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DOSE REDUCTION AND COST-BENEFIT ANALYSIS AT JAPAN'S TOKAI NO. 2 PLANT

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ABSTRACT

In the Tokai No. 2 power plant of the Japan Atomic Power Company, about 80% of the annual dose equivalent is received during periodic maintenance outages. A project group for dose reduction was organized at the company's headquarters in 1986; in 1988, they proposed a five-year program to reduce by half the collective dose of 4 person-Sv per normal outage work. To achieve the target dose value, some dose-reduction measures were undertaken, namely, permanent radiation shielding, decontamination, automatic operating machines, and ALARA organization. As the result, the collective dose from normal outage work was 1.6 person-Sv in 1992, which was less than the initial target value.

INTRODUCTION

In 1957, the Japan Atomic Power Company (JAPC) was established by the electric power companies of Japan. JAPC now operates four reactors of three different types at two sites: one GCR and one BWR at the Tokai site, and one BWR and one PWR at the Tsuruga site. Tokai No. 2 plant, a BWR Mark-II, type-2 with 1100MWe of electric output, started commercial operation in November 1978. As a consequence of its safe and stable operation, the station holds Japan's record for power generation for a single unit. In August 1992, a world record for BWRs of 100 billion KWH was achieved. For several years after start of commercial operation, the annual collective dose equivalent was about 4 person-Sv, but later, by 1985, this value had increased to about 7 person-Sv. About 80% of this annual dose equivalent was due to the periodic maintenance work. A project organization on dose reduction was set up to halve the collective dose for regular outage work.

ORGANIZATION FOR DOSE REDUCTION

ALARA Coordination Committee

The Tokai No.2 plant, which was planned and constructed on the basis of experience from the Tsuruga No.1 plant (BWR Mark-I, Type-2, 357MWe), started commercial operation in March 1970. For several years, the dose rate in the working environments was maintained at a low level; but the surface dose rate of major lines increased year by year. As a consequence, by 1985, the annual collective dose equivalent had reached to 7 person-Sv. Figures 1 and 2, respectively, show the annual collective doses at Tokai No. 2 and the trend of surface dose rate of the PLR lines.

At the seventh outage (1985), the CUW piping had to be replaced as a countermeasure to SCC; the collective dose from this outage was anticipated to be more than 10 person-Sv. Therefore, a special organization for the dose reduction was set up on site, and an ALARA program was instituted before the outage. This activity is referred to as the INPO program.[1]

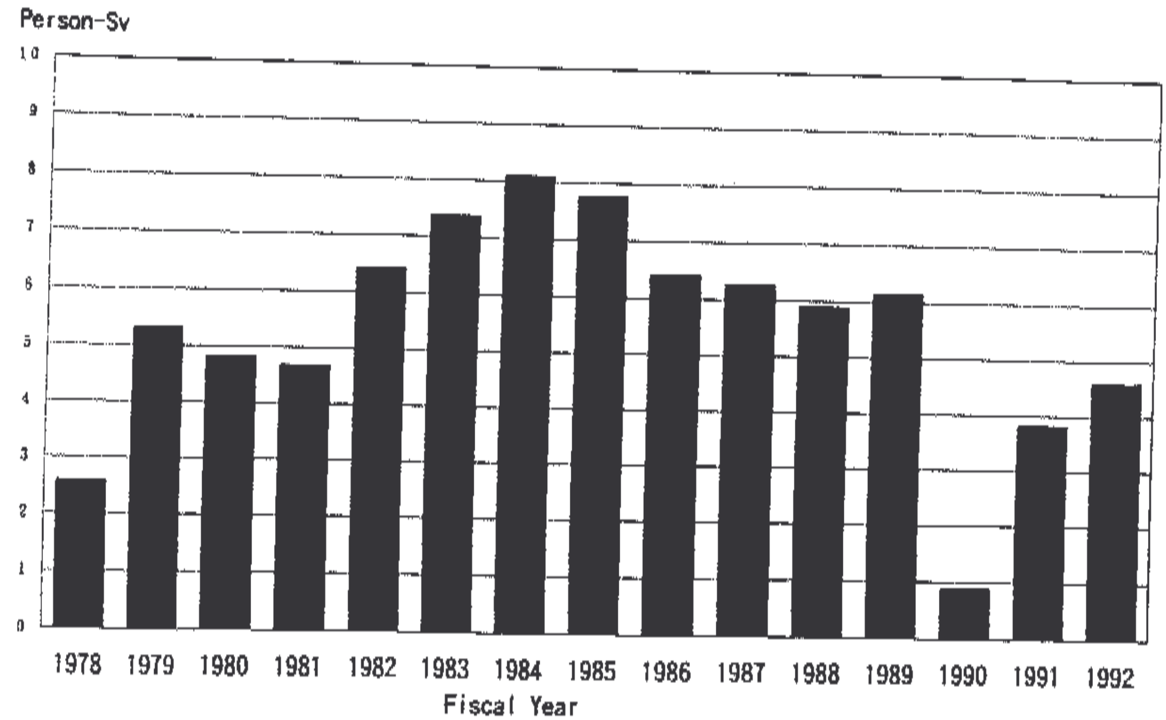


Fig. 1 Collective Occupational Dose

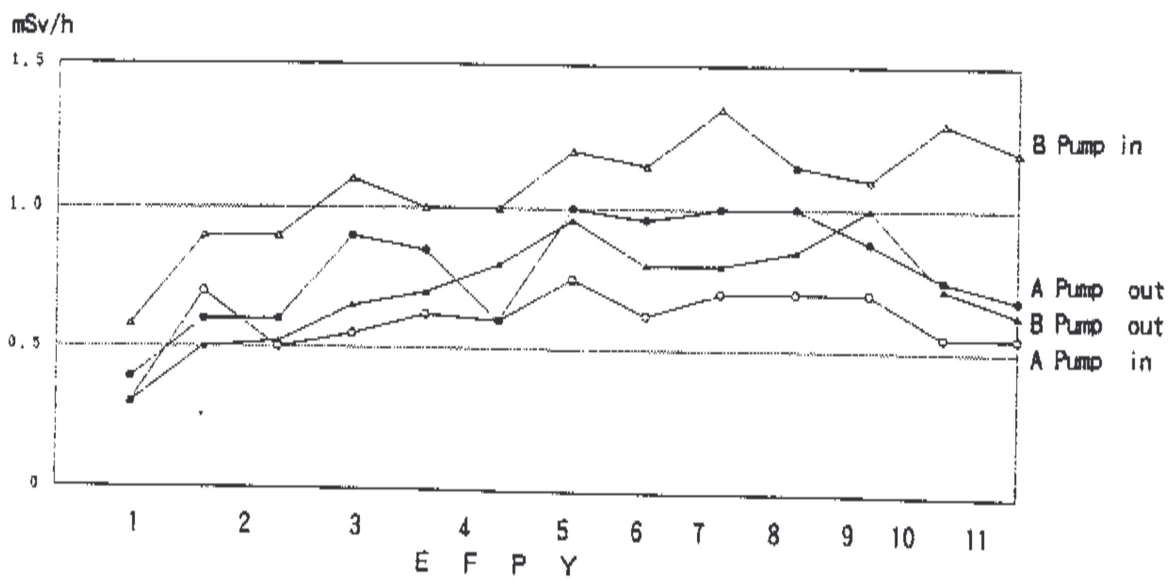


Fig. 2 Surface Dose rate of PLR Line

The organization, called the ALARA coordination committee, meets on a regular basis to review the status of the ALARA program. The committee is composed of about 20 members drawn from the major functional departments on site, deputy managers of each section of JAPC, and radiation control managers of the main contracting companies. The deputy superintendent of JAPC is the chairman, and both the deputy superintendent of outage contractors and the manager of the radiation control section of JAPC are the sub-chairmen.

The activity of this committee starts six months before the beginning of a periodic maintenance outage. First, the work items, work contents, and work places are recognized and initial estimate of exposure is made for each job step. Subsequently, work and job steps that involve high doses are identified and dose reduction measures are sought for them. Possible countermeasures that could be carried out in an outage are considered. Figure 3 shows the flow chart of ALARA program in JAPC. This committee meets once a week to check dose-reduction measures and give advice accordingly if the doses are higher by 10% compared to the estimates. Further, the group discusses selection of lines for flushing or additional shielding, the transfer of high-radiation equipment, and changing of the working area. The weekly report of the committee is sent to the outage schedule management committee that compares the results and the plans presented for ALARA. After the outage period, the ALARA activity, radiation data, survey data, and related photographs are compiled and a report with an evaluation of the yearly trend is written and edited. The results of this report is reflected to the next outage works. Figure 4 shows the results of outage dose. This ALARA coordination committee has been continuously managing outages from the seventh one and still is working effectively in the thirteenth outage this year.

The Organization of Dose Reduction for Whole Company

In the Japan Atomic Power Company, dose reduction activities were carried out individually in each section. To unify these programs, in June 1986 a dose reduction promoting group (DRPG) was organized at headquarters, and a dose reduction countermeasures committee (DRCC) was organized at the site. The DRPG is composed of the following members: executive general manager (managing director), who is the chairman of this group, the general managers at headquarters, and the superintendent of the sit. It meets about twice a year. The main objectives of this group are include the following: 1) planning a target for dose reduction; 2) assessing the needs of long and semi-long term planning and evaluating the results of dose reduction, 3) examining techniques for dose reduction, and 4) considering ALARA information for domestic and foreign nuclear plants.

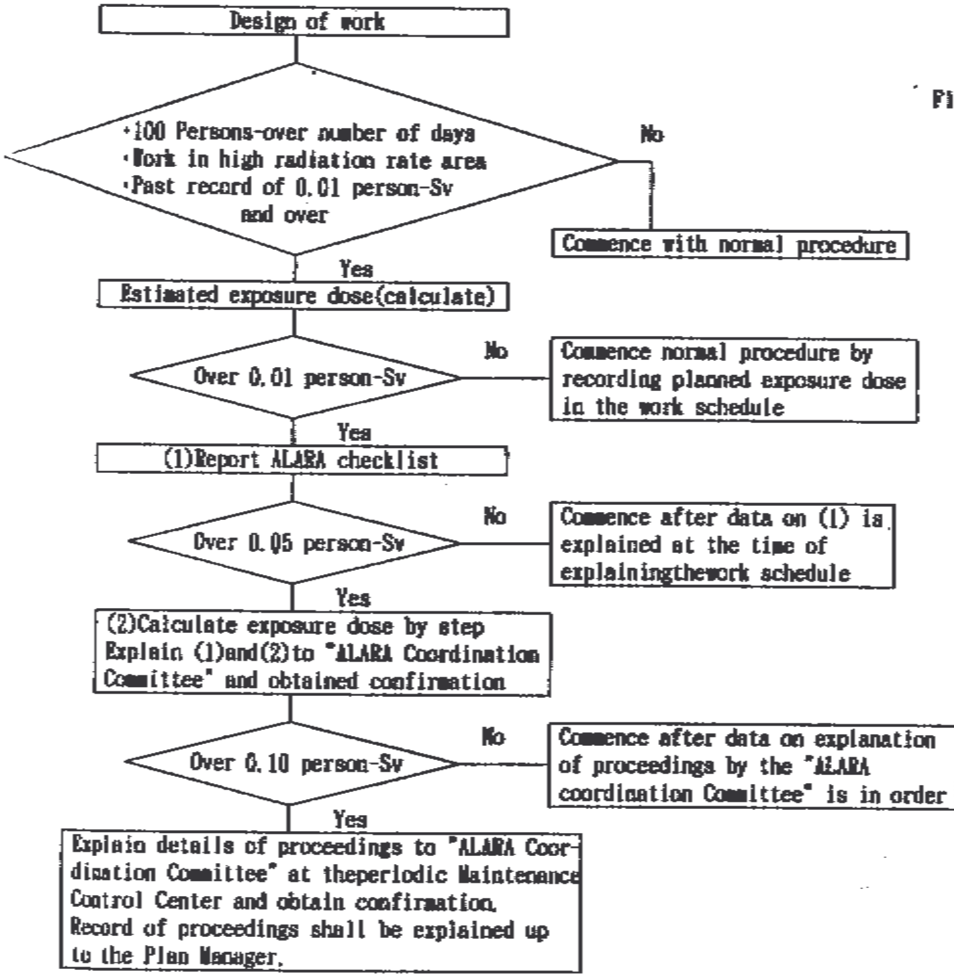
The DRCC is composed of the deputy superintendent of the site, who is the chairman, and the managers of each sections and meets about twice a year. The main objectives of this group include the following: 1) planning methods to achieve the target of dose reduction, 2) examining the difference between the initial estimated dose and the actual dose for the report to the of ALARA coordination committee, 3) analyzing factors that might disturb dose reduction, and 4) reporting to the DRPG.

PROPOSING THE FIRST 5-YEAR PLAN

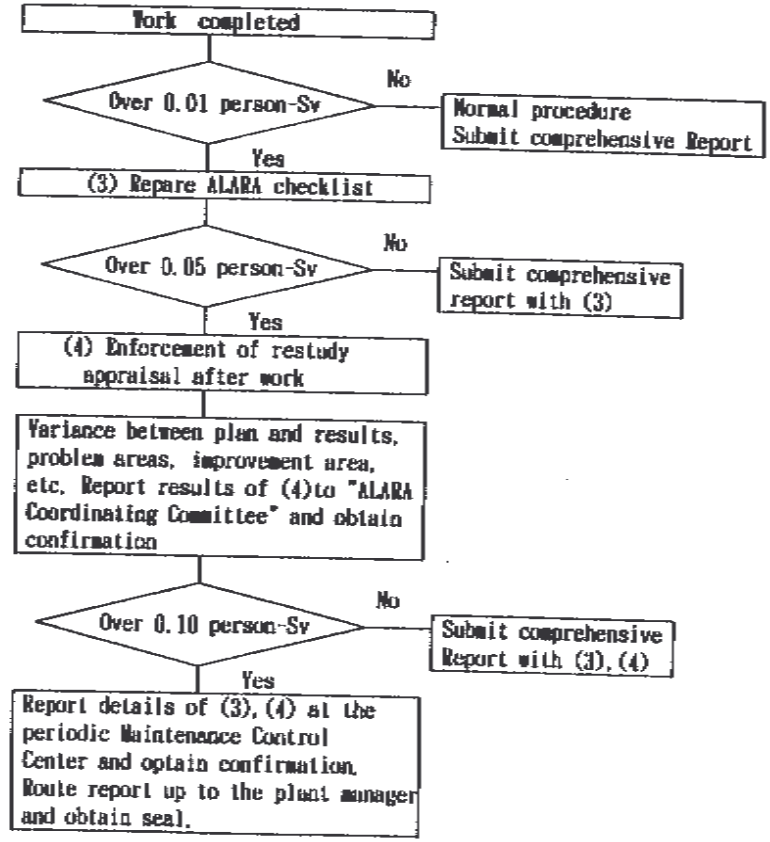
In 1988, the long and semi-long term planning for dose reduction at Tokai No. 2 was discussed by both the DRPG and the DRCC. Recognizing recent dose conditions, they analyzed the collective dose and effective dose rate of each work and each job-step, and the dose ratio of different sources. Consequently, items for dose reduction were selected in each field of work and each work place. In planning the dose-reduction targets, only the dose targets for regular outage work were discussed, and it was proposed to reduce the dose to 2.5 person-Sv per outage after five years from the average 4 person-Sv per outage of the sixth or seventh outage. Adoption of the techniques for dose reduction was finally decided upon, according to the results of a cost-benefit analysis.

Fig. 3 ALARA Plan Procedures

Flow chart 1 ALARA plan procedure before initiating work



Flow chart 2 ALARA plan procedure after work



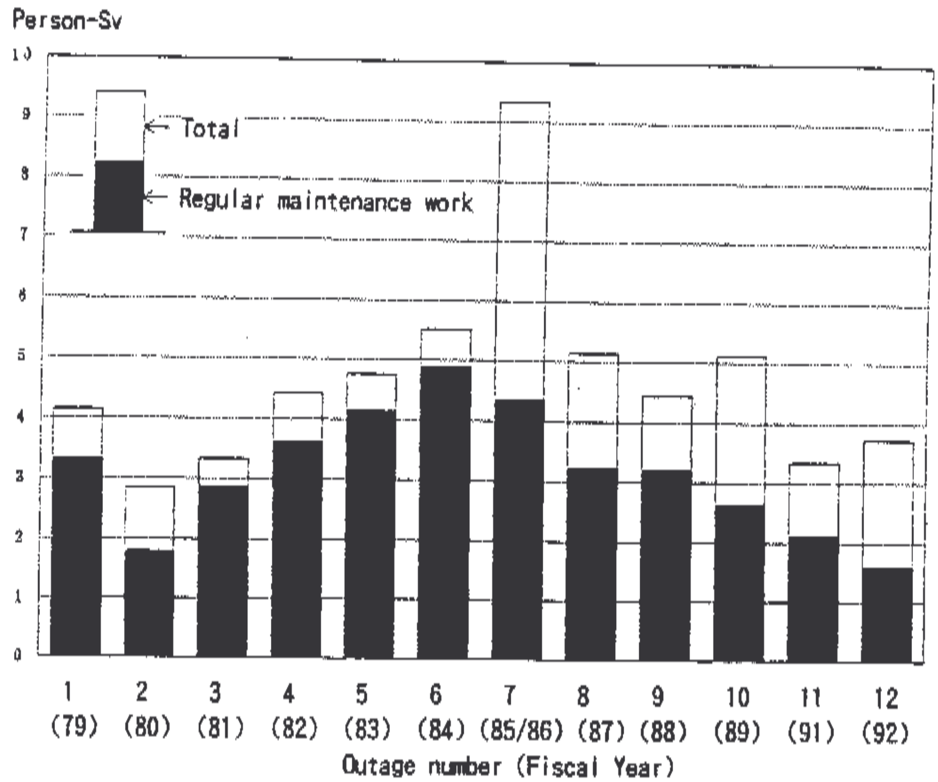


Fig. 4 Outage Dose

CARRYING OUT THE 5-YEAR PLAN

Some dose-reduction measures were undertaken, starting at the ninth outage (1988). In these 5 years since 3.3X109 yen ($3.3X107) has been invested for permanent shielding, decontamination, automatic operating machines, and so on. In consequence, the dose from periodic maintenance work in the twelfth outage (1992) was reduced to 1.6 person-Sv per outage, so achieving the initial target of reducing exposure from 4.0 person-Sv per outage to 2.5 person-Sv per outage. Furthermore, in the decontamination of reactor in the twelfth outage, 300 Ci CRUD was removed. This radioactivity was not directly removed from exposed sources such as the PLR piping, but from the steam separator and reactor annulus. The effect of this decontamination is expected to reduce gradually the dose rate of the PLR piping, although the effect of this countermeasure has not been evaluated yet. The following are the main countermeasures carried out for dose reduction:

1. permanent radiation shielding for the piping in the PCV,
2. decontamination of the reactor wall and shroud,
3. application of automatic operation and remote control,
4. renewal of construction materials,
5. enhancement of worker's consciousness for ALARA.

Tables 1 and 2 show the results of these measures. The results of cost-benefit analyses also are shown in same tables, in which the cost per person-Sv was calculated, considering the cost for each countermeasure and the accumulated dose in the effective working period for each task. The addition of permanent shielding and the enhancement of ALARA consciousness were the most effective of all the measures and their costs were low; their cost to effect amounted to 4X104 yen/person-mSv($4X103/person-rem), the lowest of all. The cost to effect other countermeasures were between 4X104 and 4.3X105 yen/person-mSv($4X103-$4.3X104 /person-rem).

SETTING UP STANDARDS FOR COST-BENEFIT ANALYSIS

The process of promoting of dose reduction is as follows;

1. recognition of dose-reduction needs
2. setting of target values
3. selection of items for dose reduction
4. evaluation of cost-benefit analysis
5. recognition of countermeasures for dose reduction
6. decision on countermeasures
7. development of the plan in each year
8. design and operation of countermeasures
9. evaluation of reduced dose

In this process, the most difficult matters to optimize are setting target values and evaluating the cost-benefit analyses. In setting a target value, other factors are considered, such as comparisons to other plants, the economic scope for dose reduction, the balance of dose limits of each worker, and management of persons working at other plants. An objectively useful cost-benefit (dose-reduction cost) index is necessary to promote an active ALARA program. But it is difficult to define this index because of 1) changes of social concepts on radiation exposure, 2) the variety of evaluation methods, 3) and changes in the economy of nuclear power plants.

At Tokai No. 2 plant, we are directing the contractors to plan individual outage doses of less than 1 mSv/day, unless a special plan is proposed. Following this direction, contractors plan individual doses of 0.3-0.5 mSv/day and schedule an effective working time of several hours in a high radiation area. If the dose rate in this

Table 1. Results of Dose-Reduction Measures at Tokai No. 2

Years (outage number)	Collective Dose (Person-Sv)
1988 (8th)	4.0

Reduction Measures	Dose Reduction Effect	Cost Benefit	
	Person-Sv/outage	($/person-mSv)	($/person-rem)
1. Permanent radiation shield	1.23	400	4000
• Piping in PCV (PLR, RHR, CUW sys)	1.00	---	---
• Piping out of PCV	0.23	---	---
2. Dose reduction by target dose management	1.00	400	4000
3. Automation and remote control of the work	0.31	4200	42000
• Automatic operation by advanced CRD exchanger	0.19	---	---
• Remote operation by reactor well decontamination equipment	0.06	---	---
• Others	0.06	---	---
4. Decontamination of reactor wall and piping	0.13	800	8000
5. Others	0.03	---	---
Total	2.60	---	---

1992 (12th)	1.6

Table 2. Exposure of Periodic Regular Maintenance Work (The 8th Maintenance Outage at Tokai No. 2)

Work Area		Ratio (%)
PCV	PLR sys	24.3
	RHR sys	9.8
	CUW sys	6.6
	Others	19.4
	Subtotal	57.1
R/B (Out of PCV)	6FL (operating floor)	
	RHR sys	3.6
	CUW sys	5.1
	Others	11.6
	Subtotal	39.2
RW/B, T/B		3.7
Total		100

working area can be decreased by half, then a person can work for twice as long at the same dose. Considering the relationship between labor cost per increased working time and reduced dose, the price per person-mSv becomes 1X105-3X105 yen($1X103-3X103). A report[2] of the BNL ALARA Center gives the same value. Considering of all of these factors, we have established an index of cost-benefit of 3X105 yen/person-mSv($3X104/person-rem) in the Tokai No. 2 plant.

CONCLUSION

In the Tokai No. 2 plant, the project groups were organized to consider dose reduction and some countermeasures were carried out. Setting up an index of cost-benefit of 3X105 yen/person-mSv($3X104/person-rem), several measures were adopted, such as permanent shielding, decontamination, automatic or remote operation, and renewal of equipment. As a consequence, the dose from regular maintenance work decreased 4.0 person-Sv to 1.6 person-Sv. The results of cost-benefit analysis of these measures were estimated roughly as 4X104-4.3X105yen/person-mSv ($4X103-4.3X104/person-rem) and were evaluated to be in the reasonable range. In 1993, a second five-year program was proposed to reduce to 1 person-Sv the dose from regular maintenance work. This program was started in 1994.

REFERENCES

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2. John W. Baum,"Valuation of Dose Avoided at U.S. Nuclear Power Plants", Nuclear Plant Journal, March-April 1991.

Author Biography

Kazufumi Taniguchi is a deputy manager at the radiation control office of the Japan Atomic Power Company. Presently, he is primarily engaged in managing and developing the computer system for radiation control (mainly occupational dose management). From 1981-84, he worked at the radiation control section of Tsuruga Power Station, where his work focussed on environmental control. Before coming to the radiation control office of JAPC, he was temporarily transferred to the Japan Nuclear Fuel Service Company (JNFS), which is now the Japan Nuclear Fuel Company (JNF). For the three years that he was there, he was engaged in developing an in-line monitor for radioisotopes.

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DISCUSSION

Unknown: I am interested in the decontamination that you did inside the reactor on the walls and the steam separator. You cleaned the reactor vessel walls and the separator to remove the 300 Ci. What recontamination rate have you seen or do you expect? Do you expect it to build back up to that level or have you done something to keep it from reoccurring and having to perform another decontamination in future?

Taniguchi: The recontamination rate for this equipment and the effects of the removal of 300 Ci are now being evaluated, including the implementation of the continual decontamination of inner reactor.

Cody: You mentioned that the reactor well decontaminator saved three days of outage time. Could you explain how that was possible? Usually refuel floor are on the critical path, which makes that very attractive.

Taniguchi: For manual decontamination in former times, as you know, the scaffolding had to be set up. Through the introduction of the automatic decontaminator of reactor well, the construction of footing is now not necessary, and the removal of reactor water and the decontamination of reactor well are possible to be done at the same time. It took about 8 days to decontaminate before using this automatic decontaminate.

Cody: The name of the manufacturer of the reactor well decontaminator was ATOX, Inc. Is that a Japanese company?

Taniguchi: Yes, ATOX is a Japanese company. The telephone number is 0471-45-8801. The fax number is 0471-45-3649.