

= Samut Prakan radiation accident =

A radiation accident occurred in Samut Prakan Province , Thailand in January ? February 2000 . The accident happened when an insecurely stored unlicensed cobalt @-@ 60 radiation source was recovered by scrap metal collectors who , together with a scrapyard worker , subsequently dismantled the container , unknowingly exposing themselves and others nearby to ionizing radiation . Over the following weeks , those exposed developed symptoms of radiation sickness and eventually sought medical attention . The Office of Atomic Energy for Peace (OAEP) , Thailand 's nuclear regulatory agency , was notified when doctors came to suspect radiation injury , some seventeen days after the initial exposure . The OAEP sent an emergency response team to locate and contain the radiation source , which was estimated to have an activity of 15 @.@ 7 terabecquerels (420 Ci) , and was eventually traced to its owner . Investigations found failure to ensure secure storage of the radiation source to be the root cause of the accident , which resulted in ten people being hospitalized for radiation injury , three of whom died , as well as the potentially significant exposure of 1 @,@ 872 people .

= = Background = =

Cobalt @-@ 60 (^{60}Co) is a synthetic radioactive isotope of cobalt , with a half @-@ life of 5 @.@ 27 years , and emits highly penetrating gamma rays . It is commonly used as a radiation source for radiotherapy and equipment sterilization in the hospital setting , and has several other industrial uses as well . The device involved in the Samut Prakan accident was a rotational Gammatron @-@ 3 teletherapy unit , manufactured by Siemens and imported to Thailand in 1969 . It was licensed for and installed at Ramathibodi Hospital in Bangkok ; the radiation source involved was a replacement installed in 1981 , with an initial radioactive activity of 196 TBq (5 @,@ 300 Ci) . At the time of the accident in 2000 , its activity was estimated to have decayed to 15 @.@ 7 TBq (420 Ci) .

The licensing of radioisotopes and nuclear material for import , export , possession and use in Thailand is regulated by the Thai Atomic Energy Commission for Peace and its working body , the Office of Atoms for Peace (OAP) , formerly known as the Office of Atomic Energy for Peace (OAEP) . In principle , the licensing process would involve annual safety inspections , but due to lack of personnel and resources , such inspections were not always properly done , nor were regulatory and control protocols strictly enforced .

The hospital retired the radiotherapy unit in 1994 and acquired a new one from Nordion via its Thai agent Kamol Sukosol Electric Company (KSE) . The old unit and its ^{60}Co source could not be returned either to its original German manufacturer Siemens , which had stopped producing or servicing them , or to the Canadian supplier Nordion , which was not the original manufacturer . Consequently , the hospital sold the old unit to KSE , which already had another licensed unit in storage . However , neither the hospital nor KSE informed the OAEP of the transfer . In 1996 an OAEP inspection found that KSE had three unlicensed units in its warehouse , which had been licensed for the storage of a single unit in 1988 .

KSE 's lease of the warehouse was terminated in 1999 . KSE subsequently returned the licensed unit , while moving the three unregistered units to an unused car park in Bangkok 's Prawet District , which was owned by its parent company . The car park was fenced , but the fence had been breached and nearby residents regularly entered to play football in its empty areas . KSE notified the OAEP of its transfer of the licensed unit , but did not mention the other three , which remained orphan sources .

= = Accident = =

On 24 January 2000 , the part of the radiation therapy unit containing the radiation source was acquired by two scrap collectors , who claimed to have bought it from some strangers as scrap metal for resale . They took it home , planning to dismantle it later . On 1 February , the two , together with another two associates , attempted to dismantle the metal part (a 97 @-@ kilogram ,

42 @-@ by @-@ 20 @-@ centimetre lead cylinder held in a stainless steel casing) , which was the unit 's source drawer . Using a hammer and chisel , they only managed to crack the welded seam . Two of the men then took the metal piece , along with other scrap metal , to a scrapyard on Soi Wat Mahawong in Phra Pradaeng District , Samut Prakan Province . There they asked a worker at the scrapyard to cut open the cylinder using an oxyacetylene torch . As the cylinder was cut open , two smaller cylindrical metal pieces , which had held the source capsule , fell out . The worker retrieved the two pieces and kept them in the scrapyard , but was unaware of the source capsule itself . The lead cylinder was returned to the scrap collectors for them to complete the disassembly .

That same day , the four men present when the cylinder was opened (two of the scrap collectors and two scrapyard employees) began to feel ill , experiencing headaches , nausea and vomiting . The scrap collectors succeeded in taking the lead cylinder apart , and took the parts to sell at the scrapyard the next day . The scrapyard employees continued to feel sick during the following week , and on 12 February the scrapyard owner , believing the metal to be causing the illness , asked the scrap collector to take it elsewhere , and had the two smaller metal pieces thrown away .

By mid @-@ February the symptoms of those involved were deteriorating ; their symptoms included burn wounds , swollen hands , diarrhoea , fever , and hair loss . One of the scrap collectors went to Samut Prakan Hospital on 15 February and was admitted the next day , while the two scrapyard employees were also admitted , on 16 and 17 February . The scrapyard owner 's husband was admitted to Bangkok General Hospital on 17 February due to epistaxis (nosebleed) , while the scrapyard owner , her mother , and her maid (all of whom lived across the street from the scrapyard and sometimes entered) also began to feel ill . A stray dog that was often seen in the scrapyard also died .

Two of the patients at Samut Prakan Hospital were admitted to the surgical ward , while the other was admitted to the medical ward . All were nauseated and vomiting , and two of them were showing leukopenia (low white blood cell count) . Reviewing the cases on 18 February , the doctors realized their symptoms were likely caused by radiation exposure , and notified the OAEP .

= = Response = =

Upon receiving notification , the OAEP sent two officers to investigate , who met the doctors and patients at the hospital shortly after noon on 18 February . After questioning the scrapyard owner , they searched for the cylindrical metal pieces initially suspected to be the radiation source , but found that they were not radioactive . They then headed to the scrapyard , and noted abnormally high levels of radiation as they approached , late in the evening . At the scrapyard entrance they measured radiation at an equivalent dose of 1 millisievert per hour (mSv / h) and decided to request additional assistance .

Recognizing the event as a serious radiological accident , the OAEP organized an emergency response team to manage the situation , in conjunction with the local public health and civil defense authorities . They conducted contamination and radiation level surveys and found that there was no contamination , but the radiation dose rate was as high as 10 mSv / h near the source , which kept them from getting close enough to determine what the source was . Surveys to locate the source continued throughout the night . The scrapyard and immediate vicinity were cordoned off , but evacuation was deemed unnecessary .

Retrieval operations began in the afternoon of the following day (19 February 2000) , after planning and rehearsing . An excavator was used to clear the way into the scrapyard , and a lead wall was placed to help shield operators from radiation . Scrap metal pieces near the source were removed one by one , using a grasping tool for large pieces , and an improvised electromagnet attached to a 5 @-@ metre (16 ft) bamboo rod for smaller ones . A high range radiation dose rate probe was used to screen these metal pieces for radioactivity . A fluorescent screen was used to ultimately determine the exact location of the source , but the team had to wait for cloud cover to reduce moonlight enough to see properly . The source capsule was finally retrieved shortly after midnight and placed in a shielded container . It was identified by in situ gamma spectroscopy as ^{60}Co , and had an estimated activity of 15 @-@ 7 terabecquerels (420 Ci) .

The ⁶⁰Co source was transferred for storage at the OAEP headquarters . Subsequent surveys found radiation in the scrapyard to have returned to normal background levels . During the same time , the OAEP was informed of the three teletherapy units in the car park , and a separate investigating team found one of the units to have had its drawer assembly missing . This was confirmed to be the origin of the source , and the three units were removed for temporary storage on 21 February .

The OAEP reported the incident to the International Atomic Energy Agency (IAEA) , which sent a team of experts on 26 February to assist in the management of the situation and the treatment of those injured .

= = Casualties = =

In total , ten people were admitted to hospital with radiation sickness : the four scrap collectors , the two scrapyard employees , the scrapyard owner , her husband , her mother , and her maid . Of these , four people (those working at the scrapyard) were estimated to have received radiation doses of over 6 gray (Gy) . All patients were ultimately referred to Rajavithi Hospital , where they received inpatient care . All but one of the patients developed agranulocytosis or bicytopenia (depletion of white blood cells and / or platelets) . Several also developed burns , and one (the first scrap collector) had to have his finger amputated . Three patients (the two scrapyard workers and the owner 's husband) ultimately died of uncontrolled infection and sepsis , all within two months of exposure .

In addition to these casualties , 1 @, @ 872 people living within 100 metres (330 ft) of the scrapyard were potentially exposed to different levels of ionizing radiation . Physical exams and blood tests were provided to nearly half these people , who sought medical attention . Radiation doses received by OAEP personnel working to recover the radiation source did not exceed 32 mSv , as measured by individual thermoluminescent dosimeters .

= = Public reaction and aftermath = =

The accident became a subject of intense news coverage . The origin of the poorly stored radioactive source was traced to KSE , which was charged with possessing radioactive substances without permission and was fined 15 @, @ 000 baht (approx \$ 450) . Environmental Litigation and Advocacy for the Wants (EnLAW) , a non @-@ governmental advocacy group , later filed a class action lawsuit against KSE on behalf of the victims , and also against the OAEP in the Administrative Court . The Administrative Court later ruled in 2003 in favour of the plaintiffs , ordering the OAEP to pay 5 @, @ 222 @, @ 301 baht (approx \$ 155 @, @ 000) as restitution . KSE was ordered by the Civil Court to pay a total of 640 @, @ 246 baht (approx \$ 19 @, @ 000) .

In media reports of the accident , several reporters commented negatively on the emergency response team 's operation , perceiving them as " not taking the matter [of radiation hazard] seriously " and being unprofessional and lacking training . The BBC told of " officials searching through scrap metal heaps for radioactive waste using sticks and wearing cotton gardening gloves and cloth face @-@ masks . " The IAEA defended the team in its report , noting that it included " experienced personnel with expertise in dealing with high radiation fields and control of known contamination , " and that they " used innovative means to achieve rapid recovery of the source . " It also commented that the lead aprons worn by some members of the response team were not appropriate for use in the situation , as they would not offer adequate protection against ionizing radiation .

As public concern over the accident grew while information and education was limited , misconceptions arose about the nature of radiation hazards . Residents near a Buddhist temple protested and prevented the cremation of one of the victims , believing that the body could spread radiation , despite assurances by the OAEP to the contrary .

The IAEA report noted that the main contributing factors to the accident were : difficulties in the disposal of radiation sources , the OAEP 's limited oversight capacity , transfer of the disused source

without the OAEP 's approval , moving the sources to an unsecured location , lack of understandable warnings , and the dismantling of the device . An article published in Australasian Physical & Engineering Sciences in Medicine commented that " the most serious omission occurred when the medical users ... returned the obsolete units to the Medical Dealer without notifying the OAEP " and that their insecure storage " invited theft . " It called for provisions for the safe return and verified disposal of all significant radioactive sources , and stated : " National action is needed to cope with the regulatory problem of orphan sources by maintaining accountability of sources through national registers and the legal enforcement of compliance with the regulations . "

The accident , along with other similar events , prompted the IAEA to re-evaluate the effectiveness of the radioactive hazard trefoil as a warning symbol . Although the symbol was displayed on the teletherapy head , none of those handling the device were aware of its meaning , nor were there written warnings in Thai . Together with the International Organization for Standardization (ISO) , the IAEA developed a new symbol that would serve as an intuitive warning for large sources of ionizing radiation . The new symbol was published in 2007 as ISO 21482 , and is intended to accompany the trefoil on internal components of devices containing dangerous sources to prevent persons from unknowingly disassembling them .

In Thailand , however , substantial efforts to prevent further such occurrences had not materialized in the months following the accident . Labour activists , trade unions and workers were lobbying for the creation of an independent occupational health and safety institute . Social critics pointed out that the accident , along with several prior disasters such as the Kader toy factory fire , was part of a trend in which the country 's rapid industrialization resulted in increasing health and environmental hazards due to poor regulations and lack of official willingness to tackle the issue .

Similar incidents occurred in Thailand in 2008 , without injuries . In June 2008 , a cesium ^{137}Cs sealed radioactive source was found among scrap metal sold to a scrap dealer in Ayutthaya Province . The dealer recognized the trefoil symbol , and notified the OAP , which responded and found no leak of radiation or contamination . It could not , however , determine the origins of the equipment . In August , a recycling factory in Chachoengsao Province notified the OAP after a piece of scrap metal set off its gate detector alarm . The OAP found that the piece of metal contained radium ^{226}Ra sources , and concluded that it originated from unlicensed use in a lightning preventer .