OPERATIONAL IMPACTS OF THE FUKUSHIMA NUCLEAR EVENT ON RADIONUCLIDE MONITORING OF UNITED STATES IMS STATIONS

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ABSTRACT

General Dynamics acts as the equipment provider and oversees the operations and maintenance (O&M) responsibilities for the radionuclide monitoring systems of the International Monitoring System (IMS) which are owned and/or maintained by the United States—specifically, 11 aerosol systems and 4 xenon systems. As such, we are in a unique position to gather and evaluate performance data and assess the operational impact of both equipment and O&M issues and anomalous events.

On 11 March 2011, a 9.0 magnitude earthquake and tsunami rocked the eastern coast of Japan, resulting in power loss and cooling failures at the Daiichi nuclear power plant(s) in the Fukushima prefecture. Several institutions reported on the early measurements of short-lived aerosol fission products and gaseous xenon isotopes detected outside Japan following the release of radioactive material. We present a summary of the operational impacts of the Fukushima incident on the U.S. network of aerosol monitoring stations.

OBJECTIVES

We present a summary of the operational impacts of the Fukushima incident on the U.S. network of aerosol monitoring stations.

RESEARCH ACCOMPLISHED

The Comprehensive Nuclear-Test-Ban Treaty (CTBT) specifies in Annex I to the Treaty Protocol, the locations of all components of the IMS. These components are seismic, infrasound, hydroacoustic, and radionuclide monitoring systems supported by radionuclide laboratories and the International Data Center. General Dynamics is the designated Station Operator for the Untied Statess (U.S.) Radionuclide stations shown in Figure 1. These stations house both Particulate and Noble Gas detection systems.

Figure 1. Locations of Particulate and Noble Gas Stations

System Design:

Particulate

The U.S. particulate system is the Radionuclide Aerosol Sampler/Analyzer (RASA), which employs an innovative continuous feed system that automatically conducts sampling, decay, and acquisition in a secure housing with infrequent on-site human support (Figure 2). The key to the RASA's compact design is the division of the filter sampling area into six individual sampling areas that are reassembled and encapsulated into an efficient geometry for radionuclide measurement (Figure 3).

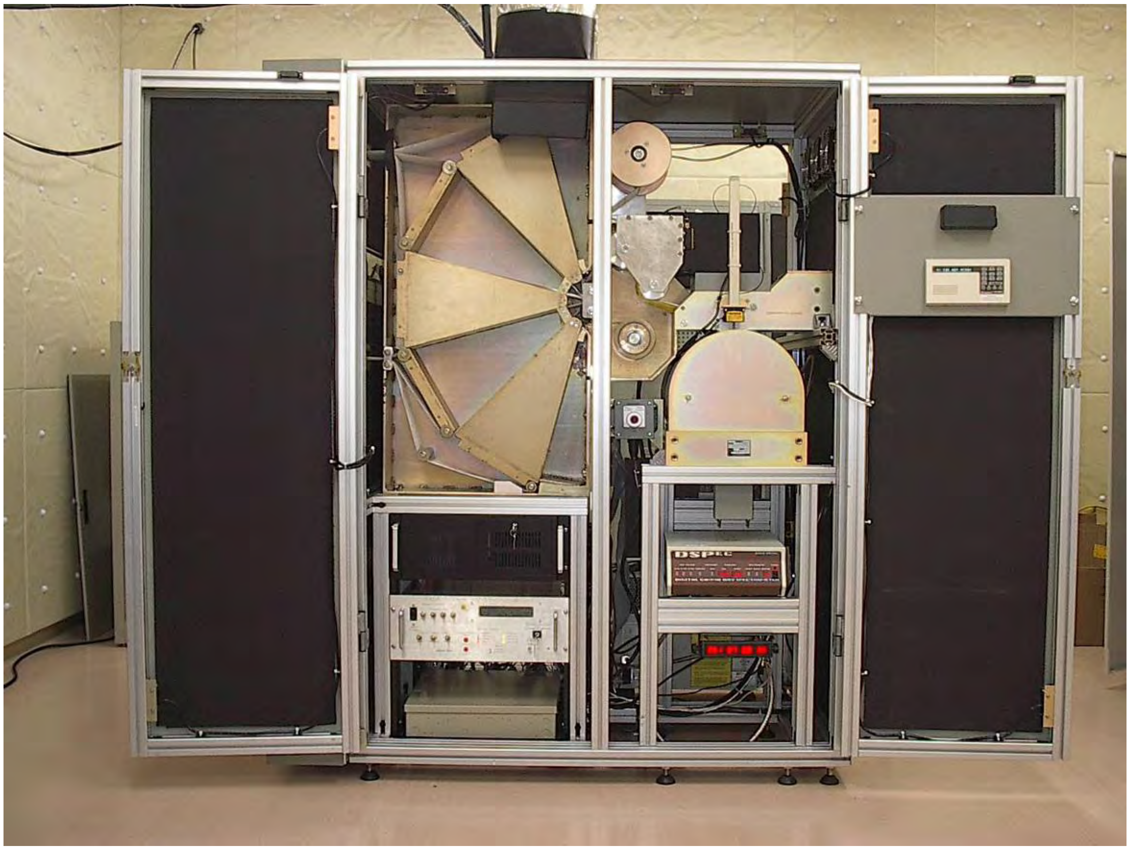

Figure 2. RASA - Radionuclide Aerosol Sampler / Analyzer

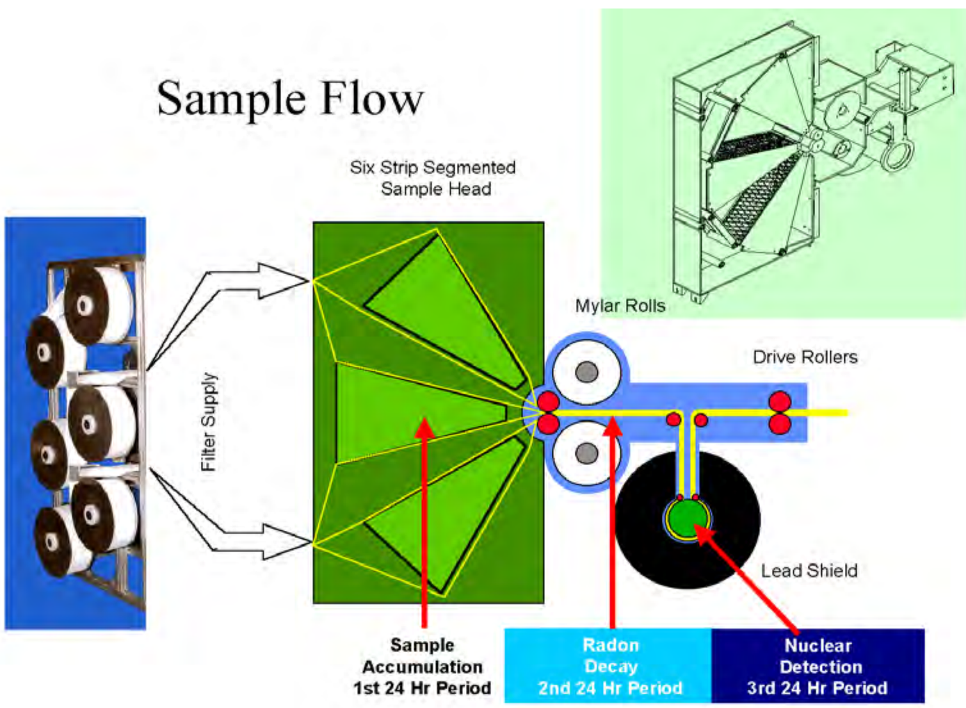

Figure 3. RASA Provides a large Sampling Area in a Small Space

Noble Gas

The U.S. uses the Swedish Automatic Unit for Noble gas Acquisition (SAUNA) for xenon detection (Ringbom et.al., 2003). SAUNA consists of a rack containing sampling and processing units and two detectors utilizing beta-gamma coincidence detectors (Figure 4).

Figure 4. SAUNA - Swedish Automatic Unit for Noble gas Acquisition (Courtesy of Gammadata)

SAUNA data is presented in the form of 3-D beta-gamma spectra (Figure 5, Berglund, 2009) which requires special data reduction and analysis software.

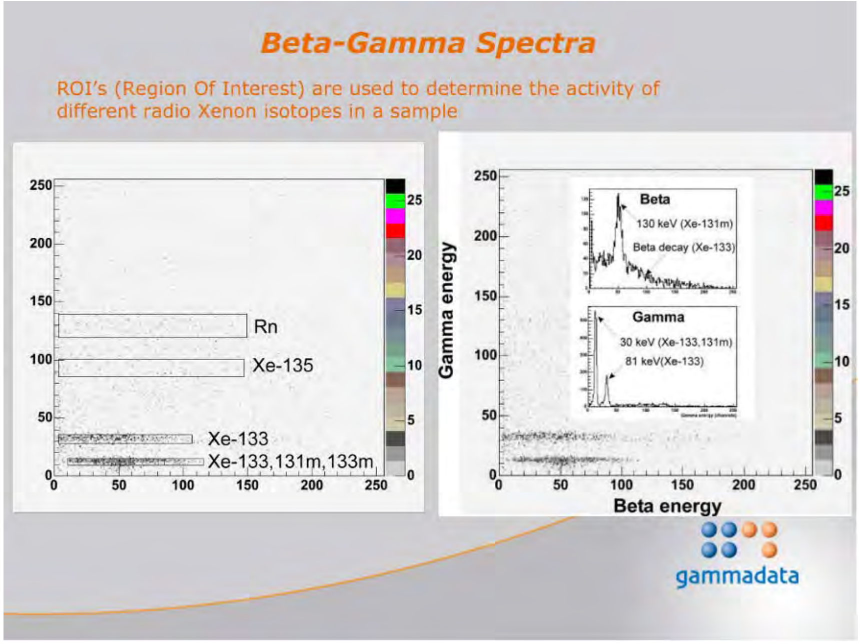

Figure 5. 3-D beta-gamma spectra

Normal Operations:

During periods of normal operation, scheduled station operation and maintenance include daily, biweekly, and semi-annual activities, some carried out by local operators on-site and some by senior operators on-site and at the Sensor Operation Center located in Fairfax, Virginia. These activities are supplemented, as required, by unscheduled maintenance when equipment failures occur.

Daily Activities

The key element in General Dynamics' responsive Operation and Management Plan is the Daily Standup meeting. Each morning during the work week, a brief Operations Meeting is held to review the status of all stations. This meeting is led by the Hardware Team Leader and features details of the previous day's system performance as well as pending logistics issues. The system performance is measured against the requirements set by the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO) (CTBTO, 1999). Remotely-located team members and those on travel are included by teleconference. During the meeting, actions to correct any station problems are discussed and assigned.

RASA Requirements

Test	Characteristics	Minimum requirements	Tests
1	Air flow	>500 m^3/hr	Was the flow rate at least 500 cubic meters per hour averaged over the previous 24 hours?
2	Rolling hourly avg. air flow	rollingAvg >500 m^3/hr	Did the rolling hourly average airflow always exceed 500 cubic meters per hour over the collection period?
3	Rolling hourly avg. air flow deviation	|avg - rollingAvg| / avg <30%	Did the rolling hourly average airflow differ by more than 30 percent from the overall average flow?
4	Collection time	≥21.6 hrs	Was the collection time greater than or equal to 21.6 hours?
5	Collection time	≤26.4 hrs	Was the collection time less than or equal to 26.4 hours?
6	Decay time	=24 hr ± 2.4 hrs	Was the decay time in the interval 24 ±2.4 hours?
7	Measurement time	≥18 hrs	Was the acquisition time greater than or equal to 18 hours?
8	Time before reporting	≤72 hrs	Was the time between the beginning of collection and the transmission of the FULL PHD file less than or equal to 72 hours and not due to GCI problems?
9	Base line sensitivity	10 to 30 µBq/m^3 for ^{140}BA	Was the ^{140}BA MDC less than or equal to 30 micro Becquerels per cubic meter?
10	HPGe resolution	<2.5 keV at 1332 keV	Was the FWHM at 1332 keV less than 2.5 keV?

SAUNA Requirements

Test	Characteristics	Minimum requirements	Tests
1	Xe Volume	≥0.87 cc	Was the combined Xe volume for both samples greater than or equal to 0.87 cc?
2	Minimum Detectable Concentration	1 mBq/m^3 for ^{133}Xe	Was the ^{133}Xe MDC for each spectrum less than or equal to 1 mBq/m^3?
3	Total volume of sample	≥10 m^3	Was the sample volume for each sample greater than or equal to 10 m^3?
4	Air flow	≥0.4 m^3/hour	Was the average airflow for each sample greater than or equal to 0.4 m^3/hour?
5	Time before reporting	≤48 hours	Was the time between the beginning of collection and transmission of the FULL PHD file less than or equal to 48 hours and not due to GCI problems?
6	Reporting frequency time	daily	Was a FULL SAMPLE PHD file received for each sample in the time period of interest?
7	State of health	Number of SOH messages fully cover collection period	Was SOH data received and fully cover the collection period of each sample?

Bi-Weekly Activities

A bi-weekly on-site station visit is made by at least one of the two local operators to perform routine maintenance, check on the station condition, and ensure that no problems are developing .

Semi-annual Preventative Maintenance visit

Twice each year, a General Dynamics engineer from the IMS Hardware Team visits each station and conducts a detailed regimen of tests and procedures designed to detect or forestall potential problems. These tests provide an early indication of required maintenance or replacement and provide detailed documentation of each station’s condition. Scheduled upgrades, equipment replacements and Local Operator initial and refresher training are provided at this time.

CONCLUSIONS AND RECOMMENDATIONS

Fukushima-Daiichi Release Event

The first reported release of radiation (intentional, to reduce pressure in the reactor) occurred on 12 March 2011 (The Nuclear Energy Agency (NEA) of the Organisation for Economic Co-operation and Development (OECD), 2011).

The first major release of radionuclides from the Fukushima-Daiichi reactor site was reported on 19 March 2011 (NEA OECD, 2011). Prior to the release, a typical spectrum from USP70, the RASA particulate system in

Sacramento, California showed only normal background radiation due to uranium and thorium decay products and other natural nuclides such as K-40 and Be-7 (Figure 6).

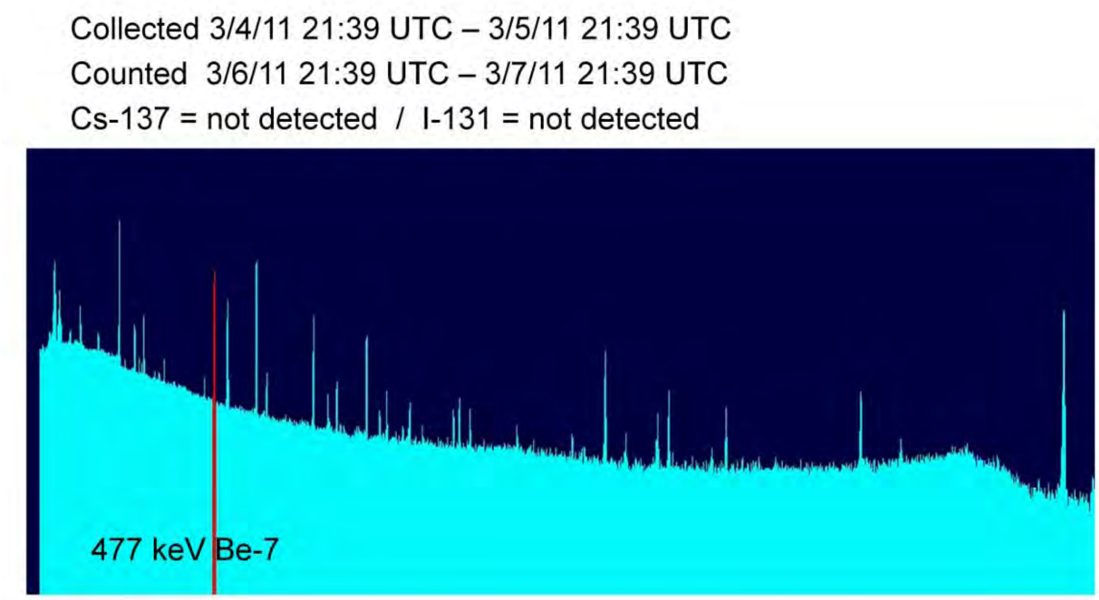

Figure 6. USP70 - Before The Release

Following the release on 15 March 2011 and subsequent releases on succeeding days, a typical spectrum (Figure 7) and detection inventory at USP70 (Table 1) included both long and short half-life nuclides.

Table 1. Nuclides Seen at RN70 on 23 March 2011

Nuclide	Half-Life	Conc(µBq/m3)	%RelErr	MDC(µBq/m3)
CS-134	2.062 Y	1.20E+03	1.29	4.4
CS-136	13.16 D	1.60E+02	1.76	3.82
CS-137	30.1 Y	1.40E+03	1.1	4.73
I-131	8.04 D	8.20E+03	1.82	7.32
TE-129	9.99899 Y	7.30E+02	8.18	Not calculated
TE-129M	33.6 D	1.30E+03	36.77	Not calculated
TE-132	3.204 D	1.50E+03	4.74	9.53

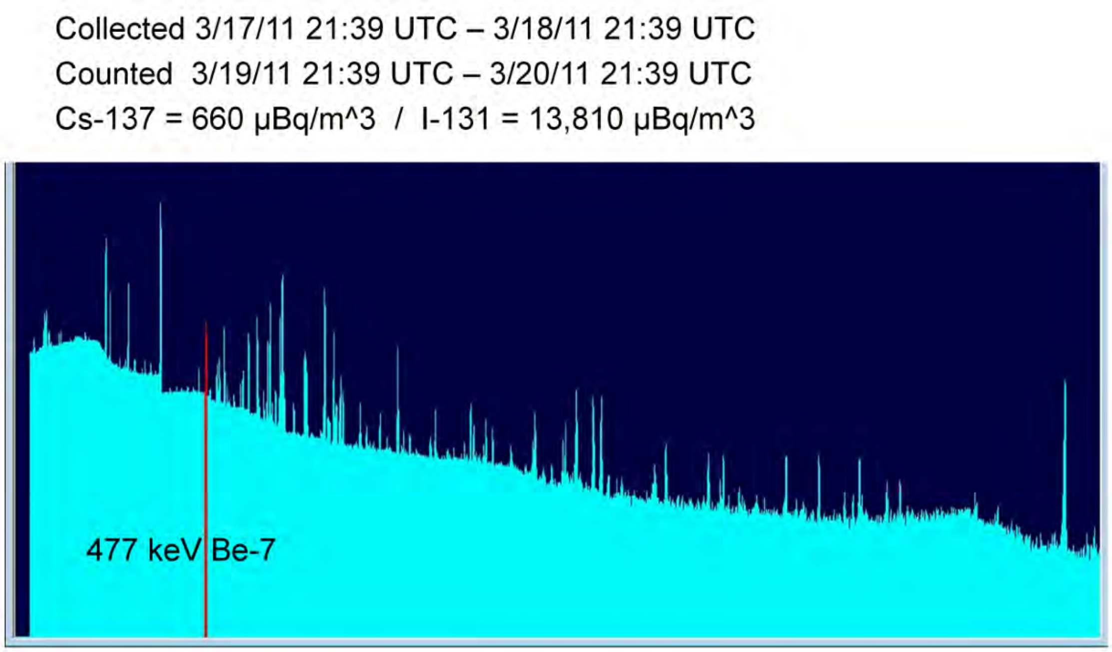

Figure 7. USP70 – During the Release

For the particulate systems, the highest levels of Cs-137 occurred for the 24-hr sample collections starting on 21 and 22 March 2011 (UTC) (Figure 8). The greatest concentration of Cs-137 was recorded in the Aleutian Islands at RN71, Sand Point AK (9,808 µBq/m3).

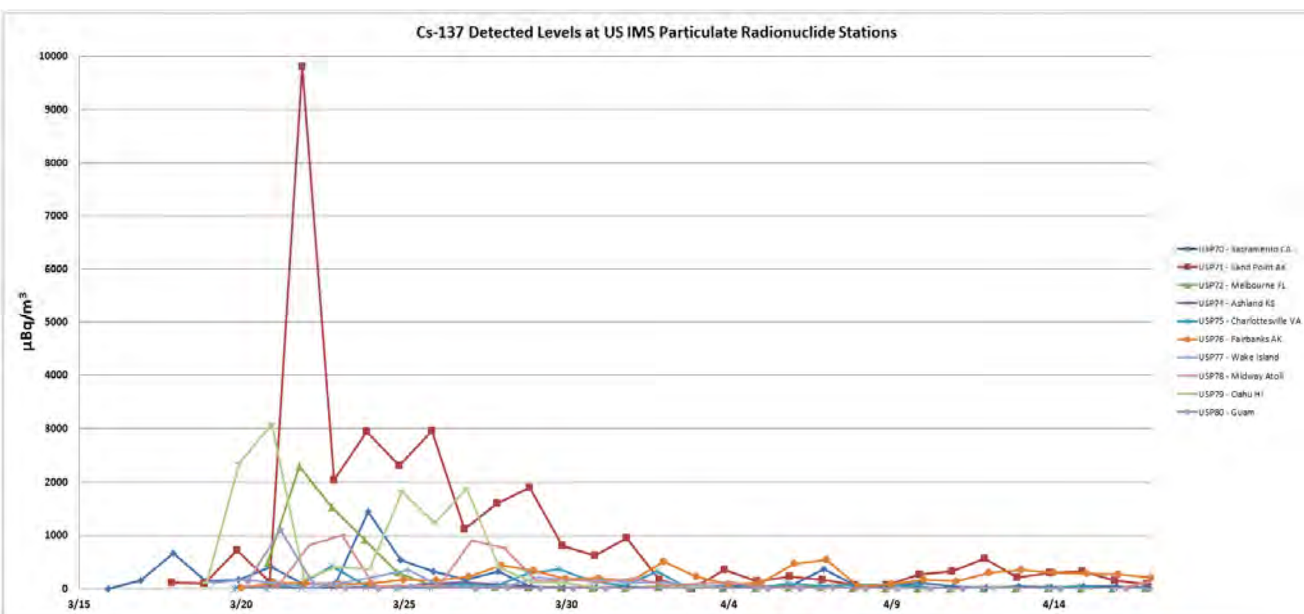

Figure 8. Cs-137 Detected Levels at US IMS Particulate Radionuclide Stations

For the Noble Gas systems, the highest levels of Xe-133 occurred for the 12-hr sample collections on 21 through 23 March 2011 (UTC) (Figure 9). The greatest concentration of Xe-133 was recorded in Ashland KS at RN74 (13,453 µBq/m3).

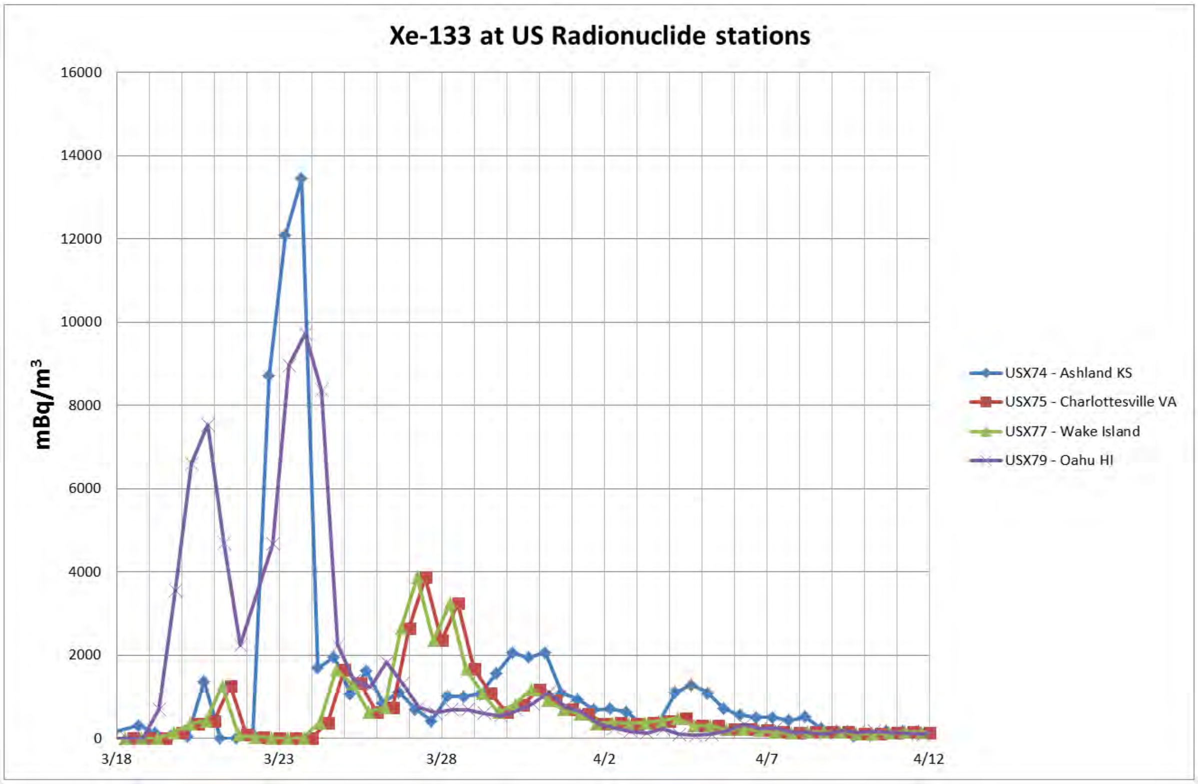

Figure 9. Xe-133 at US Radionuclide Stations

The Daiichi release was detected at all U.S.-operated IMS radionuclide stations except RN73 (Palmer Station, Antarctica).

As might be expected, the initial arrival of the release varied from station to station (Figure 10).

Figure 10. Plume Arrival Date

Event Impact on Operations

Immediately following news reports of the incidents at the Daiichi power plant, actions were taken to limit any potential impact on the ability of the stations to perform their primary collection and detection mission in support of the CTBT.

- All non-critical operations at the stations that would interfere with continuous collection were postponed to avoid interruptions in data. This included the delay of scheduled “blank” measurements acquired routinely on a periodic basis to detect potential contamination.

- The samples collected in March were held at each station instead of being sent to Vienna in the Quarterly shipments of archival samples.

- Inlet plenums were not removed unless absolutely necessary. Normal internal cleaning of the inlet plenums was postponed.

- Tests during semi-annual preventative maintenance visits to measure bypass flow were postponed as these tests require shutting down the blower, removing the inlet plenum and blocking the airflow path through the filters.

- Operations were modified to minimize stirring up contamination that may have settled in the station or inside the inlet plenum of the system.

- Floors in the station were damp-mopped instead of swept to avoid spreading any potential contamination to the detector region of the RASA system.

- Split samples were requested by the CTBTO from many of the stations in order to provide samples to two different certified laboratories. Local operators had been previously trained to prepare these, and a step by step procedure was emailed to the local operator with each split sample request

- Once anthropogenic nuclides were no longer being detected at a station, swipe samples were taken following a carefully prepared procedure and counted under double-blind conditions to ensure unbiased results. Acquisition and counting of these swipe samples is ongoing.

Network Performance and System Effects During the Month After the Release

All stations were “Fully Mission Capable” during the entire first month of this incident.

The SAUNA Noble Gas monitoring systems are known to have memory effects caused by xenon adhering to the walls of the beta cell. This effect is routinely seen during calibration as well as being seen during this event. Following the detections in mid-March, the MDC for the Noble Gas systems was moderately elevated from 0.6 mBq/m3 before the release to about 7 mBq/m3 a week after the release. Measured xenon levels a week after the peak of the release (13,452 mBq/m3 at RN74 on 23 March 2011) were still in the 1000 – 2000 mBq/m3 range.

Based on early swipe results, no U.S. stations appear to be contaminated due to the plume from the Daiichi nuclear power plant.

ACKNOWLEDGEMENTS

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