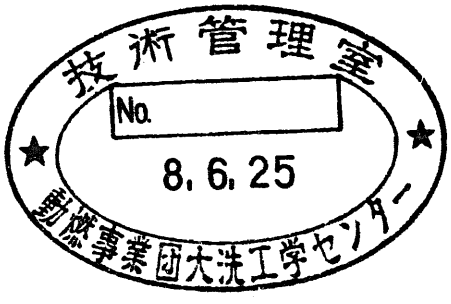
PNC TN9100 96-006

Radiological Work Control at Nuclear Facilities

February, 1996



O-ARAI ENGINEERING CENTER
POWER REACTOR AND NUCLEAR FUEL DEVELOPMENT CORPORATION

公　開　資　料
PNC TN9100 96-006
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原子力施設における放射線作業管理

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前　書

いかなる放射線作業においても，経済的及び社会的要因を考慮のうえ，放射線被ばくは，合理的に達成できる限り低く保たれなくてはならない（ALARA)。この目的を達成するためには，以下が重要である。

1．基本的な要求事項と管理要素
（1）全ての作業からの個人職業被ばくは，線量限度を超えてはならない。
（2）作業の集団総実効線量当量は，最小化されなければならない。
（3）作業の管理レベルは，被ばくの量に応じたものでなければならない。
（4）放射線作業管理のための実務的な手順書が作成されていなければならない。
（5）放射線防護を管理する組織ができていなければならない。

2．現場組織と責任
（1）放射線管理者は，他のライン管理者から独立性を維持していなければならない。
（2）全体の責任は，施設管理者にある。
（3）作業活動の適切な計画及び管理を保証する責任は，ライン管理者にある。
（4）放射線防護管理者の責任は次のとおりである。
・施設管理者に専門的な放射線防護アドバイスを提供する。
・ライン管理者の放射線作業計画立案を助ける。
・放射線防護手順のあらゆる面の承認及び見直しを行う。
・放射線防護サービスを提供する。

3．放射線被ばくの低減
（1）外部被ばく
線源の除去，放射能の減衰，汚染の除去，専用治具の使用，被ばくの時間の短縮
（2）内部被ばく
汚染の除去，換気，閉じ込め，放射能の減衰，専用防護衣及び呼吸器の使用，被ばく時間の短縮

以下に，大洗工学センターの原子力施設における放射線作業管理手順の例（マニアルの要約）並びに放射線作業の例を紹介する。

（本資料は，科学技術庁の原子力研究交流制度の研究者，JICAの放射線安全管理実務者研修等において利用可能な公開資料としてとりまとめたものである。）

1）大洗工学センター　安全管理部　放射線管理課

Radiological Work Control at Nuclear Facilities

Hideki Ando[1], Junichi Hitomi[1]

PREFACE

On any radiological work, exposures shall be kept as low as reasonably achievable, economic and social factors being taken account (ALARA). To establish above objective, the followings are important.

1. Basic Requirements and Management Factors

(1) The occupational exposures to individuals from all works shall not exceed the dose limits.
(2) Collective effective dose equivalent on the work shall be minimized.
(3) The control level of the work shall be depend on the magnitude of exposures
(4) Practical procedure documents for radiological work control shall be established.
(5) Organization for managing radiation protection shall be established.

2. Site Organization and Responsibilities

(1) Radiation Protection Officer shall be kept independent from other line managers.
(2) The overall responsibility resides with the plant manager.
(3) The responsibility for ensuring adequate planning and controlling of work activities resides with line management.
(4) The responsibility of Radiation Protection Officer is as follows.
-- Providing professional radiation protection advises to the plant manager.
-- Assisting line managers to plan radiological works.
-- Reviewing and approving all aspects of radiation protection programs.
-- Providing radiation protection services

3. Reducing Radiation Exposure

(1) External exposure
Removal of sources, decay, decontamination, shielding, use of special tools and devices, reducing exposure time
(2) Internal exposure
Decontamination, ventilation, containment, decay, use of protective clothing, respirators and other devices, reducing exposure time

We will show you an example of radiological work control procedure (summary of a manual) and an example of radiological work at the nuclear facilities of O-arai Engineering Center

1) Radiation Control Section, Health and Safety Division, O-arai Engineering Center

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Radiological Work Control at Nuclear Facilities

Power Reactor and Nuclear Fuel Development Corporation in Jaapan

February, 1996

EXAMPLE OF RADIOLOGICAL WORK CONTROL PROCEDURE

The following is one of the site-specific radiological work control procedure (summary of a manual) used at Japanese nuclear facilities. It is applied to a few facilities performing destructive examination of irradiated plutonium-uranium oxide fuels and irradiated materials.

On performing a radiological work in controlled areas, the manager in charge of the work should set up a work plan document to carry out the work in safety and efficiency and submit it to the radiation protection officer (RPO).

On the document, RPO should check the operations. RPO should give instructions and advises to the manager in view of adequate radiation protection, and record the instructions in the document to make them known to the people involved in the work.

1. Classification of Radiological Works

In view of radiation protection, radiological works in controlled areas are classified as follows.

(1) First Kind Radiological Work

Make a "First Kind Radiological Work Plan Document"

(2) Second Kind Radiological Work

Make a "Second Kind Radiological Work Plan Document"

(2) Third Kind Radiological Work

Make a "Third Kind Radiological Work Plan Document"

Definitions and control conditions related to the above works are described below. The classification of radiation works is shown in Table 1-1.

1.1 First Kind Radiological Work

(1) Definitions

The followings are First Kind Radiological Works.

a Work in which effective dose equivalent from external exposures is likely to exceed 1 mSv/week.

b Work in which organ dose equivalent to the lens of the eye is likely to exceed 3 mSv/week.

c Work in which organ dose equivalent except for the lens of the eye is likely to exceed 10 mSv/week.

d Work in which work place conditions are as follows;

(a) Dose equivalent rate from external exposures exceeds or is likely to exceed 1 mS/hour.

(b) Airborne contamination exceeds or is likely to exceed three times DAC (Derived Air Concentrations for Radiation Control Area).

(c) Surface contamination exceeds or is likely to exceed the following levels.

-- For alpha emitting radionuclides: 4 Bq/cm^2.

-- For beta and gamma emitting radionuclides: 40 Bq/cm^2.

e Work in which collective effective dose equivalent is likely to exceed 10 man mSv.

(2) Control conditions

a When the manager engages workers in more than or equal to two First Kind Radiological Works at the same time, the manager must control the exposures of the workers for each work.

b The approval of a First Kind Radiological Work is effective for three months. If the work requires more than three months, it is necessary to obtain another approval after three months.

1.2 Second Kind Radiological Work

(1) Definitions

The followings are Second Kind Radiological Works.

a Work in which effective dose equivalent from external exposures is likely to exceed 0.3 mSv/week but unlikely to exceed 1 mSv/week.

b Work in which organ dose equivalent to the lens of the eye is likely to exceed 1 mSv/week but unlikely to exceed 3 mSv/week.

c Work in which organ dose equivalent except for the lens of the eye is likely to exceed 3 mSv/week but unlikely to exceed 10 mSv/week.

d Work that involves airborne contamination or surface contamination but dose not fall into the First Kind of Radiological Work.

(2) Control conditions

The approval of a Second Kind Radiological Work is effective for three months. If the work requires more than three months, it is necessary to obtain another approval after three months.

1.3 Third Kind Radiological Work

(1) Definitions

Third Kind Radiological Work is free of airborne contamination and surface contamination and satisfies the followings. The work is out of the scope of First Kind Radiological Work and Second Kind Radiological Work. However routine works such as normal operations and visitations are not included here.

a Work in which effective dose equivalent from external exposures is unlikely to exceed 0.3 mSv/week.

b Work in which organ dose equivalent to the lens of the eye is unlikely to exceed 1 mSv/week.

c Work in which organ dose equivalent except for the lens of the eye is unlikely to exceed 3 mSv/week.

2. Control of First Kind Radiological Work

2.1 Assessment and discussion of work plan

(1) Making of the work plan

In performing a First Radiological Work, the manager in charge of the work should make a First Kind Radiological Work Plan Document to implement the work in safety and efficiency.

The following points must be described in the document clearly.

a Name of the work

b Details of the work

c Place of the work

d Period of the work

e Methods and Procedures of the work

f Names of the workers involved

g Reference values

Planned maximum effective dose equivalent value from external exposures of workers involved in the work, and planned collective effective dose equivalent value from external exposures of the work

h Evaluated dose equivalent of each worker related to the work and the basis of the evaluation.

i Organization for safety

j Actions in case of abnormal conditions

k Measures for radiation protection

(2) Assessment and discussion

Based on the work plan provided by the manager in charge of the work, the RPO should check the operations and evaluate the methods and procedures of the work, paying attention to the following points in view of radiation protection, especially by comparing with similar works performed in the past.

a Dose equivalent rate from external exposures, airborne contamination and surface contamination in the work place

b Dose equivalent from internal exposures, possibility of internal exposure and possibility of skin contamination

c Selection of proper protective devices such as clothing, respirator, etc., and proper measures to prevent spread of contamination

d Protective measures against external exposure (shielding, etc.)

e Reference values of dose equivalent from external exposures (assessment of dose equivalent, exposure history of the workers, etc.)

2.2 Approval of First Kind Radiological Work

A First Kind Radiological work Plan Document needs approval of both RPO and the plant manager.

2.3 Implementation of the work

(1) Confirmation before the work

In view of radiation protection, the following points should be checked.

a Necessary protective measurers described on the work plan document

b Dose equivalent rates from external exposures related to the work plan

c Concentration of airborne and surface contamination related to the work plan

d Preventive measures against the spread of contamination related to the work plan

e Control of workers' exposure related to the work plan

f Management of waste disposal related to the work plan

g Other necessary measures for radiation protection

(2) Supervision of the radiological work

Supervision should be made, depending on the each operation of the work, at the beginning of the operation, during the operation, and at the end of the operation. Especially, the following operations require the supervision by RPO staff.

a Operations in which airborne or surface contamination might occur

b Operations in which radiation level is likely to fluctuate on large scale

c Operations which has never been experienced in the past

(3) Workplace monitoring

RPO should be aware of the radiation levels by monitoring the dose equivalent rates from external exposures, airborne contamination and surface contamination, depending on each operation of the work.

During the work, RPO staff should try to detect any abnormal conditions as early as possible, and the results of monitoring should be made known to workers depending on the conditions. RPO staff should give necessary instructions and advises to ensure the safety of the work.

a Monitoring of external radiation

-- Measure the dose equivalent rates resulting from gamma and neutrons in the workplace by employing survey meters. The measurement should be done at proper places and with reasonably frequency.

-- Supervise the dose equivalent rates related to the operations by area-monitors and verify there is no abnormal condition

-- If a large fluctuation of dose equivalent rate is expected, set portable area monitors with alarm at proper points to supervise and measure the fluctuation of dose equivalent rate continuously.

b Monitoring of surface contamination

-- In view of preventing spread of contamination, the measurement should be performed at proper points and with proper frequency for each operation of the work.

-- If the workplace floor is large, the measurement of surface contamination should be performed by smear method.

-- The measurement of surface contamination of hands, feet and clothing of workers should be directly done by survey meters.

c Monitoring of airborne contamination

When airborne contamination has occurred or is likely to occur, portable monitors or portable air samplers should be employed to monitor the concentration of airborne contamination.

Sampling points should be selected at the places where the airborne contamination can be efficiently measured, the flow of the air in the workplace being taken into account.

-- Control by portable monitors

(a) Indicate the conversion factor from count rate to concentration, operation conditions and alarm value in front of monitors.

(b) Start monitoring before the beginning of the operations to check background levels.

(c) Record the flow rate just after the start of the sampling and just before the end of the sampling, and record sampling time.

(d) Check the condition of monitor operation during measurement.

(e) Replace filters once a day, and measure immediately gamma spectrum. If necessary, measure the filters with counter after the daughters of Rn and Tn have decayed.

-- Control by portable air samplers

In the case of dust sampling, perform in compliance with above (c), (d) and (e).

In the case of gas sampling, sample air until the pressure becomes equal to atmosphere after measuring the back-ground level of the sampling chamber. The measurement should be done immediately.

(4) Individual monitoring for the radiological work

a Monitoring by individual external dosimeters

Verify that workers have worn two type dosimeter devices properly. One is to form the individual record of external exposures and to demonstrate compliance with dose limit, such as a TLD or Film Badge. The other is a readable dosimeter to measure the dose related to the operations, such as an electronic dosimeter, pocket dosimeter or alarm meter.

b Confirmation and instructions for radiation protection measures

Verify that workers have worn protective devices properly, especially protective respirator device. Give advises on wearing protective devices, considering the contamination levels of workplaces and the "Standards for wearing protective respirators" (see Table 1-2).

c Check of the dose equivalent from external exposure received during the work

Check the exposure of the workers from time to time whether the dose equivalent from external exposure might exceed planed value.

(5) Monitoring at the end of the operations

a Contamination check of the workplace at the end of the operation

Workers should check the contamination of the floors of workplace when deemed necessary, and confirm that the operation has been carried out safely. If necessary, RPO staff assists them.

b Check of the workers' skin contamination when leaving the workplace

When workers leave the work place, they must check the contamination of clothing, hands, face, etc., to confirm that the operation has been done safely. When workers have used protective respirators, they must check the contamination of their respirators too.

c Elaborate contamination check

When contamination has been detected on clothing, hands and face, etc., after the operation with airborne or surface contamination, RPO staff should investigate the following points.

-- Through check of skin contamination

-- Contamination check of nostrils by smear test

2.4 Evaluation of monitoring results and actions to be taken

(1) Dose equivalent resulting from external exposures

RPO staff should periodically calculate the dose equivalent resulting from external exposures by using the data of electric dosimeters or alarm meters, which are readable, worn by workers during the operations.

RPO staff should compare the calculated results with the planed reference levels described on the First Kind Radiological Work document in order to evaluate the validity of the initial work plan. If the results exceed or are likely to exceed the planed reference values, RPO should notify it to the manager in charge of the work and investigate the cause of the exposures. The protective measures listed below should be rechecked.

a The results of monitoring

b The methods and procedures of the work

c The validity of the radiation protection measures

d The planing of workers and working time

Moreover RPO staff should compare the calculated results with "Standards for TLD or Film Badge measured temporarily" (see Table 1-3). If the results exceed above Standards and the reason of exceeding is unknown, the dose equivalent should be evaluated by using TLD or Film Badges worn by workers

(2) Dose equivalent resulting from internal exposures

When contamination has detected by the nostril smear test or when intake of radioactive materials has occurred, the committed dose equivalent should be evaluated. The dose equivalent should be roughly estimated from the result of nostril smear test or the concentration of airborne contamination and exposure time. The elaborate evaluation is performed on whole body counter, lung monitor, or bioassay (using urine or fecal sample).

(3) Skin contamination

If skin contamination has been detected, decontamination should be performed immediately. If the contamination cannot be removed, the organ dose equivalent of the skin should be evaluated.

2.5 Records

(1) RPO should write the results of supervision for each operation and the detailed results of the radiological monitoring.

(2) Records should be kept for ten years.

2.6 Reports

When the First Kind Radiological work has been finished, the manager in charge of the work should make a report including the following points, and submit it to RPO and the plant manager.

(1) results of dose equivalent

(2) results of exposure control
(3) performance of the protective means to reduce worker's exposures
(4) evaluation of the protective means to reduce worker's exposures
(5) results of radiological monitoring
(6) results of the use of protective devices
(7) results of the work

RPO should provide information of above (1) and (5) to the manager in charge of the work and discuss the other points with the manager.

3. Control of Second Kind Radiological Work

3.1 Assessment and discussion of work plan

(1) Making of work plan

In performing a Second Kind Radiological Work, the manager in charge of the work should make a Second Kind Radiological Work Plan Document to implement the work in safety and efficiency.

The following points must be described in the document clearly.

a Name of the work
b Details of the work
c Place of the work
d Period of the Work
e Methods and Procedures of the work
f Names of the workers involved
g Reference values

Planned maximum external dose equivalent value of workers involved in the work, and planned collective effective dose equivalent value of the work

h Measures for radiation protection
i Actions in case of abnormal conditions

(2) Assessment and discussion

Based on the work plan provided by the manager in charge of the work, the RPO should check the operations and evaluate the methods and procedures of the work.

3.2 Approval of Second Kind Radiological Work

A Second Kind Radiological work Plan Document needs approval of RPO.

3.3 Implementation of the work

(1) Confirmation before the work

In view of radiation protection, the following points should be checked.

a Necessary protective measurers described on the work plan document
b Dose equivalent rates from external exposures related to the work plan

c Concentration of airborne and surface contamination related to the work plan
d Preventive measures against the spread of contamination related the work plan
e Control of workers' exposures related to the work plan
f Management of waste disposals related to the work plan
g Other necessary measures for radiation protection

(2) Supervision of the radiation work

Supervision should be made. If necessary, RPO staff supervises operations.

(3) Work place monitoring

If necessary, RPO staff should measure the radiation levels in the workplace depending on the operations of the work. In view of radiation protection, RPO staff should give necessary instructions and advises.

(4) Individual monitoring for the radiological work

RPO should evaluate the workers' dose equivalents related to the work, using the data of readable type dosimeter devices worn by workers. If the dose equivalents from external exposures are most unlikely to exceed the levels prescribed for Second Kind Radiological Work, it is not necessary to evaluate the dose equivalents.

(5) Other points

Refer to 2.3.

3.4 Evaluation of monitoring and actions to be taken

Refer to 2.4.

3.5 Records

Refer to 2.5

3.6 Reports

If necessary, the manager in charge of the work should make a report and submit it to RPO.

RPO should provide information of the evaluation of the workers' dose equivalents to the manager.

4 Control of Third Kind Radiological Work

4.1 Assessment and discussion of work plan

(1) Making of the work plan

In performing a Third Kind Radiological Work, the manager in charge of the work should make a Third Kind Radiological Work Plan Document to implement the work in safety and efficiency.

The following points must be described in the document clearly.

a Name of the work
b Details of the work
c Place of the work
d Period of the work
e Measures for radiation protection

(2) Assessment and discussion

If necessary, the RPO should check the work plan in view of radiation protection.

4.2 Approval of Third Kind Radiological Work

A Third Kind Radiological Work Plan Document needs approval of neither RPO nor the plant manager. The manager in charge of the work should only notify the document to RPO.

4.3 Implementation of the work

(1) Confirmation before the work

In view of radiation protection, the following points should be checked

a Necessary protective measurers described on the work plan document
b Dose equivalent rates from external exposures related to the work plan
c Control of workers' exposures related to the work plan
d Management of waste disposal related to the work plan
e Other necessary measures for radiation protection

(2) Work place monitoring

If necessary, RPO staff should measure radiation levels in the workplace.

4.4 Records

RPO should record the results of the radiological monitoring.

Table 1-1 Classification of Radiological Works

Items	First Kind Radiological work	Second Kind Radiological Work	Third Kind Radiological Work
Effective dose equivalents from external exposure	D > 1 mSv/week	1 ≧ D > 0.3 mSv/week	0.3 ≧ D mSv/week
Organ dose equivalents to the lens of the eye	D > 3 mSv/week	3 ≧ D > 1 mSv/week	1 ≧ D mSv/week
Organ dose equivalents except for the eye	D > 10 mSv/week	10 ≧ D > 3 mSv/week	3 ≧ D mSv/week
Work place conditions			
Dose equivalent rates	D.R. > 1 mSv/hour	Work with cotaminatiom	Work without cotaminatiom
Airborne contamination	C. > 3 times DAC		
Surface contamination	C.(α)> 4 Bq/cm^2 C.(β, γ)> 40 Bq/cm^2		
Collective effective dose equivalent of the work	D> 10 man mSv		

DAC: Derived Air Concentration (from ALI)

Table 1-2 Standards for the wearing of the protective respirators

	Halfe face mask	Full face mask	Ventilated respirator	Ventilated suit (Frogman Suit)
Airborne contamination (α) Bq/cm^3	$0<C. \leqq 6.4/n \times 10^{-7}$	$6.4/n\times10^{-7}<C. \leqq 6.4/n\times10^{-6}$	$6.4/n\times10^{-6}<C. \leqq 6.4/n\times10^{-4}$	$6.4/n\times10^{-4}<C.$
Airborne contamination (β, γ) Bq/cm^3	$0<C. \leqq 4/n\times10^{-4}$	$4/n\times10^{-4}<C. \leqq 4/n\times10^{-3}$	$4/n\times10^{-3}<C. \leqq 4/n\times10^{-1}$	$4/n\times10^{-1}<C.$

n: Working hours per day

Basis of standards;

Average airborne contamination per day in the air, which workers are breathing in, is less than or equal to one-tenth of DAC.

Table 1-3 Standards for TLD or Film Bage measured temporary

Evaluated effective dose equivalent for external exposure
D. > 2 mSv/time D. > 10 mSv/month

EXAMPLE OF RADIOLOGICAL WORK

The following is an example of radiological work control at the nuclear facility performing destructive examination of highly irradiated materials, such as fuel claddings, ducts and control rods of reactors. Main nuclides to be subject to radiation protection are ^{239}Pu, ^{241}Am, ^{137}Cs, ^{90}Sr and ^{60}Co.

1. Work plan

1.1 Classification

The work was decided to be a First Kind Radiological work

(1) Work place conditions related to workers were expected as follows.

a Effective dose equivalent rate from external exposure is 5.5 mSv/hour.

b Air borne contamination is 0.03 $\mu Bq/cm^3$ (α) and 5 $\mu Bq/cm^3$ (β, γ).

c Surface contamination is 10 Bq/cm^2 (α) and 24 Bq/cm^2 (β, γ)

(2) Collective effective dose equivalent was expected 55 man mSv.

1.2 Initial work plan document

Abstract of the document is as follows.

(1) Name of the work

Decontamination and Dismantling of Fuel Cladding Examination Cell

(2) Details of the work

Fuel Cladding Examination Cell has the volume of 100 m^3 (length; 7.5 m, width; 3.2 m, height; 4.2 m), and is made of stainless steel surrounded by heavy concrete of 1 m thickness with glass windows and manipulators. There are many testing machines and maintenance equipment (see Fig. 2-1). The inside cell is highly contaminated with alpha, beta and gamma nuclides.

The purpose of this work is to remove these machines and equipment, and to clean up inside the cell.

a Workers enter the cell to set temporary shields for gamma rays, to repair a power manipulator with a trouble and to carry machines and equipment for decontaminating and dismantling into the cell.

b At the first stage Workers perform the operations of decontamination and dismantling with remote control. At the second stage worker enter the cell to perform the operations.

c Dismantled machines and equipment are carried out from the cell for further cutting as waste disposal.

(3) Place of the work

Main work place is inside Fuel Cladding Examination Cell.

(4) Period of the work

From April 1993 to March 1994

(5) Methods and procedures of the work

Schedule is in Table 2-1. Main flow of the work is showed in Fig. 2-2.

(Details are omitted here.)

(6) Names of the workers involved

About 20 workers are involved in the work.

(Names are omitted here.)

(7) Reference values

Effective dose equivalent value from external exposures; 5.3 mSv

Collective effective dose equivalent value from external exposures; 55 man mSv

(8) Evaluated dose equivalent of each workers

See Table 2-2.

(9) Organization for safety

See Fig. 2-3.

(10) Actions in case of abnormal conditions

(Actions are omitted here.)

(11) Measures for radiation protection

a The application of remote techniques by using a power manipulator

-- Decontamination by dry-ice blast method

-- Decontamination by electronic-chemical dissolution method

-- Dismantling by air-plasma cutting method

b The use of temporary shielding

c The use of proper protective clothing and respiratory devices

When workers enter the cell, they wear proper protective clothing and respiratory devices, depending on the reduction of airborne and surface contamination. At first stage, workers wear Frogman Suits, which are ventilated plastic clothing, and breathing air is provided from clean area. At second stage, workers wear ventilated respirators and plastic clothing with full hood. At third stage, workers wear full face masks and plastic clothing with full hood.

Other protective devices are used such as coveralls, rubber gloves, shoes, shoe covers, caps, etc.

d The use of temporary containment areas for preventing the spread of contamination with local ventilation

The area looks as a tent house consisting of metal or wood frames covered with skin of plastic sheeting, ducting to the main ventilation exhaust through temporary filters.

e The wears of TLB badges and electronic dosimeters with alarm

This electronic dosimeter can transfer the signal of dose to the wireless receiver being outside the cell, and the supervisor can also communicate to workers through the dosimeter function.

f Mock-up training

The mock-up training related to the operations inside the cell is to be done.

2. Implementation of the work

See some photographs.

2.1 Supervision of the work

RPO staff had supervised all operations.

2.2 Workplace monitoring

During the operations, RPO staff measured the effective dose equivalent rates from gamma rays by using survey meters and measured the surface contamination by smear methods with adequate frequency. Moreover, RPO staff was continuously monitoring the airborne contamination by portable dust monitors. A sampling method to measure the airborne contamination in the cell is shown in Fig. 2-4.

A few example data are showed in Fig. 2-5, Fig. 2-6 and Table 2-3. Some of data shows higher values than those expected in the initial plan.

3. Revise of the work plan

The work plan was revised several times during the work, because of the delay of the operations and worse workplace conditions.

(1) Period of the work was changed as follows.

From April, 1993 to August, 1994

(2) Reference values were changed as follows

Effective dose equivalent value from external exposures; 8.5 mSv

Collective effective dose equivalent value from external exposures; 130 man mSv

(3) The number of the workers was changed to 38.

4. Results of the work

(1) All existing testing machines and maintenance equipment in the cell were completely removed. The surface contamination inside the cell was reduced to 0.03 Bq/cm^2 (α) and 0.4 Bq/cm^2 (β, γ). The effective dose equivalent rate from gamma rays reduced to 0.05 mSv/hour except for a few local points.

(2) Exposures

Maximum effective dose equivalent from external exposures; 8.4 mSv

Collective effective dose equivalent from external exposures; 128 man mSv

There is no worker with internal exposure.

Fig. 2-1 Arrangement of testing machines and maintenance equipment in Cladding Examination Cell

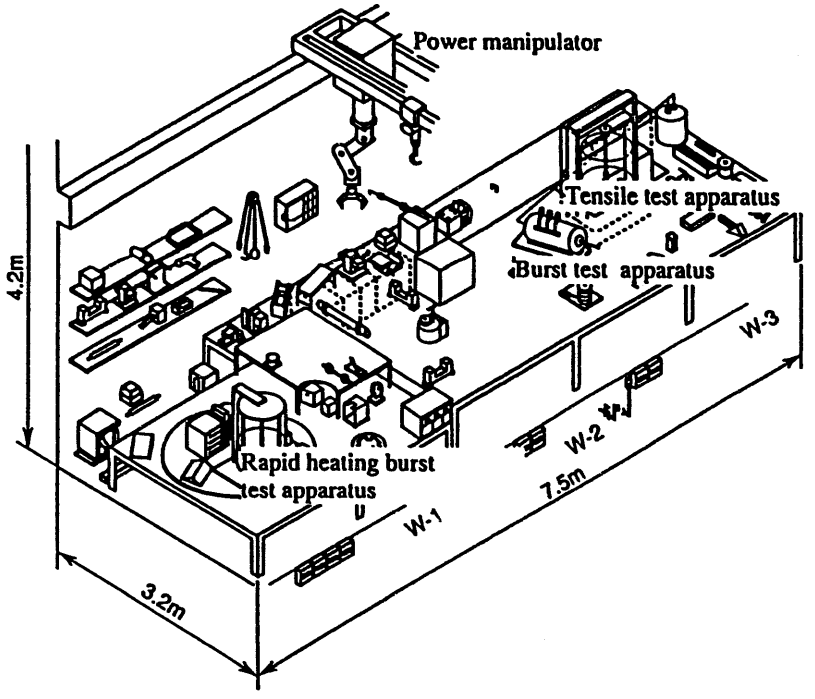


Fig. 2- 2 Main Flow of the Work

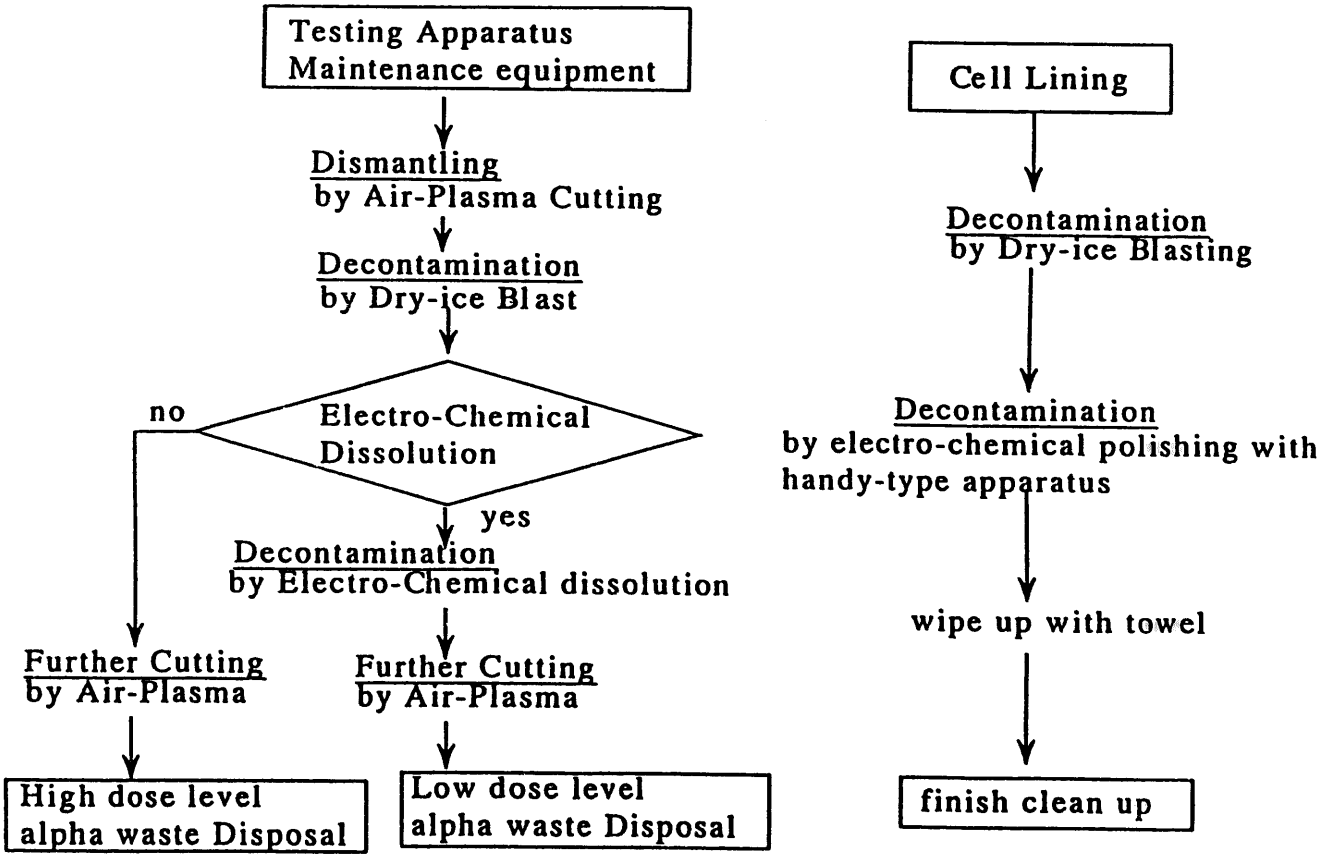


Fig. 2-3 Organization of the Work

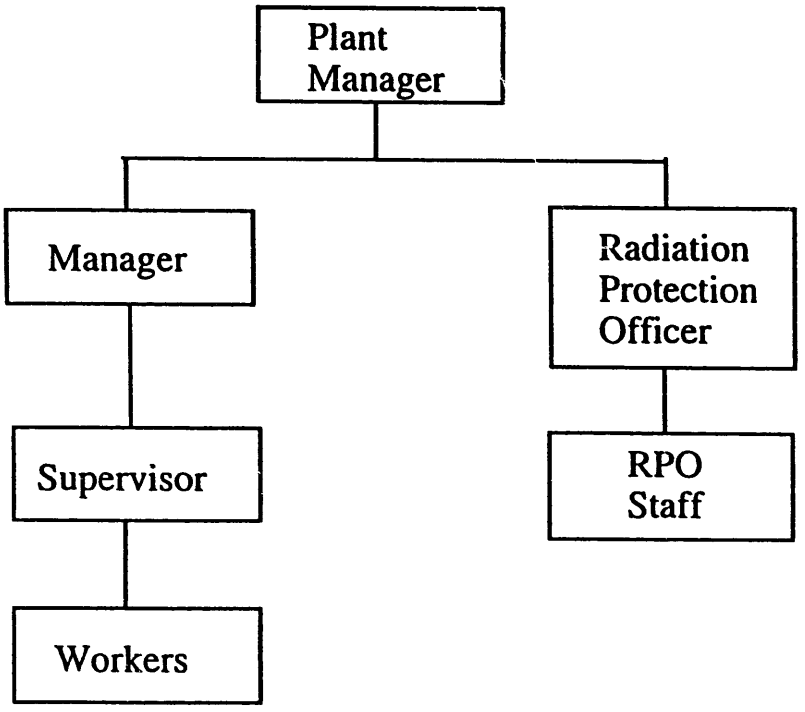


Fig. 2-4 Sampling method of measuring airborne contamination in the Cell

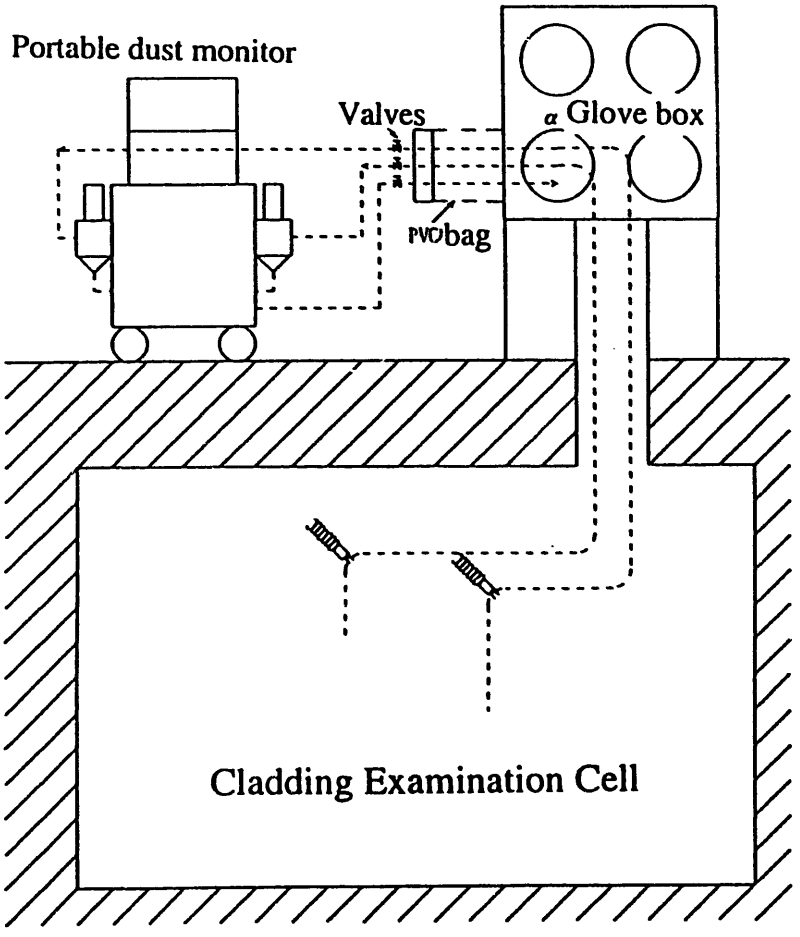


Fig. 2-5 External effective dose equivalent rates inside the Cell before decontamination

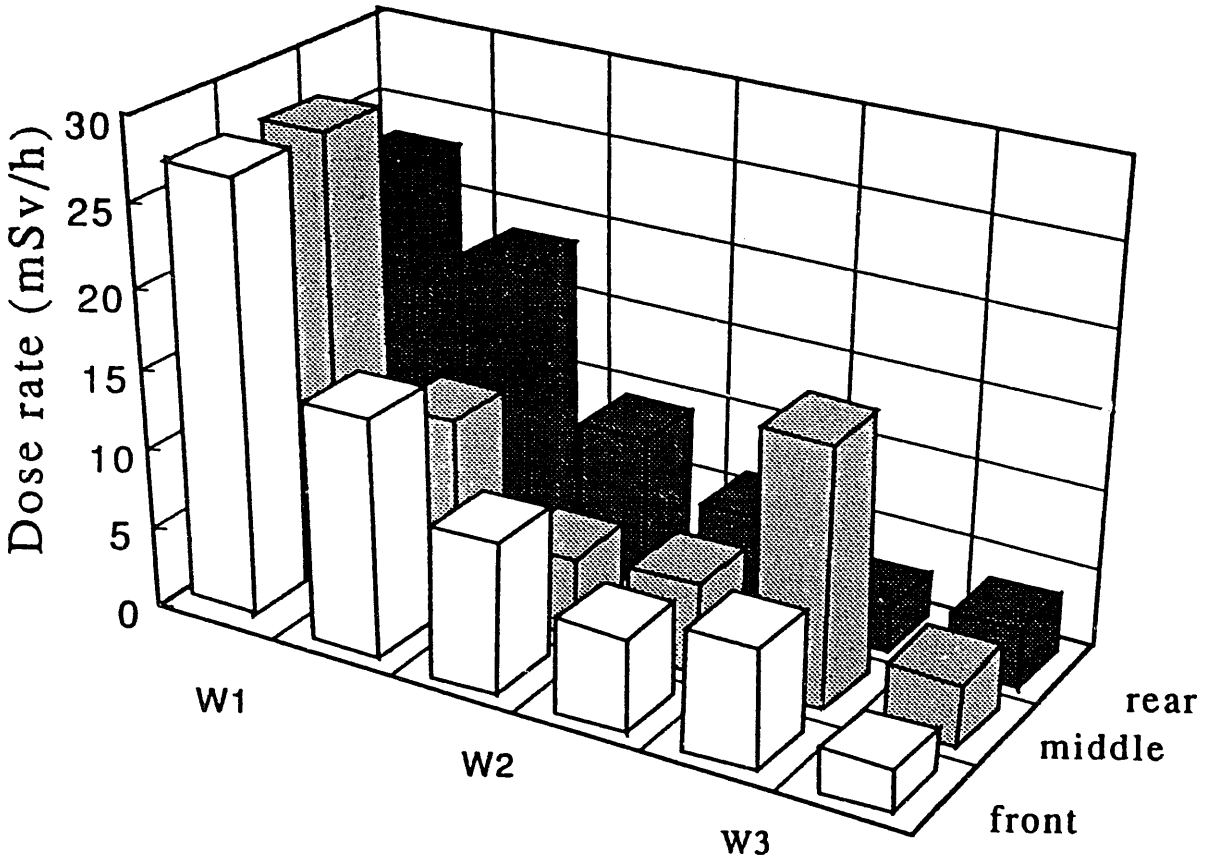


Fig. 2-6 An example of change of airborne contamination in the Cell during operation

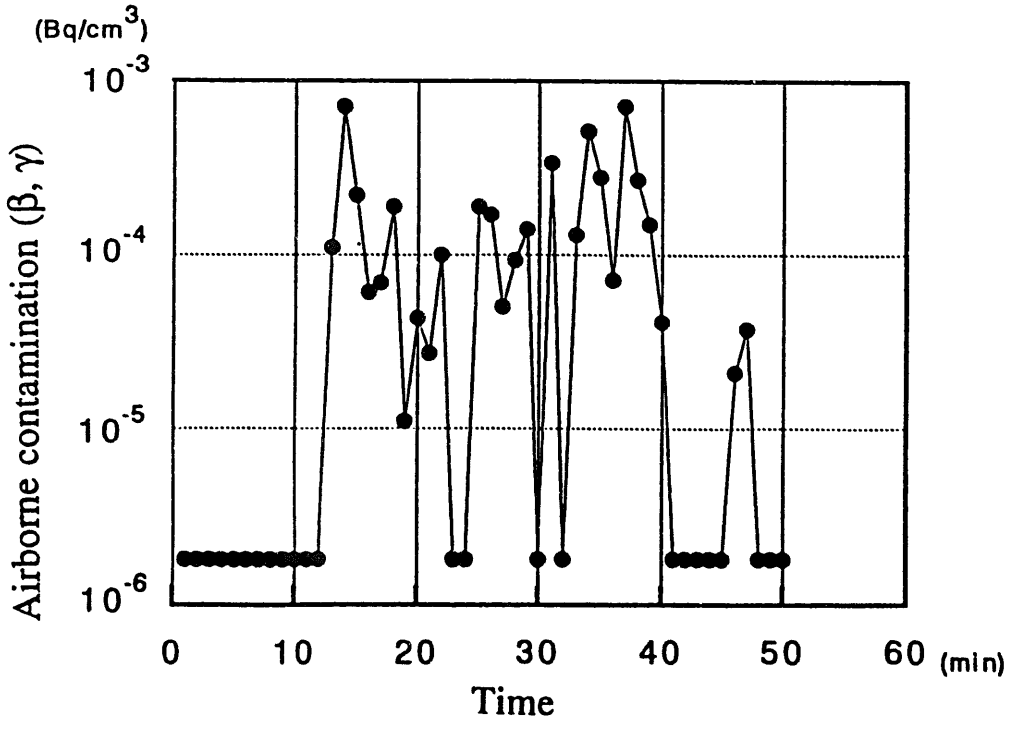


Table 2-1 Schedule of the work(Plan)

	1993									1994		
	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March
Setting shields	—											
Setting a workshop	—											
Repairing a power manipulator		—										
Decontamination and dismantling by hands	—		—	—	—		—					
Remote decontamination and dismantling		—	—	—	—	—	—					
Dismantling a Frogman instrument							—					
Decontamination of Cell lining								—				
Cutting waste disposals												
Assessment of working conditions	—		—	—	—		—					

Table 2-2 Evaluated dose equivalent of each worker (plan) 1/2

Name		Planed dose equivalent of each operations (mSv)					Amount (mSv)
		Setting temporary shields	Repairing power manipulator	Remote decontamina-tion and dismantling	decontamina-tion and dismantling by hands	Cutting waste disposals	
A	effective dose equivalent	0	0	0	0.1	0.1	0.2
B	effective dose equivalent	0.1	0.1	0.2	0.1	0.1	0.6
C	effective dose equivalent	0.1	0.1	0.2	0.2	0.2	0.8
D	effective dose equivalent	0.1	0.1	0.2	0.2	0.2	0.8
E	effective dose equivalent	0.1	0.1	0.2	0.2	0.2	0.8
F	effective dose equivalent	0.8	0.4	0	2.4	0	3.6
G	effective dose equivalent	0.8	0.5	0.8	2.4	0.8	5.3
H	effective dose equivalent	0.8	0.4	0	2.4	0	3.6
I	effective dose equivalent	0.8	0.5	0	2.4	0	3.7
J	effective dose equivalent	0.8	0.5	0.8	2.4	0.8	5.3
K	effective dose equivalent	0.8	0.5	0.8	2.4	0.8	5.3
L	effective dose equivalent	0.6	0.5	0.8	2.4	0.8	5.1
M	effective dose equivalent	0.6	0	0	2.4	0	3.0
N	effective dose equivalent	0.6	0.4	0	2.4	0	3.4

Table 2-2 Evaluated dose equivalent of each worker (plan) 2/2

Name		Planed dose equivalent of each operation (mSv)					Amount (mSv)
		Setting temporary shields	Repairing power manipulator	Remote decontamina-tion and dismantling	decontamina-tion and dismantling by hands	Cutting waste disposals	
O	effective dose equivalent	0.6	0	0	2.4	0	3.0
P	effective dose equivalent	0.6	0	0	2.4	0	3.0
Q	effective dose equivalent	0.6	0.5	0.8	2.4	0.8	5.1
R	effective dose equivalent	0.2	0.2	0.2	0.4	0.2	1.2
S	effective dose equivalent	-	0.4	-	-	-	0.4
T	effective dose equivalent	-	0.4	-	-	-	0.4
U	effective dose equivalent	0.6	0.5	0.8	2.4	0.8	5.1

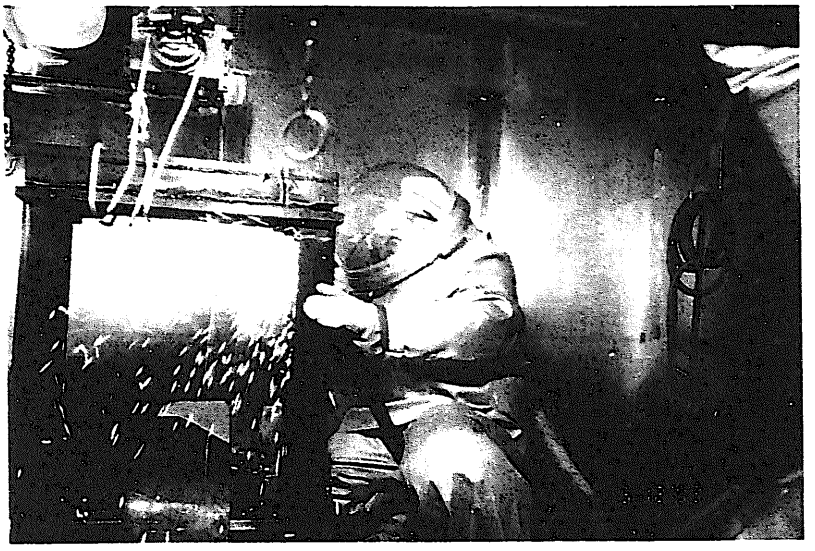
Table 2-3 An example of surface contamination in the Cell

	Surface contamination
May, June (1993)	α : 1.0 Bq/cm^2 β, γ: 1.2 × 10^1 Bq/cm^2 (Average of 10 points)
June, July (1994)	α : 1.4 × 10^{-1} Bq/cm^2 β, γ: 2.1 Bq/cm^2 (Average of 13 points)

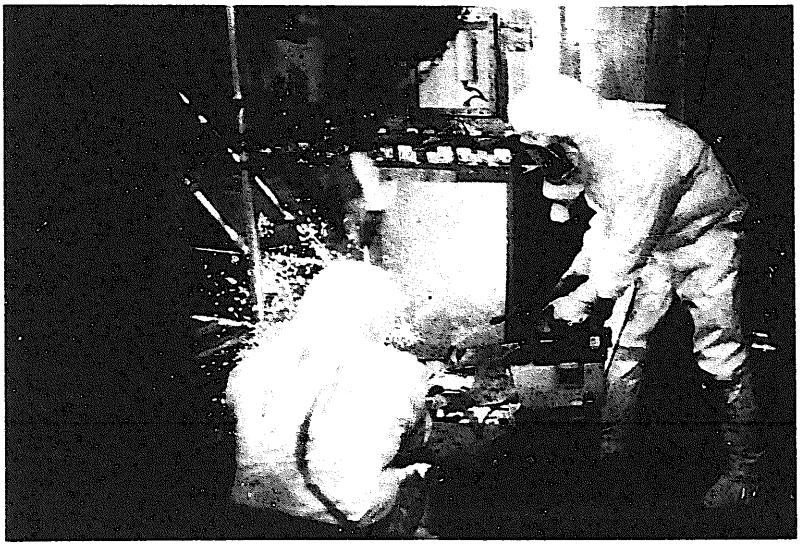
Table 2-2 Evaluated dose equivalent of each worker (plan) 2/2

Name		Planed dose equivalent of each operation (mSv)					Amount (mSv)
		Setting temporary shields	Repairing power manipulator	Remote decontamina-tion and dismantling	decontamina-tion and dismantling by hands	Cutting waste disposals	
O	effective dose equivalent	0.6	0	0	2.4	0	3.0
P	effective dose equivalent	0.6	0	0	2.4	0	3.0
Q	effective dose equivalent	0.6	0.5	0.8	2.4	0.8	5.1
R	effective dose equivalent	0.2	0.2	0.2	0.4	0.2	1.2
S	effective dose equivalent	-	0.4	-	-	-	0.4
T	effective dose equivalent	-	0.4	-	-	-	0.4
U	effective dose equivalent	0.6	0.5	0.8	2.4	0.8	5.1

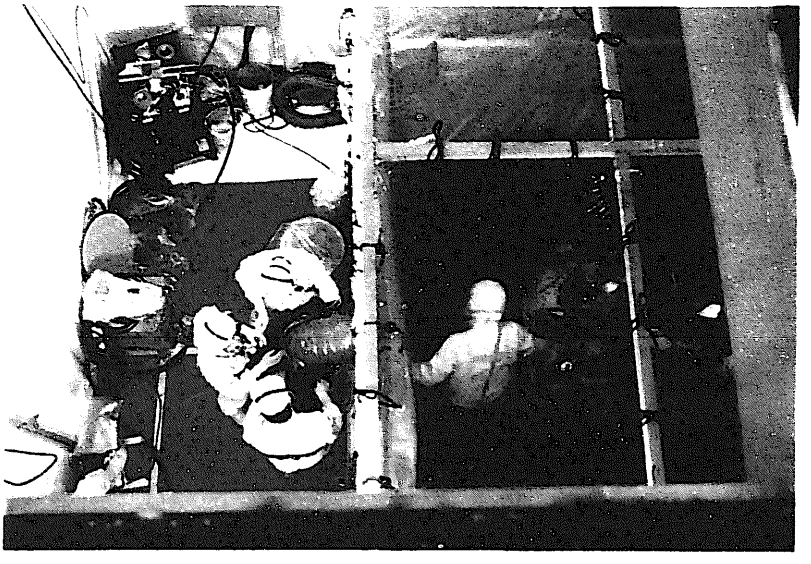
Some photographs of operations



An operation in the Cell with a Frogman suit



An operation in the Cell with ventilated respirators



A temporary containment house