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TENNESSEE VALLEY AUTHORITY

CHATTANOOGA, TENNESSEE 37401

1110 Chestnut Street Tower II
September 8, 1981

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U.S. Nuclear Regulatory Commission
Office of Nuclear Material Safeguards
Division of Fuels Cycle and Material Safety
Washington, DC 20555

Attention: Mr. Paul Guinn, Material Branch, Division of Material and Fuels Cycle Licensing

Gentlemen:

RAPID SULFUR METER BYPRODUCT MATERIAL LICENSE APPLICATION INFORMATION

In response to your letter dated June 2, 1981 (Mail Control No. 06764) to M. D. High, Director of Energy Demonstrations and Technology, Tennessee Valley Authority, regarding TVA's application for a byproduct material license for the custom rapid sulfur meter, we are enclosing the additional information needed in support of the application. If you require further explanation or additional information, please feel free to contact Gary R. MacDonald or me at FTS 857-6531 or (615) 755-6531, 1110 Chestnut Street Tower II, Chattanooga, Tennessee 37401.

Sincerely,

L. Barry Goss

L. Barry Goss, Ph.D.
Chief, Environmental Support Staff

Enclosures

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Proposed Use

The Rapid Sulfur Meter (RSM) will be used to monitor and control the sulfur content of clean coal produced by TVA's Paradise Coal Washing Plant. It will provide a continuous coal sulfur analysis to ensure an acceptable sulfur level in clean coal at a maximum clean coal recovery.

The RSM will be interfaced with the existing automatic coal sampling system of the coal washing plant on the ground floor of the Cleaned Coal Storage and Sampler Building. Installation details are shown on previously supplied drawing TSSEC-C4922. The Cleaned Coal Storage and Sampler Building, a seven-story structure, contains a three-stage coal sampler and a 350-ton capacity temporary storage bin for clean coal.

Only a small portion of the clean coal output of the coal washing plant as sampled by the automatic coal sampling system will be monitored by the RSM. Clean coal input to the RSM will be in the size range 1/4 inch x 0 and will have a surface moisture content of about 8 to 10 percent by weight and a nominal sulfur content of about 2 to 3 percent by weight. After sulfur analysis, coal will be discharged from the RSM and recombined with unmonitored clean coal and will be conveyed to the plant coal storage yard stockpile.

Except during the 100-second sulfur measurement cycle, when at least one cubic foot of coal is present in the RSM, the californium neutron source remains retracted within a lead shield. Internal RSM logic will allow source extension from the lead shield to the measurement position only when significant coal is present and only after other normal operating events have occurred in proper sequence. In the unlikely event of an

accident or fire near the RSM, the source is doubly encapsulated in stainless steel and is further enclosed in the multicomponent source shield assembly which in turn is enclosed in the aluminum shell of the RSM. The source stainless steel encapsulation is rated to withstand high temperature. The source shield assembly contains borated polyethylene, lead, bismuth, and other shielding materials. The aluminum shell holds borated paraffin neutron shielding. Boric acid added to the paraffin also serves as a flame retardant for the paraffin shielding. In the event of power failure, the source is retracted to the storage position; in the event of a computer failure, the computer controlled source movement is overridden by a time delay relay that retracts the source if the computer fails to first issue the command.

The RSM is fully automated requiring no operator intervention under normal operating conditions. The normal rest state of the sulfur meter is to be waiting for arrival of coal with the source in the stored position. When coal is fed to the RSM, the following sequence is followed under computer control:

- wait for coal to fill RSM chute
  (detected by commercial level gauge)
- move source from storage to chute wall
- count capture gamma rays for 100 sec.
- move source away from chute wall to storage position
- analyze data
- output results
- go back to start of sequence and wait for coal

For calibration, an operator is required to lower a box of coal into the RSM. This sequence is as follows:

- operator flushes coal from system and stops conveyors
- operator moves source control switch to "bypass" position
  (this stores the source)
- operator lowers calibration box into chute
- operator moves source control switch to "calibrate" position
  (this inserts the source)
- computer electronics counts captured gamma rays
- source retracts by computer command
- sequence can be repeated by operator reinserting source (as above)

At the conclusion of a calibration, the source is retracted automatically, the box is removed, and switches are set to normal operation.

For maintenance on or around the RSM, the coal conveyors will be shut down with coal in the chute and the source moved and locked in its storage position. The dose rate one foot from the surface of the system is then at its lowest, less than 2 mrem/hr.

The RSM is meant to be a permanent feature of the Paradise Coal Washing Plant and as such will not be moveable from location to location without considerable preparation and construction of support structures. There will be no diversion from the RSM's intended use as a coal sulfur monitor.

RSM operators will be trained personnel and will be familiar with all aspects of RSM normal operation and situations that will cause RSM shutdown. The limited access of the RSM will protect from nontrained personnel entering the area.

Construction (See attached annotated drawing D-KRSM-005)

Human Access

During normal operating conditions, fencing and warning signs will limit access of nontrained personnel to the RSM.

Labeling and Instruction of Use

There will be a metal label attached in clear view to the source holder outside stating the type and quantity of radioactive material. The label will bear the conventional radiation symbol as defined in the Code of Federal Regulations Title 10 Part 20.203. The label will not be removed from the device.

Availability of Services

The initial installation, source exchange, major repair and maintenance, shutter checks, and final disposal will be performed by the manufacturer. The source will be delivered in a DOT approved shipping cask. The source is manually transferred from the shipping cask to the RSM by means of a handling rod. The actual transfer takes approximately 10 seconds. Dose to the person transferring the source is less than 10 mrem total.

Leak Testing

Leak testing will be performed by TVA in accordance with the following procedures. Leak tests will be performed by health physics technicians with a minimum of two years experience in the field and under the supervision of a health physicist with a minimum of two years field experience. The entire program is managed by the Radiological Hygiene Branch Chief who normally has many years experience in the field of health physics. Certified health physicists are available for consultation.

The sources shall be tested for leakage at intervals not to exceed three years. The test shall be capable of detecting the presence of 0.005 microcurie of alpha or beta contamination on the test sample. The test sample, using filter paper, shall be taken from the source or from appropriate accessible surfaces of the device in which the sealed source is permanently or semipermanently mounted or stored.

The filter paper will be counted in a shielded laboratory type smear counter in the central laboratory utilizing a large GM detector or gas proportional detector with an efficiency from 10 to 30 percent.

Calibration consists mainly of standard sources bought from Eberline, supplemented by sources made in our radiological laboratory and are all traceable to the National Bureau of Standards.

Sample calculation:

$$\frac{\text{counts/min}}{\text{efficiency } \frac{\text{counts/min}}{\text{d/min}} \times 2.22 \times 10^6 \frac{\text{d/min}}{\mu\text{Ci}}} = \mu\text{Ci}$$

Records of leak test results shall be kept in units of microcuries and maintained for inspection.

If the test reveals the presence of 0.005 microcuries or more of removable contamination, the source will be withdrawn from use and shall be decontaminated, repaired, or disposed of, according to applicable regulations.

Within five (5) days after determining that a source has leaked, the Nuclear Regulatory Commission shall be notified according to applicable regulations.

Emergency procedures to be followed are:

1. Immediately rope off area around the RSM to a minimum of 15 feet.
2. Inform the Radiation Protection Officer or person responsible for the use of the source as to the situation.
3. Inform proper regional NRC office of incident.
4. Notify manufacturer if their assistance is desired.
5. Limit access to source head until a radiation survey and source wipe can be performed by qualified personnel or a manufacturer's representative.

Safety Analysis

The American National Standards Institute (ANSI) has proposed the following system of classification of sealed sources based on safety requirements for specific uses. The prototype source was subjected to and met or exceeded these performance standards.

Temperature Class 4: -40°C (20 min.)
+400°C (1h) and thermal shock
400°C to 20°C

External Pressure Class 3: 25 kn/m^2abs. to
2 MN/m^2
(290 16/in^2)

Impact Class 3: 200 g (7 oz) from
1m

Vibration Class 2: 30 min
25 to 500 Hz a
5q peak amp.

Puncture Class 3: 10g (154 gr) from 1m

Test Results of Finished Device

Radiation measurements taken by the RSM manufacturer (Tables 1 and 2) show that the dose rate at one foot from the surface of the RSM is less than 2 mrem/hr, except for normally inaccessible areas directly above and directly below the RSM. This is true for either of the two normal states of the system: waiting for coal with source stored, and during a coal sample analysis.

The source is moved from storage to irradiate position via a pneumatic cylinder. Radiation level measurements at the surface and one foot from the surface of the RSM in both, stored and irradiate positions are found in Tables 1 and 2. After RSM installation, a field survey will determine if additional borated epoxy shielding is required adjacent to the RSM. The source is attached to an extension of the cylinder shaft. Power or air pressure failure will cause source retraction.

A hard-wired interlock demands the following conditions for the source to be unstored in the activate position.

- computer issues command to insert
- coal is present
- chute gate is closed
- source has been inserted for less than two minutes

If any of these conditions are violated, the source is immediately withdrawn. All logic states are chosen so that an active state is required to allow source insertion. This makes the system fail safe.

Location of the source is indicated by lights on the control panel and on the RSM itself. Provisions are made for key and/or mechanical lockout of the source in stored position for any long-term shutdown or maintenance.

The residual activity induced in coal by exposure to a Cf-252 neutron source is very low. It is only by use of long irradiation times and large sensitive detectors that the activity can be measured. The natural background radioactivity in 70 pounds of coal before irradiation was compared to the residual activity 100 sec and 1000 sec following irradiation by a 37 μg Cf-252 neutron source. Irradiation time was 1000 sec.

Figure 1 shows the gamma energy spectra measured before irradiation and 100 sec following irradiation. Counting time was 1000 sec in each case. Three peaks are observed before irradiation--K-40, H, and Tl-208. The first results from a naturally occurring potassium isotope. The 2223 KeV peak of H resulted from neutron sources in the laboratory. Tl-208 appears in coal and contributes to the 2613 KeV peak.

After irradiation, one can see an additional peak due to Al-28. This is a short half-life isotope (2.5 min half-life) produced by thermal neutron

capture in Al. The Al-28 activity decays to a negligible level 1000 sec after irradiation as shown in Figure 2. The natural background radiation of coal is increased by about 20 percent, 15 min after irradiation. A 6 x 6 NaI detector was used for these measurements.

Starting 100 sec after the end of irradiation, a 1000 sec measurement gives a radiation level a factor of 2 above background. Background is about 0.01 mrem/hr; hence, the induced radiation is also 0.01 mrem. In fifteen minutes, the induced activity is only .002 mrem/hr.

Table 1

Radiation Level Measurements
28 µg Cf-252 Source

A. Source stored; no coal in RSM; measurement at RSM surface

	N mrem/hr	ɣ mrem/hr	Total @ 28 µg (actual)	Total @ 50 µg (calculated)
1.	.20	.27	.47	0.71
2.	.30	.00	.30	0.45
3.	2.00	.60	2.60	3.9
4.	.10	.00	.10	0.15
5.	.10	.18	.28	0.42
6.	.22	.12	.34	0.51
7.	.22	.12	.34	0.51

B. Source stored; no coal in RSM; measurement 1 ft. from RSM surface

	N mrem/hr	ɣ mrem/hr	Total @ 28 µg (actual)	Total @ 50 µg (calculated)
1.	.10	.06	.16	0.24
2.	.10	.00	.10	0.15
3.	.80	.24	1.04	1.56
4.	.07	.00	.07	0.11
5.	.10	.12	.22	0.33
6.	.17	.06	.23	0.35
7.	.18	.06	.24	0.36

Diagram

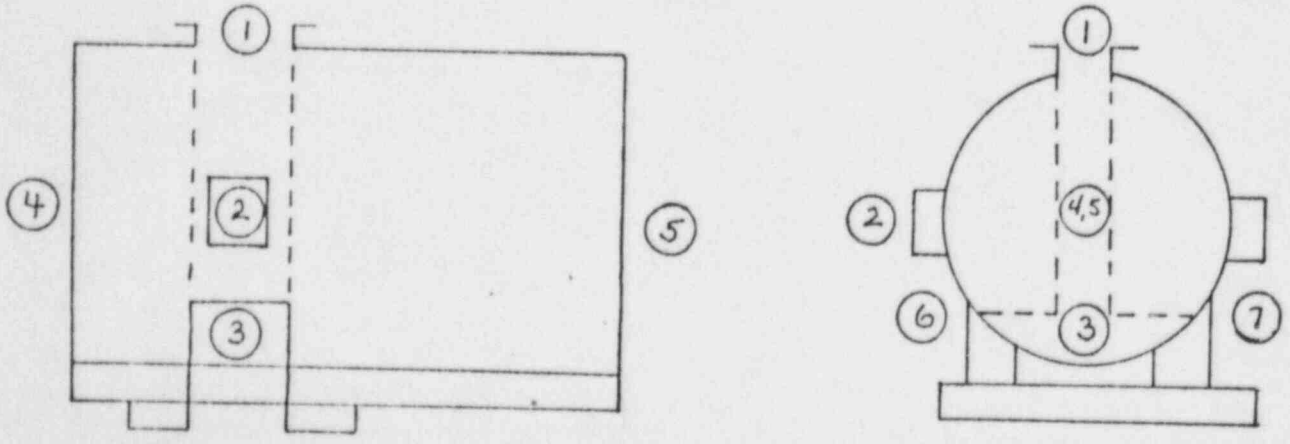


Table 2

Radiation Level Measurements
28 µg Cf-252 Source

A. Source extended; coal present in RSM; measurement at RSM surface

	N mrem/hr	δ mrem/hr	Total @ 28 µg (actual)	Total @ 50 µg (calculated)
1.	8.0	4.00	12.0	18.0
2.	.5	.62	1.12	1.68
3.	22.0	10.40	32.4	48.6
4.	.5	.18	.68	1.02
5.	.2	.08	.28	0.42
6.	1.8	.72	2.52	3.78
7.	2.0	.63	2.63	3.95

B. Source extended; coal present in RSM;
measurement 1 ft. from RSM surface

	N mrem/hr	δ mrem/hr	Total @ 28 µg (actual)	Total @ 50 µg (calculated)
1.	4.0	1.70	5.7	8.55
2.	.5	.39	.89	1.33
3.	12.0	3.6	15.6	23.4
4.	.06	.02	.08	0.12
5.	.1	.05	.15	0.23
6.	.8	.36	1.16	1.74
7.	.8	.44	1.24	1.86

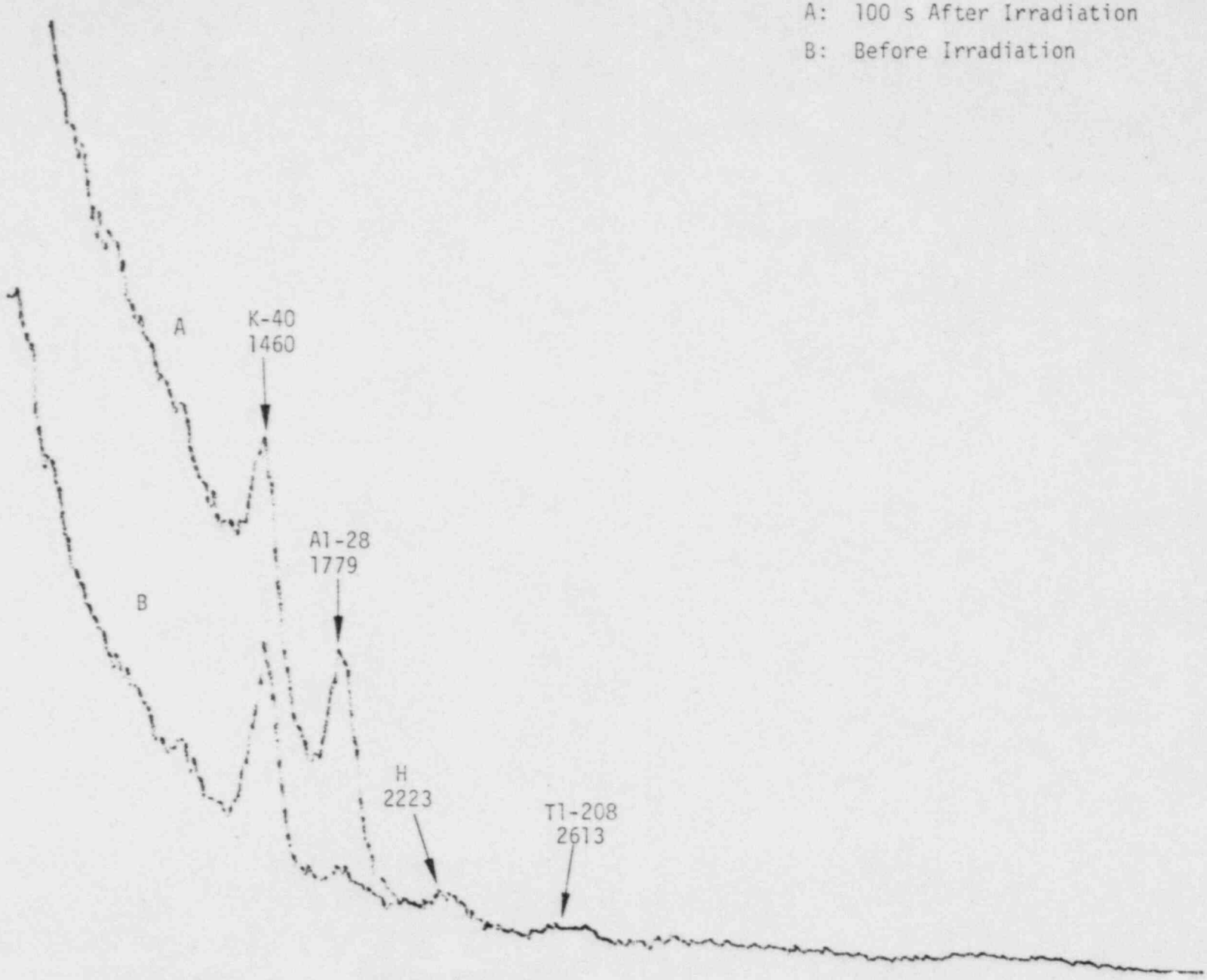


Fig. 1 Comparison of Coal Radioactivity Before and 100 s After Irradiation

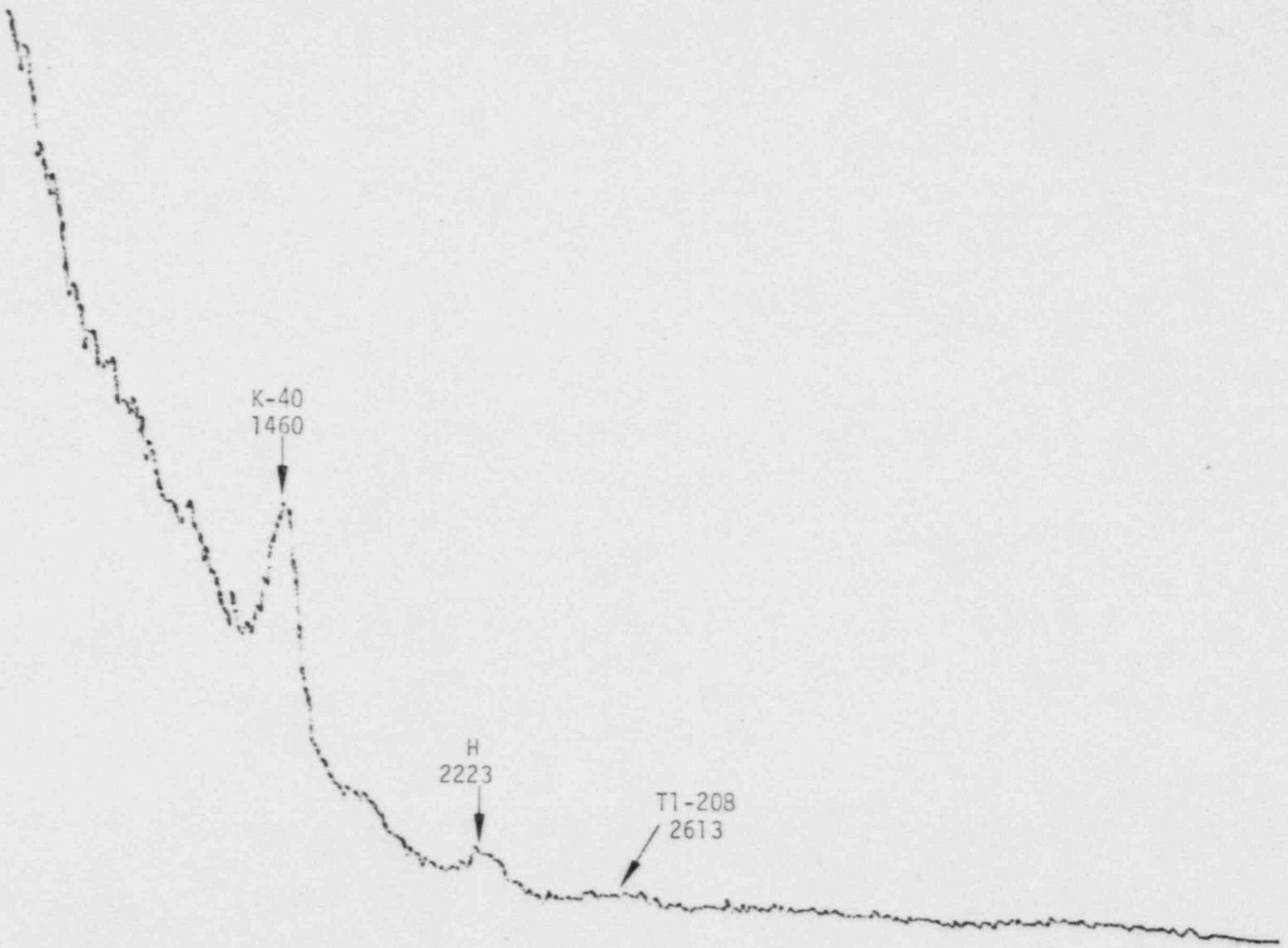
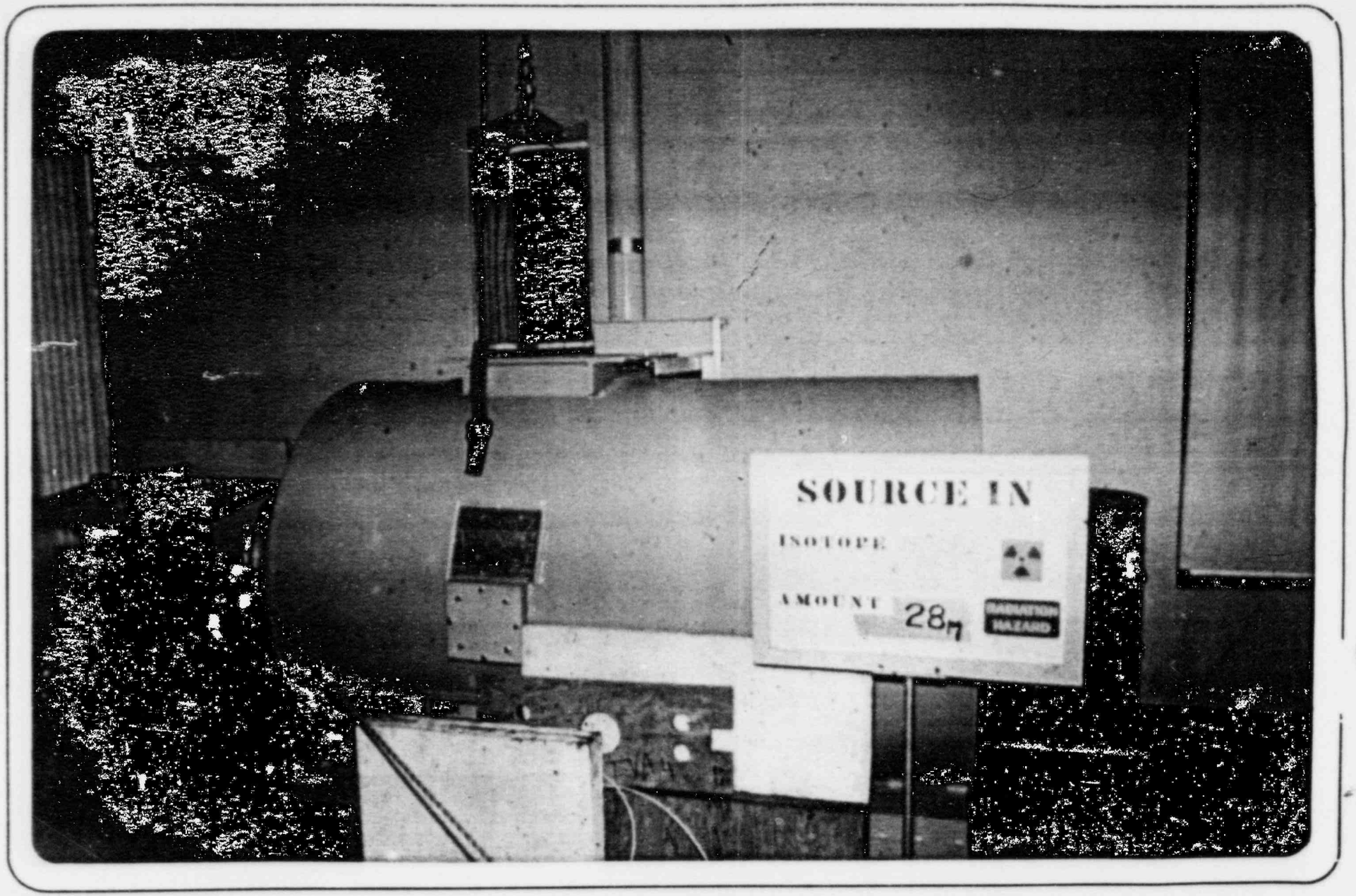


Fig. 2 Residual Coal Radioactivity 1000s after Irradiation



Rapid Sulfur Meter