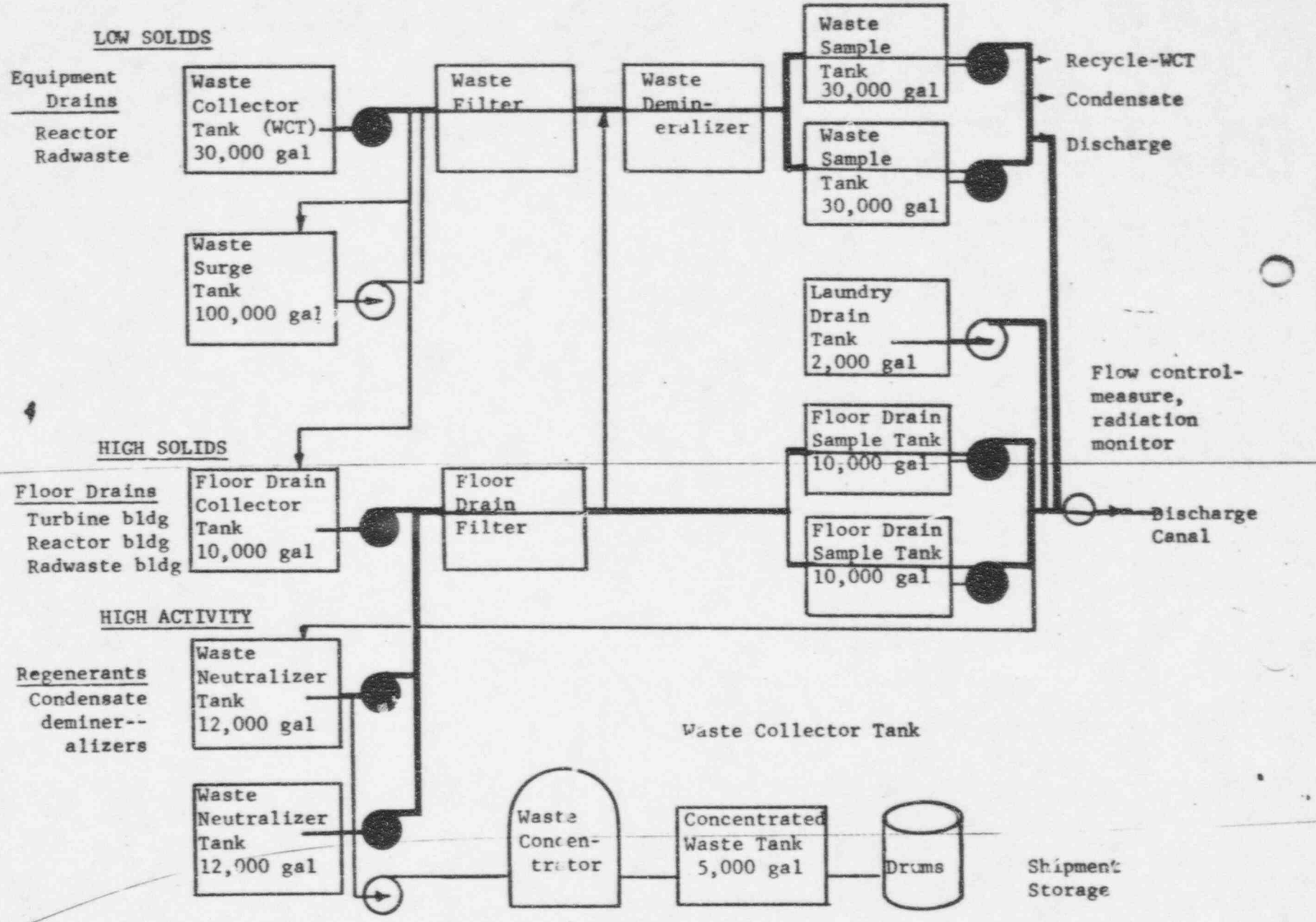
Liquid waste from laundry operation and waste from shipping cask decontamination are collected in the laundry drain tank. After sampling and analysis these wastes are discharged to the circulating water discharge canal.

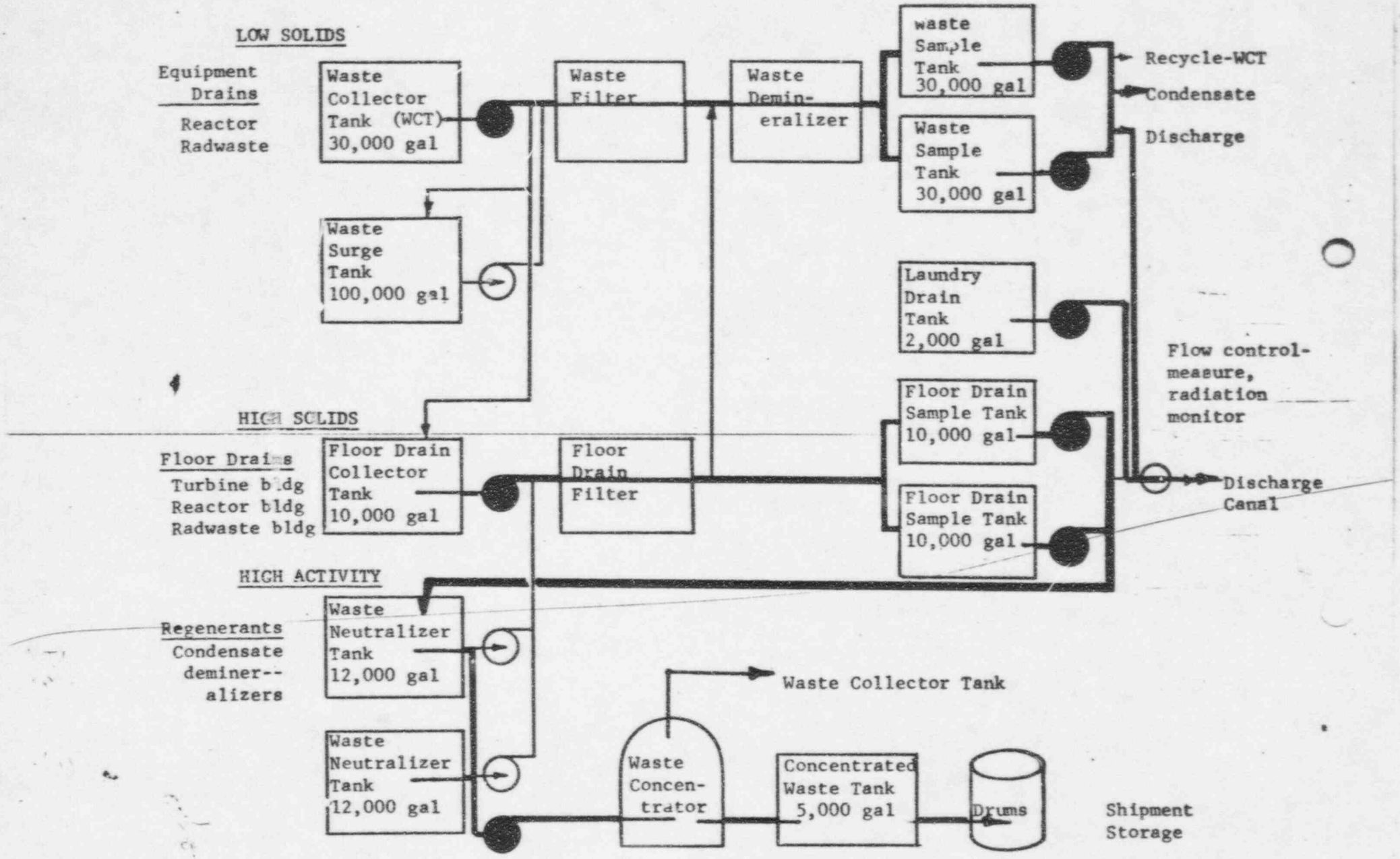

LOW SOLIDS
Equipment Drains
Reactor Radwaste
Waste Collector Tank (WCT) 30,000 gal
Waste Surge Tank 100,000 gal
Waste Filter
Waste Demin-eralizer
Waste Sample Tank 30,000 gal
Waste Sample Tank 30,000 gal
Recycle-WCT
Condensate
Discharge
Laundry Drain Tank 2,000 gal
Flow control-measure, radiation monitor
HIGH SOLIDS
Floor Drains
Turbine bldg
Reactor bldg
Radwaste bldg
Floor Drain Collector Tank 10,000 gal
Floor Drain Filter
Floor Drain Sample Tank 10,000 gal
Floor Drain Sample Tank 10,000 gal
Discharge Canal
HIGH ACTIVITY
Regenerants
Condensate deminer--alizers
Waste Neutralizer Tank 12,000 gal
Waste Neutralizer Tank 12,000 gal
Waste Collector Tank
Waste Concen-trator
Concentrated Waste Tank 5,000 gal
Drums
Shipment Storage

5. System Performance (CO rpt 71-01, attachment 1, par E)

The last inspection disclosed that the licensee had been "unsuccessful in determining what the (design) objectives (of the waste system) are". Substantial variances were observed in actual use of the radwaste system as compared with statements in the FSAR: (a) the majority of liquid wastes in waste collection drains were intended to be reused as condensate; however, during 1970 less than 10% were processed for reuse with the remainder discharged to the environment, (b) chemical wastes were to be sampled and concentrated with the distillate processed to the waste collection system. During 1970 essentially all such waste was discharged to the environment through the floor drain system, (c) actual concentrations of radioactivity in the floor drain system ranged from 20 to 100 times the expected value of 0.5×10^{-4} μCi/ml and, (d) actual isotopic concentrations and activity composition of liquid wastes were found to vary substantially from expected values listed in the FSAR.

The licensee reported (Pelrine, Stoudnour, Ross) that shortly after the last inspection the concentrator had been employed about 16 to 18 hours per day, primarily for floor drain liquids. Figure 3 shows the major flow paths for liquids processed in the system at the present time.


LOW SOLIDS
Equipment Drains
Reactor Radwaste
Waste Collector Tank (WCT) 30,000 gal
Waste Filter
Waste Demin-eralizer
Waste Sample Tank 30,000 gal
Waste Sample Tank 30,000 gal
Recycle-WCT
Condensate
Discharge
Waste Surge Tank 100,000 gal
Laundry Drain Tank 2,000 gal
Flow control-measure, radiation monitor
HIGH SOLIDS
Floor Drains
Turbine bldg
Reactor bldg
Radwaste bldg
Floor Drain Collector Tank 10,000 gal
Floor Drain Filter
Floor Drain Sample Tank 10,000 gal
Floor Drain Sample Tank 10,000 gal
Discharge Canal
HIGH ACTIVITY
Regenerants
Condensate deminer--alizers
Waste Neutralizer Tank 12,000 gal
Waste Neutralizer Tank 12,000 gal
Waste Collector Tank
Waste Concen-trator
Concentrated Waste Tank 5,000 gal
Drums
Shipment Storage


LOW SOLIDS
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Recycle-WCT
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Waste Surge Tank 100,000 gal
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Flow control-measure, radiation monitor
HIGH SOLIDS
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Reactor bldg
Radwaste bldg
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HIGH ACTIVITY
Regenerants
Condensate deminer--alizers
Waste Neutralizer Tank 12,000 gal
Waste Neutralizer Tank 12,000 gal
Waste Collector Tank
Waste Concen-trator
Concentrated Waste Tank 5,000 gal
Drums
Shipment Storage

Table 1 shows the volumes of liquid waste processed through the system and a breakdown of volumes discharged to the environment and volume recycled for use within plant systems. Table 2 shows a breakdown of waste discharges by volumes from the waste sample tanks and floor drain sample tanks.

6. Waste Releases (CO rpt 71-01, attachment 1, par B)

Table 3 shows total activity discharged from the plant in two columns; one value is that reported by the licensee in semi-annual reports and based on their gross beta analysis, the other value is the "corrected" total activity which the licensee intends to report as a result of the last inspection. The corrected totals do not include dissolved gaseous activity, i.e., Xenons, which have been identified in samples of processed waste collection system water.

The basis for the correction factor of waste releases for the year 1970 (multiplying reported values by 4.1) was explained by Ross (the data was also presented to ACRS by Ross):

a. Comparison of an OC-1 gamma spectrum analysis for 1970 to a gross Beta count used for a release gave a factor of 6.2; total gamma activity / gross beta = 6.2.

b. Comparison of results of isotopic analysis between OC-1 and three other laboratories (Radiation Management Corp, Isotopes, Inc, General Electric) indicated that OC-1

Table - 1

Oyster Creek - 1 Waste Release Data

Gallons x 10^3

1970	Released		Returned	Total Processed	Cumulative
Jan	1309.2			1309.2	1309.2
Feb	1014.0			1014.0	2323.2
Mar	1174.6		167.1	1341.7	3664.9
Apr	1047.2			1047.2	4712.1
May	977.3			977.3	5689.4
Jun	1100.3			1100.3	6789.7
Jul	1153.2			1153.2	7942.9
Aug	1492.4			1492.4	4435.3
Sep	1289.8			1289.8	10725.1
Oct	1230.1			1230.1	11955.2
Nov	1161.0	*	93.0	1254.0	13209.2
Dec	673		643.3	1316.3	14525.5
1971					
Jan	590.0		805.6	1395.6	15921.1
Feb	748.8	**	440.6	1189.4	17110.5
Mar	977.2		349.1	1326.3	18436.8
Apr	748		302.7	1050.7	19487.5
May	517	***	796	1313.0	20808.5
Jun	244	****	1000	1244	22052.5

* Stoudnour hired to supervise waste system

** Leak developed in a makeup line from demin water tank to condensate storage tank; inleakage to condensate storage tank which prevented reuse of some water processed in waste system therefore it had to be released.

*** May 10 the leak (**) was repaired.
Total also includes about 8000 gallons from laundry tank.

**** Total includes about 8000 gallons from laundry tank.

Table 2

Oyster Creek - 1 Waste Release Data

Gallons x 10^3

Source of Liquid Releases from Waste System

1970	Waste Sample Tank	Floor Drain Tank	Total
Jan	597.8	711.42	1309.2
Feb	477.8	536.2	1014.0
Mar	518.3	656.3	1174.6
Apr	533.1	514.1	1047.2
May	367.6	598.7	977.3
Jun	645.6	454.7	1100.3
Jul	675	478.2	1153.2
Aug	926.2	566.2	1492.4
Sep	819.8	470.0	1289
Oct	736.9	493.2	1230.1
Nov	726.4	434.6	1161.0
Dec	190.9	482.1	673
1971			
Jan	144.2	445.8	590.0
Feb	508.4	240.4	748.8
Mar	683.6	293.6	977.2
Apr	606.0	142	784
May	460	49	509
Jun	219	7	226

Table 3

Oyster Creek - 1 Liquid Waste Releases

	Curies		
		Unidentified	
1970	Tritium	Reported	Corrected
Jan	2.62	0.283	1.16
Feb	1.38	0.424	1.74
Mar	2.18	0.196	0.804
Apr	1.88	0.185	0.759
May	0.87	0.060	0.246
Jun	1.42	0.613	2.51
Jul	1.89	0.721	2.96
Aug	2.55	0.461	1.89
Sep	1.99	0.353	1.45
Oct	1.72	0.392	1.61
Nov	1.93	0.495	2.03
Dec	1.41	0.320	1.31
Totals		Xenons from pg	
1971			
Jan	1.67	0.354	1.45
Feb	2.3	0.518	1.73
Mar	2.14	0.952	2.86
Apr	1.84	0.918	0.96
May	1.31	0.884	0.884
Jun	Not available	0.44	0.44

While OC-1 still reports activity other than tritium as"unidentified" the total curies are based on results of isotopic analysis of each batch release. However, even though identification is made the release is controlled on the basis of 1×10^{-7} μCi/ml.

results were high in all cases. A total of four samples were used in the evaluation, one laboratory analyzing two samples. Results showed OC-1 to be high by factors of 1.96, 1.20, 1.49, 0.7, 0.8. OC-1 then used another correction factor from this data of 1.5 which was applied to the 6.2 factor from paragraph a above: 6.2 / 1.5 = 4.1, and 1970 values of total activity are to be multiplied by this value. 1971 values for total activity, January through April, are corrected in a similar manner; however, the value varies for each month according to the amount of activity that was released based on gross beta analysis. Beginning in May 1971 all releases are being made on the basis of isotopic analysis: 18 beta-gamma emitters by gamma isotopic analysis, Xenon 133, 135, tritium, and strontium-90. Each batch is analyzed in this manner except that a value for strontium-90 is used based on the experience from several sample analyses; infrequent re-sampling is performed to verify the strontium-90 value used.

Ross was reluctant about reporting an estimate of noble gases or Xenons released in liquid discharges. He said that it would be difficult, if not impossible, to reconstruct enough data upon which to base a value. I outlined one method for Ross which I feel has as sound a basis as the one used to correct total activity. Analysis of waste sample tanks show the presence of

Xenon 133,135 in the range of 10^{-4} μCi/cc, whereas results of analysis of floor drain system liquids do not show the presence of Xenons. The apparent absence of the gas in floor drain liquids can be explained by (1) it is indeed not present or, (2) the activity is masked, in the gamma spectrum, by the presence of plutonium-239 and/or other activity. It is detectable in the waste collection system because the gamma spectrum is fairly clean due to removal of the major portion of the activity in filters, concentrator, and the demineralizer. Further, one would not expect significant if any amount of the gas in floor drain liquids because they have probably evolved from exposure in sumps and other portions of the system.

If an estimate, better termed a guess, must be made of dissolved gases released in liquids, the method following is as good as any:

a. From a review of records at OC-1 for the period of May 15, 1971 through June 20, 1971 where the results of 77 analyses of waste samples showed the presence of Xenon-133, 135 the average concentration of the gases was about 2×10^{-4} μCi/ml. Xenons were identified in analysis of waste sample tanks and never in floor drain sample tanks.

b. The total volume of liquid waste released in 1970 was 13.6×10^{6} gallons; 7.2×10^{6} from waste sample tanks and

6.4 x 10^6 gallons from floor drain sample tanks. If the assumption is made that all liquids released contained dissolved gases then

'13.6 x 10^6 gallons)(2 x 10^{-4} μCi/ml) = 10.3 Curies

would be the guesstimate. If the assumption is made that Xenons were present only in waste sample tank releases then

(7.2 x 10^6 gallons)(2 x 10^{-4} μCi/ml) = 5.4 Curies

would be the guess. However, a review of gaseous releases reveals that total curies released per month increased from a low of about 3500 to a high of about 14,400 during 1970. The values reported for 1971, January through May, varied from about 16,700 curies to the high (in May) of 35,000 curies. Correcting these values reported for total curies to amounts of Xenon-133,135 (from averaging percent of composition by isotope in gas analyses) the average curies of Xenon-133,135 released per month in 1970 is about 1,633; the average curies of Xenon-133,135 released for the months of April and May 1971 (June is not available as yet; May and June are the months for which Xenon-133,135 values are averaged for a "gas in liquid" concentration) is about 4,833. If the assumption is made that Xenon-133,135 dissolved in liquids is proportional to that produced and released, then the estimated values for gas in water given above can be corrected by the factor

1970 average/1971 period average = 1633/4833 = 0.34

If the assumption is that all liquids released contained Xenons the gaseous activity in liquids is

10.3 Curies X 0.34 = 3.5 Curies as a guess.

If the assumption is that Xenons were present only in waste sample tank releases the gaseous activity in liquids is

5.4 Curies X 0.34 = 1.8 Curies as a guess.

7. Isotopic Composition/Distribution (CO rpt 71-01, attachment 1)
A review of the results of startup test number 1, Chemistry and Radiochemistry, disclosed that measurements of iodine carryover indicated values in the order of 1 to 2 percent; concentration of iodine in steam/concentration of iodine in reactor water. This is the same range of values reported at Millstone-1. The startup test reports at both facilities state that this probably results from changes (from Dresden-1 design) in the cleanup systems and steam dryers. The values reported in both Millstone and OC-1 FSAR for isotopic composition in wastes are based on Dresden-1 experience and data.

8. Liquid Waste Monitor (CO Report 71-01, attachment 1, par D)
The background radiation problems for these monitors have been reduced to about 80 to 100 cps by replacement of contaminated (carbon steel) piping with stainless steel and addition of

external shielding. A major part of high background radiation was from external sources. The current setpoint for the alarm corresponds to a concentration of about 1×10^{-3} μCi/ml. The monitor serves an alarm function only, it does not serve to trip or close valves to halt a waste discharge. The discharge pumps from waste sample tanks are rated for 300 gpm; the dilution or circulating water flow is about 460,000 gpm; the dilution factor (at maximum discharge) would be 460,000/300 or about 1500.

To ensure that an instantaneous concentration of 1×10^{-7} μCi/ml is not exceeded in the discharge canal the monitor setpoint would be $(1 \times 10^{-7}$ μCi/ml)(1500) $= 1.5 \times 10^{-4}$ μCi/ml as compared with the selected value of 1×10^{-3} μCi/ml which is higher than the calculated value by a factor of about 10. Technical specifications allow a maximum daily average of 10 times the annual average. The volume of a waste sample tank is 30,000 gallons and at the rated maximum capacity of the pump of 300 gpm the tank would be emptied in about 1.5 hours. A continuous daily discharge at 300 gpm would amount to 432,000 gallons/day.

Gaseous Effluents

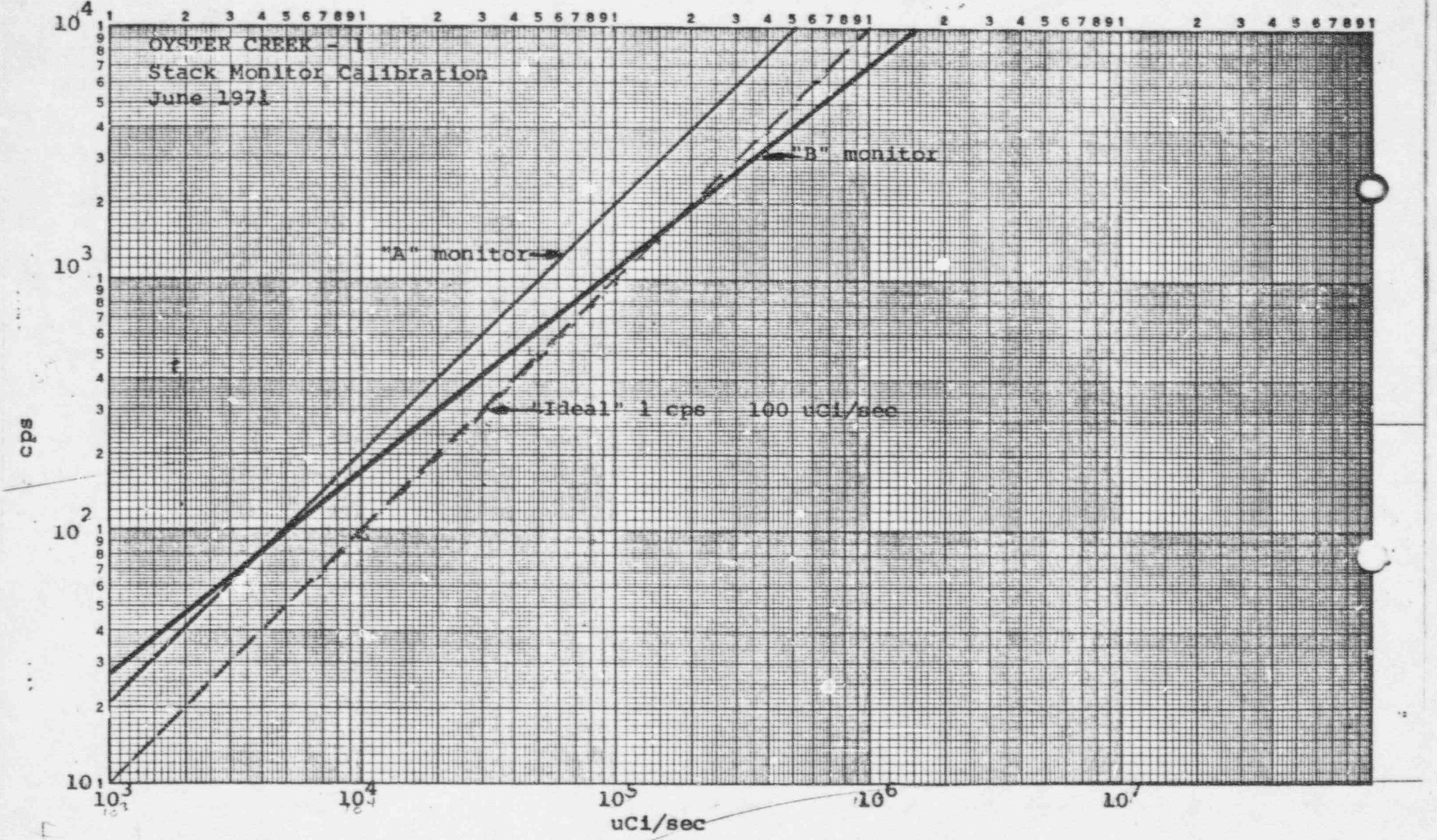
9. Stack Gas Monitors

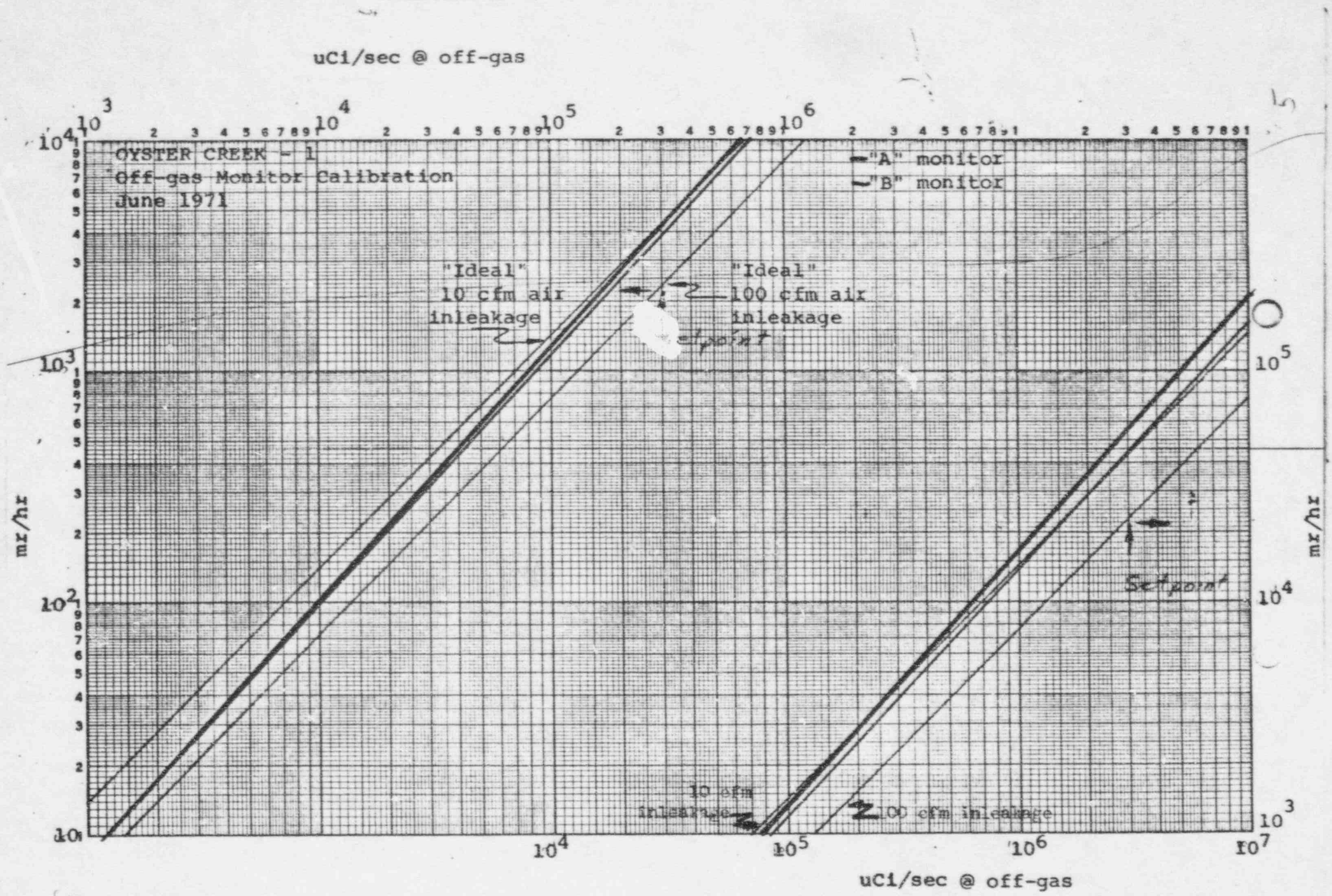
Calibration curves for the two stack gas monitors are shown in Figure 4 . The current setpoint for the "high-alarm" corresponds to a stack release of about 0.03 Ci/second, 1/10 of the annual average release rate limit; the "high-high alarm" corresponds to the annual average release rate limit of 0.3 Ci/sec. The monitors serve an alarm function only and have no isolation or trip functions.

A stack monitor calibration factor is determined on a weekly basis from (1) analysis of a grab sample of off-gas and (2) holdup time from off-gas flow determination. The indicated activity at the off-gas sample line is decayed for the holdup time and a calibration factor is determined in cps/μCi/sec. The stack gas activity as indicated by the monitors is continuously recorded (cps) and on a weekly basis the ~~weekly~~ calibration factor is applied to integrations of the readings of strip chart recorders.

10. Off-gas Monitors

Calibration curves for the two off-gas monitors are shown in Figure 5 . The current setpoint for the "high-alarm" corresponds




uCi/sec @ off-gas
OYSTER CREEK - 1
Off-gas Monitor Calibration
June 1971
"A" monitor
"B" monitor
"Ideal"
10 cfm air
inleakage
"Ideal"
100 cfm air
inleakage
Set point
Set point
10 cfm
inleakage
100 cfm inleakage
mr/hr
mr/hr
uCi/sec @ off-gas

to the 0.3 Ci/sec annual average release rate limit as measured at the off-gas monitor for air inleakage of 100 cfm; the "high-high alarm" corresponds to the 3.0 Ci/sec 48-hour release rate limit of technical specifications, the 3.0 Ci/sec is also as measured at the off-gas monitor.

At present the setpoints have two "factors of conservatism"; present air inleakage is determined to be about 10 to 30 cfm and the setpoints do not take into consideration the decay through holdup time.

The present average off-gas flow is about 110 cfm (about 15 cfm inleakage) which affords a holdup time of about 60 minutes; with 100 cfm inleakage the holdup time would be, of course, about 30 minutes.

11. Isotopic Analysis, Σ 6 vs Σ 22 Gases in Effluents

OC-1 is presently converting activity measurements of Σ 6 fission gases at the air ejector to predicted Σ 22 fission gases at the stack.

By definition: (GE BWR's)

Equilibrium component or mixture of fission gases exist when conditions are such at a long delay time (relative to half-lives of composition) is present between production of the gas and its release. The activity (A) in an equilibrium mixture = a derived constant (K_e) X the fission yield (Y):

$$A = K_e Y$$

and when data is normalized

$$K_e \text{ Krypton} = K_e \text{ Xenon} \geq K_e \text{ Iodine } (\sim X\ 10).$$

An equilibrium mixture of gases is indicative of very small holes or fuel defects. There is no consistent correlation of releases with power level; low release rates; some spiking on changes in reactor power.

Recoil component or mixture of fission gases exist when there is essentially no delay time between production and release. The activit (A) in a recoil mixture = a derived constant (K_r) X the fission yield (Y) X the decay constant (λ):

$$A = K_r Y \lambda$$

and when data is normalized

$$K_r \text{ Iodine} = K_r \text{ Xenon} = K_r \text{ Krypton} \ldots$$

An equilibrium mixture of gases is indicative of large holes or fuel defects, fuel in the coolant or fuel in contact with the coolant. Activity release rates follows power and no spiking on power changes.

Diffusion component or mixture of fission gases is the intermediate condition between the two previous conditions, i.e., there is intermediate delay time between production and release of the gas. The activity (A) in a diffusion mixture = a derived constant (K_d) X the fission yield (Y) X the square root of the decay constant ($\sqrt{\lambda}$):

$$A = K_d Y\sqrt{\lambda}$$

and when normalized

$$K_d \text{ Iodine} = K_d \text{ Xenon} = \ldots .$$

A diffusion mixture is indicative of small fuel defects. The release rates follow an exponential increase with power level, spikes occur on power changes.

Assuming the activity release is due to one of the three "pure" components described above, the following summarizes the decrease (by decay) of total activity according to holdup time; $\leq$ 6 gases measured, $\leq$ 22 gases calculated.

Equilibrium	0 minutes	$\leq$ 6	-	
	30 minutes	$\leq$ 22	-	$\Delta A = 1.2$
	60 minutes	$\leq$ 22	-	$\Delta A = 1.4$
Diffusion	0 minutes	$\leq$ 6	-	
	30 minutes	$\leq$ 22	-	$\Delta A = 1.8$
	60 minutes	$\leq$ 22	-	$\Delta A = 2.8$
Recoil	0 minutes	$\leq$ 6	-	
	30 minutes	$\leq$ 22	-	$\Delta A = 2.5$
	60 minutes	$\leq$ 22	-	$\Delta A = 5.8$

Figure 6 is a graph of the ratio of Σ 6 to Σ 22 in off-gas mixtures for various holdup times and gives an indication of relative error if the measured activity of the Σ6 gases is not corrected for the presence of the 22.

From the measurement of the 6 gases it is fairly simple to calculate the release of 22 gases, for a given holdup time, if the mixture consists of a "pure" component, i.e., recoil, diffusion, or equilibrium. If there is contribution from two or three of the components to the activity mixture the calculation becomes somewhat more involved.

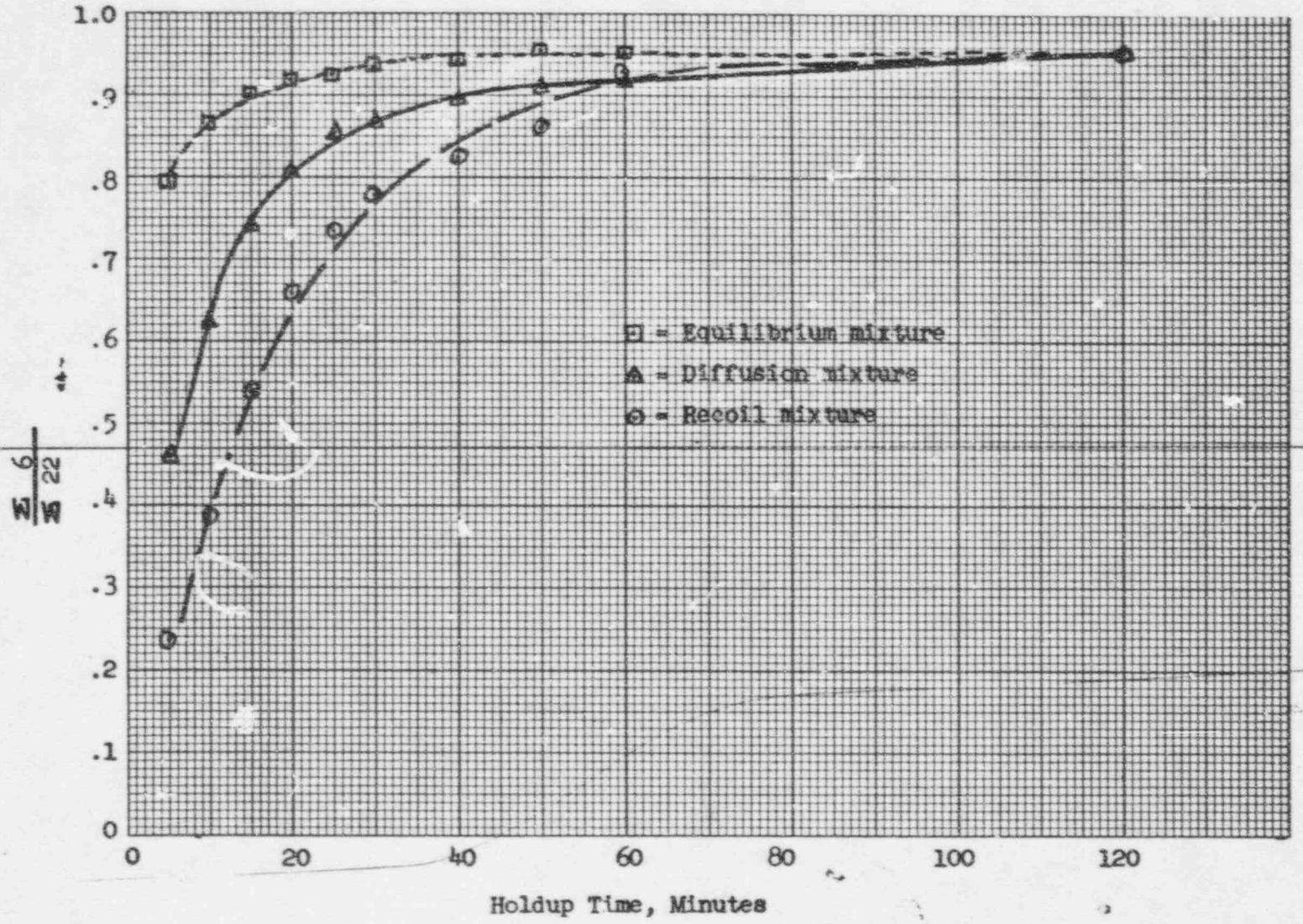
Example: $A_{recoil} = K_r \; Y \; \lambda$

$A_{equil} = K_e \; Y$

$A_{diff} = K_d \; Y \; \sqrt{\lambda}$

To normalize gaseous (and iodine) activity where two of the components are present in the mixture:

RATIO OF Σ 6 TO Σ 22 IN OFF-GAS MIXTURES FOR VARIOUS HOLDUP TIME

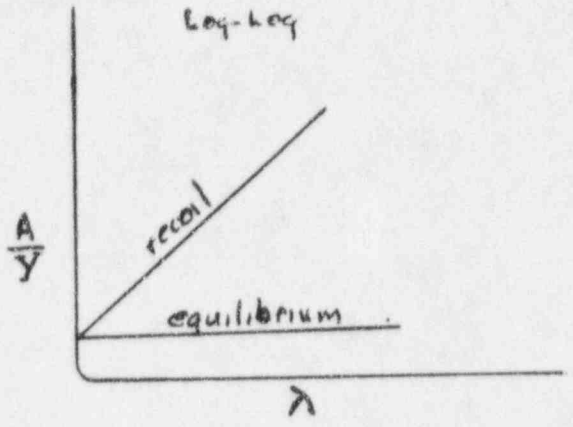


librium + Recoil

$$A_{total} = A_{recoil} + A_{equil}$$

$$= K_r Y \lambda + K_e Y$$

$$\frac{A_t}{Y} = K_r \lambda + K_e$$



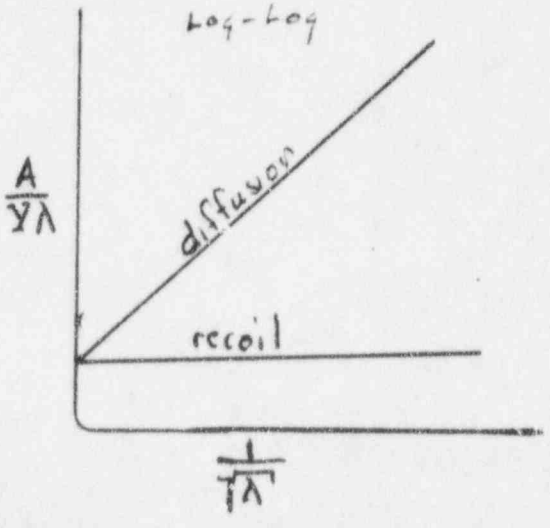
If the data from the measurement of the 6 gases is normalized and plotted on a graph such as the one above and the plot followed a horizontal line tendence, the mixture is an equilibrium mixture; if the data plotted to a slope or 45° angle the contribution is from recoil. An intermediate slope is indicative of contribution from a diffusion component.

Diffusion + Recoil

$$A_{total} = A_r + A_d$$

$$= K_r Y\lambda + K_d Y\sqrt{\lambda}$$

$$\frac{A_t}{Y\lambda} = K_r + K_d\sqrt{\lambda}$$



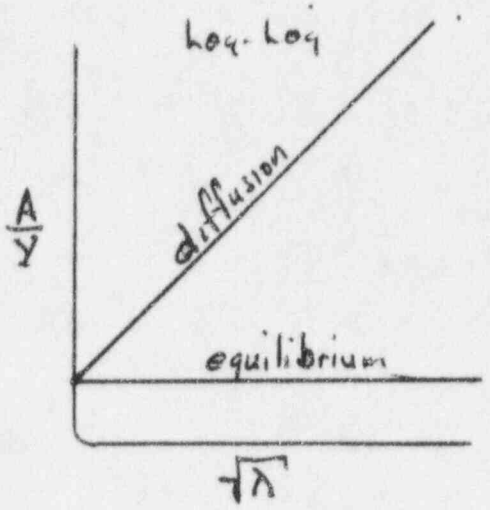
As indicated above if the slope of the plotted data follows the curves in this type plot, the activity contribution is from the component indicated. A best fit curve falling between the horizontal and a 45° angle would indicate a mixture of the two components.

Diffusion + Equilibrium

$$A_{total} = A_d + A_e$$

$$= k_d Y \sqrt{\lambda} + K_e Y$$

$$\frac{A}{Y} = k_d \sqrt{\lambda} + K_e$$

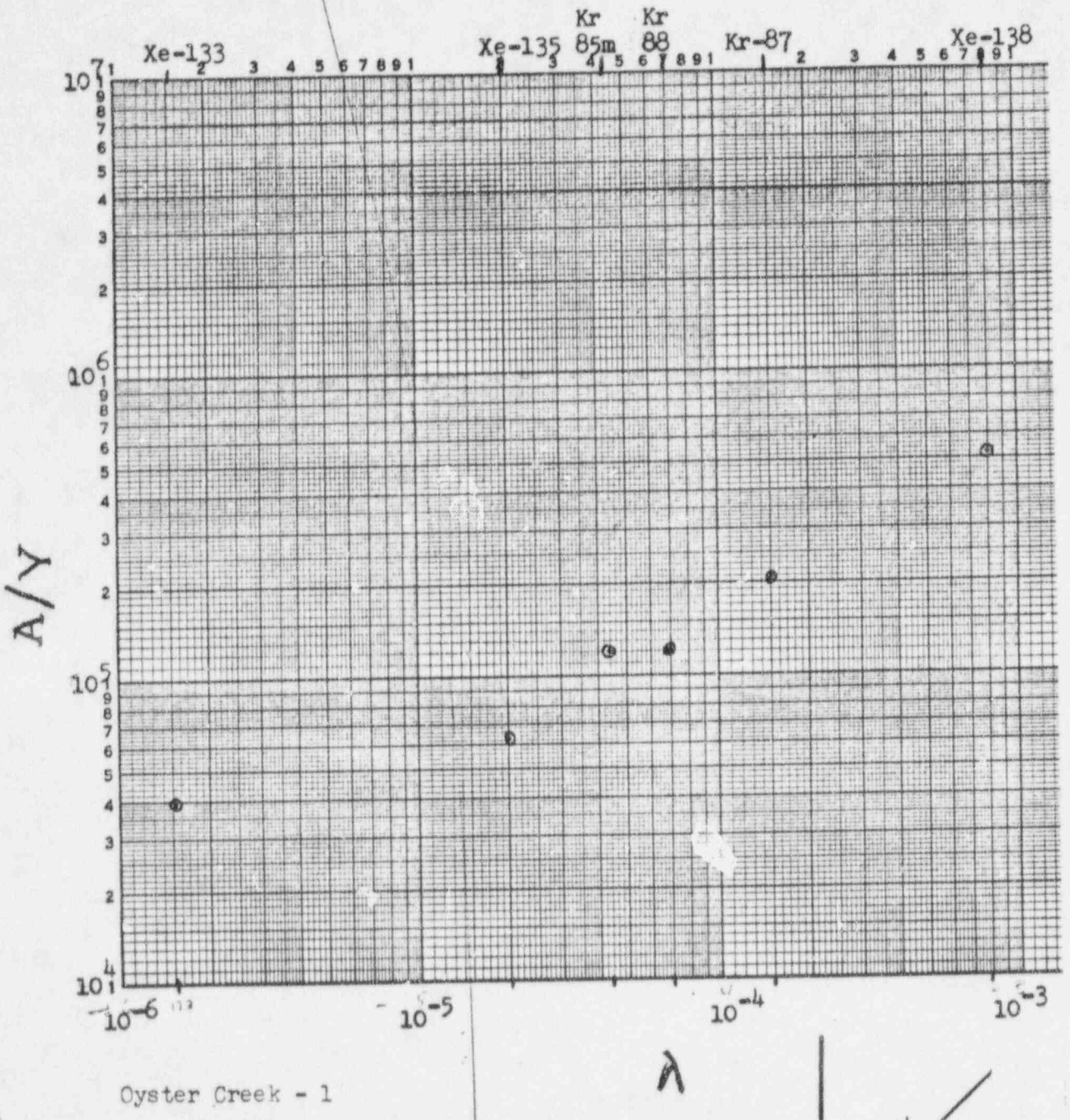


As before.

Figures 7, 8, and 9 are graphs plotted from measurement of the six gases at OC-1 on May 12, 1971.

From these figures it appears that the majority of the activity is contributed by a diffusion component with small contribution of Xenon-133 from equilibrium. Note that as the mixture strays from equilibrium toward recoil, more short-lived activity is added to the mixture; at pure recoil the majority of total activity is short-lived activity.

Another approach to graphical analysis of the mixture is to plot $1/Y\lambda$ vs λ ; this is shown on the following page with an explanation of data.

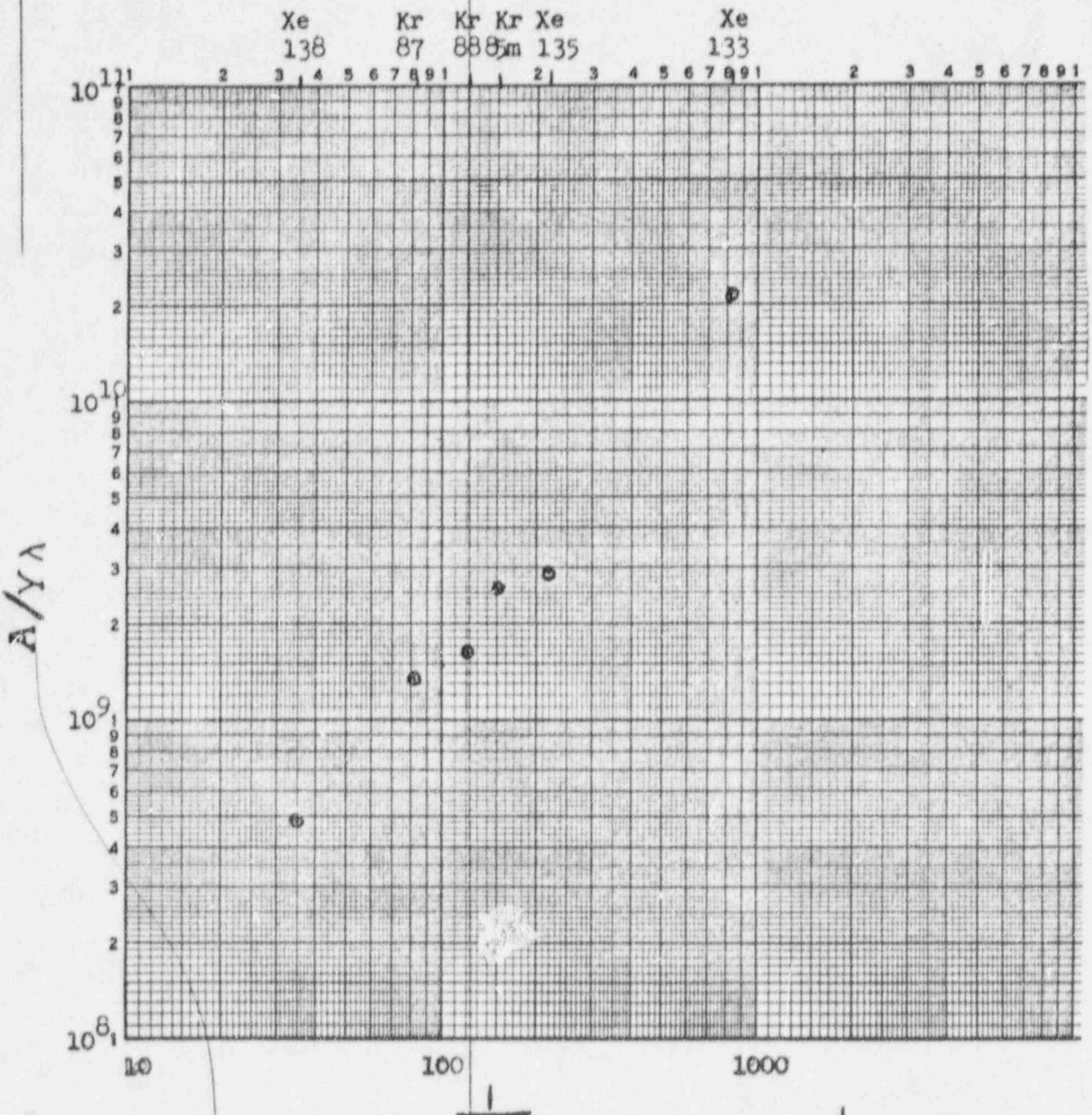


Oyster Creek - 1

Fission Gas Release Pattern

May 12, 1971

Figure 7



Oyster Creek - 1
Fission Gas Release Pattern
May 12, 1971

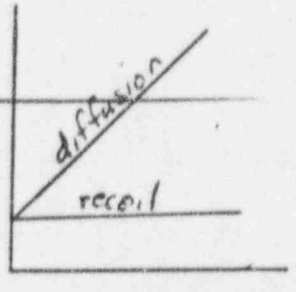
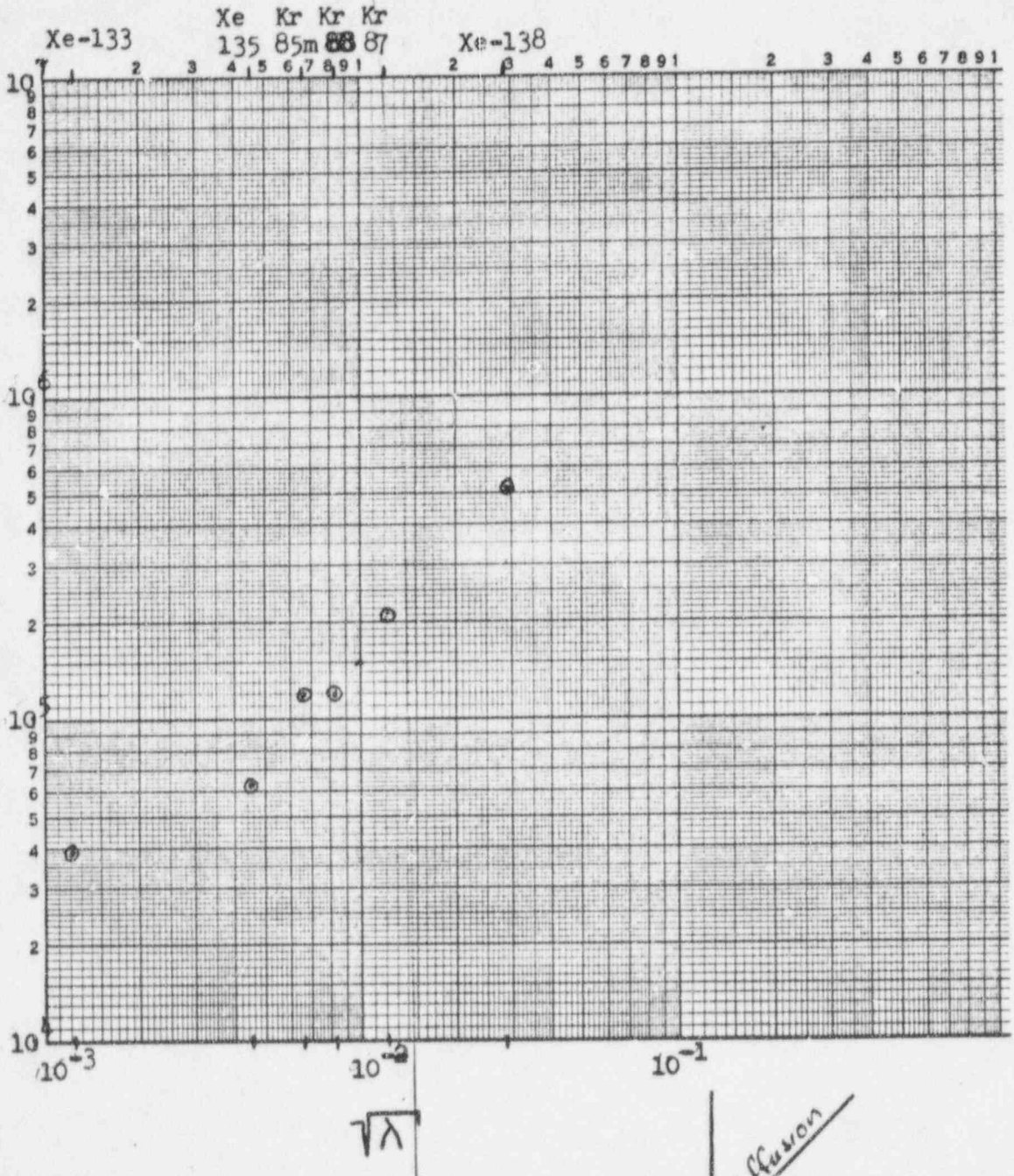


Figure 8

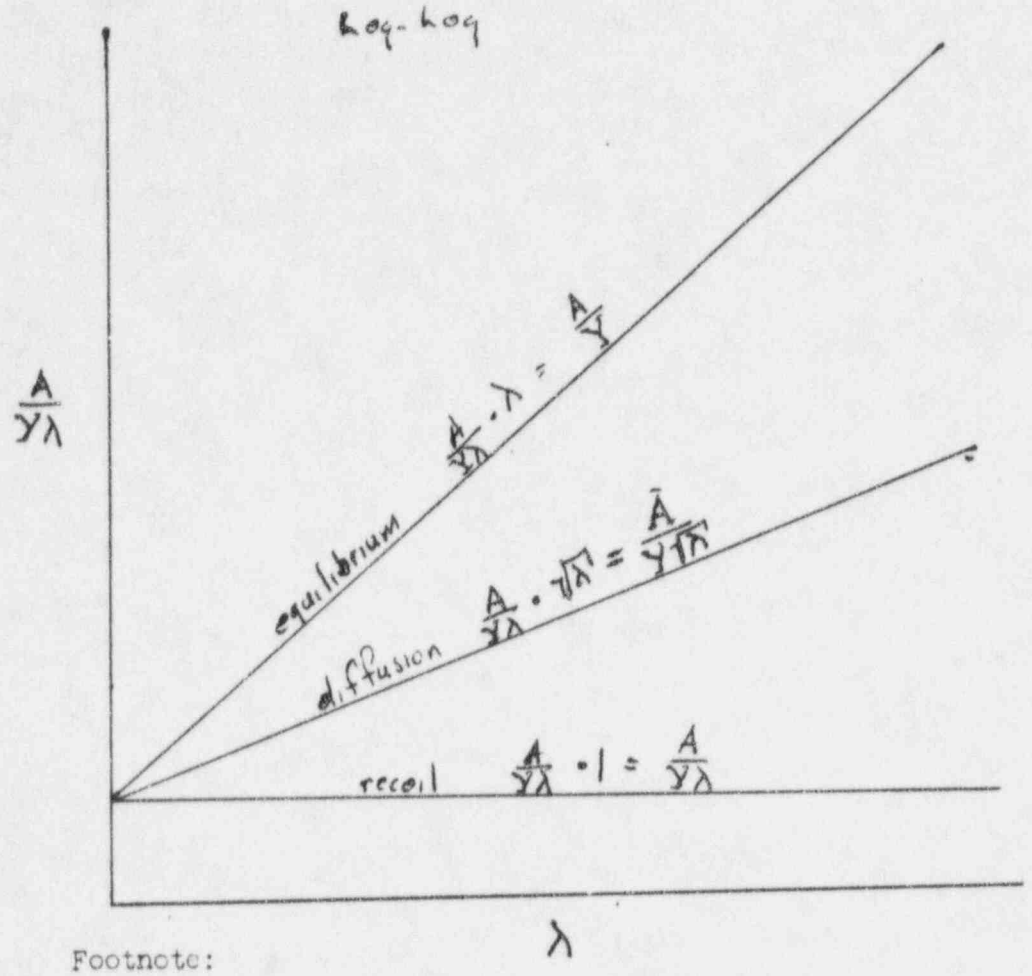


Oyster Creek - 1

Fission Gas Release Pattern

May 12, 1971

Figure 9



Footnote:

equilibrium $\frac{A}{\gamma} \times 0.263 =$ mR/sec $\Sigma\gamma$ @ S.J.A.E.

diffusion $\frac{A}{\gamma\sqrt{\lambda}} \times 2.75 \times 10^{-3} =$ mR/sec $\Sigma\gamma$ @ S.J.A.E.

recoil $\frac{A}{\gamma\lambda} \times 5.69 \times 10^{-5} =$ mR/sec $\Sigma\gamma$ @ S.J.A.E.

In this type of plot it is, I think, easier to see the type or component contribution to the gas mixture; the slopes shown are the "ideal" case for pure components. The footnote gives factors to determine, from graphed data, the total Activity for a pure mixture, e.g., from a "best fit" curve

which has been drawn through the plotted data of measurements of the six gases a point is picked on the curve; the $A/Y\lambda$ for the point is multiplied by the λ for the point (in the case of an equilibrium component) and the result is multiplied by the value in the footnote, i.e., for equilibrium, times 0.263. While the values in the footnotes may,at first, seem like some "fudge factors" they are:

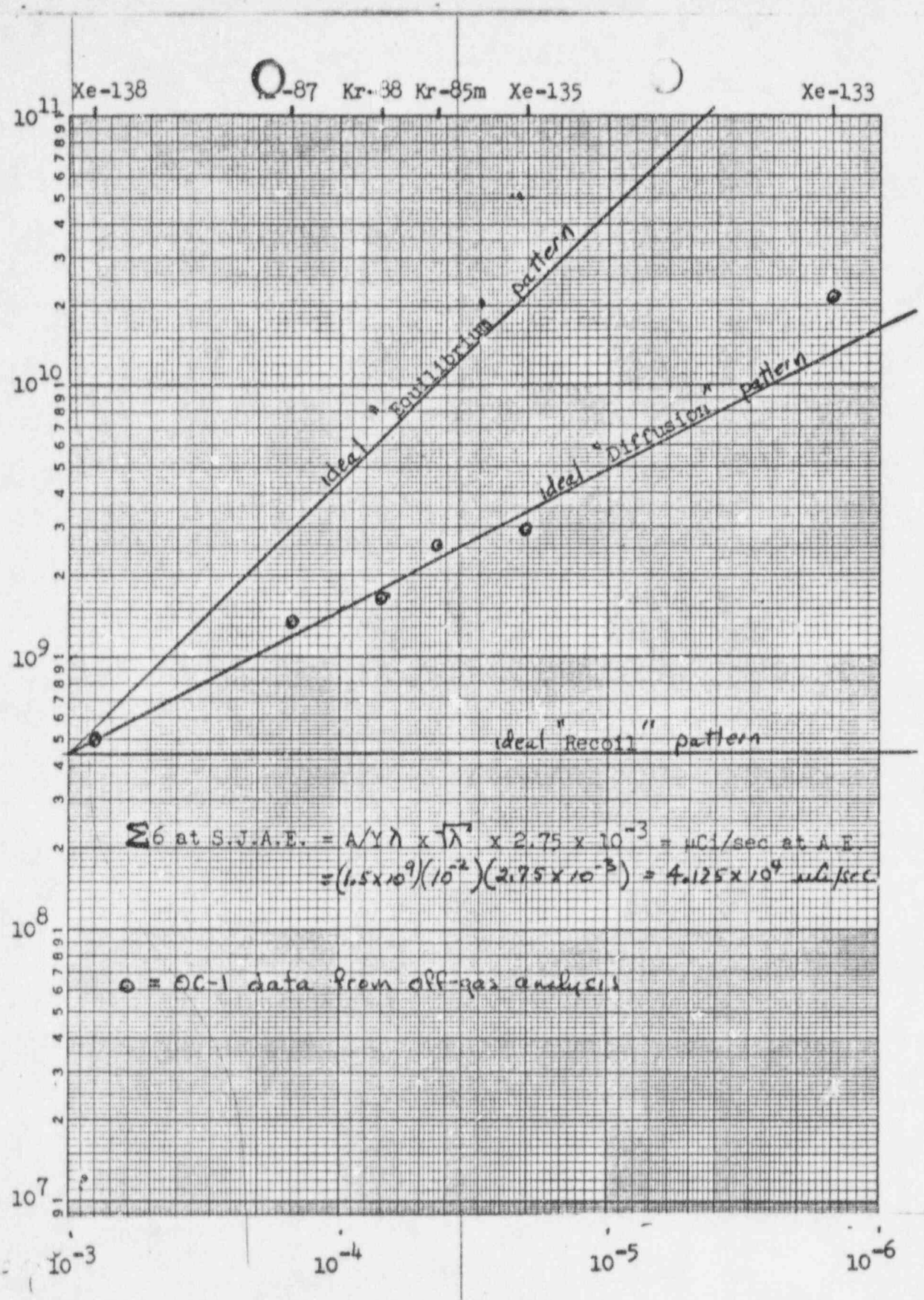
equilibrium = ≤ 6 Y = 0.263

diffusion = ≤ 6 Y $\sqrt{\lambda}$ = 2.75×10^{-3}

recoil = ≤ 6 Y λ = 5.69×10^{-5}

Figure 10 is a plot of the May 12, 1971 data from OC-1 for measurements of the 6 gases from the off-gas. The slope of the plot is indicative of a diffucion mixture. H wever, there is probably some small contribution from other components but it would appear to be relatively small.

The May 12, 1971 example was used as OC-1 had reviewed their data while evaluating the error in not accounting for the ≤ 22, i.e., comparison of ≤ 6 vs ≤ 22. In doing this type comparison D. Ross and E. O'Conner calculated a resultant curve for a theoretical mixture of the gaseous components, e.g., curves for 10% recoil, 60% diffusion, 30% equilibrium. The curves drawn for various mixtures are used in a template



Oyster Creek-1 Fission Gas Release

May 12, 1971

Figure 10

form to draw a "best curve" fit through plotted data points from an isotopic analysis ($\leq$ 6) of an off-gas sample. The template which fits a best curve line through the data points (e.g., 10% r, 60% d, 30% e template) decides the correction factors to apply to the measured activity to determine the summation of 22 gases at the stack. For their May 12 data the evaluation sheet read:

4.06×10^4 μCi/sec measured at the off-gas

1.51×10^4 μCi/sec was recorded as the stack release rate

off-gas flow indicated a 63 minuted holdup time, used 60 minutes in evaluation.

for pure components the stack release rate would have been:

recoil $\quad 4.06 \times 10^4 \cdot \dfrac{8.19 \times 10^6 \Sigma_4 @ t_{time}=0}{4.79 \times 10^7 \Sigma_{22} @ t_{time}=60m} = 6.94 \times 10^3$ μCi/Sec

equil $\quad 4.06 \times 10^4 \cdot \dfrac{1.6 \times 10^{11}}{2.2 \times 10^{11}} = 2.95 \times 10^4$

diffusion $\quad 4.06 \times 10^4 \cdot \dfrac{8.34 \times 10^8}{2.31 \times 10^9} = 1.47 \times 10^4$

30% recoil = 0.3 X 6.94×10^3 = $.21 \times 10^4$ μCi/sec

10% equil = 0.1 X 2.95×10^4 = $.30 \times 10^4$

60% diff = 0.6 X 1.47×10^4 = $.88 \times 10^4$

1.39×10^4 μCi/sec at stack

The recorded value for the stack release rate was 1.51×10^4 which is higher than the calculated value by a factor of (1.51/1.39) = 1.09, or about 9% high. If I had performed

the evaluation I would have settled for a straight or pure diffusion mixture as indicated from Figure 10. My total activity at the air ejector would have been (from Figure 10) about 4.125×10^{4} μCi/sec and the stack release rate from this would be about 1.49×10^{4} μCi/sec, as compared with their calculated value of 1.39×10^{4} μCi/sec and their recorded value of 1.51×10^{4} μCi/sec.

Examination of Figure 6 , the ratio of $\leq$ 6 to $\geq$ 22 for various holdup times indicates that the maximum error that could be experienced for a 60 minute holdup time, if only $\geq$ 6 is considered rather than $\geq$ 22, is in the order of 8%. Of the several evaluations that I examined at OC-1, some had overestimated the release rate, as in the above example, and some had underestimated the stack release rate; that is the comparison of stack release rate calculated on the basis of $\geq$ 6 vs calculation of $\leq$ 22 considering makeup of the gas mixture. The "unders" and "overs" would about balance out in the ones I examined. The maximum error of 8% given above is for a holdup time of about 60 minutes.

Figure 11 is a graph of holdup time vs off-gas flow for the holdup volume reported to be available. Following is some data of off-gas flow measurements at OC-1 that was taken from records. The values reported, or given below, are averages for the monthly periods.

1970	cfm off-gas	1971	cfm off-gas
Jan	211	Jan	105
Feb	103	Feb	104
Mar	121	Mar	111
Apr	115	Apr	108
May	117	May	108
Jun	101	Jun	109
Jul	99		
Aug	95		
Sep	95		
Oct	99		
Nov	101		
Dec	111		

The average for the 18 month period is about 112 cfm, or an average holdup time of about 63 minutes.

Figures 12 through 17 are plots of the noble gas patterns for measurements at OC-1 in June and May 1971. To the plots of noble gas patterns I have added iodine production patterns from measurements of reactor water; noble gases from isotopic analysis of off-gas grab samples, iodines from grab samples of reactor water the same date. Note that the iodine patterns parallel the noble gas patterns and are usually lower by a factor of about 10, as indicated for the normal case in discussion of component pattern analysis presented previously.

HOLDUP TIME vs OFF-GAS FLOW

(Holdup volume 6900 cu. ft.)

Oyster Creek - 1

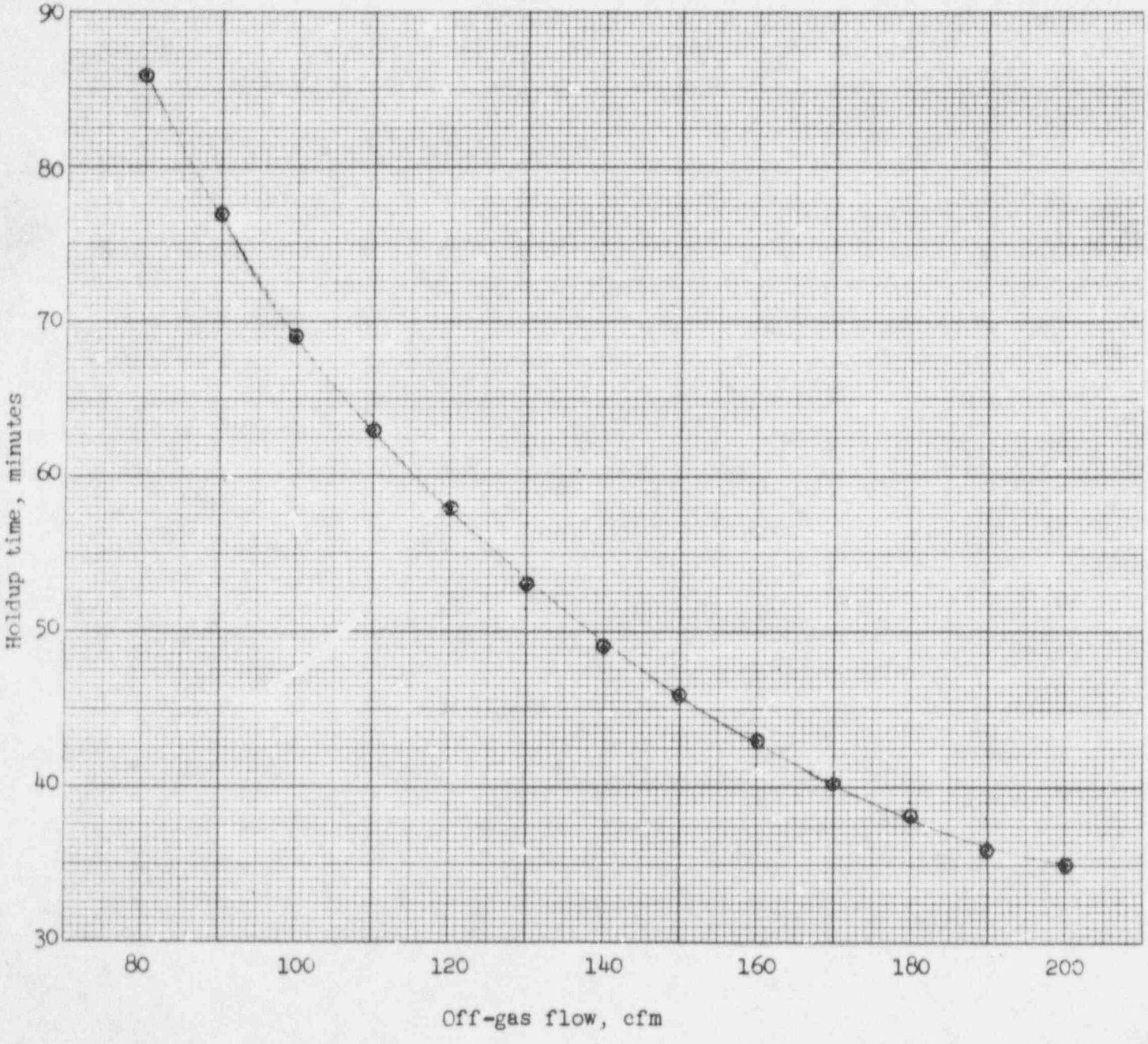
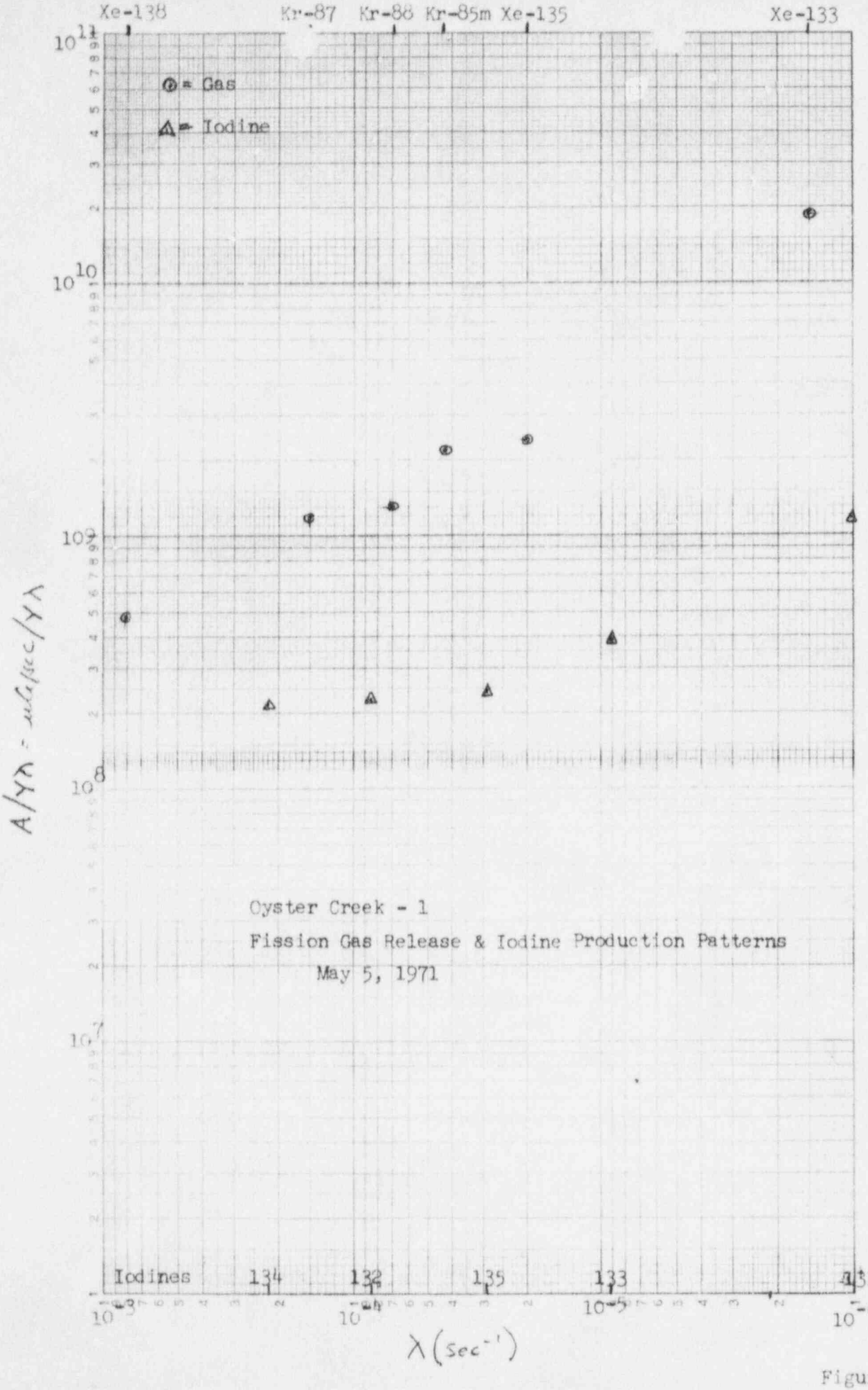


Figure 11



Oyster Creek - 1

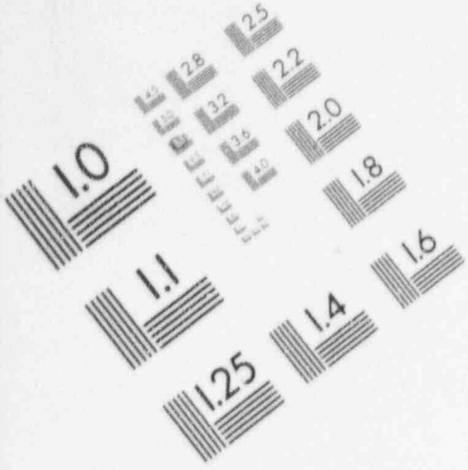
Fission Gas Release & Iodine Production Patterns

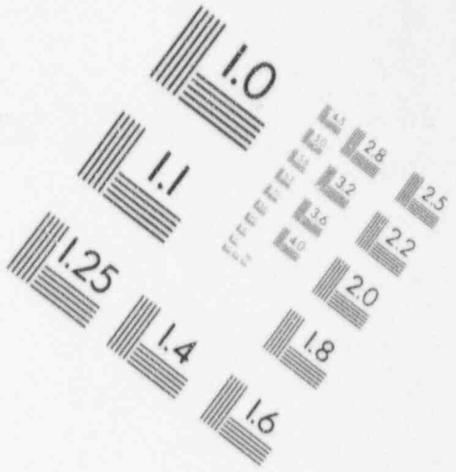
May 5, 1971

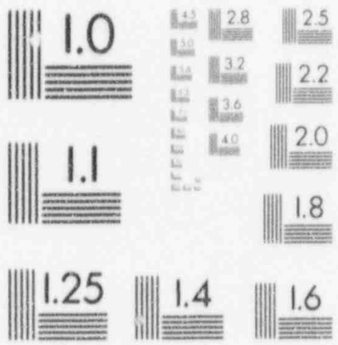
Figure 12

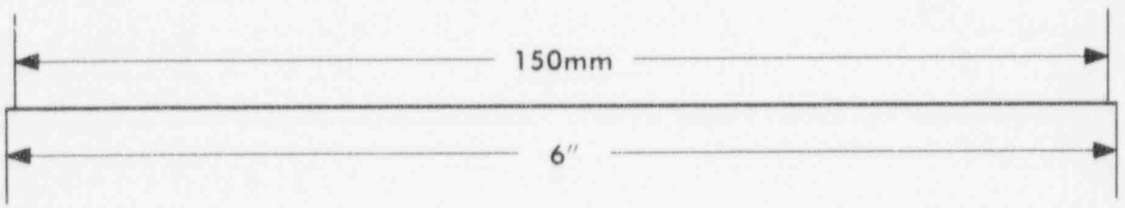
2

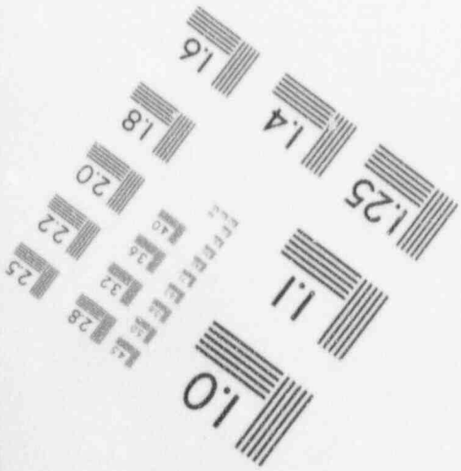
IMAGE EVALUATION TEST TARGET (MT-3)

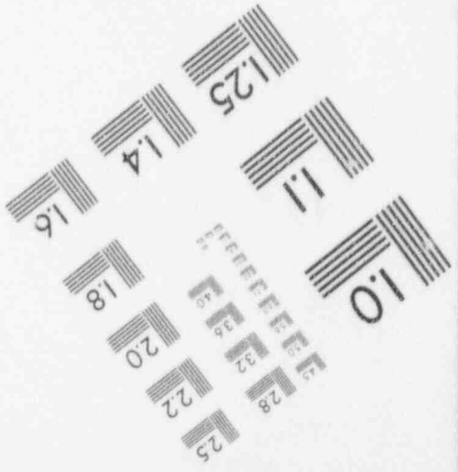












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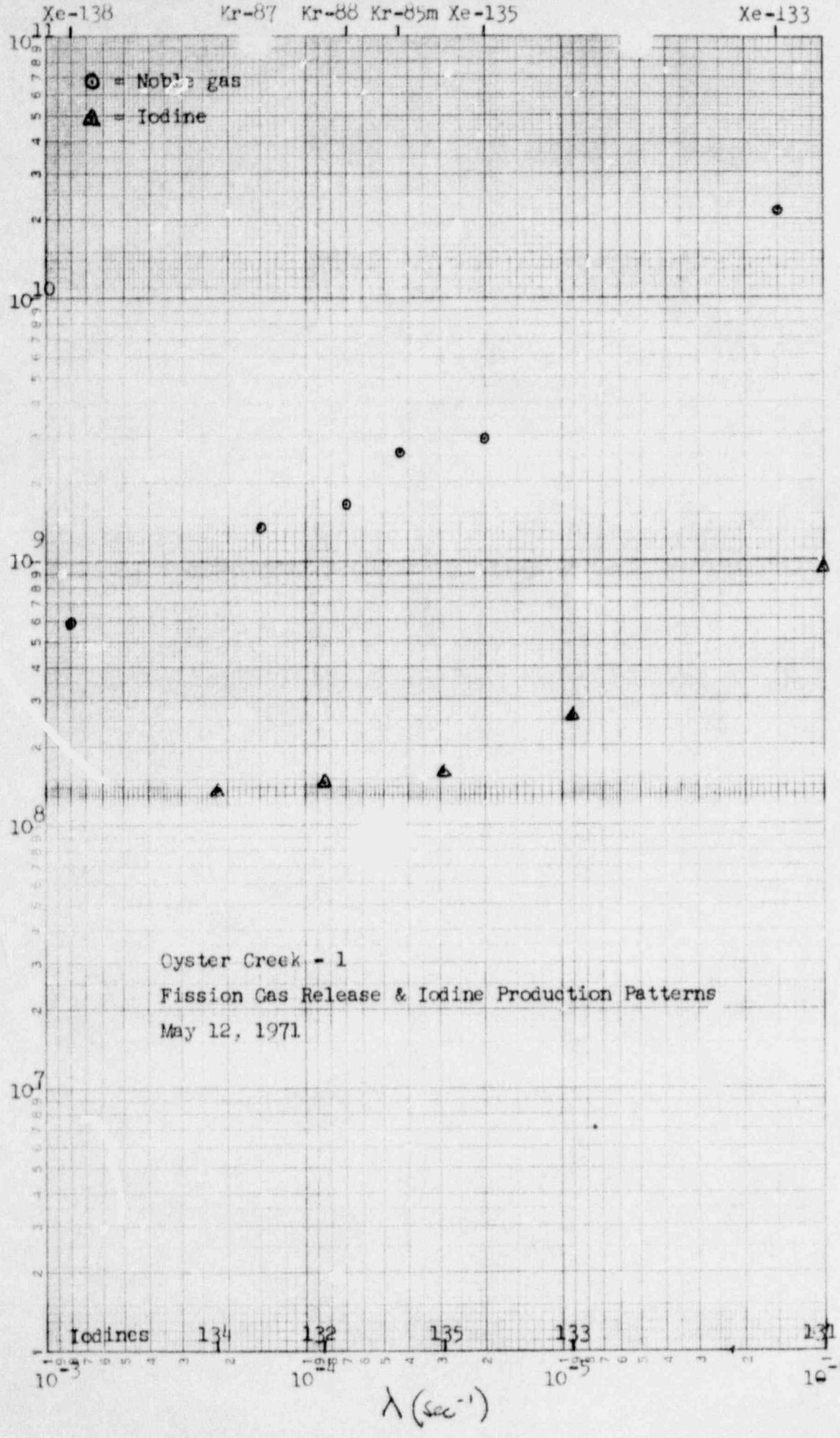

Xe-138
Kr-87
Kr-88
Kr-85m
Xe-135
Xe-133
= Noble gas
= Iodine
A/γλ
Oyster Creek - 1
Fission Gas Release & Iodine Production Patterns
May 12, 1971
Iodines
134
132
135
133
131
λ (sec⁻¹)

Figure 13

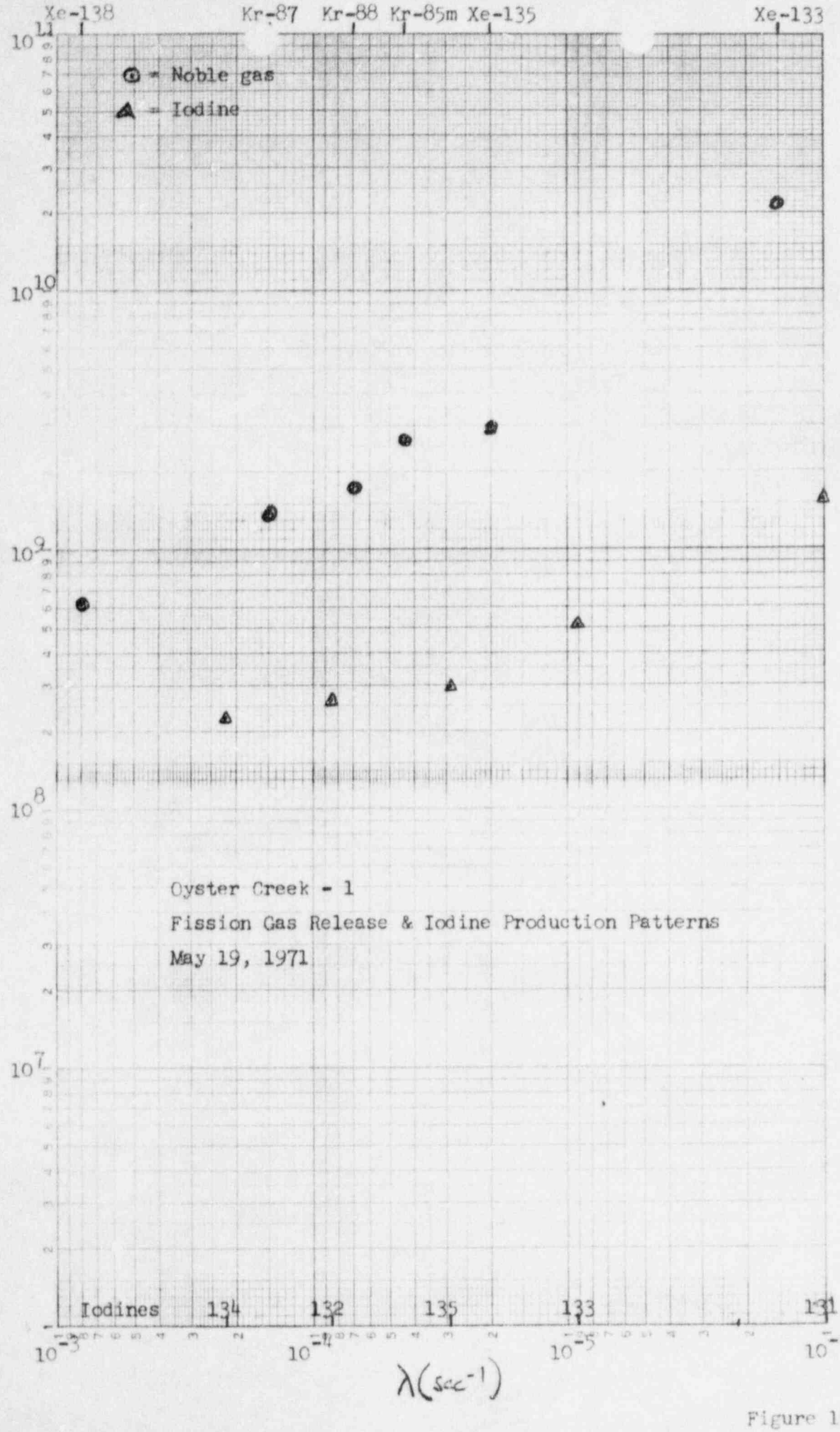

Xe-138
Kr-87
Kr-88
Kr-85m
Xe-135
Xe-133
Noble gas
Iodine
A/λ
Oyster Creek - 1
Fission Gas Release & Iodine Production Patterns
May 19, 1971
Iodines
134
132
135
133
131
λ(sec⁻¹)

Figure 14

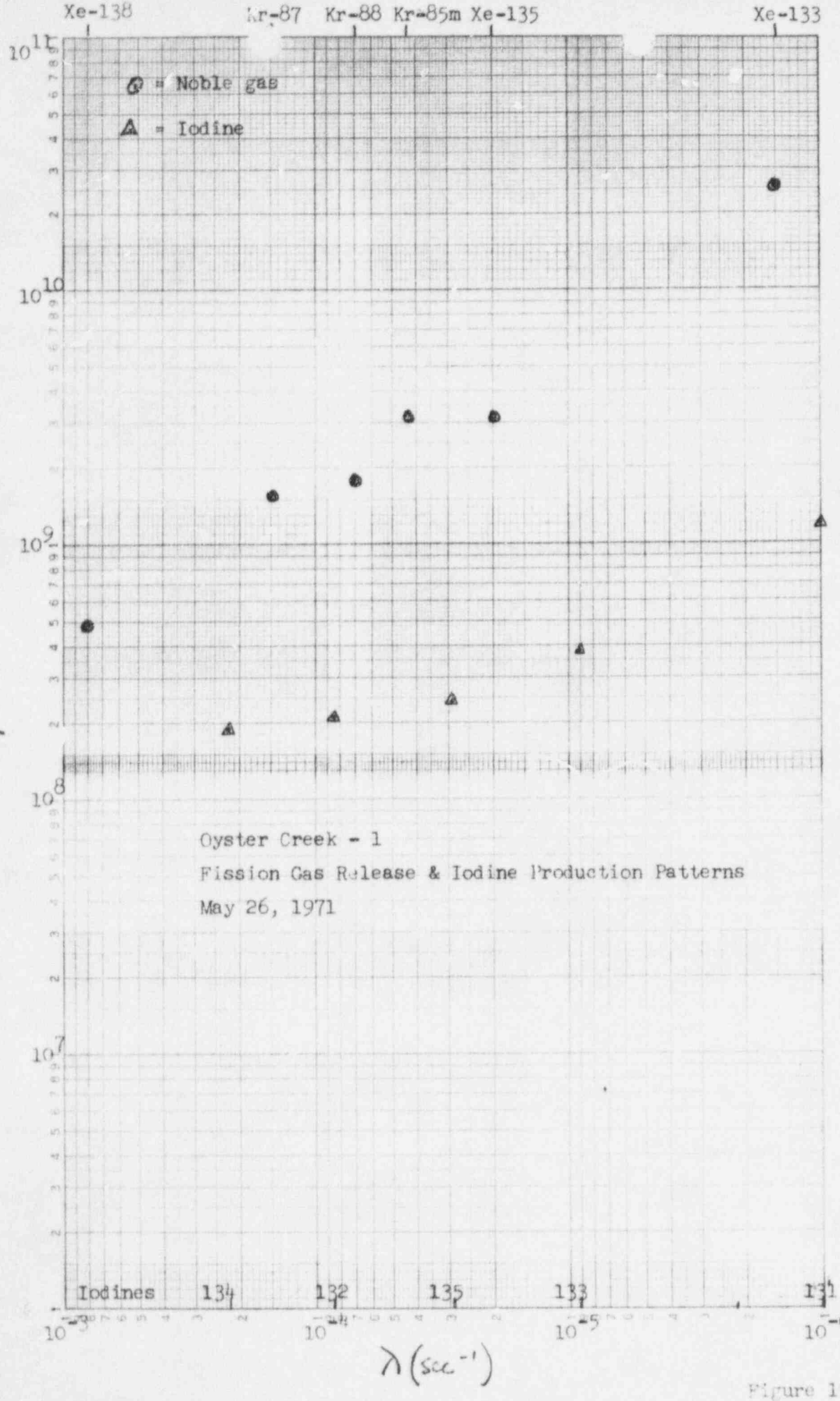
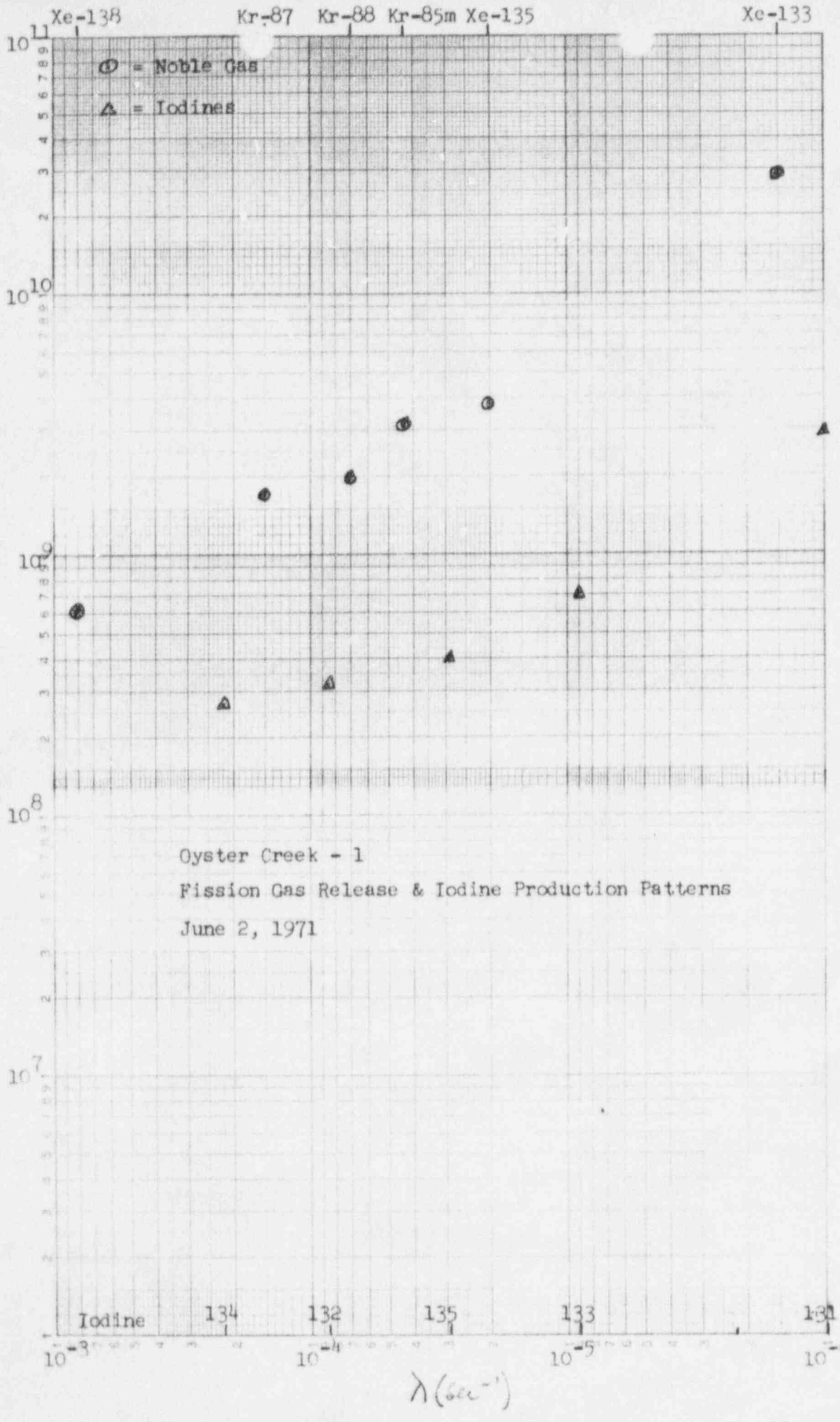

Xe-138
Kr-87
Kr-88
Kr-85m
Xe-135
Xe-133
⊗ = Noble gas
△ = Iodine
A/γλ
Oyster Creek - 1
Fission Gas Release & Iodine Production Patterns
May 26, 1971
Iodines
134
132
135
133
131
λ (sec⁻¹)

Figure 15



Oyster Creek - 1

Fission Gas Release & Iodine Production Patterns

June 2, 1971

Figure 16

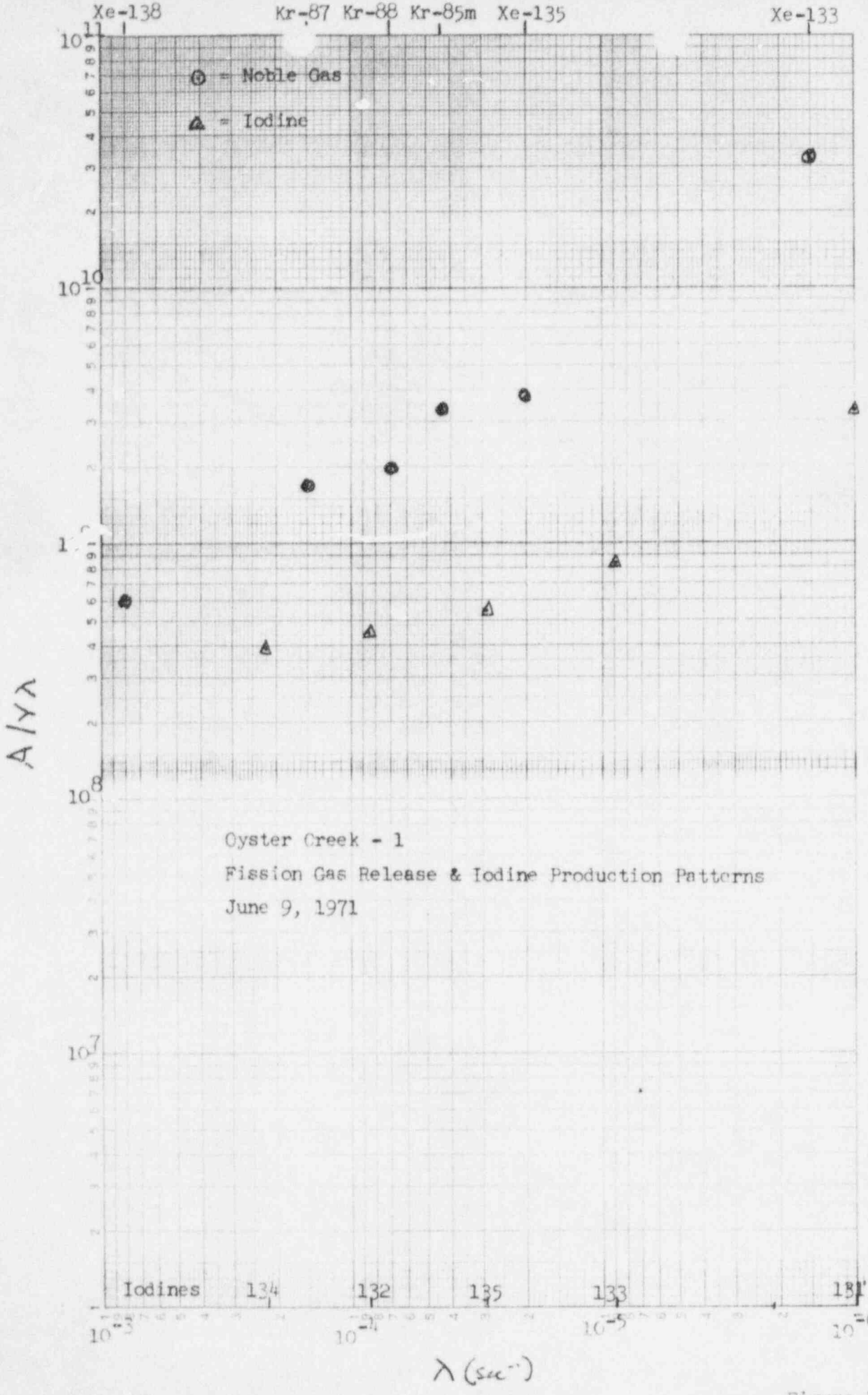

Xe-138
Kr-87
Kr-88
Kr-85m
Xe-135
Xe-133
⊙ = Noble Gas
△ = Iodine
A/Yλ
Oyster Creek - 1
Fission Gas Release & Iodine Production Patterns
June 9, 1971
Iodines
134
132
135
133
131
λ (sec⁻¹)

Figure 17

Figures 18 through 19 present iodine patterns for samples of reactor water in January 1971.

Iodine production rates were determined by:

[concentration (μCi/ml)](volume of water in reactor) X

[(decay constant + removal constant in cleanup system + removal constant from carryover)] = μCi/sec

Some further notes on the GE method of analyzing off-gas mixtures. Figure 20 is a plot of $1/Y\lambda$ vs λ for the 6 fission gases; Figure 21 is a plot of $1/Y\sqrt{\lambda}$ for the 6; and Figure 22 is a plot of 1/Y.

As mentioned previously when the gas mixture strays from an equilibrium component (relatively long delay time between production and release, indicative of very small defects) to a recoil component (short delay time between production and release, indicative of relatively large defects, fuel in the coolant or in contact with the coolant) the ratio of short-lived activity to long-lived activity will increase and in a recoil mixture the short-lived activity predominates.

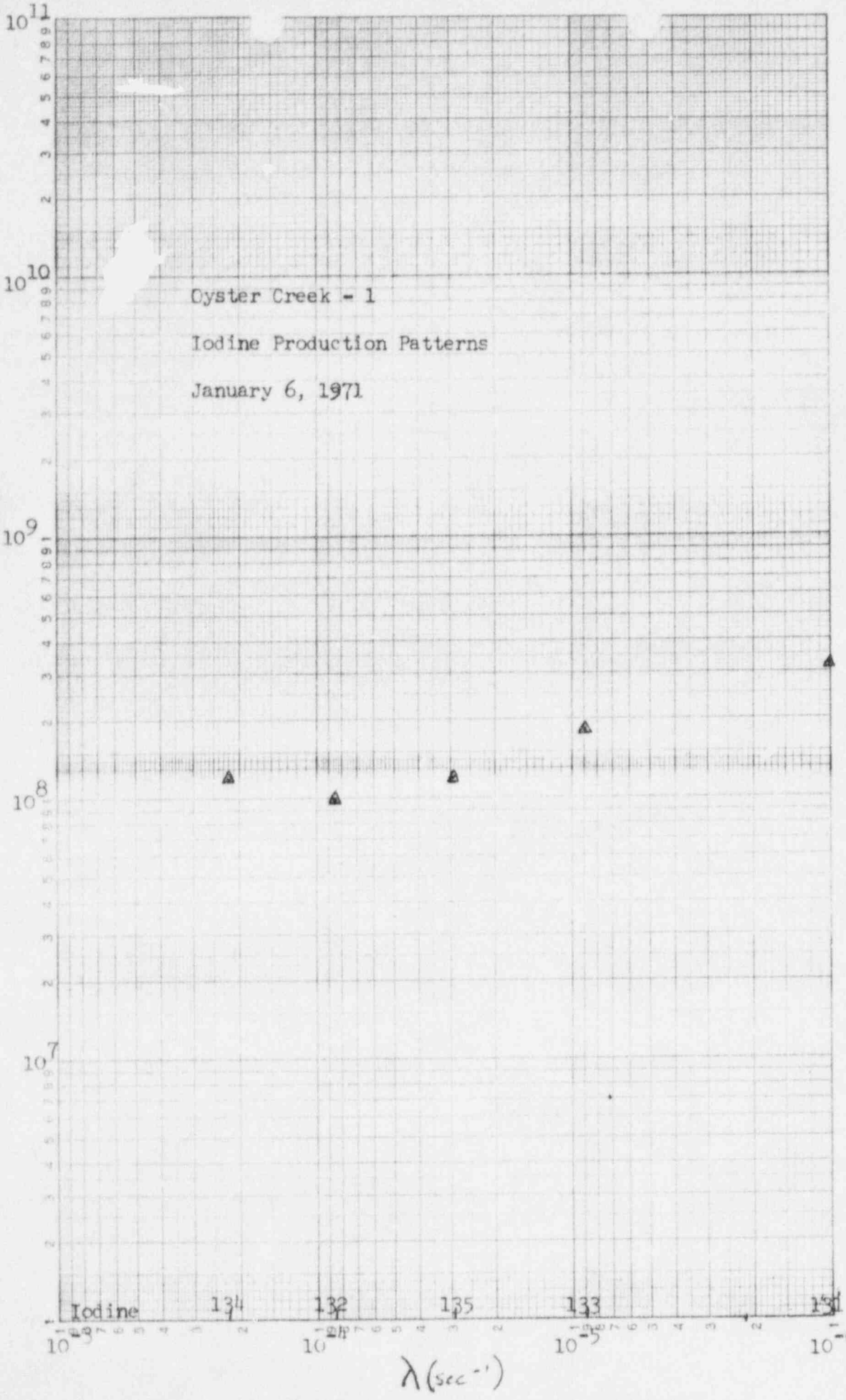

Oyster Creek - 1
Iodine Production Patterns
January 6, 1971
A/γλ
λ (sec⁻¹)
Iodine
134
132
135
133
131

Figure 18

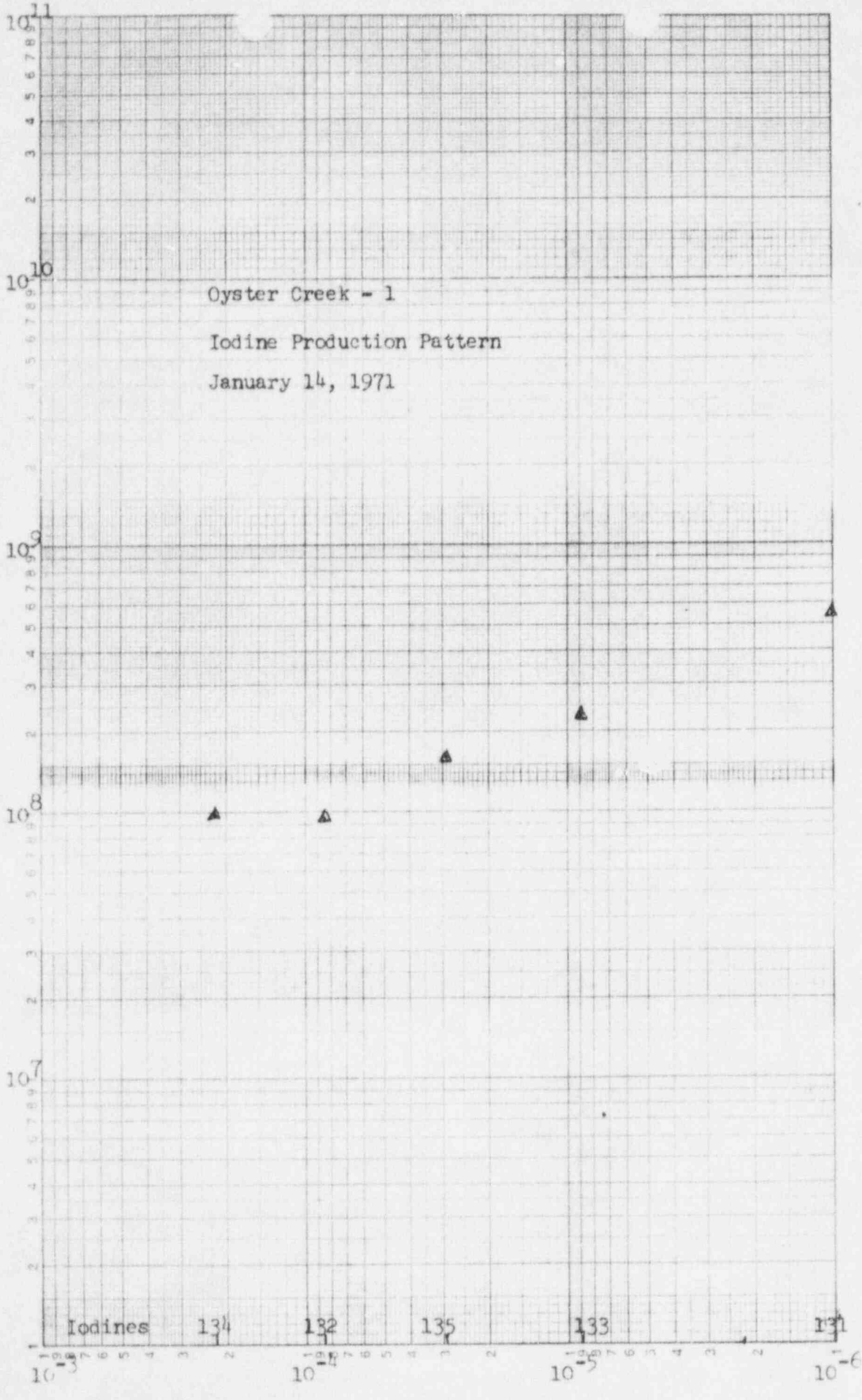

Oyster Creek - 1
Iodine Production Pattern
January 14, 1971
Iodines
134
132
135
133
131

Figure 19

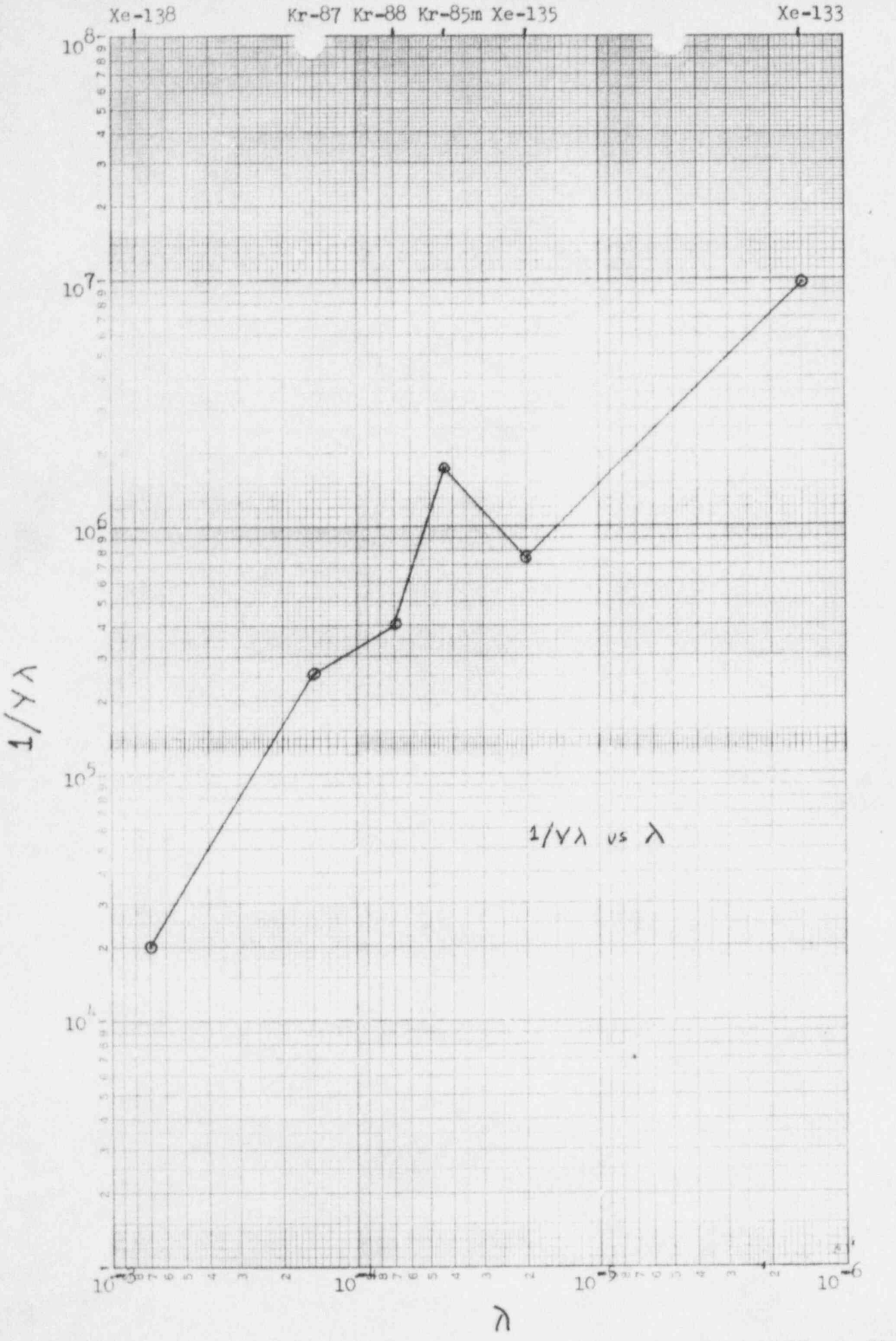

Xe-138
Kr-87 Kr-88 Kr-85m Xe-135
Xe-133
10^8
10^7
10^6
10^5
10^4
$1/\gamma\lambda$
$1/\gamma\lambda$ vs λ
10^{-3}
10^{-4}
10^{-5}
10^{-6}
λ

Figure 20

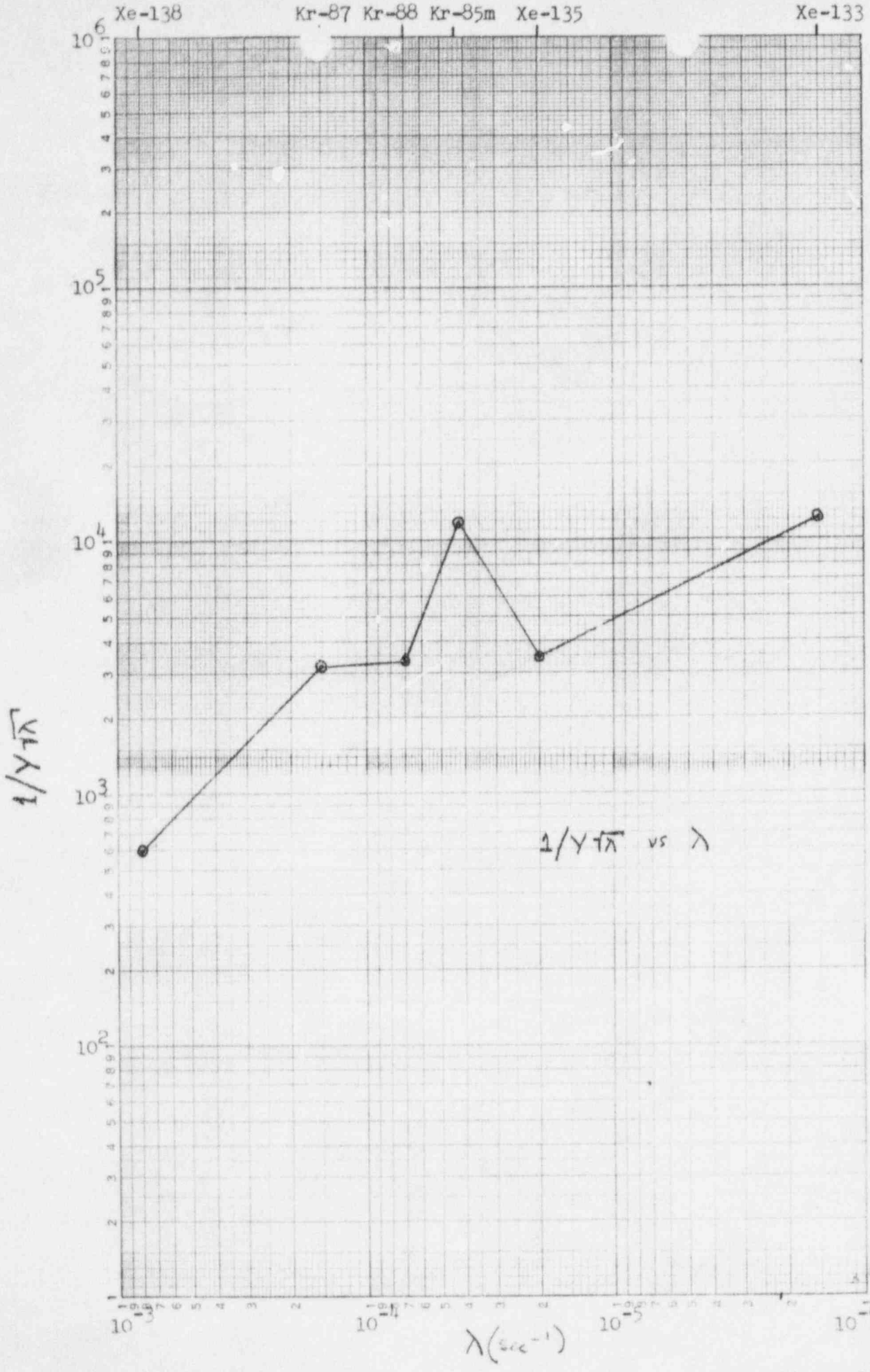

Xe-138
Kr-87
Kr-88
Kr-85m
Xe-135
Xe-133
10^6
10^5
10^4
10^3
10^2
$1/Y\sqrt{\lambda}$
$1/Y\sqrt{\lambda}$ vs λ
10^{-3}
10^{-4}
10^{-5}
10^{-6}
$\lambda(sec^{-1})$

Figure 21

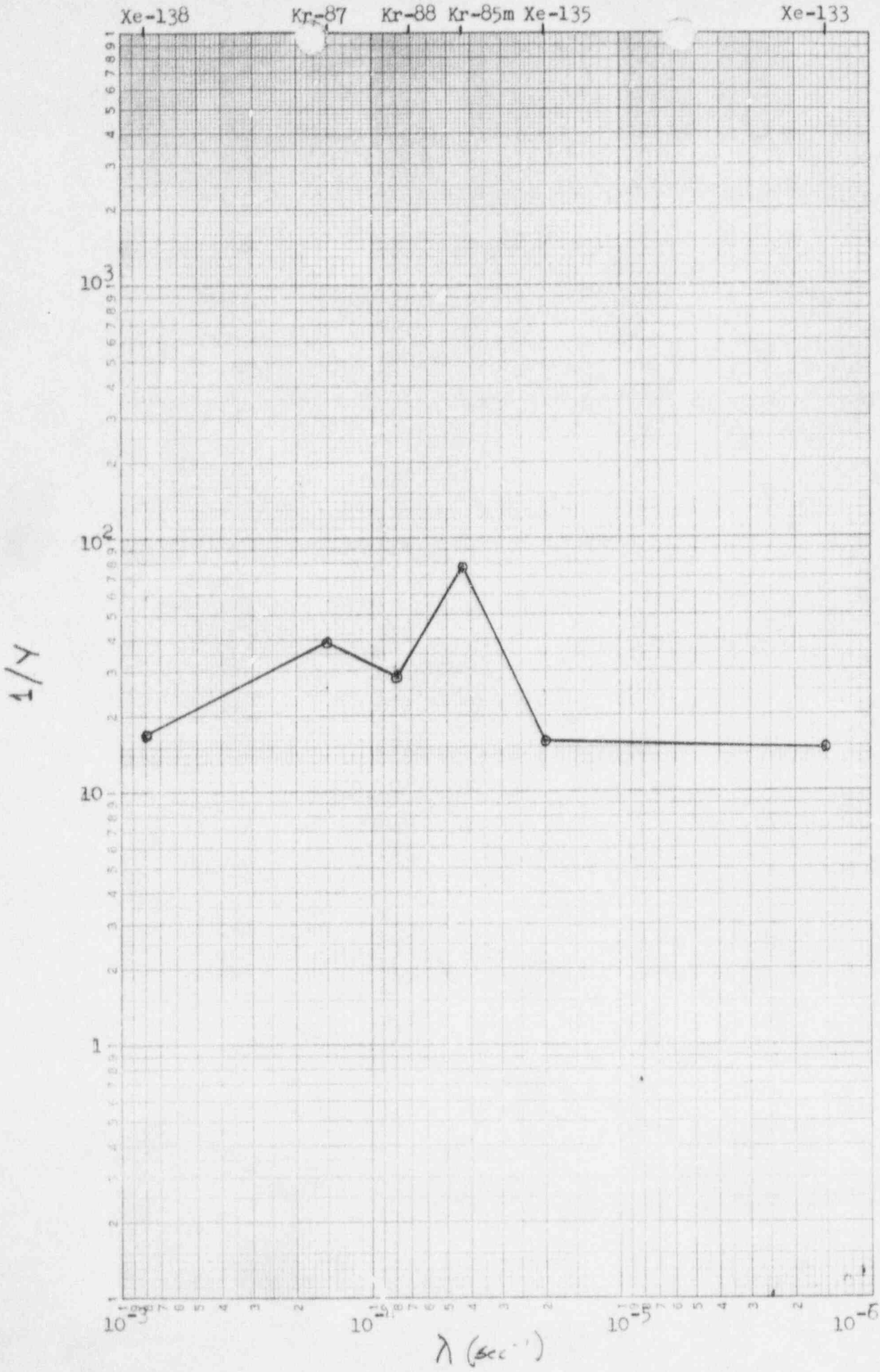

Xe-138
Kr-87
Kr-88
Kr-85m
Xe-135
Xe-133
1/Y
10^3
10^2
10
1
10^{-3}
10^{-4}
10^{-5}
10^{-6}
λ (sec⁻¹)

Figure 22

Figure 23 is a plot of the ratio of Xenon-138 (14 min) to the other 5 gases of the measured 6. Ideal ratios are plotted for the three mixture components, i.e., recoil, diffusion, and equilibrium, and for each component the ratio existing at time = 0 and time = 10 minutes is shown. For recoil conditions the ratio of Xenon-138 to Xenon-133 (5 day) is about 500 at t = 0. Figure 24 shows a family of curves for gas mixtures comprised of percentages of contribution from all three components.

Figure 25 is a plot showing OC-1 data for the year 1970, i.e., ratios of the 6 isotopes to Xenon-138. Figure 26 is a similar plot of 1971 OC-1 data. Figure 27 and 28 are plots of two specific analyses of OC-1 off-gas in May 1971. A diffusion component has predominated the OC-1 gas release since early 1970.

For comparison, Figures 29, 30 and 31 are "ratio plots" of Millstone-1 data for three specific analyses of off-gas in March and April 1971. The data indicates that an equilibrium component dominated the mixture.

Counting and Analysis

12. Gross Beta Counting

The calibration error that was disclosed during the last inspection has been corrected. While gross beta counting is still being performed the results are not being used to determine total activity or concentrations released; this is being done by isotopic analysis of each batch of liquid released.

13. Carbon - 14

Results of several samples sent out for analysis showed levels in liquids of about 10^{-6} μCi/ml to 10^{-5}; the MPC is 8×10^{-4} μCi/ml. Samples were of undiluted waste and/or reactor water.

14. PI 3300 Samples

Two liquid samples were obtained of waste sample tanks; 500 ml each, shipped in glass bottles with plastic caps and sealed with paraffin; each treated with $K_2S_2O_5$ and 10 ml conc. HCl per instructions from IDO-HSL.

Two samples of off-gas collected; standard 14.1 ml glass vials used for plant sampling; one was sealed with paraffin one was not; this was to determine if gas is lost during shipment through the rubber serum cap. The samples were sequential; five were taken with OC-1 using the middle three #1 and #5 shipped to IDO-HSL; gross counting of the five gave results within statistical error

and the samples shipped to IDO-HSL should be representative of the OC-1 samples.

Stack sampler charcoal cartridge and particulate filter for the sample period preceding the inspection were shipped to IDO-HSL.

No results have been received as of July 7, 1971.

Curie Content in Outside Storage Tanks

15. As with waste releases, the curie content of storage tanks is controlled on the basis of isotopic analysis rather than gross beta counting. A review of records revealed no instance where technical specification limits (total of 0.7 Curies) had been exceeded since the last inspection.

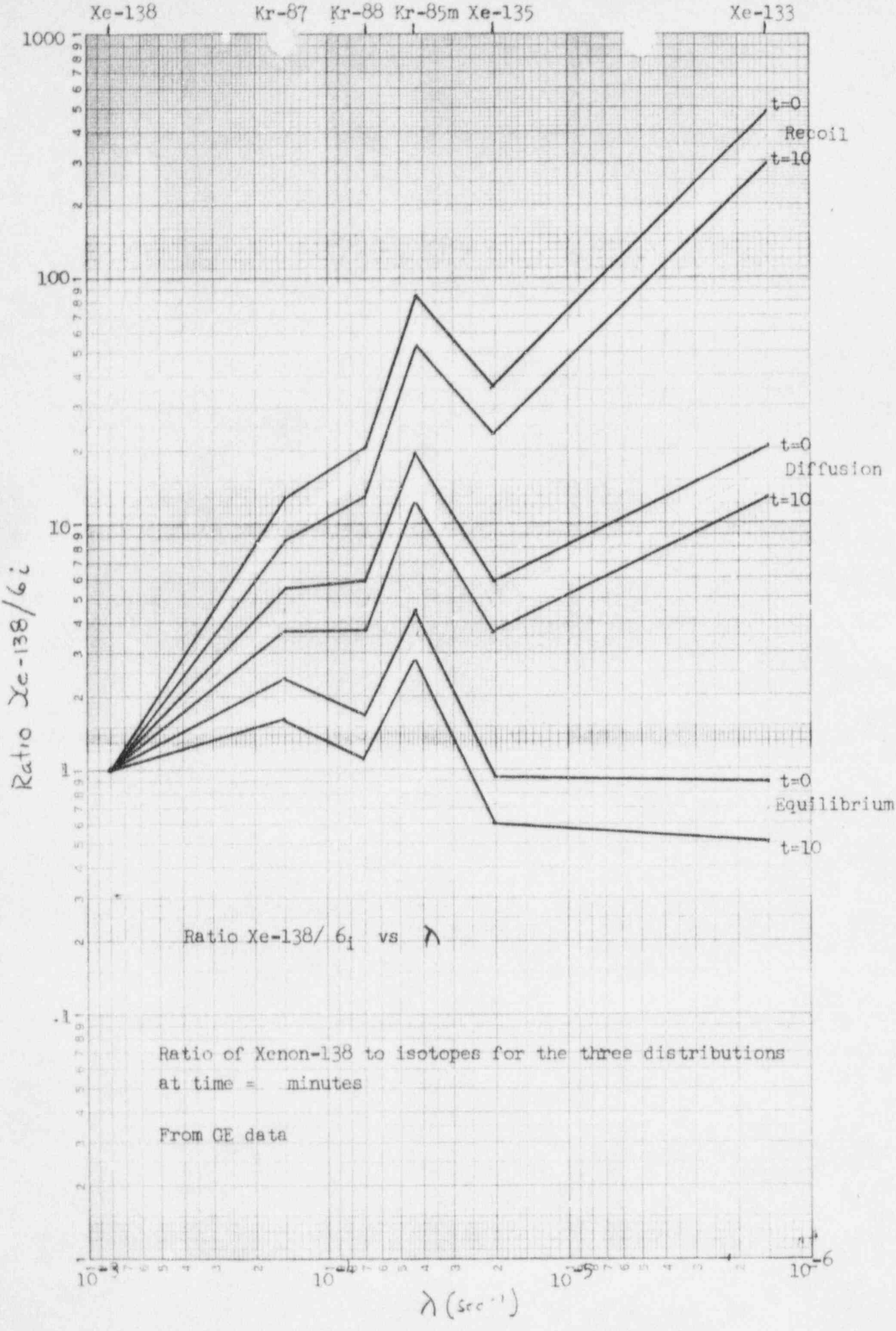

Xe-138
Kr-87
Kr-88
Kr-85m
Xe-135
Xe-133
1000
100
10
1
.1
t=0
Recoil
t=10
t=0
Diffusion
t=10
t=0
Equilibrium
t=10
Ratio Xe-138/6i
Ratio Xe-138/ 6_i vs λ
Ratio of Xenon-138 to isotopes for the three distributions
at time = minutes
From GE data
10^{-3}
10^{-4}
10^{-5}
10^{-6}
λ (sec^{-1})

Figure 23

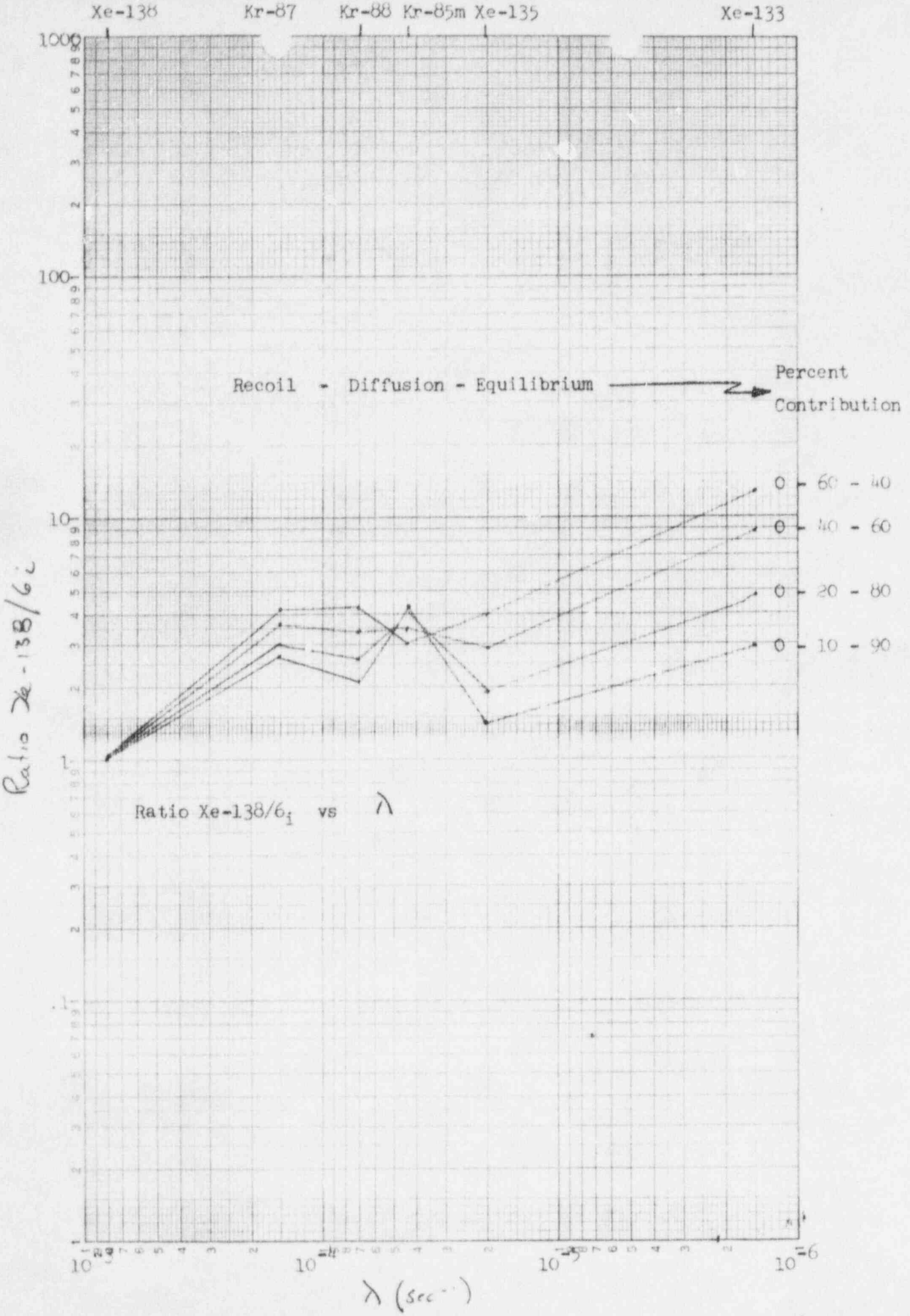

Xe-138
Kr-87
Kr-88
Kr-85m
Xe-135
Xe-133
1000
100
10
1
.1
Recoil - Diffusion - Equilibrium
Percent Contribution
0 - 60 - 40
0 - 40 - 60
0 - 20 - 80
0 - 10 - 90
Ratio Xe-138/6i
Ratio Xe-138/6i vs λ
10^-3
10^-4
10^-5
10^-6
λ (sec^-1)

Figure 24

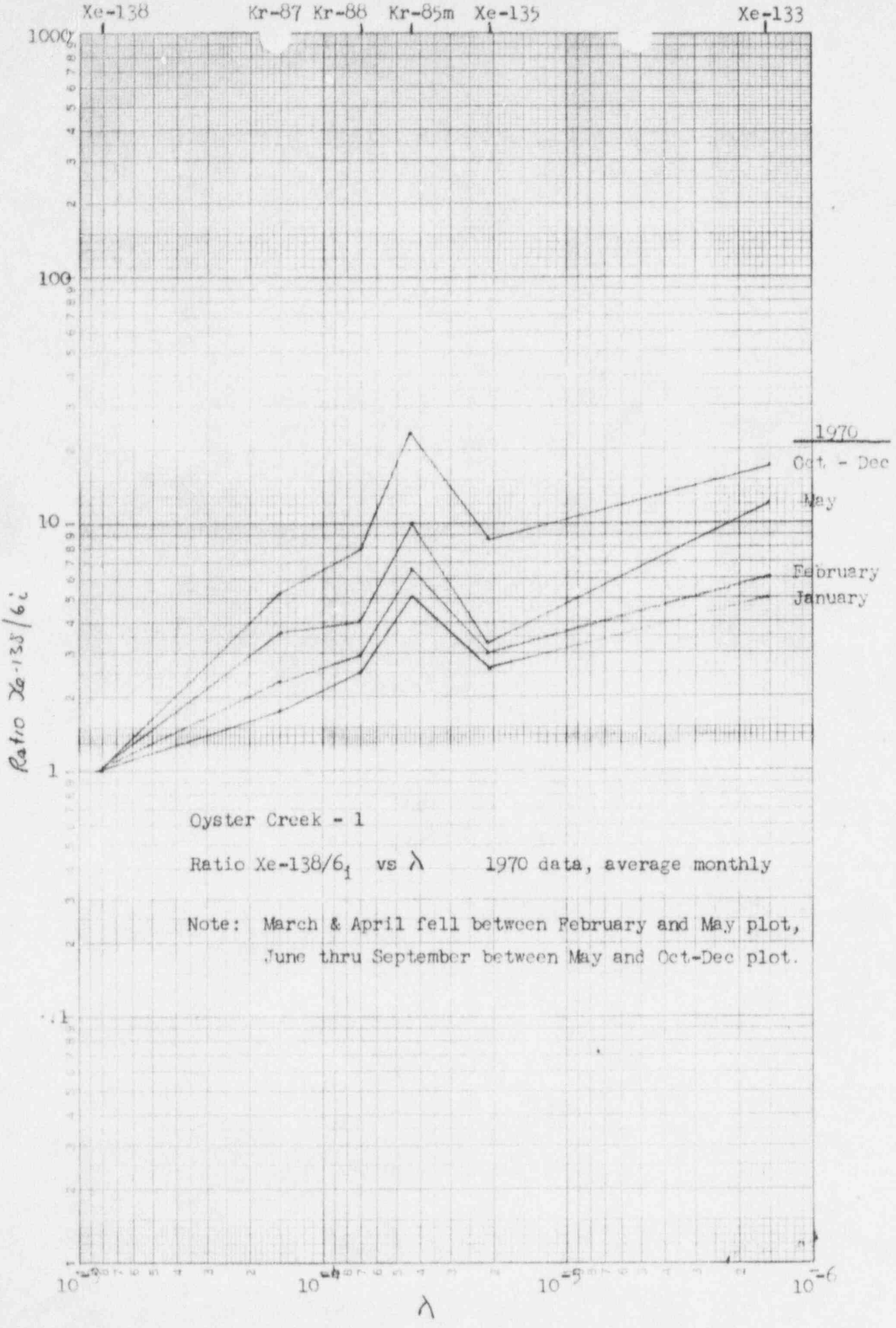
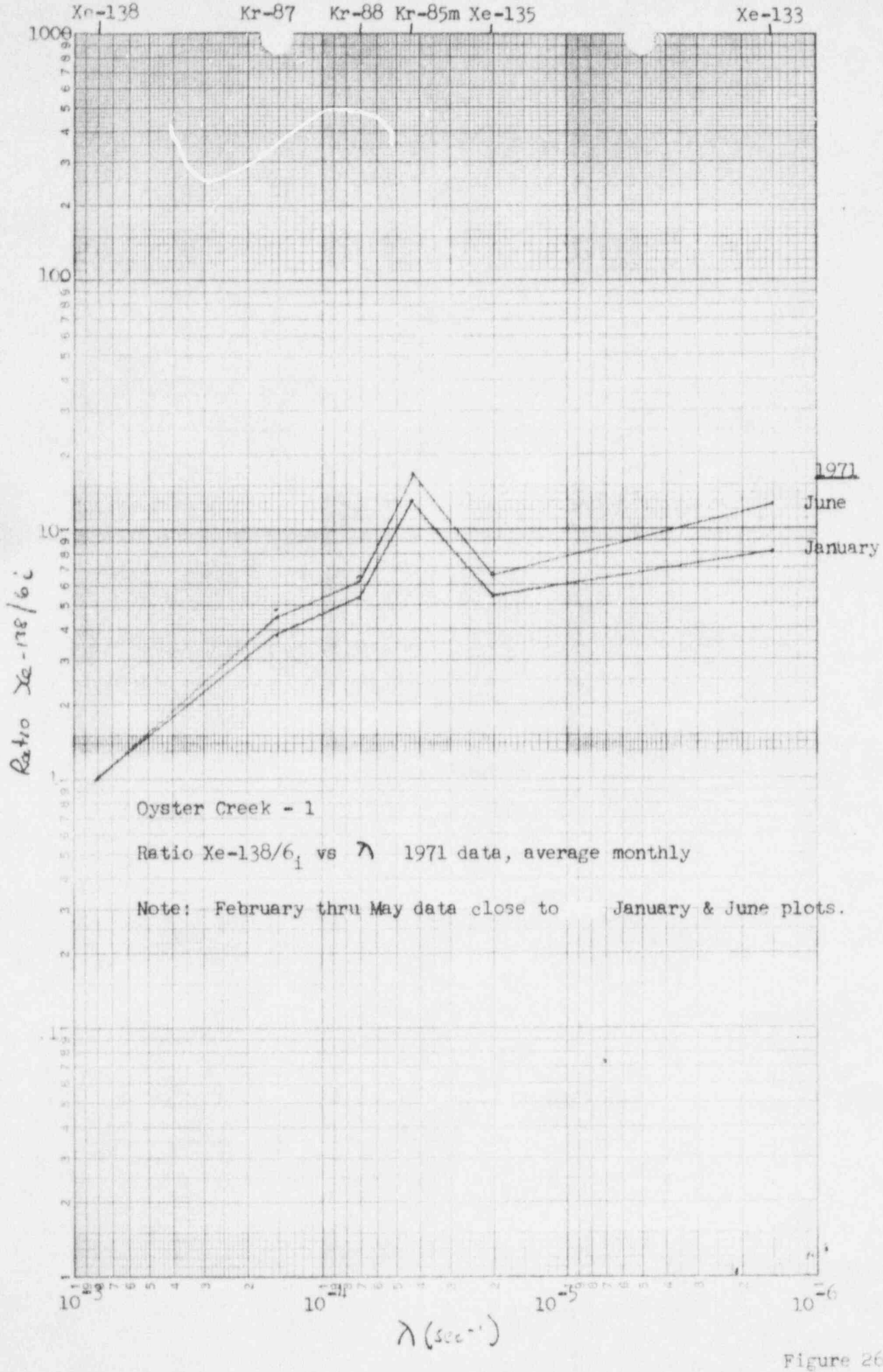

Xe-138
Kr-87
Kr-88
Kr-85m
Xe-135
Xe-133
1000
100
10
1
.1
Ratio Xe-135/6i
1970
Oct. - Dec
May
February
January
Oyster Creek - 1
Ratio Xe-138/6i vs λ 1970 data, average monthly
Note: March & April fell between February and May plot,
June thru September between May and Oct-Dec plot.
10^-3
10^-4
10^-5
10^-6
λ

Figure 25



Oyster Creek - 1

Ratio Xe-138/6_i vs λ 1971 data, average monthly

Note: February thru May data close to January & June plots.

Figure 26

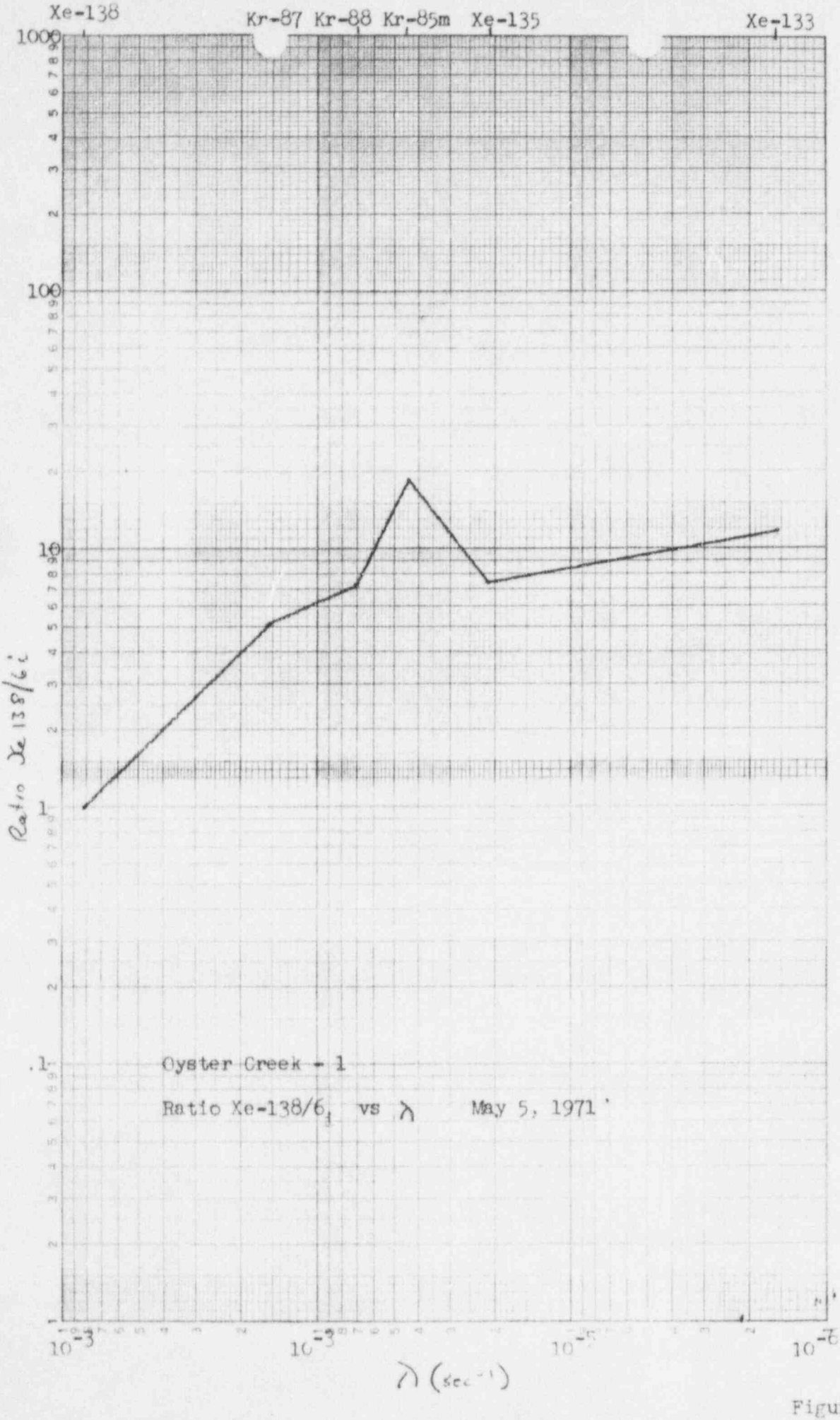

Xe-138
Kr-87 Kr-88 Kr-85m Xe-135
Xe-133
1000
100
10
1
.1
Ratio Xe 138/6i
Oyster Creek - 1
Ratio Xe-138/6i vs λ May 5, 1971
10-3
10-4
10-5
10-6
λ (sec-1)

Figure 27

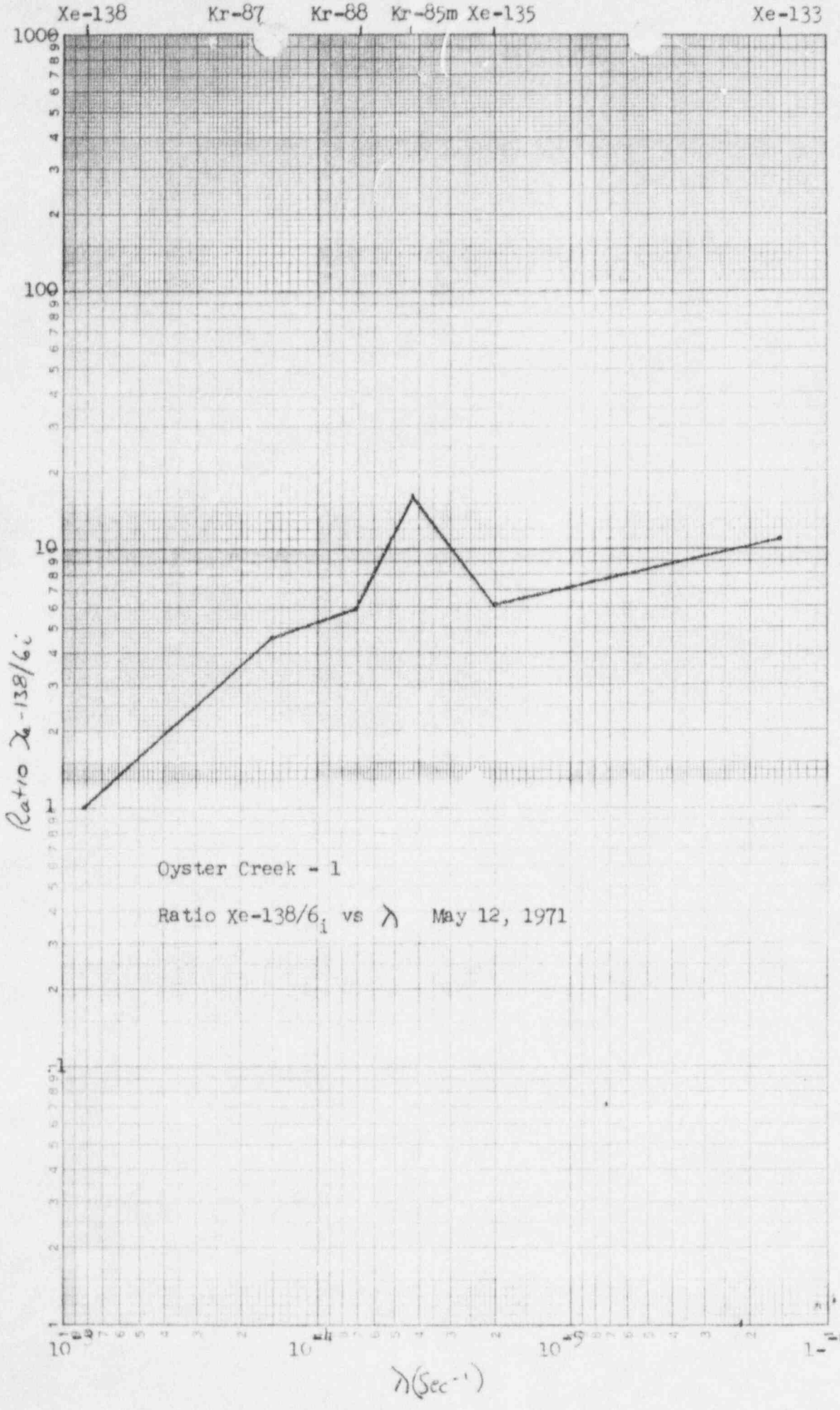

Xe-138
Kr-87
Kr-88
Kr-85m
Xe-135
Xe-133
1000
100
10
1
Ratio $\lambda_{Xe-138}/6_i$
Oyster Creek - 1
Ratio Xe-138/6_i vs λ May 12, 1971
10^{-2}
10^{-4}
10^{-5}
10^{-6}
λ(Sec^{-1})

Figure 28

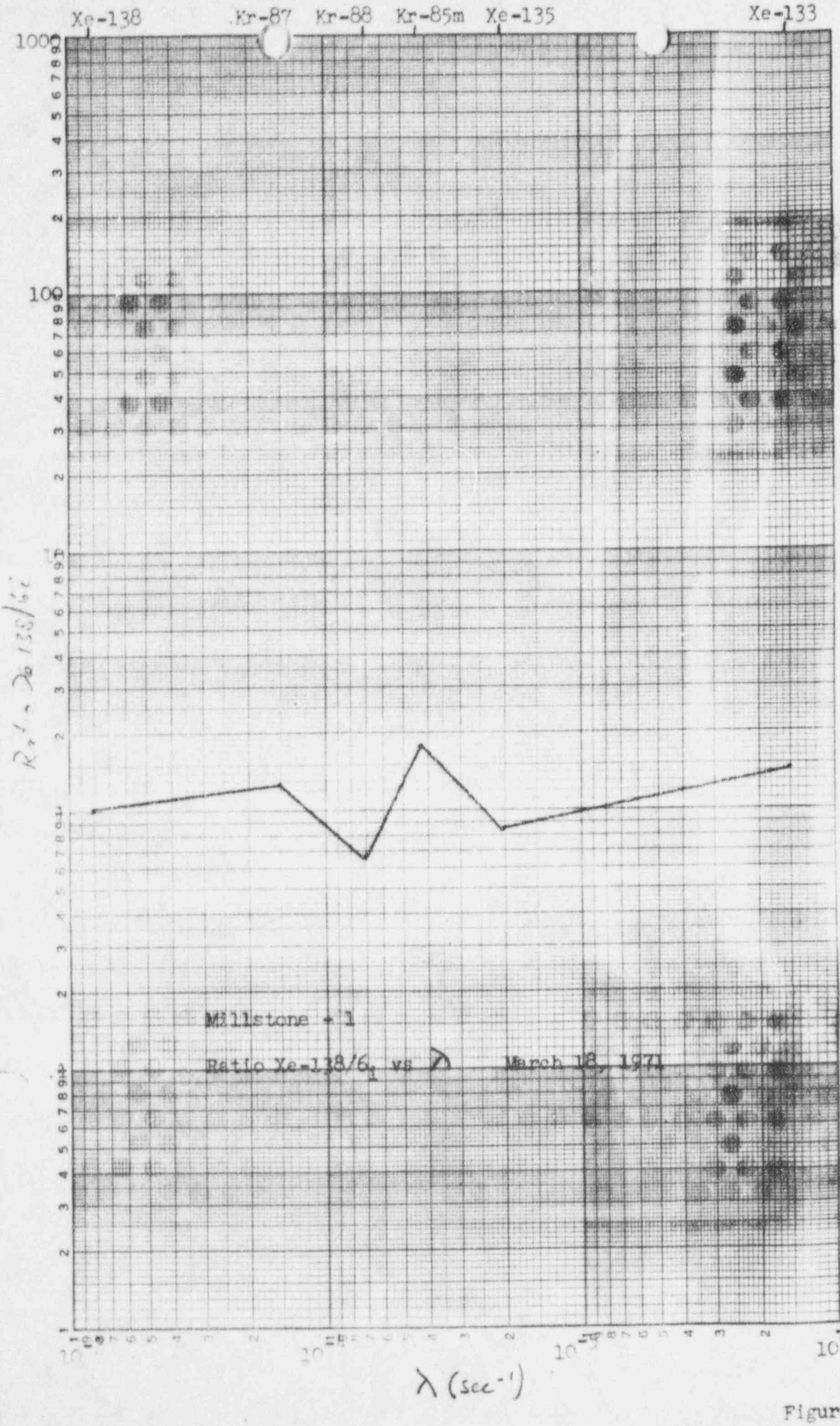

Xe-138
Kr-87
Kr-88
Kr-85m
Xe-135
Xe-133
1000
100
Millstone + 1
Ratio Xe-138/6₂ vs λ
March 18, 1971
λ (sec⁻¹)

Figure 29

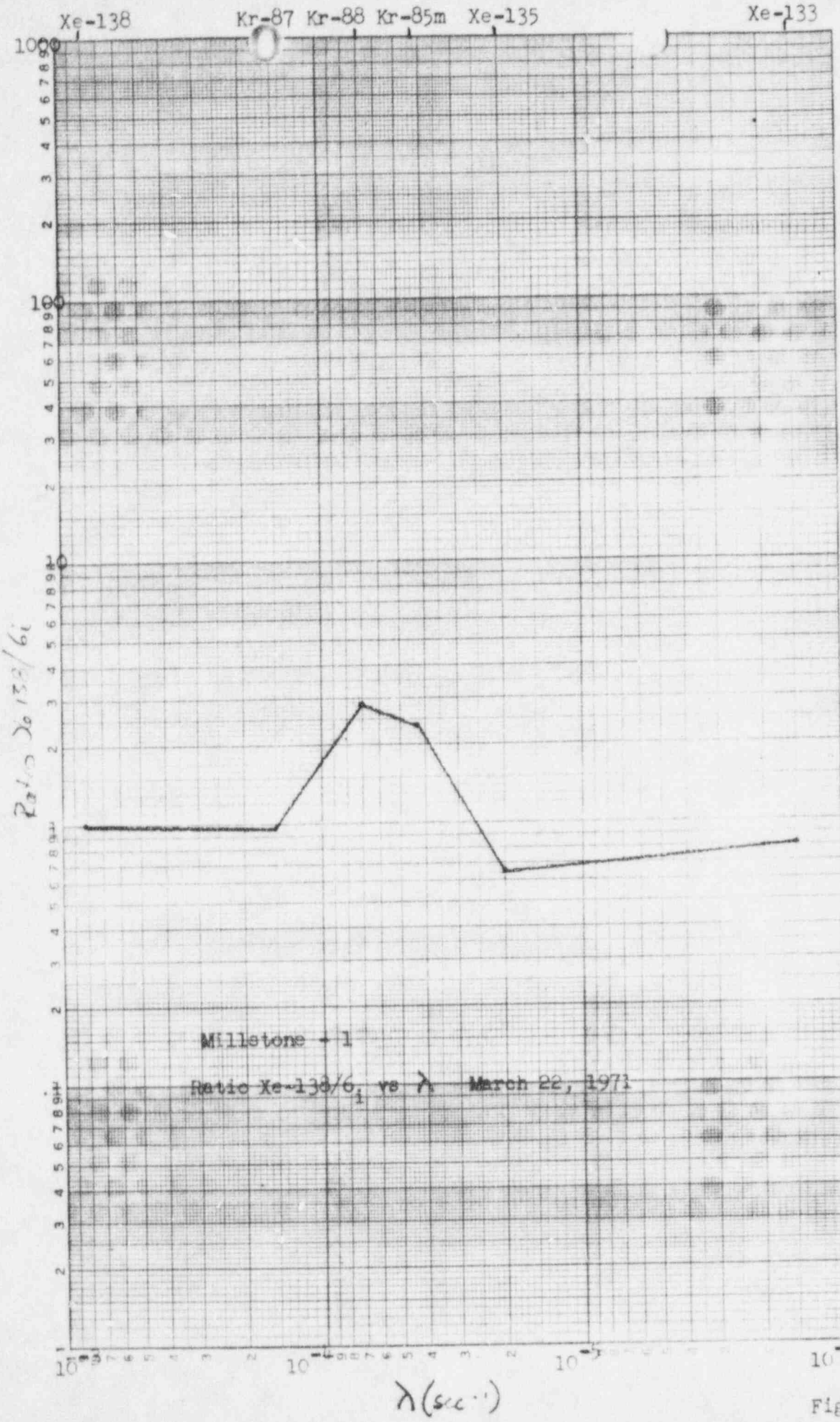

Xe-138
Kr-87
Kr-88
Kr-85m
Xe-135
Xe-133
1000
100
10
Millstone - 1
Ratio Xe-133/6i vs λi March 22, 1971
λ(sec⁻¹)

Figure 30

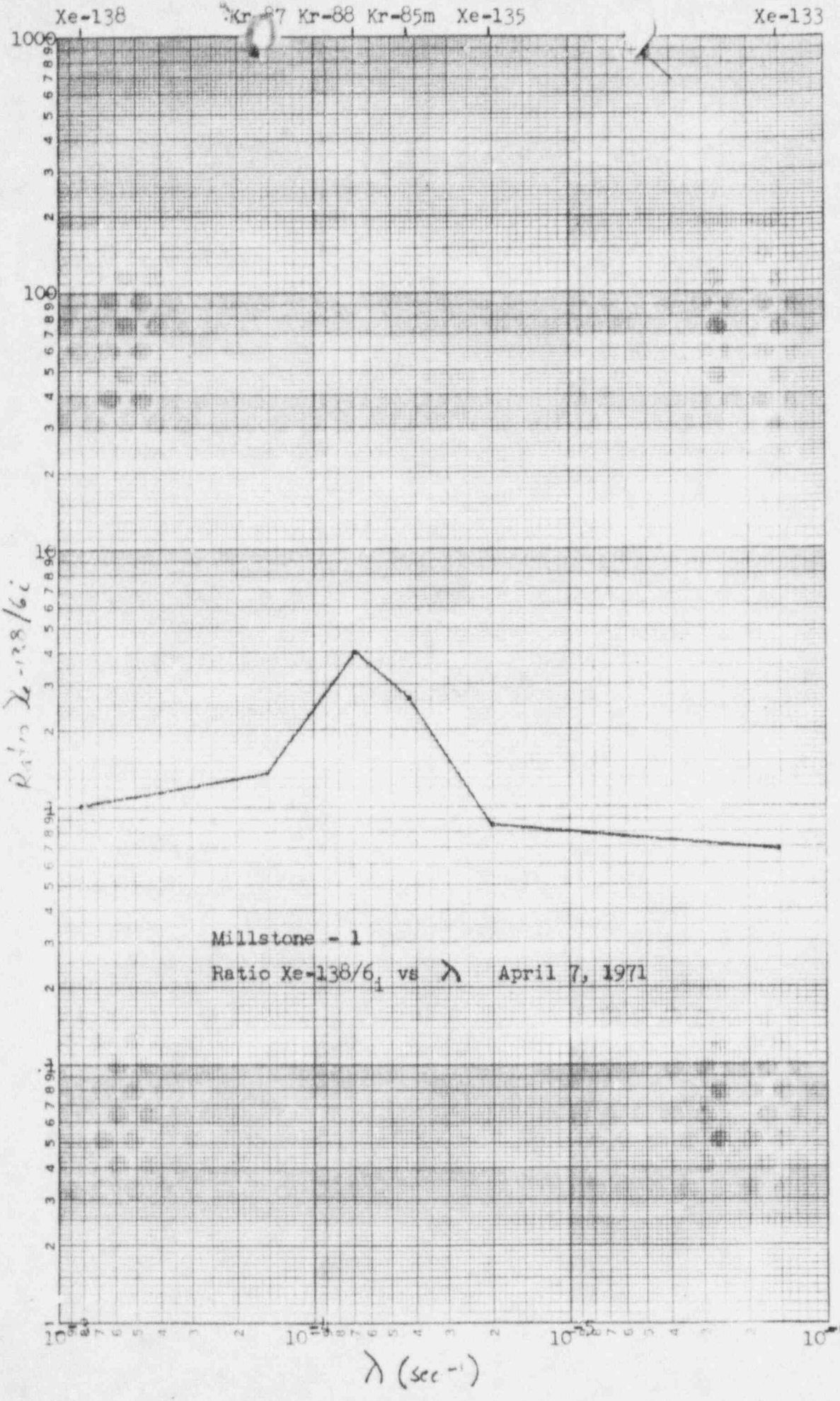

Xe-138
Kr-87
Kr-88
Kr-85m
Xe-135
Xe-133
1000
100
10
1
Ratio λ-138/6i
Millstone - 1
Ratio Xe-138/6i vs λ April 7, 1971
10^-4
10^-5
10^-6
λ (sec^-1)

Figure 31