

Contamination of the CO₂ System at Hunterston B Nuclear Power Station

Iain Clenahan

Introduction – What and Why?

- An incident that occurred at the Hunterston B Nuclear Power Station in February 1997
- It wasn't a “disaster” in the traditional sense, but the incident had negative consequences for the operator, and caused disruption to some food and drink supplies
- The issues identified are not unique to the nuclear sector
- It is an incident with local (Scottish) interest
- It was the subject of a published regulators' official report

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Contamination of the carbon dioxide supply system at Hunterston B Power Station, February 1997

The following is an abstract from a priced publication. The publication is available from HSE Books, P.O. Box 1999, Sudbury, Suffolk CO10 6FS, tel: 01787 881165, fax: 01787 313995.

Introduction and event summary

1. On 3 March 1998 Scottish Nuclear Ltd (SNL) reported to HM Nuclear Installations Inspectorate (NII) and the Scottish Environment Protection Agency (SEPA) an event which was first discovered by the operators at Hunterston B Nuclear Power Station on 20 February 1997. The station is located on the Ayrshire coast approximately 30 miles south west of Glasgow and comprises two Advanced Gas-cooled Reactors (AGRs) which became operational in the mid-1970s.
2. The immediate cause of the event was a number of defective valves which allowed an unintentional backflow of carbon dioxide gas. This gas is used as reactor coolant and flowed on that occasion from the reactor's high pressure circuit to the station's storage tanks used for holding liquid carbon dioxide supplies (operational storage tanks). The cause for

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Introduction – What and Why?

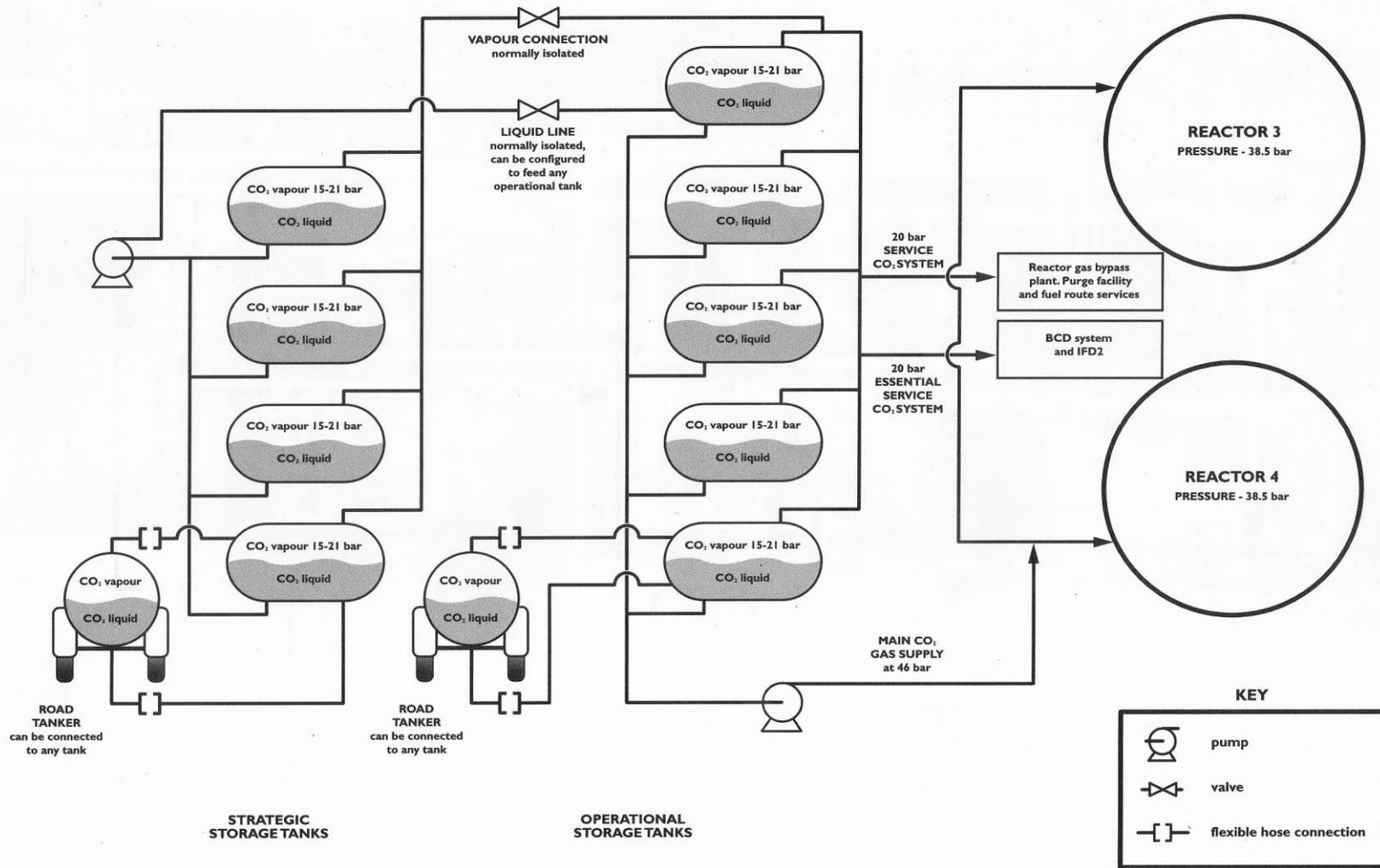
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- The issues identified are not unique to the nuclear sector
- It is an incident with local (Scottish) interest
- It was the subject of a published regulators' official report
- Chemical engineers work in the nuclear industry!
- An excuse to moan about regulators (if one were needed)!!

Hunterston B – Background

- Hunterston B Power Station comprises 2 Advanced Gas-cooled Reactors (AGRs)
- Carbon dioxide is the coolant (heat transfer medium) employed
- Hunterston B (with Dungeness B and Hinkley Point B) was in the first wave of AGRs commissioned during the mid/late 1970s
- Nominally rated at $2 \times 1.6\text{GW}_{\text{th}}$ and $2 \times 660\text{MW}_{\text{e}}$
- Operated by Scottish Nuclear Ltd (SNL) in 1997

Reactor CO₂ Cooling Circuit

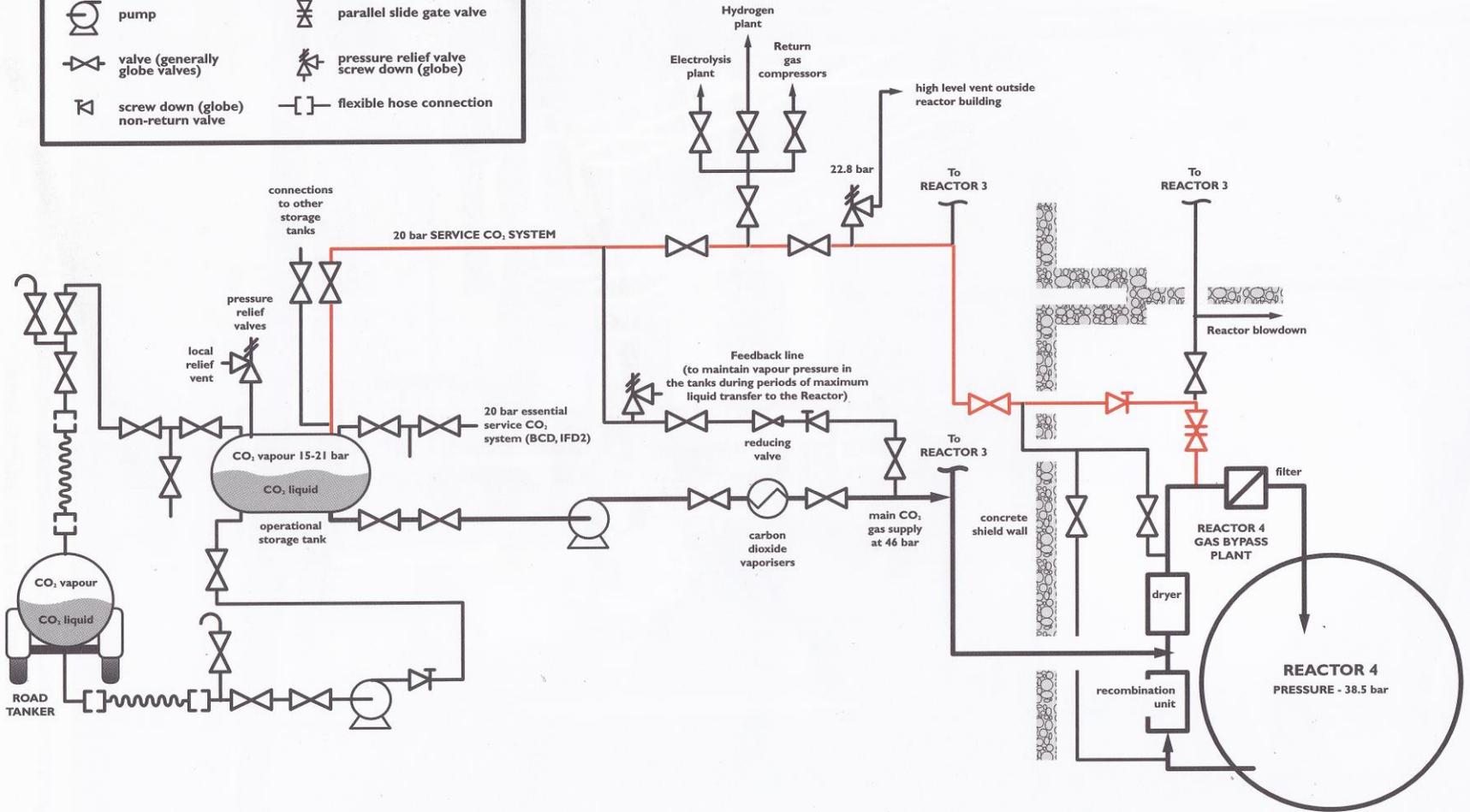
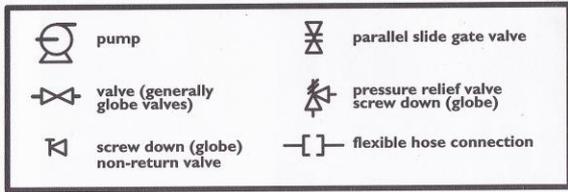
- The CO₂ (referred to as “reactor gas”) is recirculated at ca 40 bar
- Contaminants can build up within the reactor gas - this needs to be maintained within a desired range, and this is achieved by diverting some reactor gas via a bypass plant
- Losses of reactor gas (2–4 tonnes/day/reactor) occur for various reasons – the circuit therefore needs to be periodically topped up
- Fresh CO₂ is supplied from local storage tanks held at ca 20 bar
- The station has both operational storage tanks (OSTs) and strategic storage tanks (SSTs), which hold 370 tonnes and 690 tonnes respectively



What happened?

- 3 valves in series on the low pressure CO₂ supply system failed to provide a gas-tight seal in the line from the reactor gas bypass plant to the OSTs
- The difference in pressure between the reactor gas circuit (ca 40 bar) and the operational storage tanks (ca 20 bar) resulted in backflow of reactor gas into the OSTs

KEY

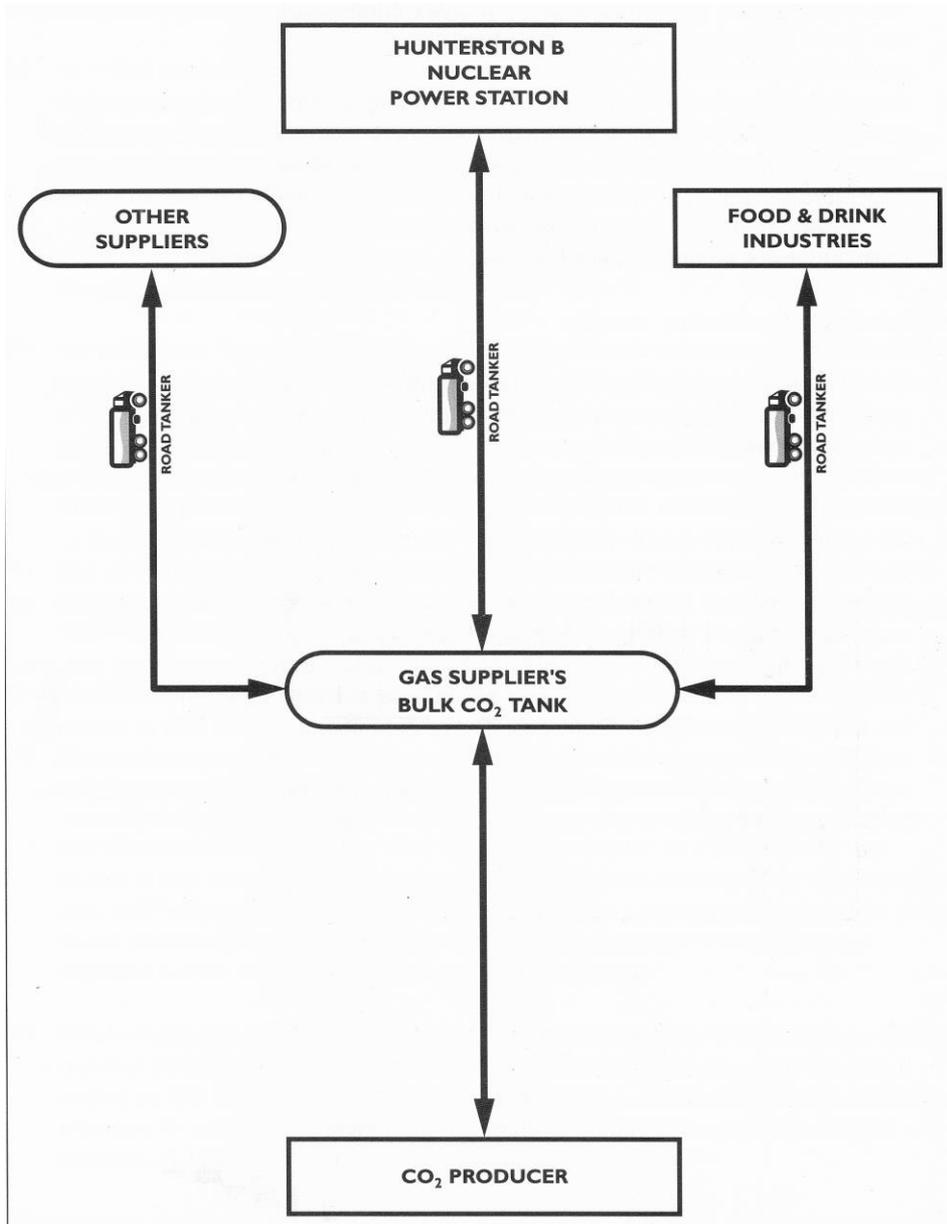


How was the problem identified?

- A routine health physics survey identified elevated radiation levels in the vicinity of the low pressure CO₂ supply pipework
- Initially it was thought that the problem was caused by a pressurisation during “burst can detection” (BCD) activities on Reactor 3 – it was thought action to address this would solve (had solved?) the problem
- This judgement was not correct, and the true source of the problem (the passing valves associated with Reactor 4) was identified after 4 days of using gamma monitors to detect where ⁴¹Ar was present within the low pressure supply system

How could it affect CO₂ network?

- Station's storage tanks require periodic top-up deliveries of (liquified) CO₂
- Made by road tanker from the gas supplier's bulk tank
- Road tanker coupling involved liquid supply and headspace connections → potential for displacement of contaminated gas to the road tanker
- When road tanker refilled from gas supplier's bulk tank headspace connections also made → potential for contamination of the bulk tank
- Gas supplier's bulk tank also served other users and suppliers → potential for onward spread of contamination, including to food and drink sector



Chronology of Events

- **Feb 20:** Problem identified, delivery diverted to SSTs, BCD disconnected, OSTs purged and sampled
- **Feb 21:** Incident report raised, OSTs confirmed to still be contaminated, decision taken to stop deliveries to OSTs
- **Feb 22 & 23:** Purging of OSTs continued, but ineffective
- **Feb 24:** Delivery diverted to STTs
- **Feb 25 & 26:** Cause of contamination finally identified, leak diverted to blowdown system, purging of OSTs effective, only delivery diverted to SSTs
- **Feb 27 & 28:** Potential significance of incident first understood, **and realisation that a delivery had been made to the OSTs on Feb 21 after they had been sampled**

Consequences

- Health
- Public Interest/Concern
- Political
- Wider Business
- Regulatory
- Legal

Potential Health Consequences

- Under normal conditions, reactor gas contains ^{41}Ar , ^{14}C , ^{16}N , ^3H , ^{35}S
- In the event of a fuel container failure, it can also contain fission rare gases, iodine isotopes, and ^{137}Cs
- Information indicated that there wasn't a problem with fuel containment around Feb 21, and this was confirmed by sampling
- Assessments therefore concentrated on the potential impact of public exposure to normally-expected radionuclides

Assessment of Health Impacts

- SNL estimated the potential dose that could have resulted based on an assumption of the amount of reactor gas present in the OSTs based on CO as a surrogate
- SEPA assessed the basis for SNL's estimate and concluded that, although SNL may have underestimated the presence of reactor gas by about 20%, its estimate of the possible off-site transfer was nevertheless credible
- On receiving this information, the Chief Medical Officer for Scotland concluded that the risk to public health was negligible
- A worst case assessment (assuming OSTs' headspaces were 100% reactor gas) indicated a potential dose of 0.05 $\mu\text{Sv/l}$ carbonated drink (the public dose limit is 1000 $\mu\text{Sv/year}$)

Public Interest/Concern

- The public are generally concerned (fearful?) about anything related to radioactivity, and particularly risks perceived to be associated with nuclear power stations
- Suspicions are such that a statement from “technical experts” indicating that there isn’t a health issue is not always believed
- This attitude sometimes reflects a belief by the general public that they should never be unnecessarily exposed to radioactivity as a result of an avoidable event
- Anything that reinforces these views, and can be taken to confirm any perception of a lack of adequate control, has obvious consequences for the operators of nuclear power stations

NEWS

5th March 1997

Drinks in radiation leak scare



THE Hunterston nuclear power plant in Ayrshire was at the centre of a major public health scare last night over fears that radioactive gas had been transmitted to supplies of beer, soft drinks, mineral water, and other products.

Scottish Nuclear admitted that "slightly" contaminated carbon dioxide may have accidentally been carried away from the complex in three gas tankers which then made deliveries to other customers.

The Scottish Office last night said it thought the risk to health was "negligible", but has declared an official Food Hazard Warning, and has set up a helpline to deal with public concerns from this morning.

Scottish Secretary Michael Forsyth, who was informed about the radiation threat on Monday evening, said last night: "I appreciate, and share, public concern. I have ordered immediate action."

Following media inquiries, the Scottish Office issued a full list of drinks manufacturers which could have received contaminated supplies of CO2.

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News

Radiation risk to bottled water

Wednesday 5 March 1997 01:02 |

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Checks were ordered on bottled mineral water after fears of a radiation leak at a nuclear power station, it emerged last night.

"Slight contamination" was found in tanks used to supply carbon dioxide to reactors at Hunterston B power station on the Ayrshire coast. The find raised fears that road tankers used to carry carbon dioxide to the plant may also have become contaminated, according to Scottish Nuclear.

It said it was working with the gas transportation company, Messer UK, to check contamination had not passed to other users of the gas, including the carbonated water industry. Scottish Nuclear said any radiation which may have been passed on could have been only a fraction of the naturally occurring background radiation found in mineral water.



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NEWS

6th March 1997

Nuclear chief admits 'failure'. Fear of food risk



THE CHAIRMAN and chief executive of Scottish Nuclear yesterday admitted that "failures in rigorous safety procedures" at Hunterston B power station are behind a radiation scare surrounding some of the UK's best-known brands of food and drink.

Dr Robin Jeffrey also admitted that a potential link between Hunterston and the food chain via supplies of carbon dioxide (CO2) had "never occurred to Scottish Nuclear or the Nuclear Installations Inspectorate."

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Political Consequences

- A statement on the incident was requested in the House of Commons on 5 March by George Robertson (the then Shadow Secretary of State for Scotland)
- Michael Forsyth (the then Secretary of State for Scotland) provided a statement, and this was followed by contributions from many Scottish MPs
- The main issues raised were:
 - SNL's delay in notifying
 - The need to allay any fears that the public may have
 - Risk of collateral impact on other industries
 - The use of a common CO₂ delivery network

**During his statement,
Michael Forsyth said the following:**

I am—and, I am sure, the whole House will be—relieved that there appears to be no risk to public health as a result of this incident. There are, however, a number of aspects which give rise to concern—notably the delays that took place in drawing this problem to the attention of the authorities and the fact that it is possible for carbon dioxide tankers supplying the food industry also to make deliveries to a nuclear power station. I have asked the Scottish Environment Protection Agency and Nuclear Installations Inspectorate for a full report on the incident, which I expect to receive within a week and which I will publish. In the light of this I will consider what further action should be taken.

**In his response,
George Robertson said the following:**

Although serious questions need to be answered about the incident, especially about the time it took for Scottish Nuclear to notify the outside world, and about the procedures for delivering carbon dioxide to a nuclear power station, I believe that the Secretary of State was absolutely right to publish a list of the companies that had been supplied with carbon dioxide and to institute immediate sample checks of their products. Ultra-caution must be the rule when it comes to the safety of food and drink—the public deserve nothing less.

No amount of technical assessment or expert guesswork will satisfy a public increasingly concerned about food safety scares.

**For those interested,
all the MPs' contributions can be found here:**

<https://api.parliament.uk/historic-hansard/commons/1997/mar/05/hunterston-power-station>

Wider Business Consequences

- SEPA sampled the CO₂ supply network, and the Scottish Office sampled food and drink supplies – all samples were subject to radiochemical analysis by NRPB
- This caused disruption to various producers' activities, as they were reluctant to offer potentially affected products for sale until the results of the testing were made available
- Some businesses chose to adopt a precautionary approach and withdrew potentially affected products from sale

News

Brewery recalls CO2 cylinders

Saturday 8 March 1997 01:02 |



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A brewery last night recalled carbon dioxide cylinders used to pour pints in pubs after tests revealed a trace of radioactivity.

Carlsberg-Tetley in Alloa is recalling all cylinders at present in use in Scotland after tests revealed a "slightly elevated level" of radioactivity in one cylinder. The tests were being carried out after Scottish Nuclear discovered a leak at Hunterston B nuclear station in Ayrshire which could have contaminated a road tanker delivering supplies of carbon dioxide. The same tankers are used in deliveries to the food and drinks industry.

The Scottish Office said in a statement that the effect on consumers from such a level would be "negligible".

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Regulatory Consequences

- SNL's delay in notifying the regulators was problematic for numerous reasons:
 - No timely influence on SNL's investigations, assessments and actions
 - The regulators may have been “on the back foot” in the event of news of the incident breaking before they had been informed – NB SNL had contacted the gas supplier 5 days before notifying the regulators
 - The sampling and analysis of the CO₂ supply network by SEPA (and other CO₂ users' supplies and products by the Scottish Office) was delayed, and this meant that it could not be relied upon to provide a robust picture of the degree of onward contamination

The regulators' official report included the following paragraphs:

- 38 The throughput of carbon dioxide via the gas supplier's road tankers, bulk tank, and distribution network is considerable. The supplier's bulk storage tank has a capacity of 165 tonnes, and is topped up with approximately 90 tonnes of freshly generated carbon dioxide daily. Any radioactive contamination transferred to the supplier's bulk tank at the distribution centre via a road tanker which had previously made a delivery to the station would therefore have been progressively diluted by the daily topping up of the tank.
- 39 As the concentration of radioactivity in the bulk tank would have more than halved over each passing day, by the time SEPA was able to obtain a sample from the bulk tank 12 days after the station first embargoed road tanker deliveries to its operational storage tanks, any carbon-14 contamination in the bulk tank would have reduced to a small fraction of its original concentration. The level would have been extremely small relative to the normal carbon-14 level in the bulk tank, and therefore impossible to distinguish from the background.
- 40 The fact that no elevated level of carbon-14 was detected in the carbon dioxide samples obtained from the bulk tank or road tankers on 5 March 1997 does not show that no contamination had occurred around the time of the event. Nevertheless, it does indicate that no contamination had occurred during the day or two before the samples were taken.

Regulatory Requirements

- In response to the incident, the regulators required:
 - Measures to prevent a recurrence
 - Improved incident investigation and assessment procedures, and more effective internal communication systems
 - Better (quicker) external reporting arrangements
 - An assessment of whether there had been any previous similar incidents
 - An assessment of whether other fluid systems had similar vulnerabilities

Prevention of a Recurrence

- Initially, all deliveries of CO₂ to Hunterston B (and other stations) were embargoed until the regulators were content that suitable measures were in place
- The embargo was lifted once the following (medium-term?) arrangements were fully established:
 - Deliveries to be made to SSTs only, with transfers between SSTs and OSTs to take place without pressure equalisation
 - Gamma radiation detectors installed on “clean” CO₂ pipes
 - Daily sampling of OSTs and SSTs, and sampling of each departing road tanker for reactor gas
 - A robust and comprehensive implementation procedure

Prevention of a Recurrence

- An additional (longer-term) solution was identified that would bring Hunterston B into line with precautions adopted by other AGR stations – reconfiguration of the plant to provide a pressure barrier between the OSTs and the reactors
- The regulators concluded that the suggestion by various MPs that dedicated tankers should be employed “had little technical merit”, as it would not be feasible to provide a dedicated bulk tank and CO₂ source

Investigation and Internal Communications

- The regulators' investigations revealed the potential for improvements in Hunterston B's arrangements for initial identification and subsequent follow up of events.
- In response, Hunterston B restructured its arrangements for monitoring and reviewing incident and event follow-ups:
 - Additional forum for looking at "minor" events
 - Extended scope for the multi-departmental meetings
 - Formalised communications between technical groups

External Reporting

- Regulators identified the need for improvements in the reporting of events with (likely) low radiological significance but wider public interest
- SNL (and Nuclear Electric Ltd) acknowledged this, and set up arrangements whereby regulators would be notified immediately in the event of such an incident
- SEPA reviewed the wording of its then authorisations with a view to clarifying the reporting requirements

Previous Similar Incidents?

- An investigation of plant (valve) maintenance records and health physics surveys identified that the “clean” CO₂ system had been contaminated twice during 1996
- Neither the maintenance records nor the health physics surveys had resulted in the identification of events requiring investigation
- There were therefore inadequacies in plant monitoring that were not identified, investigated, or corrected

Other Vulnerable Fluid Systems?

- HAZOP studies were carried out at all UK nuclear sites on all gases and fluids brought in via pipework, bulk road tanker, and other reusable containers or bottle systems where there was even the remotest chance of back-contamination
- No major weaknesses were found, but various enhancements were identified, including:
 - Improving responses to the failure of protective barriers through appropriate alarms and procedures
 - Better physical isolation of lines/systems not in regular use
 - Reduce system complexity where possible

Legal Consequences

- The Procurator Fiscal required both SEPA and the NII (now ONR) to separately provide reports on the incident
- SEPA's addressed potential breaches of the Radioactive Substances Act 1993
- This focused on whether there had been an unauthorised disposal of radioactive waste
- Disposal in this context includes simply removal from the site
- The Crown Office eventually instructed that there would be no criminal proceedings