Automatic Radiation Measurement System for Transport of LLW

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INTRODUCTION

In Japan there are 50 nuclear power plants in operation at 18 sites, generating 41 GW of electricity (Fig.1). Approximately 28,000 low-level waste (LLW) drums are annually generated from these plants and placed in containers of 8 drums each, and then loaded into a specially built ship for shipment to Mutsu-Ogawara Port. They are subsequently transferred overland to the LLW Disposal Center, located 9 km from the port.
The annual shipment is approximately 2,500 containers corresponding to 20,000 drums. This takes 12 voyages, as the ship carries approximately 210 containers on average. As the ship usually stays 2 days at the port, unloading operations of LLW drums must be accomplished during this short period (Fig.2). In order to transport all the containers to the Disposal Center, 60 round trips of 2-container trucks are required for 1 day. Radiation levels around the container are measured and confirmed before shipment at the nuclear power plants. Although the radiation level is not thought to increase during the voyage, measurements of the dose-equivalent rate are carried out on all of the containers in order to ensure the safety of land transport. The Automatic Radiation Measurement System, which we call "Gate Monitor", has been developed to meet the requirements at the port.

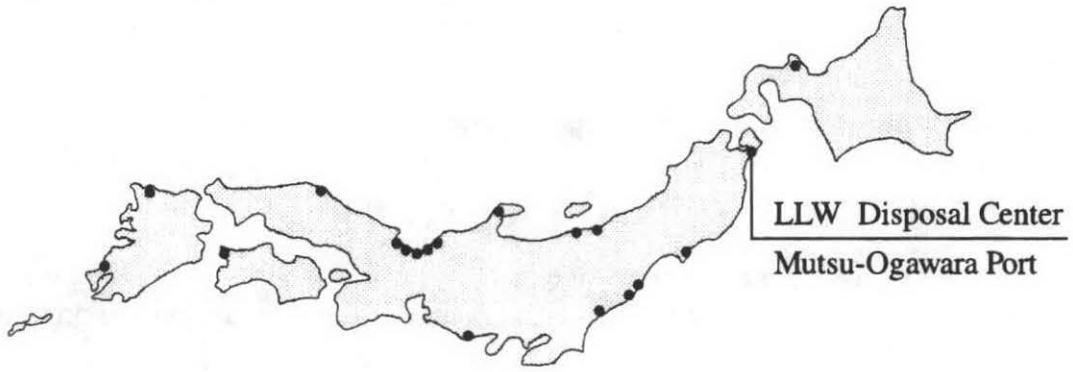

Fig.1. Sites of Nuclear Power Plants and LLW Disposal Center

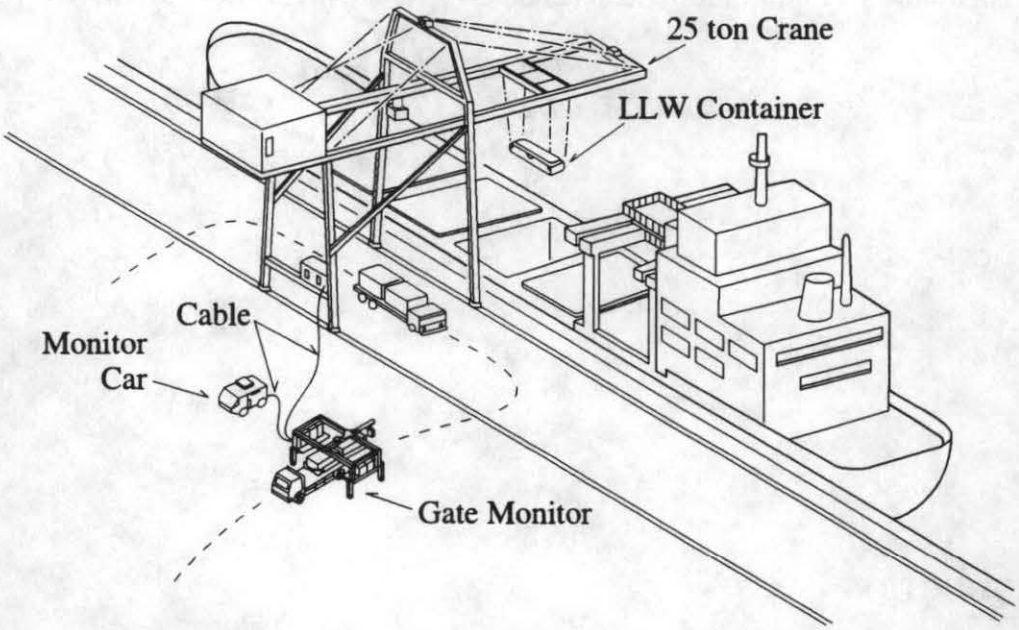

Fig.2. Unloading of LLW Containers

PURPOSE OF SYSTEM DEVELOPMENT

(1) Reduction of personnel radiation exposure
Approximately 60 roundtrips of vehicles are required daily, which makes the reduction of inspectors' exposure imperative.

(2) Reduction of number of personnel for radiation measurement
The period of time allowed for radiation measurement is about 4 minutes per truck, and as many as five to six persons have to be engaged in such an operation. Therefore it is imperative to reduce the number of personnel.

(3) Enhancement of safety in cold weather
Radiation measurement is carried out at the quay, outdoors, and in cold and snowy conditions. Therefore, the operation should be automated to enhance the safety of the personnel.

(4) Reliability of measurement
For the sake of quality assurance in transport operations, the results of all measurements must be kept at the same level of accuracy. We designed and built an automatic system that is best suited for such a purpose.

(5) Ease of recording and measurement of data
A system of radiation detectors and data processors must be used to record and process a large amount of data.

DESIGN REQUIREMENTS

(1)Operational conditions	
a)Entry of LLW-loaded ship at the port	10 times per year
b)Period of port call	2 days per entry
c)Number of vehicles inspected	100 vehicles per day
d)Time spent for inspection	4 minutes per vehicle
(2)Environmental conditions	
a)Temperature	
Outdoor maximum temperature	40°C
Outdoor minimum temperature	-20°C
b)Rainfall	
Maximum rainfall	50mm/h
c)Snowfall	
Maximum snowfall	190cm
d)Wind velocity	
Maximum wind velocity during operation	16m/s
Maximum wind velocity during installation	30m/s

DESIGN AND CONSTRUCTION OF "GATE MONITOR"

Based on the above objectives and design requirements, an automatic radiation measurement system or "Gate Monitor" was designed and constructed with the following components (Fig.3).

(1)Radiation monitoring devices
Consisting of radiation monitors and vehicle number and container number recording devices, the radiation devices are driven by a drive mechanism.

(2)Drive mechanism
The drive mechanism moves the radiation monitoring devices to the surface of the vehicle and to a point 1m therefrom.

(3)Control device
The control device operates the drive mechanism and is controlled by a computer system via an interface. Start-up of the control device is initiated by the control panel in the monitor car.

(4)Computer system
The computer system processes and records the vehicle number and dose-equivalent rates data given by the radiation monitoring device.

(5)Monitor car
An air conditioned monitor car carries the control device, computer system, and emergency power source, and also accommodates the operator.

(6)Power supply
Power for the radiation monitoring devices, drive mechanism, and monitor car is supplied via the 25-ton wharf crane.

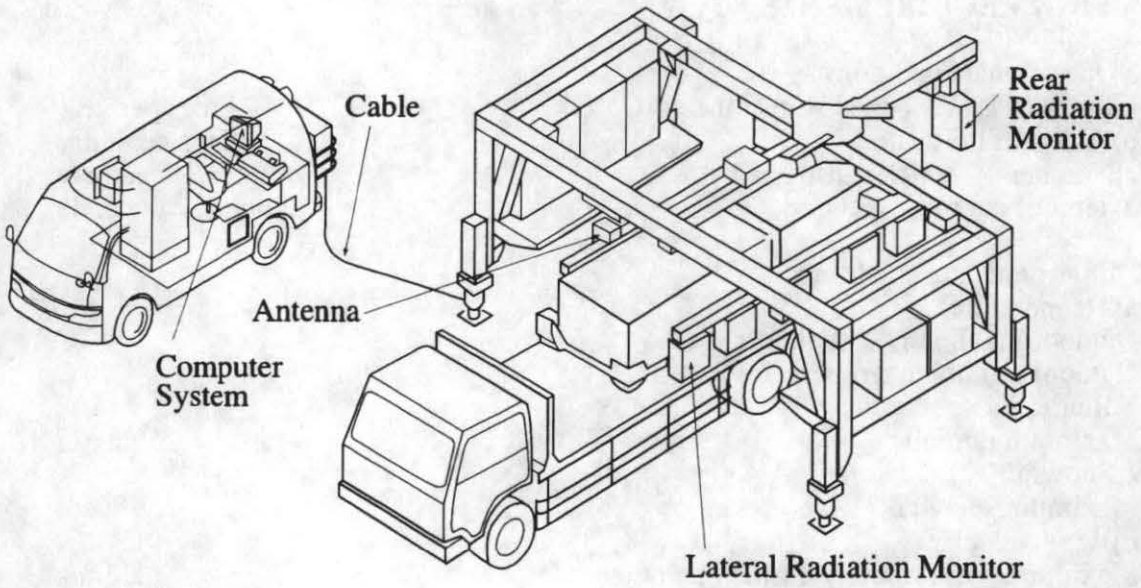

Fig.3. Gate Monitor

MEASUREMENTS

(1)Recording of vehicle number
One data carrier is attached to the vehicle, which emits weak signal waves to the antenna of the Gate Monitor 25cm apart. It automatically records the vehicle number, which is fundamental to vehicle management (Fig.4).

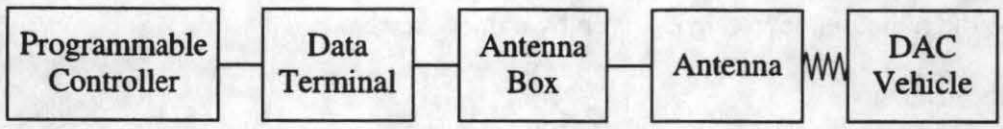

Fig.4. Recording of Vehicle Number

(2)Recording of container number
The container number is recorded by the same process in (1). The number is recorded to confirm the quantity of containers and contents distribution.

(3)Measurement of dose-equivalent rate at the vehicle surface
The dose-equivalent rate is automatically measured at five points on each side of the truck by a semiconductor type area monitor (Fig.5). Acceptance level is set at 20% below regulatory value. The vehicle number and container number are also recorded.

(4)Measurement of dose-equivalent rate at 1m from the vehicle
The dose-equivalent rate is also measured at 1m from the vehicle surface at five points on each side and at one point from the rear side (Fig.5) .

(5)Measurement of dose-equivalent rate at vehicle underside
The same measurement is carried out at one point on the underside of the vehicle (Fig.5).

(6)Measurement of dose-equivalent rate at driver's seat
The dose-equivalent rate is measured at the driver's seat by a GM survey meter, and the data are recorded together with the vehicle and the container numbers.

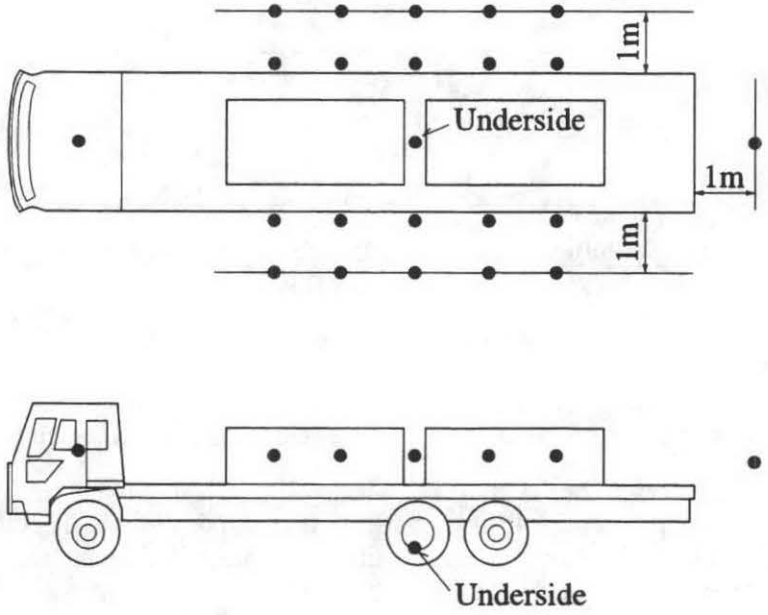

Fig.5. Radiation Measurement Points

FEATURES

(1)Mobility
A hydraulic jack attached to the Gate Monitor raises and lowers the main unit.
The Gate Monitor can be moved to any place by means of a truck (Fig.6).

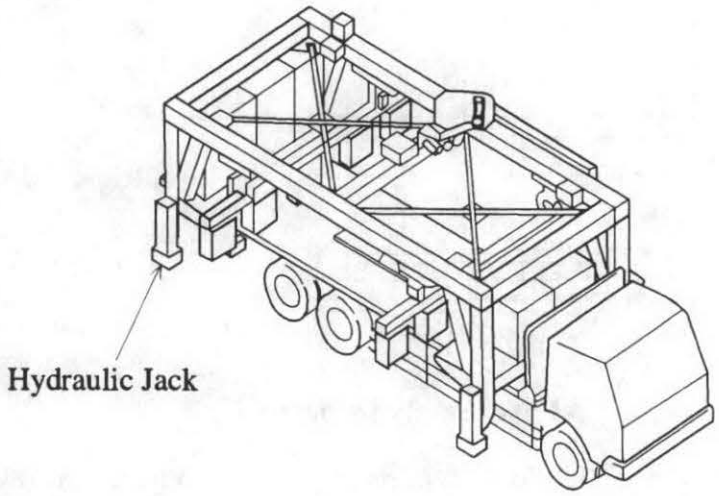

Fig.6. Moving of the Gate Monitor

(2)Light sensor assisted vehicle positioning
Light sensors of the transparent type are equipped on the Gate Monitor and used to position the vehicle at the right place. The accuracy of the vehicle positioning is determined by the distance of the light sensors, No.2 and No.3, and it is set at ±10cm (Fig.7).

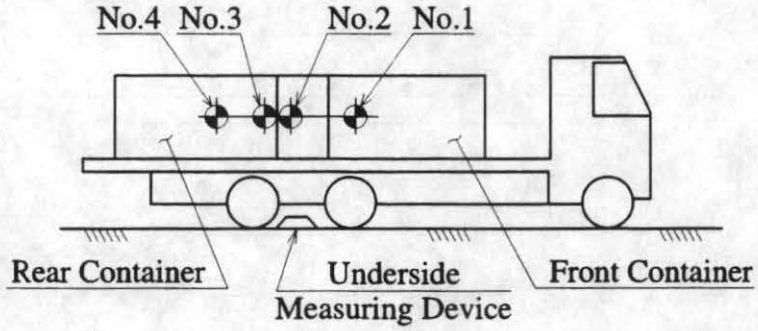

Fig.7. Method of Vehicle Positioning

(3)Remote measurement of distance
A supersonic wave machine detects the vehicle surface and the distance therefrom.

(4)Remote reading of container ID numbers
Data carriers (DAC) operated by lithium battery, memorize the ASCII code number. DACs are attached to both container and vehicle, and numbers are remotely read through the antenna by receiving the response from the DAC. It starts to operate when the programmable controller emits the signal to start. Then the DAC answers the number through the antenna.

(5)Safety devices
With regard to the driving mechanism of the Gate Monitor and the vehicle, measures are taken to prevent personnel from getting jammed between the vehicle and the radiation detector (Fig.8).

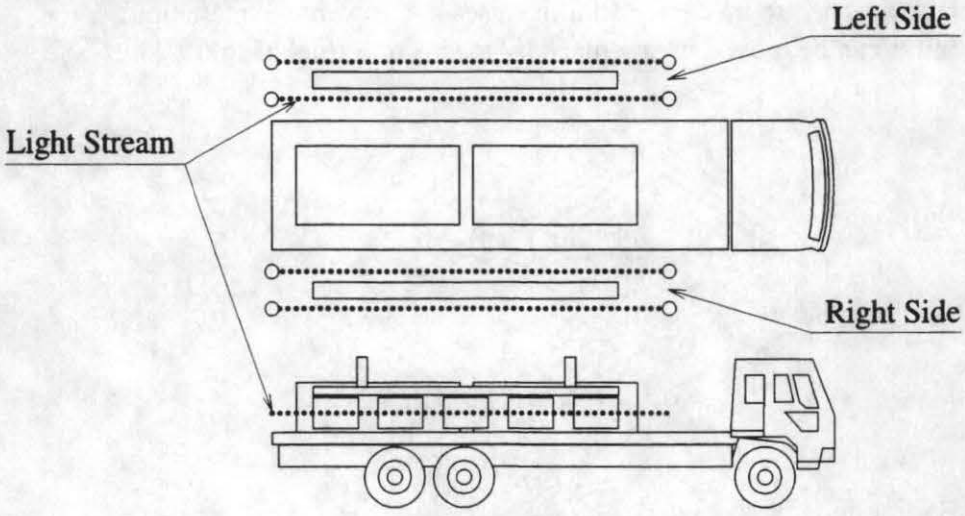

Fig.8. Safety Devices

In the dotted area around the Gate Monitor, infrared rays are emitted.If the rays are interrupted by a person or materials, operation of the Gate Monitor automatically stops. Even if the safety devices become inoperative, the operation automatically stops by means of a backup overload detector.

OPERATIONAL EXPERIENCE

Since December 1992 the Gate Monitor has been in use, and 3,486 vehicles have been measured as of September 1995 (Fig.9). There has been no significant failure in the operation of the Gate Monitor. There have been some cases of dead batteries in the DAC and incorrect alignment of the vehicle in the Gate Monitor.

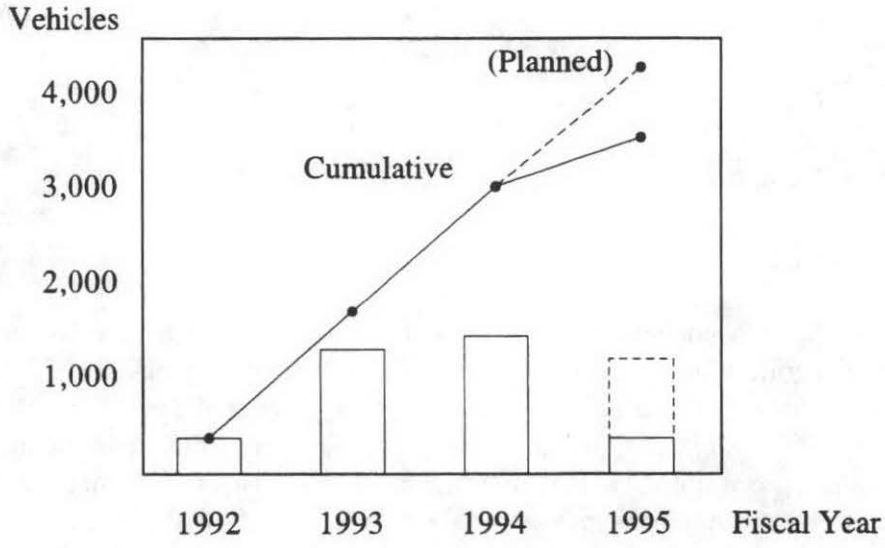

Fig.9. Transport of LLW Vehicles

PROPOSED IMPROVEMENTS

(1)The Gate Monitor is made of steel and weighs approximately 8 tons. In the future it is proposed to make it lighter by replacing steel with aluminum and providing casters for ease of transfer. It may be possible to move it by a tractor in approximately 10 minutes.

(2)It is also proposed to implement automatic radiation measurement at the driver's seat. At present the measurement is carried out manually by the driver and then input to the computer operator by wireless equipment.

(3)Instead of cable transmission to relay data, all devices in the monitor car are proposed to be installed indoors to protect the instrument under severe weather conditions. All data will be transmitted by wireless equipment.

CONCLUSION

The Gate Monitor has been operated all year around, even under winter snowstorms, and we have not experienced any breakdowns. On the basis of the experience obtained so far, other types of Gate Monitor systems are proposed for spent fuel and residue return HLW transport.