



UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

DEC 10 1990

*SP-1000-
Taylor
Lynch
Linsam
Gibbs
Fisher*

*A Korean representative
to Bureau of the IAEA
in the time since case
and a copy filed with
the report.*

MEMORANDUM FOR: Chairman Carr
Commissioner Rogers
Commissioner Curtiss
Commissioner Remick

FROM: *JRS* James R. Shea, Director
International Programs
Office of Governmental and Public Affairs

*Also, copy of
to Steve and
return to me*

SUBJECT: KOREAN REPORT ON THE "AMERSHAM INCIDENT"

Attached for your information is an English version of the report to the Korean Minister of Science and Technology on the exposure incident which occurred in the U.S. in early 1990 when a depleted Iridium-192 sealed radiation source was accidentally shipped from Korea to the Amersham Corporation in Massachusetts in a presumed-empty source changer. NRC's investigation of the incident was reported in NUREG-1405.

The Korean investigation found that established procedures for discarding waste materials were not followed. Although the Ir-192 pellet was improperly stored in a source changer, it was within the shielded chamber of the changer during transportation within Korea. The Korean investigation concluded that the pellet was dislodged following shipment from Korea. Film badge testing of those who had direct and indirect contact with the radioisotope during the shipment to the U.S. showed an exposure level of 10 mrem (page 20).

The report states the following measures will be taken to prevent a recurrence of the incident (page 21):

- o When radioactive material is to be disposed of, a disposal plan must be developed and approved by the superior officer.
- o Such material is to be placed only in a waste storage container.
- o A source changer is never to be used for a radioactive waste box.
- o A source changer must always be checked for radioactivity and pollution levels.

CONTACT:
D. Chaney, IP
x20644

9012260174 901220
PDR ORG NEXD PDR

- o When a survey is conducted, the surveyor must allow enough time for the survey meter to respond and must follow examination steps specified in regulations.

Attachment:
As stated

cc w/attachment:
J. Taylor, EDO
H. Denton, GPA
S. J. Chilk, SECY
W. Parler, OGC

KINS/AR-004

Investigative Report on the Accidental Leakage of the Ir-192 Sealed Source

May 3, 1990

The Korean Nuclear Power Technology Department

Content

1. The Content of the Inquiry.....
 - A. The Date of the Inquiry.....
 - B. The Originator of the Inquiry & its Route.....
 - C. The Content of the Inquiry.....

2. Involved Agencies
 - A. The Korea Industrial Testing Corporation
 - B. The NDI Corporation

3. Investigation on the Cause of the Accident.....
 - A. The Problem Source
 - B. Formation of the Investigative Team
 - C. Date of Investigation
 - D. Method of Investigation
 - E. Content of Investigation
 - 1) Identifying the fact that the source was exported to the
Amersham Corporation in America
 - 2) Identifying the Shipping Company.....
 - 3) Identifying the companies which were exposed to the source..
 - 4) The Account of the Waste Source Ir-192:6.8 Ci entered in the
source changer.....
 - 5) The account of the Container Returned with the Source Ir-192:
4.2 in it even though it was Supposed to be Returned as
an Empty Source Changer
 - 6) The Account of Collecting the Source Changer.....
 - 7) Transporting Procedures of Empty Containers
 - 8) The Account of Packaging the 14 Source Changers and
Shipping

- F. The Investigative Team's Opinion on the Result
 - 1) The Korea Industrial Testing Corporation
 - 2) The NDI Corporation

4. Possible Radioactive Exposure Level and Physical Examination of the Involved Personnel
 - A. Possible Radioactive Injuries and Expected Individual Exposure Level
 - B. Result of the Physical Examination
 - C. Evaluation on the Possible Radioactive Injury

5. Adherence to the Nuclear Power Regulation
 - A. The Korean Industrial Testing Corporation
 - B. The NDI Corporation

6. Conclusion.....
 - A. The Cause of the Accident.....
 - B. Possible Radioactive Injury
 - C. Measures Taken to Prevent any Future Accident

Attached

1. Result of the Physical Examination
2. The Documentation on the Source Changer, Model No. :
AI 500 CU)
3. The Model Graph of the Source Changer
4. The Source Model, the Source No. and the graph of
Energy Decrease Rate
5. Reports from the Involved Personnel
6. Radioactive Material Waste Record Log Book (The Korea
Industrial Testing Corporation).....
7. Result of the Radioactive Exposure Level
8. Content of the Inquiry on the Source Changer with
Radioactive Level.....

The Report

Submitted To: The Minister of the Science/Technology Department

This report is submitted as the Investigative Report
on the accidental leakage of the Ir-192 sealed waste
source which was inquired by the NRC of America.

May 3, 1990

Submitted By: Lee, Sang Hun, The Director of
The Korean Nuclear Safety Technology Department

Investigative Report

The Investigative Report on the Leakage of the Ir-192 Sealed Source
inquired by the NRC of America.

The Director of the Investigation: Kyun, Suek Keun
Investigator : Kim, Chong Hak
Investigator: Kim, Chong Tae

Report on the Result of Investigation on the Ir-192 Sealed Source Leakage

1) The Content of the Inquiry

- o The Date of the Inquiry: 3/3/1990 (Friday) around 13:00 hour
- o The originator of the inquiry and its subsequent route: From The Amersham Corporation of America to The American NRC to the American Science Bureau in Korea to The Science/Technology Department in Korea
- o The content of the inquiry
 - The NDI Corporation which imports sealed source from the American Amersham Corporation to distribute to the domestic consumers in Korea, had exported the 14 empty containers used for Ir-192 sealed source to the United States. Upon receiving the containers, the Amersham Corp. performed a survey on the 14 containers (3/8/90) and found a container (Tech/Ops, Model No. :AI 500 SU, Product No. S/N 610) contained the Ir-192 source (about 2.6 Ci) as the pig-tail was cut. They found 150 R/hr radioactive level in the 15 cm distance from the surface of the container and 100 mR/hr on the surface of the vehicle loaded with the containers. The American NRC sent an inquiry about the leakage to the Korean Science/Technology Department in 3/9/90, 13:00 hour through the American Science Bureau stationed in Korea.

2) Involved Companies

A) The Korea Industrial Testing Corporation

- The Representative : Kim, Nam Won (370615-1345516)
- Address: Yongsan Ku, Namyong Dong, 13-1, Seoul
- Date of License: 12/23/72
- Utilization: Radioactive X-Ray Survey (moving around)

·X The Content of Accident : Accidental Leakage of the sealed waste source (Ir-192)

B) The NDI Corporation

- The Representative : Kim, Yang Ki (560113-1068311)
- Address : Kangnam Ku, Poi Dong 168-5, Seoul
- Date of License: 9/24/87
- Utilization : Sales of Nuclear Isotopes
- Address of Business : Kangnam Ku, Poi Dong, 168-5, Seoul

·X The content of accident : Transporting the container with sealed source in it as if it was a general container.

3) Investigation on the cause of the accident

A) The Source in the Accident

The sealed source in the accident was an Ir-192 source. It was the kind of source frequently used for none-destructive testing along with Co-60. The emitting r-ray was 0.317 MeV and other energies. The source was the product of (N,R) response, the product generated in the process of Ir-192. And the duration of the sources' physical response was 74 days. This was produced by the American Industrial Nuclear Company (see attached 4). The source was imported by the Bukyung Corporation in 4/24/89 and was supplied to the Korea Industrial Testing Corporation. At the time of the source was imported, its radioactive level was about 50.1 Ci.

The Korea Industrial Testing Corporation used this source at the plant in Incheon as well as other places until its ending time in 11/25/89. At the time the source was put in waste in the Korea Industrial Testing Corp. waste facility, its radioactive level was about 6.8 Ci.

B) The Formation of the investigative Team/Field Investigation:

Science & Technology Department:

Radioactive Manager : Choi, Hong Sik

Radioactive Level Recorder: Chung, Kyung Sub

Korean Nuclear Safety Department:

Controller: Kuen, Suk Keun

Technician: Kim, Chong Hak

C) Date of the Investigation:

1st time - 3/12/90 : Korea Industrial Testing Corp.

2nd time - 3/13/90 : The NDI Corporation

- The Dail Shipping Corp., Sangam Dong Plant

- Woojin Cargo Packaging Company

D) Method of Investigation:

- o Interviews with the people who were supposed to be involved in the accident by visiting the involved companies.
- o Investigation on how the source was handled in the course of transportation. And if the proper procedures for transporting were followed.
- o Investigation on whether there were any radioactive injuries.

E) Content of the Investigation

This investigation was conducted based on the reports submitted by the involved personnel. Therefore we are expecting to have some degree of discrepancies in the course of descriptions. However, such discrepancies would be considered in the final analyzation of this report.

(1) Identifying the fact that the source changer was reexported to the Amersham Corporation in America.

- The NDI Corporation which imports radioactive isotopes usually send a requisition for radioactive isotopes to the Amersham Corp. Far East Bureau (in Hong Kong). Then Amersham Corp. put the radioactive source in their home-made transporting container (the safety of this transporting equipment is guaranteed by the IAEA and the American NRC, see attached 2) and export to Korea. When the source is shipped to Korea, it would pass through the Custom Service and then, in general, directly distributed to the consumers.
- Once the source has arrived at a plant, it is taken out of the source changer and put in radioactive testing machine (at this time the source changer would be emptied). This empty source changer is randomly collected by the NDI Corporation to be sent back to the Amersham Corporation in America.
- The NDI Corporation collected the 14 empty containers (source changers) which were imported and distributed in the period of 3/15/89 to 1/15/90, from 8 different companies including the Korea Industrial Testing Corporation to return to the Amersham Corporation (for detailed chart information, see figure 1).
- To ship the collected 14 source changers back to the Amersham Corporation, The Dail Shipping Company (located in Seoul) was called to do the job. The Dail Shipping Corporation sent a bongo truck to the NDI Corporation in 1/29/90, around 14:00 hour to pick up the source changers which subsequently were loaded into the truck. The bongo truck left the NDI Corporation loaded with the 14 source changers.

Figure 1. Ir-192 Transporting source Changer (Empty Container)

No.	Equipmt No (S/N)	Date of Delivery	Date of Collection	Name of Company	Comapny Collected
1	518	'89.3.15	'89.11.14	Korea Industrial Testing Corporation	NDI Corporation
2	530	'89.7.11	'90.1.9	Korea Industrial Testing Corporation	
3	556	'89.9.18	'90.1.8	Dae Han Testing Technology Corpo	
4	547	'89.10.10	'89.10.10	Han Kuk Heavy Industrial Corp.	
5	522	'89.10.11	'90.11.14	Han Yang Synthetic Testing Corp.	
6	517	'89.10.25	'89.11.4	Han Kuk Industrial Engeering Corp.	
(7)	(610)	('89.10.31)	('90.1.18)	(Korea Industrial Testing Corp.)	
8	618	'89.11.3	'90.1.8	Bu Ill Industrial Testing Corporation	
9	527	'89.11.27	'89.11.27	Egergy Regulatory Agency	
10	566	'89.11.27	'89.11.27	Han Kuk Gass Safety Agency	
11	699	'89.12.28	'90.1.11	Han Yang Synthetic Testing Corp.	
12	599	'89.12.28	'90.1.12	Korea Industrial Testing Corp.	
13	660	'90.1'5	'90.1.18	Han Kuk Industrial Engineering	
14	689	'90.1.15	'90.1.18	Han Kuk Industrial Engineering	
Total : 14 Containers					

() indicates the equipment in which the preblemmed waste source Ir-192 was contained.

- 2) Investigation on the Shipping Company transported the empty source changer.
 - The Dail Shipping Corporation which received the 14 source changers from the NDI Corporation in 1/20/90, around 14:00 hour, brought the source changers to the Sangam Dong Plant. Then the professional packaging company, Woojin Cargo Packaging was called to do the packaging. The employee, Kim, Joo Pill started to build a wooden box for the 14 source changers completing it in an hour. Then, the 14 source changers were put in the wooden box, thus completing packaging. In 1/21/90, 14:00 hour, a 8t truck came in. And the wooden box which contained the 14 source changers was put in a larger cargo container which was subsequently loaded into the truck. The truck left with the loaded cargo container for Jaeso Dong in Pusan Harbor. Upon arriving in Pusan Harbor, the cargo container was transferred to the already reserved ship, Hanjin Mockpo Ho. The ship left Pusan Harbor for Los Angeles in America. Then the cargo was unloaded in Los Angeles to be shipped by truck for the rest of the way to the Amersham Corporation in Boston.
- 3) Identifying the companies which were exposed to the source changer in the accident.
 - The investigation on where the source changer which had high radioactive level (figure 1, equipment No. 610) was delivered to and collected back from, showed that the container was used to deliver the source (Ir-192). The NDI Corporation delivered the source changer to the Korea Industrial Testing Corporation in 10/31/89. This source changer was identified as the source changer Mr. Kim, Yong Chul, the NDI employee in charge of supply, collected from Mr. Park, Jown Yong of the Korea Industrial Testing Corp. in 1/18/90.
 - As soon as we received the inquiry on the accidental leakage of the radioactive source, we asked to the Korea Industrial Testing Corp. whether they had put the cut pig-tail of the Ir-192 source in its container (Tech/OPS Company product, Model No. 610). Then we found out the following facts. When the source was decided to be put in waste, the pig-tail was cut in the storage room in 11/25/89. (see attached 4, source No. 1062). Afterwards realizing that the

waste source (Ir-192, 6.8 Ci) had high radioactive level, they decided to keep the waste source in the source container temporarily since the container can decrease its radioactive level more effectively. The original design was that the waste pig-tail was to be kept until 1/18/90 in the container and then to be put in the company's waste container to be stored in their radioactive waste storage. But in 1/18/90, when the NDI Corporation came to collect the source changer, they handed the container with the pig-tail in it over, forgetting the fact that the waste pig-tail was in it. The above stated facts were acknowledged by Mr. Song, Hong Sik, the X-ray Safety Director and Mr. Park, Joon Yong, the Safety Manager. Thus the origin of the waste source was identified as the Korea Industrial Testing Corporation (see attached, 5-6)

- 4) The account of the waste source Ir-192 : 6.8 Ci was entered in the source changer.
 - The owner of the problemed source, the Korea Industrial Testing Corp. is a licensed company to handle radioactive material accordance to the Nuclear Power Regulation No. 65. It is a none-destructive testing technology agency.
 - They obtained the source in 4/24/89 from the Bukying Company (RI sales agency). (At the time its radioactive level was 50.1 Ci, the source No. 1062, see attached 6). The source was utilized in various none-destructive testings operations. But when its radioactive level was found to be too low to be effective in the operation, they decided to waste the source. At the Yoe Chun branch office of the Korea Industrial Testing Corp. they entered the source (at the time it was around 9 Ci) in the source changer (equipment No. 610). It was in 10/26/89. Then the source changer was brought by Mr. Im, Dong Hyun (licensed personnel) of the Yoe Chun branch office to the maine office of the Korea Industrial Testing and was handed over to the Safety Manager, Mr. Park, Joon Yong. Mr. Park had stored the source changer with the source in it for 28 days to decrease its radioactive level.

- In 11/25/89, the source changer in the storage room was opened by turning the screw on the cover and the source pig-tail was pulled out (about 15-16 cm). As the source still in the container, the pig-tail was cut by using a cutting scissors. Although the source waste with pig-tail cut was supposed to be intered imeediately after in a radioactive waste box, finding that the source's radioactive level was too high (6.8 Ci), they decided to leave the source in the source changer temporarily until its radioactive level was decreased, before intering it in the storage waste box. (see attached 5-6).
 - The Radioactive Safety Director then received the report on the waste source from the Safety Manager, Mr. Park, Joon Yong and assumed that it was put safely in the radioactive ~~WASTE~~ box and recorded on the record book of the sealed radioactive isotopes waste. (see attached 6)
- 5) The account of the returned source changer with the source Ir-192: 4.2 Ci, in it even though it was supposed to be returned as an empty source changer.
- When a source is supplied by the retail company, it is in a source changer. The supplied source would be taken out of the source changer and be put in the radioactive testing machine to be utilized in radioactive operations.
 - Once the operation removing the source from the source changer is completed and the source is put in the radioactive testing machine, the source changer becomes an empty container which is to be put in the keepings until the supplier comes to reclaim it.
 - The suppliers randomly collect the source changers from the consumers and deliver them to shipping companies for reexport. In 1/13/90, the source supplier, the NDI Corporation sent Mr. Kim, Yong Chul, the Sales Manager, to the Korea Industrial Testing Corp. to collect the empty container (equipment No. 610). As Mr. Kim asked for the source changer, Mr. Park, Joon Yong of the Korea Industrial Testing brought the source changer (the container which had the radioactive waste in it) out of their storage room and handed it over to Mr. Kim, Yong Chul of the NDI Corporation.
 - The Radioactive Safety Manager of the Korea Industrial Testing, Mr. Park, Joon Yong forgot about the fact that in the source changer

he handed over to Mr. Kim in 1/18/90, there was the waste source wasted in 11/25/90. The waste source had been in the source changer for 55 days by the time. Mr. Pak, forgetting about the waste source in the container, assumed that the containers was empty, and handed the container over without checking for its radioactive level.

- 6) The account of the steps taken to collect the source changer
- The Radioactive Isotopes Sales Manager of the NDI Corporation, Mr. Kim, Yong Chul arrived at the Korea Industrial Testing in 1/18/90. And he collected the empty container from Mr. Park, Joon Yong, the Radioactive Safety Manager of the Korea Industrial Testing. The collected source changer (S/N 610) was the source supplied to the Korea Industrial Testing earlier in 10/31/89.
 - When Mr. Kim, Yong Chul of the NDI collected the source changer from the Korea Industrial Testing, he did not perform a radioactive level survey to see if there was any waste source in it. Assuming that it was an empty container, Mr. Kim, Yong Chul carried the container himself from the 3rd floor of the Korea Industrial Testing building to the car of the NDI Corporation (license Seoul, 1 Co. 3619) parked at the front gate. He loaded it in the car, then left the Korea Industrial Testing for the NDI Corporation. Then the empty container was stored in their radioactive storage room.
 - The source changers collected from the various companies were stored in the storage room of the NDI Corp. waiting to be shipped back to the American Amersham Corporation. In 1/18/90, the Dail Shipping Co. was asked to ship the containers to America. In 1/20/90, the Manager, Mr. Hong, Won Pyo of the Dail Shipping came to the NDI Corporation to collect the 14 empty containers. (see attached 5-7)
 - About 2 hours and 30 minutes before the empty containers were handed over to the shipping company, the Dail Shipping, the Radioactive Safety Manager of the NDI Corporation, Mr. Kim, Yang Ki took the 14 empty containers out of the RI storage room and put them on the floor of the supply room to check the radioactive level. It was around 11:30 am in 1/20/90. He surveyed the surfaces of the 14 containers (about 708 cm distance) for radioactive level using a radioactive survey machine (the Survey Meter, Model FH-40-F6, S/N, 27-1289,

made by Dosimeter Corp.). The testing result indicated about 0.9 MR/H which is about the normal level for an empty container. Thus the all 14 containers were determined as empty source changers. (see attached 5-5)

- Also a sight-checking was performed. When he opened the tops of all the 14 containers to see if there were any pig-tails contained, he didn't see any source in them. With the result of above radioactive testing level and the sight checking, the 14 empty containers were assumed as empty containers, and subsequently were handed over to the Dail Shipping Corp. around 14:20 of the same day.
- The Dail Shipping personnel left the NDI Corporation with the 14 empty containers in their car for the Dail Shipping factory located in Mapo Ku, Sangam Dong, Seoul.

7) Transporting Procedures of Empty Containers

- The empty containers collected from the consumer companies are stored in the source changer box until the date set for shipping. Then the empty containers are checked to make sure if small parts of the containers were in places, such as tube cap, seal plug and locking devices. After the radioactive level is tested, they are handed over to a professional shipping cargo company.
- There are times when some parts of the collected source changers such as tube cap (seal plug) or locking devices are not in the place or missing. If a locking device is missing the container's top would be wired as to prevent the opening of the container. (see attached 5-2) Also when a tube cap (seal plug) of a source is lost, it would be replaced with new parts already in the stock. Then, it would be handed over to the appointed shipping company (see attached 5-5).

8) The account of packaging the 14 source changers and Shipping.

- The 14 empty containers were loaded on a bongo truck at the NDI Corporation (located in Kangnam Ku, Poi Dong) and left for the shipping company in 1/20/90. After driving for one hour, the bongo truck arrived at the Dail Shipping (located in Mapo Ku, Sangam Dong, Seoul) in 15:20 hour of the same day. The driver, Mr. Kim, Joo Pill of Woojin Packaging Company unloaded the 14 containers and stored them in the large cargo container temporarily. Then, he started to built

a wooden box (protective box, 100mm thick and 24mm attaching wood). When the wooden box was completed, the 14 source changers in the large container were taken out and were put in the newly built wooden box, thus completing the cargo packing for shipping. (see attached 5-8)

- A day after the completion of the wooden box for the 14 source changers (in 1/21/90, 14:00 hour), a vehicle (about 8 ton) arrived at the Sangam Dong factory. The truck was equipped with a facility to carry a large cargo container. The wooden box containing the 14 source changers was loaded by a carrier vehicle into the large cargo container which was in turn loaded into the 8 ton truck. The truck left (1/21/90, 15:00) for the Jesong Dong dock in Pusan. Upon arriving on the Pusan dock, the cargo container with the 14 source changers was unloaded at the already reserved place.
- The large container which contained the 14 empty containers was loaded on the ship, Hanjin Mokpo Ho in 1/29/90. The ship left subsequently for America arriving in Los Angeles in 2/9/90. But we do not have any account on subsequent journey the cargo had taken in the soil of America.

F) The Investigative Team's Opinion on the Result

The radioactive isotopes technology is being utilized in many different professional fields such as agricultural technology, industrial and medical technology. In recent years its usages have spread fast into the field of automatizations and the high-tech areas. Thus, the companies using the radioactive technology is in the increase. There were 633 companies using the radioactive technology as of 12/31/89.

All of these companies are licensed by the Science/Technology Department adherence to the Nuclear Power Regulation's criteria. The Regulation prescribes that they appoint a radioactive safety manager and set up provisions for their own radioactive safety measures which should be approved by the regulatory agency to operate businesses.

When a business is to be licensed for operating radioactive material, the criteria set on the radioactive atom, radioactive quantity, method, the size of facility, radioactive facility, equipment, safety facility, health plan and safety manager must be met. And when all these provisions are thought to be properly addressed, the license would be granted for operating radioactive material.

After a license is granted, the regulatory system monitor the state of the radioactive atom, the quantity, form of utilization, facility equipment and managing style continually. Monitoring on the radioactive safety measures is performed randomly.

The most of the radioactive consumer companies are using the radioactive material safely under the direction of the safety directors adherence to the Nuclear Regulation or the company's radioactive safety measure regulations. The executives of the companies using radioactive materials are showing high rate interests in safety measures as evidenced in purchasing safety equipments as alarm monitor and survey meter. The trend of such high investment for safety measures is regarded as the sign indicating that the safety conscious culture is in the process of being implemented in the society.

The cause of the accident originated from the fact that the waste source was intered in the source changer instead of placing it in the licensed waste storage and subsequently was forgotten about. And the people who handled the source changer afterwards assumed that it was an empty container.

1) The Korea Industrial Testing Corporation

Storing any radioactive waste in the waste container is not only prescribed by the Safety Regulations but also it is the basic philosophy for radioactive safety. But the Safety Manager of the company, Park, Joon Yong used the source changer temporarily to decrease the level of the radioactive waste material and forgot about it subsequently when the source changer was reclaimed by the supplier, assuming that the source changer was empty, he failed to follow the procedures of safety measures such as checking on the radioactive level of the material which should be performed on any radioactive materials coming in and going out.

Even though it was an empty source changer, it was the container of actual radioactive material, the proper safety procedures should have been kept when a container was taken in and out, or moved to some other places.

Also, the company's radioactive safety director, Song, Hong Sik had failed to take the prescribed procedures for the radioactive safety and

overseeing the whole safety operation. He also, like his subordinate failed in performing his responsibilities to keep safety measures, thus originating this irreversible error.

2) TV - NDI Corporation

The Sales Manager, Mr. Kim, Yong Chul was to take the safety measures checking on the radioactive level and possible pollution whenever a delivery of a source or collecting a source changer were made. But failing to take these safety measures, he neglected his responsibility. Although the Radioactive Safety Manager, Mr. Kim, Yang Ki said that he did perform a survey on the 14 source containers for radioactive levels, he violated the basic principle of surveying as to not waiting to see the readings of the survey meter and performing a superficial survey, thus he failed to identify that one of the 14 source changers contained a waste pig-tail which was shipped back to America.

Also he said that he checked for any missing or misplaced parts of the source changers. But the source containers arrived in America were found in bad conditions. Some of the parts of the source changers were missing or not in place properly such as locker device and seal plug, which evidences that he did not perform a proper procedure of safety checking. If the seal plug was safely engaged and the locker device was locked properly, the waste source in the container wouldn't have produced such high possibilities of radioactive pollution.

Also, when radioactive materials are to be transported domestically or overseas, it must be performed according to the Nuclear Power Regulation. The Regulation No. 85-8, "the Regulation on Packaging and Transporting of Radioactive Materials" which is posted by the Science/Technology Dept. prescribes the technical criteria on transporting radioactive materials as to check on the radioactive level, radioactive pollution rate, and adequacy of packaging and safety before hands. But these safety procedures were not kept properly because the containers were thought to be empty.

Also, when transporting empty containers, they must take the procedures posted in the "Regulations on Packaging and Transporting Radioactive Materials". But they failed to take the prescribed procedures.

4) Speculative Evaluation on the Possible Radioactive Pollution and Health Examination of the Possible Radioactive Victims

A) Radioactive Injuries and Individuals possibly exposed to the Pollution

o Individuals possibly exposed to radioactive level of the Ir-192 source intered in the source changer can be evaluated as the Figure 2. The hypothesis applied to calculate the exposed level is as follows.

- To calculate the affected radioactive level, we used the following simple and basic equation.

$$D = \frac{\Gamma \cdot S}{r^2} B(\mu t) e^{-\mu t}$$

Here, D = Radioactive Rate

Γ = Gamma

B = Accumulative Element

t = Thickness of the container

r = the distance between the source & body

S = The source's radioactive level

μ = decrease rate of the source's energy

- Assuming that the Ir-192 waste source was not placed in the normal position of the inside of the source changer and instead was placed in the bottom of front plate (hood) from the beginning, makes the prognosis of exposed radioactive level to be rather conservative. The container's cover was made of steel 2mm thick, we assumed. Since the steel was 2mm thick, the accumulative element was ignored.
- The duration of exposure time was taken for the most possible exposure time period and the radioactive of the Ir-192 source was calculated with $A = A_0 e^{-\lambda t}$. Here, A=t is the radioactive level after the exposure, A0 is exposure level of the beginning, λ = disintegrating rate and t is disintegrating duration.

Figure 2. the Speculated Radioactive Exposure Level in Each Individual

Type Company	Name (age)	Work	Exposure Time	Expected Exposure Level	Test Results ('90 1/4 report)
Korea Industrial Testing	Park, Joon Yong (43)	-He cut the pig-tail of the source	about 2 min.	$\frac{0.48 \times 6.7 \times 2/60 \times 1000}{0.5^2}$ = 428.8 mrem	1/4 quarters : 30 mrem (10 mrem for a Mon)
		-He stored the waste source in the source changer temporarily.	about 2 min	$\frac{0.48 \times 5.5 \times 2/60 \times 1000}{1^2}$ $\times e^{-\frac{1.82}{13}} \times 2 = 79.1$ mrem	
		- He took out the waste source and handed it over to NDI Corp.	about 2 min	$\frac{0.48 \times 4.2 \times 2/60 \times 1000}{0.5^2}$ $\times e^{-\frac{1.82}{13}} \times 2 = 241.6$ mrem	
		Total 749.5 mrem			
NDI Corporation	Kim, Yong Chul (31)	-Received the container with the waste source	about 2 min	$\frac{3.48 \times 4.2 \times 2/60 \times 1000}{0.5^2}$ $\times e^{-\frac{1.82}{13}} \times 2 = 241.6$ mrem	"
		-Transported the container from the Korea to the NDI.	about 2 min	$\frac{0.48 \times 4.2 \times 0.5 \times 1000}{1^2}$ $\times e^{-\frac{1.82}{13}} \times 2 = 906.1$ mrem	
		-carried the container from the car to the storage.	about 2 min	$\frac{0.48 \times 4.2 \times 2/60 \times 1000}{0.5^2}$ $\times e^{-\frac{1.82}{13}} \times 2 = 241.6$ mrem	
		-transported the container from the storage to the car for shipping	about 2 min	$\frac{0.48 \times 4.1 \times 2/60 \times 1000}{0.5^2}$ $\times e^{-\frac{1.82}{13}} \times 2 = 235.9$ mrem	
Total 1,625.2 mrem					

Type Company	Name (age)	Work	Exposure Time	Speculated exposure Level	test re- sult ('90 1/4 report)
	Hong, Jong Man (33)	- transported the container from the storage to the car came from Dail Shipping Co.	about 2 min	$\frac{0.48 \times 4.1 \times 2/60 \times 1000}{0.5^2}$ $\times e^{-\frac{1.83}{13}} \times 2 = 235.9 \text{ mrem}$	
Woojin Packaging Company	Kim, Joo Pil	- Loaded the 14 containers in the car at the NDI and drove to Mapo Ku, Sangam Dong. - took out the 14 containers from the car and put them in the storage. - built the wooden box and put the 14 containers in it.	about 60 min about 2 min about 2 min	$\frac{0.48 \times 4.1 \times 1 \times 1000}{1.5^2}$ $\times e^{-\frac{1.83}{13}} \times 2 = 786.2 \text{ mrem}$ $\frac{0.48 \times 4.1 \times 2/60 \times 1000}{0.5^2}$ $\times e^{-\frac{1.83}{13}} \times 2 = 235.9 \text{ mrem}$ $\frac{0.48 \times 4.1 \times 2/60 \times 1000}{0.5^2}$ $\times e^{-\frac{1.83}{13}} \times 2 = 235.9 \text{ mrem}$ Tot. 1,258 mrem	
Dail Ship- ping Corp.	A driver who drove export cargo truck.	- He drove the truck loaded with the 14 containers from Seoul to Pusan.	about 6 hours	$\frac{0.48 \times 4.1 \times 6 \times 1,000}{4^2}$ $\times e^{-\frac{1.83}{13}} \times 5 \times 2 = 4^{??} 0 \text{ mrem}$	
				-Seoul-Pusan=6 hours -2 large cargo containers thickness:5 mm(steel) -thickness of the empty container:2 mm(steel) -Steel 1/2 value Layer : 13 mm(Ir-192)	
		Loading the export cargo container into the ship, Hanjin Mokpo Ho	-		

B) The Result of Physical Examinations

The calculation of the radioactive exposure level on the affected personnel in the case, indicated that the person who was considered most affected was Mr. Kim, Yong Chul. The approximated exposure level was 1,600 mrem. But the attached material 7-2, exposure rate calculation (film badge reading result) showed 10 mrem (January, 90). This figure shows the fact that at the time the source changer was handled by these people, the waste source was in the proper place of the source changer. Therefore, we figured that the reason for the source was found in the bottom part of the front plate of the container in America was that while it was being transported, the waste source must had been slipped through to the inside of front plate.

According to the result of radioactive exposure level calculation, the investigative team found that the people considered to be exposed to the radioactive level have no possibilities of developing any radioactive illness. But to alleviate the possible anxieties experienced by the involved people and adherence to the Nuclear Power Regulation No. 105, the exposed people were administered to have physical examinations. The result of the physical examinations showed normal health condition as we expected, as the chart 3 illustrate it.

C) Evaluation on the possible radioactive illness

o The persons who handled the source changer containing the waste source in it.

- The measure of the exposed radioactive level was rather minimal. If they were affected by the amount of the radioactive level shown in the figure 2, we don't think it was large enough to cause any radioactive injury. The result of the actual physical examination (figure 3) showed that their physical conditions were appeared to be normal.

- On the other people who had indirect exposures to the container. The person who was exposed to the container indirectly was the driver of the truck which transported the container. Also there were others who helped in moving the containers into the ship. But they were not considered to have had any direct contacts with the contaminated container. When the contaminated container was carried into

Figure 3. Result of the Physical Examination

Name	Health Examination			others
	Result	Date	The hospital	
Park, Joon Yong	normal	'90. 3.14	Nuclear Hospital	
Kim, Yong Chul	normal	'90.4.16	Choi Hak Lim M.D.	
Hong, Jong Man	normal	'90. 3.14	Nuclear Hospital	
Kim, Joo Pil	normal	'90. 3.27	Nuclear Hospital	

the ship, it was hauled by machine operation. Therefore we determined that they were not exposed to any radioactive level.

5) Adherence to the Nuclear Power Regulation

A) The Korea Industrial Testing Corporation

- When a agency utilizing radioactive material is to put a radioactive material in waste in the premises of the business, the waste material must be kept in the "Waste Facility" which is specified in the Nuclear Power Regulation No. 212, Clause 7, Item "C" as well as specified in the Nuclear Regulation No. 71 (responsibility), Clause 1 and also No. 219 (waste), Clause 1, Item 11 "4". Violating the above Regulation, in 11/25/89, after the sealed source Ir-192: 6.8 Ci (made by the Industrial Nuclear, the source No.: 1062, Model 8) was put in waste by cutting its pig-tail in the storage room, the pig-tail was left in the source changer instead having it put in the waste storage facility of the company. The the source change with the pig-tail in it was left to be picked up by the collector, the NDI Corporation.

- The record-keeping of the radioactive waste material

The Nuclear Power Regulation No.69(recording keeping) and the same Regulation No. 84 (record keeping), Clause 1, Item (E) and "4" specify that when a radioactive waste material occurs, the date and time of the event, the radioactive level, quantity, the applied method, the place (box) and the name of the person performed shall be recorded in the waste material log book. But in 11/25/89, when the waste source was intered in the source changer which was waiting to be collected, the event of waste was not recorded in the waste log book. Instead it was recorded as though it was in the regular waste facility.

B) The NDI Corporation

1. Adherence to the criteria of packaging-transporting of nuclear waste.

- Packaging for transporting radioactive material must be done in accordance to the Nuclear Power Regulation No. 87 (criteria for packaging & transporting), Clause 2 and No. 240 (criteria for packaging & transporting) Clause 1 that are specifying that the nuclear waste material must be packaged safely for transporting as to be sealed completely to prevent any possible radioactive leakages. And also, the above Regulation

specifies that the appearance, the size, the surface shape, the leverage facility and the binding facility must be accordance to the specification posted by the Minister of the Science & Technology Department.

- When the NDI Corporation collected the source changer from the Korea Industrial Testing Corporation in 1/18/90 to export the source back to the Amersham Corporation in America, they didn't recognize that there was the source, Ir-192: about 4.2 Ci in the container and packed it as any other cargo material and sent back to America.
- 2) Adherence to the criteria for transporting the empty container.
 - The Regulation No. 244(empty container transporting), Clause 1 and the criteria for packaging & transporting of radioactive material, Clause 18, Item 1 specify that when an empty container is polluted but the container is not broken and sealed completely, and the surface radioactive level is less than 0.5 milli rentgen, it can be considered as none-radioactive material.
 - But the Safety Manager, Mr. Kim, Yang Ki of the NDI Corporation failed to take the steps of the safety procedures specified in the Regulation.

6) Conclusion

A) The Cause of the Accident

- 1) When a radioactive material was to be put in waste it should have been stored in the waste material facility (storage). But instead it was put in a source changer which was waiting to be collected by the supplier.
- 2) When the radioactive source was to be put in waste, a plan of wasting procedure must be drawn to be approved by the superior officer. Then, the source should be put in waste according to the planned procedure. And an entry should be made in the waste material log book which should again be submitted to the superior officer for an approval. But in this case, the waste of the source was conducted without taking such steps. And the matter was ended by just having the Safety Manager's signature on the waste material log book.
- 3) The survey on the source changer for any radioactive level and any possible pollution was carried out superficially.

B) Radioactive Injury

- 1) The radioactive exposure level testing (film badge testing) on the people who were exposed to the container with the source, Ir-192, directly and indirectly while it was in the process preparing to be exported to America, showed as 10 mrem. But 10 mrem is not considered to be dangerous as to cause any radioactive injury. Such small dosage of the affected radioactive level indicates that while the source changers were being transported, the waste source was in the normal position of the source changer. And it is conceivable that the waste source was moved out of the position by the moving impacts.
- 2) We knew that there could not be any radioactive injury by such low level of radioactive. Nevertheless we performed a thorough physical examinations on the people who were exposed to the container directly or indirectly to alleviate their mental anxieties on any possible radioactive injury they might have sustained. Also the Nuclear Power Regulation No. 105 prescribes such provisions.

C) Measures taken to Prevent any future Accident

- 1) When a radioactive materials is to be put in waste, a plan of waste procedure must be drawn and submitted to the superior officer for an approval. And the waste process must be performed according to the plan, and subsequently it must be recorded in the waste log book precisely, and again be submitted to the superior for an approval.
- 2) When a radioactive material is to be put in waste, it must be intered only in the waste material facility (waste container).
- 3) A source changer shall never be used for a radioactive waste box.
- 4) A source changer must always be checked for radioactive level and a pollution level. And its safety states must be examined by the surveyor's physical eyes.
- 5) When a survey is conducted, the surveyor must give enough time for - : to respond and must follow all the examination steps specified in the Regulation.

General Blood Test

病者名 56826 Park, Joon Yong	L-1
検査科 内科	
検査項目 全血球算	
検査日時 2014. 12. 14	検査時間 15:28
<input type="checkbox"/> 全血球算 <input type="checkbox"/> 全血球算	<input type="checkbox"/> 全血球算 <input type="checkbox"/> 全血球算
TEST No.	
SA 39 5.15 17 55 41 33 33 315 214 6.8 17 52 2	DIFFERENTIAL POLY 39 BAND LYMPH 51 MONO 2 EOS 7 BASO 2 META NYELO PLT BLAST NRBC/10WBC LYMBRETIC L107EOS
検査結果 NDAR	
検査結果 NDAR	
検査結果 NDAR	
検査結果 Within Normal Limit	
検査科 内科	
検査科 内科	
検査科 内科	

General Blood Test

病者名 568260 Hong, Jong Man	
検査科 内科	
検査項目 全血球算	
検査日時 2014. 12. 14	検査時間 15:28
<input type="checkbox"/> 全血球算 <input type="checkbox"/> 全血球算	<input type="checkbox"/> 全血球算 <input type="checkbox"/> 全血球算
TEST No.	
SA 9 5.04 16 46 92 32 35 12 288 215 7.5 18 77 13	DIFFERENTIAL POLY 9 BAND LYMPH 35 MONO 5 EOS 7 BASO 1 META NYELO PLT BLAST NRBC/10WBC LYMBRETIC L107EOS
検査結果 NDAR	
検査結果 NDAR	
検査結果 NDAR	
検査結果 Within Normal Limit	
検査科 内科	
検査科 内科	
検査科 内科	

General Blood Test

569762		
Kim, Joo Pil		
570808-1357918		
Nuclear Hosp. 90-4-2		
Swallow		
3 29 70		
ROUTINE CBC		
DIFFERENTIAL		
TEST NO.		
SA	DIFFERENTIAL	DIFFERENTIAL
70	WBC	70
446	RBC	446
146	Hgb	146
408	Hct	408
914	MCV	914
328	MCH	328
259	MCHC	259
131	RDW	131
300	PLT	300
	NEUT	NEUT
	LYM	LYM
	MON	MON
	EOS	EOS
	PLAS	PLAS
	BLAST	BLAST
	NRBC	NRBC
	LOW RETIC	LOW RETIC
	0	0
	LOW EOS	LOW EOS
WBC DIFFERENTIAL		Normal
DIFFERENTIAL		
Blood smear stain		
Remarks:		
90-4-2 70 Swallow		

Korea Cancer Center Hospital, K.A.I.H.I.

Report

1) The account of purchasing the source changer

This company imports nuclear power material to supply to the domestic consumer companies. We have been importing radioactive materials from the American nuclear power supplier, the Amersham Corporation. When the radioactive material is imported, the source is intered in the safety container which is produced by the Amersham Corporation. After the source is supplied, the container must be returned within the specified time period.

- We collected the source changer (S/N 610) in 1/18/90 from the Safety Manager of The Korea Industrial Testing Corporation, Mr. Park, Joon Yong. The source was originally supplied to the Korea Industrial Testing prior in 10/31/89.
- At the time of collecting the container, I, Kim, Yong Chul did not perform the required testing to measure the radioactive level to make sure that it was an empty container. Assuming that it was an empty container, I received it at the 3rd floor of the Korea Industrial Testing building and carried it in my own hands. Then I loaded it in the car (Seoul, 1 Co. 3619).
- In 1/18/90, I put the container in the storage room for keeping empty containers.

2) The Account of Transporting the container to the Dail Shipping Corp.

- The container was kept in our storage room until 1/20/90 am. In the afternoon of the same day, I called the shipping company, The Dail Shipping. Subsequently The Dail Shipping sent a bongo truck in around 2:00 pm.
- In order to make sure that there were not any radioactive pig-tail within any of the containers, I opened the tops of the containers and checked to see if any of the lockers or the tops were missing. (I didn't see any pig-tail at the time).
- In the morning of 1/20/90, I performed a survey on the 14 containers using survey meter. At the time I didn't detect any irregularities.

- 1/1/8 53
- I, Kim, Yong Chul and another employee, Mr. Hong, Jong Man, together we carried the 14 source changers out of the storage room (2nd floor) and loaded them into the car from the shipping company including the source changer from the Korea Industrial Testing. It took us about 20 minutes from 2:00 pm. to 2:20 pm.
- 3) The Account of Transporting by the Podding Company's Vehicle
- The 2 employees from the Dail Shipping (one, the drive, name unknown and the other Mr. Hong, Eun Pyo) didn't participate in carrying out the containers from the storage to the vehicle.
 - As soon as the loading of the 14 containers into the car was completed (1/20/90), the 2 employees of Dail Shipping Corporation left the company premises.

March 12, 1990

The Report Written By:

Kim, Yong Chul

Export/Import Manager of The NDI Corporation

Approved By:

Kim, Ki Yang

The Representative of The NDI Corporation

Attached : 5-2

1) The Account of Importing the Container

- o Nuclear isotopes is imported to be utilized in radioactive penetration and none-destructive testing for metal construction as well as metal binding in the military and other general businesses.
- o When a radioactive source (Ir-192) is ordered by a consumer, an order would be sent through fax to the Amersham Corporation's Far East branch office in Hong Kong. The radioactive source is imported as contained in the Amersham home-made container and is distributed to the consumer after passing through the Custom Services.
- o The problemed source changer (S/N 610) was imported in 10/6/89, the import No. I 1741-909 XR-00032, and it was distributed to the Korea Industrial Testing on the 31st of the same month.

2) The Procedures of Collecting the Empty Containers

- o When a radioactive source (Ir-192) is imported, it is supplied to a consumer as the source is intered in a source changer. To supply a source to a consumer we must report to the Korean Nuclear Power Safety & Technology about the imported source and receive a proper survey on the source. The the source would subsequently be supplied to the designated place. After a certain time period, we collect the containers of the supplied sources.
- o When we receive telephone calls from the consumers about empty containers ready to be collected, we set a date for a pick up and collect them on the promised date.
- o When we collect the empty source changer we are not usually equipped with a film badge or a dosi meter. However, the collected containers are stored in the container storage and are surveied for the radioactive levels until they are dispatched to America.

3) The Procedures of Transporting Empty Containers

- o The collected empty containers are kept in our storage room until the date they are shipped back to America. On the day of shipping we check the containers to make sure that the pig-tail tops and the locking devices are in places and also perform survey on their

radioactive levels. Then, they are sent to the shipping-podding company.

- o The tops of the source changers are also collected along with the source changers. If we find a top is misplace or a locking device is missing, we wire it to seal tightly as to prevent any accidental opening while they are being transported.

o The Area of Responsibilities

Our Company has no paper documenting areas of responsibilities relating with the Amerisham Corporation of America.

March 13, 1990

Written By : Kim, Yong Chul
 Export/Import Manager
 The NDI Corporation

Approved By : Kim, Ki Yang
 The Representative
 The NDI Corporation

Attached : 5-3

The 14 empty containers , at were shipped to the Amersham Corporation in America are as follows:

No.	S/N	Date deli- vered	Date collected	Name of the Company
1	518	89. 3. 15	89. 11. 14	Korea Industrial Testing
2	530	89. 7. 11	90. 1. 9	Korea Industrial Testing
3	556	89. 9. 18	90. 1. 8	Daehan Testing Technology
4	547	89. 10. 10	89. 10. 10	Hankuk Heavy Industrial
5	522	89. 10. 11	90. 11. 14	HanYang Synthetic Testing
6	517	89. 10. 25	89. 11. 4	Hankuk Industrial Engineering
7	610	89. 10. 31	90. 1. 18	Korea Industrial Testing
8	618	89. 11. 3	90. 1. 8	Buil Industrial Testing
9	527	89. 11. 27	89. 11. 27	Engerby Regulatory Agency
10	566	89. 11. 27	89. 11. 27	Hankuk Gass Safety
11	649	89. 12. 28	90. 1. 11	HanYang Synthtic Testing
12	549	89. 12. 28	90. 1. 12	Korea Industrial Testing
13	660	90. 1. 5	90. 1. 18	Hankuk Industrial Engineering
14	649	90. 1. 15	90. 1. 18	Hankuk Industrial Engineering
Total				14

I certify the above stated facts.

March 13, 1990

Written By: Kim, Yong Chul
Export/Import Manager of NDI Corporation

Approved By: Kim, Ki Yang, The Representative
NDI Corporation



Certyfying Report

This Company received the license to sell radioactive isotopes in 9/24/87 and since have been engaged in the business.

- 1) The Account of not Keeping a log book on the sources in Storage
 - o When a imported source is supplied to the consumer immediately it is recorded in our sales log book. But if a source is imported but not supplied, we keep it in our storage room without having recorded in our sales log book.
 - o Although we were suppoed to keep a separate log book to keep an updted number of the stored sources we faild to do so. Only we maintained a inventory book to keep the records of the unsold sources or not yet delivered sources.
 - o We kept the record keeping system on the radioactive levels of the sources in the keeping by measuring the radioactive level of the storage itself.
- 2) The Measures taken for Future Safety
 - o We have been keeping the sources that were not sold or were sold but waiting to be picked up in our storage,
 - o To keep the safety measures on the stored sources, adherring to the Nuclear Power Regulation No. 69 and 84, we will keep storage record log book and make sure that the safety measures are taken thoroughly.

March 13, 1990

Kim, Ki Yang
The Representative of
The NDI Corporation

Attached : 5-5

Report on the Survey on the 14 source changers

- o In 1/20/90, 11:30 am., The Safety Manager, Kim, Ki Yang of the NDI Corporation, brought out the 14 source changers including the problemed source changer (S/N 610) from the RI storage room and spread them on the floor of the storage. Then he surveied the sides and above of the 14 containers to check its radioactive levels using the survey meter (Model FH-40-F6, S/N 27-1289), which was the product of Dosemeter Corporation. We speculate that the duration of the survey meter stopped on each container was about 2-3 seconds.
- o The result was that the all containters showed sames measures of radioactive level (about 0.9 mR/hr) and subsequently all 14 containers were concluded as empty source changers. On the same day 14:00 hour, the source changers were dispatched to the Dail Shipping Corporation.
- o Before the containers were sent out, he checked to see if the tube caps (seal plug) were in places and sealed. If a cap is found to be missing we replace it with the part we keep in our stock.

March 14, 1990

Kim, Ki Yange, The Representative of
The NDI Corporation

Report

We are a technology oriented subsidiary company licensed to use RI in conducting none-destructive testing. Here we submit the report on account of the problemed source as follows.

1) The account of Obtaining the Source

- o While we were working on the testing operation in our Seoul branch office on the project which was moved from Seoul Engineering plant (located in Incheon) we were in need of a source to be used in none-destructive testing (copper product). We ordered for a source (Ir-192), 50 Ci to the Bukyung Company in 4/14/89 and subsequently received the source in 4/24/89. (50.1 Ci)
- o In 4/24/89, we sent a request for an approval for transporting the source to the regulatory agency and obtained the approval in 4/26/89. And thereafter the source was sent to the Seoul Engineering Plant in Incheon.

2) Utilization

- o In 4/26/89, the source arriving in Seoul Engeering plant in Incheon, it was used for radioactive penetrating testing on copper products until 7/25/89.
- o Then the source was moved in 7/26/89 to Dae Kyung Machine Technology plant (Yoe Chon) to be used for metal binding radioactive penetration until 8/25/89.
- o The source was used for metal binding radioactive penetration at the Lucky PE plant until 10/25/89, which located in Yoe Chon.

3) The Account of the Source being put in Waste

- o To waste the source it was moved from the Yoe Chon plant to the main office in 10/25/89. At the time the source was 10 Ci (the mover was Im, Dong Hyun)
- o The Safety Manager Park, Joon Yong received the source from Ir, Dong Hyun (Yoe Su Safety Manager) on the same day.
- o The waste source was put in the storage room as contained in the original source changer in order to decrease its radioactive level until 11/24/89.
- o Then the source was decided to be wasted permanently in 11/25/89. The Safety Manager, Park, Joon Yong pulled the pig-tail of the source

as it was still in the source changer in the storage room. Thus completed waste operation.

- o The waste source should have been put in the waste box, immediately after the operation was completed. But Mr. Park, realizing that the source's radioactive measure was rather strong (7.3 Ci) worried for a possible radioactive injury and decided to seal the waste in the source changer temporarily until its radioactive level is decreased.
- 4) The Account of transporting the source to NDI Corporation
- o The imported source changers are supposed to be collected by the import company randomly and sent back to the export company (the containers are belonged to the export company). In 1/18/90, Kim, Yong Chul of the NDI Corporation came to the Korea Industrial Testing Corporation to collect the container. And the Safety Manager, Park, Joon Yong handed the container over forgetting the fact that actually the waste source was in the container. He thought it was an empty container. Also, Kim, Yong Chul of the NDI Corporation took the container without checking for the radioactive level of the source changer.

March 12/90

Radioactive Safety Manager : Park, Joon Yong
 Radioactive Safety Director: Song, Heung Sik
 Representative: Kim, Nam Won

as it was still in the source changer in the storage room. Thus completed waste operation.

- o The waste source should have been put in the waste box, immediately after the operation was completed. But Mr. Park, realizing that the source's radioactive measure was rather strong (7.3 Ci) worried for a possible radioactive injury and decided to seal the waste in the source changer temporarily until its radioactive level is decreased.
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- o The imported source changers are supposed to be collected by the import company randomly and sent back to the export company (the containers are belonged to the export company). In 1/18/90, Kim, Yong Chul of the NDI Corporation came to the Korea Industrial Testing Corporation to collect the container. And the Safety Manager, Park, Joon Yong handed the container over forgetting the fact that actually the waste source is in the container. He thought it was an empty container. Also, Kim, Yong Chul of the NDI Corporation took the container without checking for the radioactive level of the source changer.

March 12/90

Radioactive Safety Manager : Park, Joon Yong

Radioactive Safety Director: Song, Heung Sik

Representative: Kim, Nam Won

Report

In 2/20/90, 14:00 hour, I was at the NDI Corporation transferring the empty container assisted by the NDI Corporation employees to the 1 ton bongo truck (the driver, Kim, Joo Pil). After dispatching the truck to the Sangam Dong factor, I returned to my home office, the Dail Shipping.

The account of how the container was shipped is as follows.
Received the container at the NDI Corporation located in Poi Dong and loaded into the 1 ton bongo truck → the truck arrived in the Sangam Dong plant (Woo Jin Packaging) → a box was built → after the box was completed → it was loaded on a 8 ton truck → the truck left for Pusan → arrived in CY located in Jeasong Dong in Pusan → unloaded in CY → it was put in the reserved container → and was taken to the reserved ship → arrived in Los Angeles harbor → then I assume that it was received by the American supplier.

This company transported the empty container on the request made by the NDI Corporation. Here, I certify the above stated facts.

March 13, 1990

Hong, Won Pyo
The Dail Shipping Corporation

Report

In 1/20/90 around 14:00 hour, I transported the 14 source changers in my vehicle from the NDI Corporation to the Woo Jin Packaging Company (our factory) in Sangam Dong 8-7, (it took about one hour). I unloaded all the 14 containers from the vehicle and put them in the container. Then I started to build a wooden box. I took all the source changers out of the container and put them in the wooden box and nailed it. On the next day (1/21/90, 2:00 pm) a large truck (8 ton) arrived at the factory and the box with the 14 containers in it was loaded into the truck by a carriage. Then the truck left heading for Pusan. Here, I certify the above described facts.

March 13, 1990

Kim, Joo Pil
Woo Jin Packaging Company

Attached : 5-9

Investigation on the possible radioactive Injury

Name: Park, Joon Yong (470214-1258218)

In 1/18/90, 15:00 hour, he took the source changer out of the RI storage room (at the time he wasn't aware of the fact that the waste source was in it) and handed it over to Kim, Yong Chul of the NDI Corporation in front of the RI storage room.

Name: Kim, Yong Chul (590909-1386422)

In 1/18/90, in front of the RI storage room of the Korea Industrial Testing, he received the source changer (at the time he wasn't aware of the fact that there was the source in the container) from Park, Yong Joon and placed it in the trunk of his car. And upon arrived at the NDI Corporation he put the source changer in the RI storage room.

o In 1/20/90 14:00 hour, the container was handed over to Hong, Won Pyo of the Dail Shipping

o Analysis

Park, Joon Yong: the time duration of exposure to the container - 1 Minute

Kim, Yong Chul: -From the RI storage room of the Korea Industrial Testing to the car - about 1 Minute

-Driving time (from Namyong Dong to Pyo Ki Dong) - 30 minutes

-The time duration of unloading the container from the car and transporting to RI storage room - about 1 minute

-In 1/20/90, from the storage room to the Dail Shipping Bongo truck ~ 2 to 3 minutes

Certified By: Park, Joon Yong

The Korea Industrial Testing Corporation

Kim, Yong Chul

The NDI Corporation

Investigation the the Possible Radiactive Injury

Name: Kim, Yong Chul (590909-1386422)

In 1/18/90 15:00 hour, he received the source changer with the waste source in it (at the he was not aware of the fact that the waste was in the container) from Park, Joon Yong in front of RI storage room of the Korea Industrial Testing, and put the container in the trunk of his car. Then he drove to the NDI Corporation. The container was stored in their storage room.

In 1/20/90 14:00 hour, he handed the container over to Hong, Won Pyo of the Dail Shipping.

Name: Hong, Jong Man (581119-1149818)

In 1/20/90 around 13:40 hour, he carried the 14 source changers from the storage room to the truck of the Dail Shipping.

The time duration of carrying the source changers from the storage to the loading cargo of the truck was about 1 to 2 minutes.

o Analysis

Kim, Yong Chul: -From the radioactive material storage room of the Korea Industrial Testing Corp. to the car - 1 minute
-The time duration of driving from Namyong Dong to Yeo Po Dong - 30 minutes
-The time duration of unloading the 14 source changers from the car and transporting to the storage - 1 minute
-The time duration from the storage room of the NDI Corporation to the truck of Dail Shipping - 1 minute

Hong, Jong Man: From the storage room of the NDI Corporation to the truck of the Dail Shipping - 1 minute

March 13, 1990

Kim, Yong Chul: Export/Import Director of
The NDI Corporation

Hong, Jong Man: Representative

Attached : 6

KOREA INDUSTRIAL TESTING CO., LTD.

Record keeping log book on the purchasing and wasting of sealed radioactive source.

No	Kind of Atom	RI S/N	Purchasing		Wasting			Safety Manager	
			Date	Level	Seller	Date	Level		Method of Waste
235	Ir-192	7989	89.3.28	50.3 Ci	NDI Corp	1989.11.17	6.7 Ci	STOCKED IN FLAC WASTE BOX	
236	"	7988	89.3.28	50.6 Ci	NDI Corp	1989.11.17	3.8 Ci	"	
237	"	712	89.4.7	54.0 Ci	EUH INT	1989.12.26	2.5 Ci	WASTE IN STORE	
238	"	1062	89.4.24	50.1 Ci	TACHO INT	1989.11.17	6.8 Ci	WASTE IN STORE	
239	"	7-55	89.4.24	50.9 Ci	NDI Corp	1989.11.17	6.8 Ci	WASTE IN STORE	
240	"	8346	89.5.1	49.0 Ci	EUH INT	1989.12.26	2.6 Ci	WASTE IN STORE	
241	"	8025	89.5.24	51.5 Ci	NDI Corp	1989.11.17	2.8 Ci	WASTE IN STORE	
242	"	8052	89.5.20	48.5 Ci	"	1989.11.17	5.8 Ci	WASTE IN STORE	
243	"	8053	89.5.20	49.6 Ci	"	1989.11.17	7.5 Ci	WASTE IN STORE	
244	"	7488	89.6.8	50.5 Ci	TACHO INT	1989.10.21	4.0 Ci	"	
245	"	750	89.6.8	51.5 Ci	TACHO INT	1989.12.26	4.4 Ci	WASTE IN STORE	
246	"	769	89.6.24	50.3 Ci	TACHO INT	1989.12.26	5.0 Ci	WASTE IN STORE	
247	"	X-48	89.7.1	51.8 Ci	NDI Corp	1989.11.17	"	"	

Attached : 7-1

Report on the Radioactive Exposure Level

Upon examination on the film you sent for radioactive exposure level I report on the results as follows.

Dates of in keeping: 1. 01, 1990 - 1. 31, 1990

Date of Examination : 19 . .

N. of badge	Name	S.S. No.	Level	last 3 Mo.	Last 12 Mo.
	Park, Joon Yong	470214-1258218	less than 10	less than 10	less than 10
	Park, Joon Won	540808-1140711	less than 10	less than 10	95
	Park, Tae Kuen	600927-1346210	less than 10	less than 10	less than 10
	Pak, Un Chon	620925-1345312	60	60	1013
	Sue, Kue Bum	651204-1822214	less than 10	less than 10	less than 10
	Sue, Sang Moon	700903-1820524	less than 10	140	140
	Sue, Yong Do	620801-1106218	less than 10	less than 10	93
	Song, Hong Sik	480223-1235015	less than 10	less than 10	less than 10
	Sin, Kyung Nam	660331-1274912	less than 10	less than 10	480
	Sin, Dong Ku	630429-1928126	less than 10	less than 10	365
	Yan, Sung Ho	710715-1823818	12	12	12
	Ue, Jae Song	621010-1345551	less than 10	less than 10	73
	Oh, Ins Sik	481116-1930713	less than 10	less than 10	less than 10
	Yu, Kwang Ok	700701-1168321	less than 10	less than 10	1039
	Yu, Chang Su	610109-1333416	less than 10	less than 10	88

The Name of the Business : Korea Industrial Testing

To: Park, Joon Yong

Attached : 7-2

Released Report on the Radioactive Exposure Level

The report on the individuals' radioactive exposure levels shown on the January film badge is as follows.

As of 02-14-1990

To: Hanil Nuclear Power Corporation President

NDI Corporation

Wearing time: Jan 1 - Jan 31

Date of test: February 13

No.	Name	S.S. No.	Exposure level	Other
884-1	Kim, Ki Yang	560113-1088311	10 merem	
844-2	Hong, Jong Man	581119-1149818	10 merem	
884-3	Kim, Yong Chul	590909-1386422	10 merem	

02-14-1990 Examiner: Chung, Bum Cho

Attached: 8

Report on the Radioactive Level Survey on the Empty Container

- 1) Telephone communication on the radioactive level
 - A. Date : 3/9/90 (Friday) around 13:00 hour
 - B. The agencies: American NRC Cohen (The American Science Bureau in Korea)
 - C. The person talked with: Safety Investigator
 - D. The Content
 - o They detected radioactive level in one of the 14 containers imported from Korea.
 - o The radioactive level at the time: 150 R/hr was measured in the distance of 15 cm (6") from the surface of the container. (From the surface of the vehicle was 100 mR/hr)
 - E. Report on the radioactive leakage
 - o NRC of America had a press release
 - o Time: 3/9/90 22:00 hour

- 2) The Transportation of the container
 - A. Date : 1/29/90
 - B. The Agency : The NDI Corporation (this agency is licensed to sell RI by the Korean authority)
 - C. The Transporting Company : The Dail Shipping Corporation shipped the 14 containers by sea.
 - D. The route of transportation of the 14 source changers :
From Pusan (1/29/90) to Los Angles (2/9/90)
 - X In the case a source was imported was contained in source changer.
 - o The sales Company supplies the source contained in the container.
 - o Then, the source changer was to be collected within 180 days and be returned to the source manufacturer.
 - The size of container: 30 cm X 14 cm X 14 cm
 - E. The problemed container (Ir-192: 50 Ci: time: 4/24/89) was imported by the Bukyung Company and was sold to the Korea Industrial Testing. While the Korea Industrial Testing was using the source, the radioactive level was decreased to 6.5 Ci and subsequently the source was put in waste (the waste time: 11/25/89). In the course of being put in waste

51078

the source was by a mistake, sent to the NDI Corporation and subsequently shipped to America.

X According to "The Regulation on Packaging and Transporting of Radioactive Material" (Science/Technology Department No. 85-8), No. 8, it belonged to the category A, thus it didn't need to be reported to the authority.

The fact that Ir-192 was below 20 Ci was identified by the user company.

F. The NDI Corporation sent the 14 containers including the problemed container to the United States using the shipping company, the Dail Shipping Corporation.

G. The source was 3.9 Ci at the end of January, 1990. Therefore it was 1.95 R/h in 1m distance and 195 in 10 cm distance (when there is no container)

X According to the report from Nrc the source was leaked out of the container and we assume that the reported radioactive level was correct.

3. Measures taken for the Future Safety

A. Investigating the cause of the accident and implementing preventive measures to avoid future accident.

B. The account of the accident is to be reported to the authority.

C. The NDI Corporation and Bukyung Company are to retrieve the waste source and take care of it perperly.

D. Formed a n investigative team and performed examinations on the actual scene.

o Investigative Team: The Director of X-ray and 2 others
The RI Safety Director of Nuclear Power Safety
Technolgy and 2 others

o Content of investigation

- The account of the accident

- Investigation whether the source was leaked

- The possible radioactive injury caused in the process of transporting the source (the people who were involved in transporting the source from the time the source was put in waste to the time the source arrived in Los Angeles and sailers). These people were investigated and received minute physical examinations.

- Other factors related to safety managing.

Investigation performed: 3/12/1990

X The quantity of the radioactive level indicated that the source was leaked out of the inner shield and was placed in the metal container.