

# INCIDENT INVOLVING LOSS OF A 37 GBq AMERICIUM 241 SOURCE FROM A RADIATION GAUGE

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This paper describes an incident reported to the Radiation Safety Section on 31 July 1986 wherein a radioactive source was found to be missing from the source housing of a radiation gauge used at a steel mill in Hastings, Victoria.

## Description of Gauge and Process

The source was Americium 241 of activity 37 GBq, and was incorporated in a Reuter-Stokes Safety-Ray Type RSS-811 gauge (see Fig.1). It was used in one of six such gauges to detect the presence of steel slabs being rolled into sheet steel in the hot strip mill. Three were operational and three were installed as back-up devices which could be switched in should a fault develop during a rolling period. The source housings were made from stainless steel and were mounted in a comparatively inaccessible position between rollers under the hot strip mill. The radiation beam was directed upwards at an angle (see Fig.2). Below the source housings was a drop of approximately 6 metres to the flume system used to wash iron oxide scale from the mill area to collection pits.

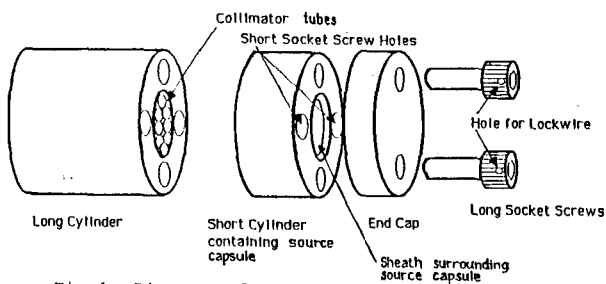


Fig.1 Diagram of Source Housing

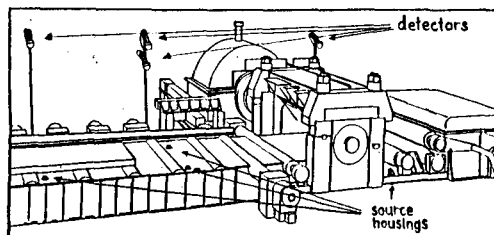


Fig.2 Typical Hot Strip Mill

## Sequence of Events

A company operation check of the gauges on 14 July 1986 had shown everything normal prior to a 7 day steel rolling period. On 23 July 1986, a further check prior to the next 7 day rolling period showed that the radiation level in the beam was 8 uGy/h compared with an expected level of 100 uGy/h. As a result the back-up gauge was switched in, the rolling period commenced, and the faulty gauge was listed for maintenance at the next down period on the mill. On 30 July 1986, during the scheduled down period, an examination of the gauge showed that the housing had become disassembled and that the radioactive source and parts of the gauge assembly were missing. A search was commenced by company personnel and one long screw and one short screw were recovered from the flume near the entrance to the finishing mill scale pit.

The following morning, 31 July 1986, the incident was reported to the Radiation Safety Section (RSS) and a full search of the flume area and finishing mill pit was commenced. No further parts of the gauge were recovered from the flume or the finishing mill pit. The search continued in the 200-300 tonnes of scale which had been removed from the pit. The scale was routinely sold to a cement manufacturer with plants at Geelong, Victoria and Traralgon, Victoria for use as a fluxing agent in the manufacturing process. It was advised that approximately 640 tonnes had been transported to Geelong and 40 tonnes to Traralgon since 14 July 1986, when the gauge was last known to be intact. The company was advised that the source may have been transported to one of their factories in the scale, and that they should not process any further scale from Hastings. They were also advised to commence a search of the unprocessed scale and to obtain suitable samples from various stages of the manufacturing process for analysis.

On 1 August 1986, a large industrial earth sifting machine was used to continue the search of the scale at the steel mill and the following parts of the gauge assembly were recovered : the second long screw, the second short screw, the short cylinder, the source sheath, and the collimator tubes. Examination of the scale at Traralgon found no trace of the gauge. RSS staff commenced a search of the scale at the cement works in Geelong. This search concentrated on hoppers which were mixing iron oxide scale with limestone. Advice from the company was that approximately 80% of the scale received since 14 July 1986 had already been processed. A press conference was held by the Health Department giving details of the incident and warning the public of the lost source.

The search of scale processed through the hoppers and conveyor systems at the Geelong plant continued until clinker cement samples examined by RSS staff on 4 August 1986, using a portable multi-channel analyser, showed traces of Am 241. These samples had been collected on a routine basis for chemical analysis. Samples from the relevant dates were forwarded to the Australian Radiation Laboratory (ARL) for assessment. No Am 241 was detected in the sample dated 25 July 1986. A maximum activity of 3-4 Bq/g was found in the sample from 29 July 1986, and lesser activities were detected on subsequent dates. Calculations indicated that, assuming an even distribution of Am 241 in the average daily output of 2500 tonnes of clinker, most of the 37 GBq of Am 241 would be accounted for. The specific activity of Am 241 in the clinker would have been further reduced as it was added to the clinker stockpile of approximately 30,000 tonnes. The cement company advised that some of this material could have been processed into cement and sold either in bulk or in bags prior to any indication of the incident.

The presence of Am 241 in the clinker indicated that the source capsule must have been processed through one of the two ball mills at the plant, and consequently that the remains of the source capsule could be still in a ball mill or in the reject material from the ball mills. Reject material from the ball mills had been used on roads in quarries and farms adjacent to the plant and on

the driveways of a number of employees. Searches of these areas were carried out but no trace of Am 241 was found.

On 5 August 1986, a meeting between the Health Department, Radiation Advisory Committee, ARL, the steel company, and the cement company confirmed that the concentration of Am 241 in the cement did not represent a hazard and a press conference was later held to report the finding of traces of Am 241 in the cement.

It then appeared most likely that the source capsule remains were still in one of the ball mills. Access to the mills was not immediately available. A motor failure prevented unloading of the small mill, and the large mill was therefore necessary for continued operation of the plant. The large mill contained about 2.3 million chromium steel balls ranging from about 2 cm diameter up to 9 cm diameter whilst the small mill contained about 1.5 million similar steel balls.

On 6 August 1986, a meeting was held with the cement company's employees to discuss their concerns regarding the incident. On the same day, a shutdown of the large ball mill was arranged to enable a search of the interior. This proved inconclusive and indicated that the mills would need to be emptied to enable an effective search for the source capsule remains.

On 12 August 1986, the small ball mill was emptied and traces of Am 241 were detected in the slurry, indicating that the source capsule had been processed in this mill. Samples from the slurry were later assessed by ARL and found to contain 22 Bq/g. Thirteen officers of the Health Department searched through the steel balls and the source capsule was recovered the following day. An examination of the capsule by ARL showed that about 1.5% of the original source activity remained, i.e. about 56 MBq. This confirmed that the majority of the activity had been processed into the cement. However, in view of the low concentration of Am 241 in the cement product, it was not considered that any action regarding decontamination of the plant or cement product was warranted.

#### **Review of Incident**

As a result of the incident a review was made of the design of the gauges and the reasons for the occurrence. The parts of the source assembly recovered were sent to the Aeronautical Research Laboratories for metallurgical examination to determine whether the gauge had been deliberately interfered with. Their report indicated no signs of interference.

The gauges on the hot strip mill are subject to wide ranges of temperature (the steel slabs on the mill are at 1100°C) and considerable vibration. It was considered that this, along with inadequate maintenance procedures and the design of the gauges, led to the screws loosening over a period of time and the source assembly eventually falling apart.

The design of the gauge was considered inadequate in that the source capsule was held in the source assembly only by the two long screws through the end cap. Whilst these had also been held by a lockwire with a lead seal, this wire had rusted through and disintegrated. It was considered that the design of the device should have been better considering the extremes of temperature and vibration and the configuration of the gauge in the hot strip mill.

Since the incident, the following conditions have been imposed on all RSS-811 gauges registered with the Health Department under the Health (Radiation Safety) Regulations :

- a) Each gauge to be removed from installation and inspected in detail in the workshop, with the following work to be carried out:
  - i) All source assembly screws examined and tightened to a torque of 8 Nt.m. Loctite 622 or equivalent to be used to ensure that they do not loosen. (It was noted that all screws were able to be tightened by at least a half turn, even a unit which had not been used but was as supplied by Reuter-Stokes).
  - ii) Rewire screw heads with MP35N or equivalent wire and seal.
  - iii) Inscribe serial numbers into body of assembly.
  - iv) Replace screws on beam window with stainless steel screws and MP35N wire or equivalent.

Source assembly then to be bolted to frame mounting at correct torque setting; bolts to be wired with MP35N wire or equivalent.

- b) Prior to each start-up of a rolling process, a physical check of frame and source assembly bolts to be carried out.
- c) For each sensor or out of calibration alarm, a physical check to be made to ensure that the source assembly is intact (to be logged).
- d) Torque on frame mounting bolts to be checked every 3 months.
- e) Torque of source assembly screws to be checked, and screws rewired, every 12 months.
- f) Mounting and removal access to the source assembly to be made simpler to allow for ease of removal for thorough inspection.
- g) A maintenance-free source holder to be designed and plans to be forwarded to the Health Department for approval; the design to allow source insertion from the top of the assembly and to negate the need for any assembly screws in the lower section.

Other State Health authorities were warned of the incident in order that they could determine whether similar gauges existed in their States and so that appropriate inspections could be carried out.

It was considered that the design of a maintenance-free source housing and the interim conditions imposed on the registrations of similar gauges would prevent any repetition of this incident.

#### Reference

Health (Radiation Safety) Regulations 1984, Victorian Government Printing Office.