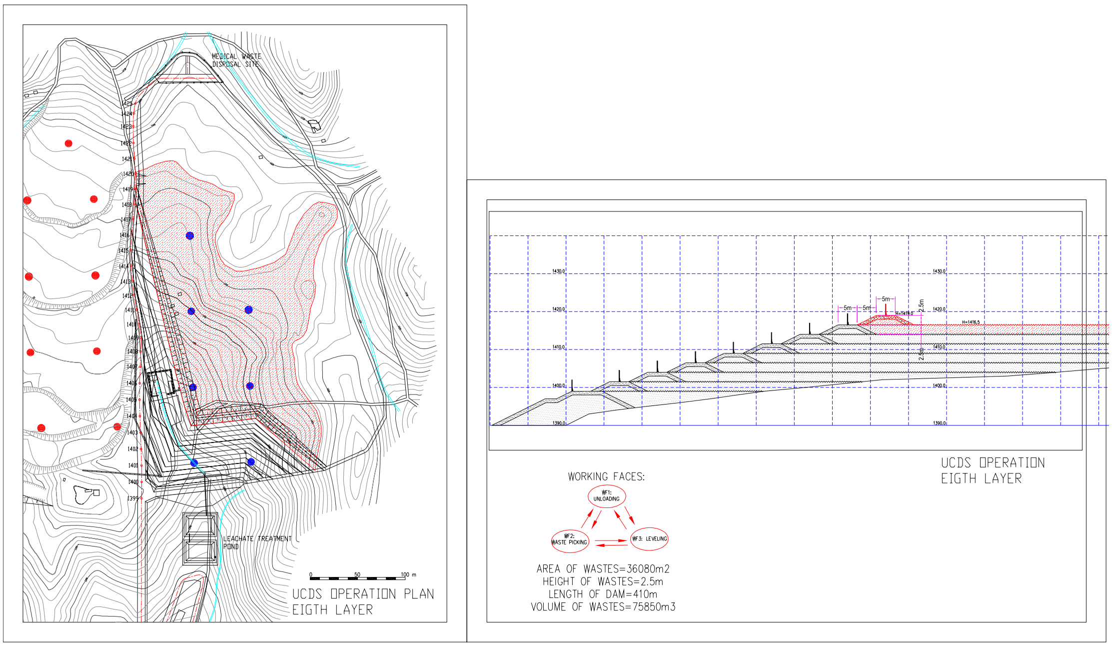


Figure 6-18: Eighth Layer

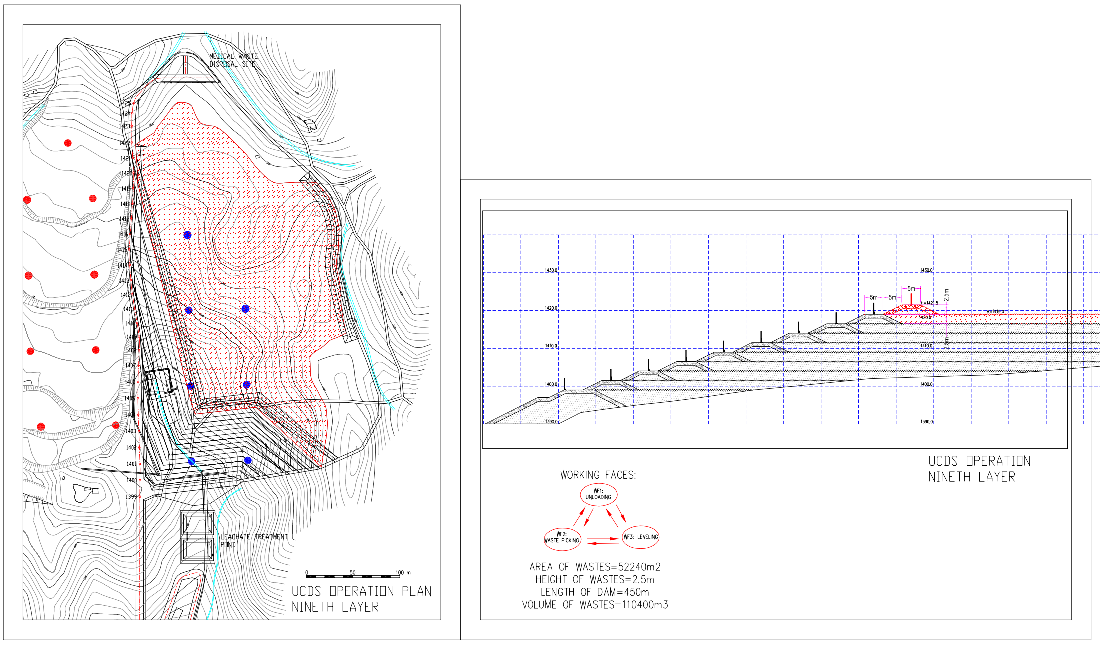


Figure 6-19: Ninth Layer

6.2.2 Evaluations

a. Evaluation by the local residents and waste pickers

An active dialogue with local residents and people who work at the UCDS is an important element for the successful result of the pilot project. Since the preparatory stage, the JICA ST tries to have as many opportunities as possible to talk to local residents and people who work at the UCDS. As a part of the dialogue, the JICA ST made an attempt to let them evaluate the pilot project.

a.1 Evaluation by Local Residents

There were two opportunities to let local residents evaluate the pilot project “Urgent improvement of the Ulaan Chuluut disposal site”. The one was Participatory Evaluation of the pilot project, which was conducted as a part of another pilot project, “Raising public awareness on waste issues”. The detailed procedure of this evaluation activity is summarized in Ch. 6.6.

The other opportunity was the third workshop, organized on October 18, 2005. This time, the main purpose of the workshop was to evaluate the progress of the two pilot projects in Khoroo 4, and main evaluators were local residents and waste pickers at UCDS. Since the two parties, local residents and waste pickers, had different views on the pilot project at the disposal site, the workshop was divided into two parts. In the first part, local residents evaluated two pilot projects in Khoroo 4, while waste pickers evaluated only the pilot project at the disposal site in the second part.

In this section, a part of the evaluation result is briefly summarized.

a.1.1. Participatory Evaluation of the Pilot Project

As of January, 2006, the Participatory Evaluation was conducted twice, on July 28 and October 18, 2005. The result was quantified, by giving a score to each choice of answer.

The quantified result is shown as reference. As explained in Ch.7.6, the participatory evaluation is regarded as a practice or experiment for the establishment of the regular monitoring system. Its evaluation method still has a lot of room for improvement.

Table 6-6: Result of the Participatory Evaluation

Items	Score of First Monitoring	Score of Second Monitoring
1.Environmental Effect		
Fire & Smoke	1.1	2.5
Offensive odor	1.1	2.8
Wastewater	1.4	2.8
Waste scattering	1.0	2.4
Animals (dogs, birds, etc)	1.2	2.5
Vermin (flies, worms, etc)	1.1	2.7
View	1.0	2.6
2.Operational Conditions		
Whole operation	1.0	2.7
Working conditions of waste pickers	1.1	1.9
Collection vehicles	1.0	2.6
Bulldozer and other landfill operation heavy vehicles	1.1	2.6
Waste dumping location	1.0	2.8
Sprinkling of insecticide or vermicide	1.0	2.6
3.Facilities		
Access road	-	2.9
Weighbridge(Control house)	-	2.8
On-site road	-	2.9
Working face (Moveable fence etc)	-	2.9
Gas removal facilities	-	2.9
Security facilities: fence (fixed type), Gate, Bank	-	2.9
Leachate Treatment Pond	-	2.9
Drainage system	-	2.8

Note 1
Number of Participant:
First Evaluation: Committee member (6) and Local residents (20)
Second Evaluation: Committee member (6), Local residents (44), NGO (2)
Note 2
The higher the score is, the higher participants evaluate the condition. The lowest and highest points are 1 and 3 respectively.

The result of the questionnaire survey after the first evaluation shows that most of the participants highly appreciated this kind of participatory activity.

a.1.2. Third Workshop

At the workshop, all the participants were required to answer the following question: Are there any changes in environmental conditions? If so, what has improved and what has worsened?

Out of the 43 participants, 39 people evaluated the progress of the projects positively, while 4 evaluated it negatively.

Here are the changes in environment conditions participants thought.

Positive response

Number of respondents	**39**
A lot of things were improved by pilot project and environmental condition became better.	18
A lot of facilities were constructed and installed at the disposal site. It is very good	11
Illegal dumping and scattered waste were decreased.	9
It is good to conduct a sanitary landfill operation.	5
Fire and offensive odor was decreased	3
Others	2

*Some participants wrote multiple answers.

Negative response

Number of respondents	**4**
A lot of children work at the disposal site	1
The number of scattered plastic bags do not decrease. Fires also do not decrease.	1
Health becomes very bad due to dust from access road	1
The pilot project at the disposal site worsened the working conditions of waste pickers.	1

a.1.3. Evaluation by Waste Pickers

At the workshop, the following three questions were asked:

Q1: Are there any changes in environmental conditions? If so, what has improved and what has worsened?

Q2: Are there any changes in working conditions? Is so, what has improved and what has worsened?

Q3: Other comments

The responses from participants are summarized bellow.

(1) Q1: Are there any changes in environmental conditions?

All the participants responded to this question. Those who thought the pilot project improved their environmental conditions selected yellow paper sheets, while those who thought the pilot project worsened the conditions selected green paper sheets.

The number of those who selected yellow paper sheets was 74, and among them 52 people specified the items which they thought had improved (some respondents wrote more than one issue). 7 participants selected green paper sheets and 6 out of 7 wrote worsened items.

Positive response

Total number of respondents who evaluated the project positively	**74**
A lot of things were improved, regarding the environmental conditions.	56
Environmental pollution was reduced and it is good for our health	6
Decreased offensive odor	8
Facilities were constructed and there are fewer scattering waste than before	4
There are fewer fires and less smoke.	9

Negative response

Total number of respondents who evaluated the progress negatively	**7**
Operation was bad, not enough	1
There is a pollution problem in the disposal site	4
There are a lot of children working at the disposal site	1
Buyers buy very cheap and miss measure our picked raw materials	1

(2) Q2: Are there any changes in working conditions?

The number of participants who responded to this question was 37, less than half of the whole number of participants. 27 people responded that the working conditions had improved, while 10 people evaluated the progress of the project negatively.

Positive response

Total number of respondents who evaluated the progress positively	**27**
Working conditions are good	13
Improved sanitary conditions and it is good for health	6
Became orderly and keeping rule	6
Others To give my thinks for listening to our opinions Registration made us confident to continue working here	4

Negative response

Total number of respondents who evaluated the progress negatively	**10**
The Working conditions were not improved	3
TV reporters met us and spread misinformation	4
Buyers buy raw materials very cheaply from us	4
Our income decreased, because a lot of new comers came due to waste picker registration	1

(3) Q3: Other comments

53 participants made general comments on the pilot project. Their comments are summarized below.

	total
Want working clothes to be supplied	7
Want public baths, lavatories and canteens to be constructed	11
Need to stop children jumping on trucks	9
If there is a place or person buying our raw materials, it is good	8
Need to stop press media broadcasting misinformation about us	3
To continue waste pickers registration and add new comers	3
A larger working area is necessary. Now there are too many waste pickers in too small a site	8
Want a f minibus and hospital service	4
Others	11

Others

It is better to start leveling and covering waste early. This makes it possible not to intervene with the unloading work during the rush hours.
Need to improve more than this
Need to sort wast
Need to do more than this
It is necessary to supply safe operation
It is necessary to establish more strict rules and order
Need to supply technical completeness
To make a cleaner environment
To create traveling-trade in the disposal site
To supply a health service

a.2 Findings

In general, local resident participants appreciated the pilot project, since they thought the environmental conditions had improved. Their knowledge on the JICA study and SWM issues had improved, but some of participants still misunderstood the progress of the project[1].

1 For example, some participants thought that the sanitary landfill operation already started.

Since the expectation of local residents about the pilot project at the disposal site seemed quite high, it is important for MUB and the JICA ST to ensure the realization of proper operation by next spring, when strong winds would worsen such problems as scattered waste and fires.

All the waste picker participants responded to the first question about the changes in environmental conditions. This reflected from the high level of interest. The majority of participants appreciated the improvement of the environmental conditions by the pilot project.

On the other hand, the number of waste picker participants who responded to the second question about the changes in working conditions was only 37, less than half of the total participants. Even though the number of people who expressed their content was larger than those who responded negatively, it could be speculated that many of those who did not respond were actually dissatisfied with the progress of the project.

Under the controlled landfill operation, collection vehicles can unload waste only at the designated place. This makes the waste picking area much smaller than before, and makes waste picking more difficult. Therefore, it is understandable that many of the waste pickers are dissatisfied with the progress of the project.

Since the controlled landfill operation is the core concept of the project and it is impossible to make a concession to them. Instead, it is necessary to make some measures for fair trade and better sanitary conditions in order to gain more support from them.

b. Interim Evaluations

The condition of the project as of 15th January 2006 was evaluated in terms of Relevance, Effectiveness, Efficiency, Impact and Sustainability.

Table 6-7: Evaluation Summary

<table>
<tr><th></th><th colspan="2">Relevance</th><th colspan="2">Effectiveness</th><th colspan="2">Efficiency</th><th colspan="2">Impact</th><th colspan="2">Sustainability</th></tr>
<tr><td>Overall Goal</td><td rowspan="2">▪ One of Japan's priority cooperation issues to Mongolia is the environmental protection
▪ The objective of SWM M/P is to establish environmentally sound SWM system in MUB by the target year 2020.</td><td rowspan="2">+
+</td><td></td><td></td><td></td><td></td><td rowspan="2">▪ Waste pickers in the site have been registered.
▪ Working conditions of WB operator (formally dispatcher) has improved so much by construction of a control building
▪ Working condition of Waste pickers has improved by the rehabilitation of completed landfill area.
▪ Residents near UCDS understand the purpose of the PP by attending several resident meetings and newsletters.
▪ Since all the incoming trucks stop at WB, it became easy for waste pickers to climb to the trucks.
▪ Working face of landfilling was reduced and it makes waste pickers difficult to pick waste.</td><td rowspan="2">+
+
+
+
-
-</td><td rowspan="4">▪ In order to implement sanitary landfilling, heavy machinery such a bulldozer should work continuously. But current machinery is too old and frequently breaks down
▪ The MUB has increased the budget for the operation of the disposal site in 2006 four times (150 million MNT) more than i that of 2005.
▪ The sanitary landfill operation, however, requires more due to operation of several heavy machines such as bulldozers, excavators, dump trucks, etc. The MUB realizes the necessity of a further budget increase and will try to increase this in future.</td><td rowspan="4">-
+
+</td></tr>
<tr><td>Project Purpose</td><td rowspan="2">▪ Many stakeholders have realized the improvement of UCDS according to the monitoring committee meeting.
▪ Important issue will be operation and maintenance of improved UCDS by Nuuts Co. in future.</td><td rowspan="2">+
-</td><td></td><td></td></tr>
<tr><td>Outputs</td><td></td><td></td><td rowspan="2">▪ Installation of WB makes it possible to have a necessary database for incoming waste.
▪ Enclosing bank and dam make the boundary of UCDS clearl.
■ Completed landfill area was rehabilitated by soil cover.</td><td rowspan="2">+
+
+</td><td></td><td></td></tr>
<tr><td>Activities</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

Table 6-8: Overall Evaluations

Criterion	Result	Basis	Justification for Basis
Relevance	Very high	▪ One of Japan's priority cooperation issues to Mongolia is the environmental protection ▪ The objective of SWM M/P is to establish an environmentally sound SWM system in MUB by the target year 2020.	▪ Environmental protection is the priority issue for all stakeholders. The project aims to maintain sanitary conditions at the disposal site. Therefore it contributes to the environmental protection directory.
Effectiveness	Progressing	▪ Many stakeholders have realized the improvement of UCDS .according to the monitoring committee meeting. ▪ Important issues will be operation and maintenance of improved UCDS by Nuuts Co. in future.	▪ The project has generally achieved its purposes. ▪ Important issue is to maintain the current condition improved UCDS by improved manner of operation by MUB and Nuuts Co., ▪ It is the winter season now, so continuous monitoring is necessary to judge effectiveness especially in spring and summer.
Efficiency	High	▪ Installation of WB makes it possible to have a necessary database for incoming waste. ▪ Enclosing bank and dam make the boundary of UCDS clearly. ▪ Completed landfill area was rehabilitated by soil cover.	▪ The budget for improving UCDS is fully utilized. Both JICA and MUB contribute simultaneously and achieve a relevant output.
Impacts	Various impacts	▪ Waste pickers in the site have been registered. ▪ Working conditions of WB operators (formally dispatchers) has improved so much by construction of a control building ▪ Working conditions of waste pickers has improved by rehabilitation of a completed landfill area. ▪ Residents near UCDS understand the purpose of the PP by attending several resident meetings and newsletters. ▪ Since all the incoming trucks stop at WB, it became easy for waste pickers to climb into the trucks. ▪ Working face of landfillings has reduced and it makes it difficult for waste pickers to pick wastes.	▪ The majority of the impacts were positive since aiming improvement of existing disposal site except some impacts on the waste pickers. ▪ Since the controlled landfill operation is the core of the concept of the project and it is impossible to make a concession to them. In stead, it is necessary to make some measures for fair trade and better sanitary conditions in order to gain more support from them. ▪ Residents near the UCDS are very cooperative. They are looking forward to future job opportunities by developing the NEDS project.
Sustainability	Medium	▪ In order to implement sanitary landfilling, heavy machinery such as bulldozers should work continuously. But current machinery is too old and frequently breaks down ▪ The MUB increased the budget for the operation of the disposal site in 2006 four times (150 million MNT) that of 2005. ▪ The sanitary landfill operation, however, requires more due to operation of several heavy machines such as bulldozers, excavators, dump trucks, etc., the MUB realize the necessity of a further budget increase and will try to increase it in future.	▪ The project is strongly supported by most of stakeholders. However to continue sanitary landfilling, budgetary assistant is essential. In 2006, the budget for landfilling has increased by 4 times. It has to be carefully observed whether it is sufficient or not.

6.2.3 Lessons and Recommendations

a. Results

Most of the stakeholders such as MUB, Nuuts Co., residents near UCDS and waste pickers working at UCDS appreciate the project very much. In particular, the negative environmental impacts such as offensive odor, waste scattering, and vermin were significantly reduced.

Many facilities were constructed and it looks better than before. But it is very important now going forward whether operation and maintenance can be improved or not. For instance, it was experienced in December 2005 that, due to the break down of a bulldozer and lack of proper instructions, collection trucks could not reach to the designated landfill area and they started to dispose of waste on the onsite road. As a result, no trucks could enter the landfill area and they disposed waste outside the fence as shown in the following pictures.


Waste Disposed at onsite road


Waste Disposed outside Fence

It is winter now and problems at the disposal site such as smoke, odor, scattering, are not significant due to coldness and relatively gentle winds compare with those of spring. Therefore, preparation for the coming spring time is essential.

b. Recommendation

We have experienced landfill operation using improved facilities for a few months now and found the following recommendations:

b.1 Replacement of Old Bulldozers

Bulldozers are one of most important and essential items of equipment for landfill operation. As of end of 2005, there were two Russian made very old bulldozers which are more than 15 years old. But one has completely broken down and used for taking spare parts. The other also frequently breaks down and once it has broken down, it needs a few weeks for repair. In fact, they have already exceeded machinery life time and it is strongly recommended to replace it with a modern one. Because using existing machinery is wasting both time and money.

As of end of 2006, following the recommendations by JICA ST, MUB purchased one second hand Chinese made bulldozer and there are two bulldozers in UCDS.

b.2 Consensus of Waste Pickers on Controlled Landfill Operation and Proposed M/P

The controlled landfill operation being conducted in the pilot project restricts the waste picking activities and the sanitary landfill operation proposed in the M/P prohibits waste picking activities at the landfill. It is, therefore, necessary to conduct the following measures as a phase 3 pilot project to get consensus of waste pickers on both controlled and sanitary landfill operation as shown in the Figure below.

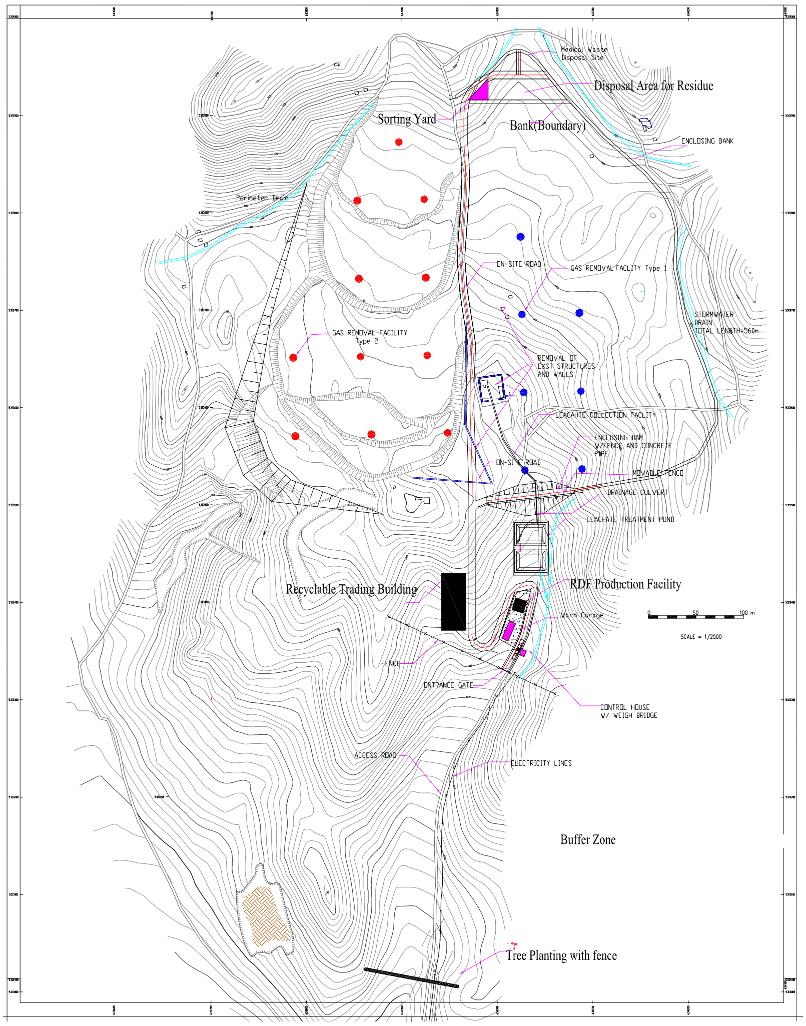


Figure 6-20: Additional Pilot Project at the UCDS in Phase 3 Study

b.2.1. Consensus of Waste Pickers on Controlled Landfill Operation

Under the controlled landfill operation, the main objective of this pilot project, collection vehicles can unload waste only at the designated place. This makes the waste picking area much smaller than before, and makes waste picking more difficult. Therefore, it is understandable that many of waste pickers are dissatisfied with the progress of the project.

Since the controlled landfill operation is the core of the concept of the project and it is impossible to make a concession to them. In stead, it is necessary to make some measures for fair trade and better sanitary conditions in order to gain more support from them.

According to the opinion of waste pickers mentioned in the previous section, there are many requests for the improvement of their working conditions. It is difficult to realize all of them but it might be necessary to provide some of them such as fair trade place of materials recovered by them. It may also include some shelters especially for winter time in exchange for the prohibition of fire in the landfill site.

b.2.2. Sorting Yard Operation in UCDS

In order to implement sanitary landfill operation as proposed in the M/P, it is critical to prohibit waste picking activities at the landfill. In stead of prohibiting waste picking activities in the landfill, the M/P will provide a sorting yard for the waste pickers to work and also conduct the separate collection in order to facilitate efficient waste picking at the yard.

Therefore, in order to reach a consensus on the sanitary landfill operation and work at the sorting yard, it is worth examining the provision of a pilot sorting yard at UCDS for separated waste.

In case that separate collection is implemented under the pilot project, the separated waste contain more valuables than others. Therefore, the pilot project will contribute to get consensus from waste pickers on the sanitary landfill operation and work at the sorting yard as proposed in the M/P.

b.2.3. RDF Production in UCDS

In the M/P, residue from the sorting yard such as low quality plastic and paper will be sent to the RDF plant. Then RDF will be produced by the residue and be used as an auxiliary fuel of coal at the power plant and/or heating plants.

In Phase 2 of the Study, 12 tons of RDF was experimentally produced for the mixed combustion test with coal at Nalaikh Heating Plant. In Phase 3 of the Study, in order to examine the economic viability of the use of RDF at the existing heating and/or power generation plant, more RDF needs to be produced and a combustion test shall be carried out for a longer time.

In order to produce more RDF, residue from the above sorting yard will be used as raw materials for the production of RDF to reduce the procurement cost of raw materials. It is, therefore, recommended to produce RDF at UCDS in order to examine the viability of the proposed M/P. But due to the budget constrain, RDF was produced outside UCDS for phase 3 RDF combustion test.

b.3 Organization of Waste Picker

According to the interview survey, there is no organization of the waste pickers. According to the M/P, these waste pickers will work at the sorting yard in an organized manner. Lack of a head or organization makes it difficult to control them.

Another problem in UCDS is the existence of child waste pickers. They are very disobedient and do not follow the rules. They climb up to the collection truck on the weighbridge and the weight of the truck is affected by this. Furthermore, it is very dangerous and other adult waste pickers also complain of these activities.

To solve these problems, not only enforcement of rules and/or punishment but also some support and assistance is necessary. Canadian consultant with the World Bank fund was supposed to implement "Waste Picker Project" but the project was not implemented, therefore, JICA ST conducted Organization of Waste pickers in phase three study.

c. Lessons Learnt

The implementation of the pilot project has found the following lessons.

- To set up clear a boundary of the disposal site is the first step in sanitary landfilling
- To measure the weight of incoming waste is the first step in doing proper SWM.
- To secure the budget for a running bulldozer is essential for sanitary landfilling
- In order to conduct sanitary landfilling, several heavy machines including excavators and dump trucks are required and further technical assistance for the operation and maintenance of them is important.
- In order to solve the waste pickers` problems, long term assistance will be required.

6.2.4 PDM

Project design matrix is presented as follows.

Project Design Matrix: PDM

Name of Project: Urgent Improvement of UCDS
Implementation Period： From Mar. 2005 to Jan. 2007.
Target Group: MUB, Nuuts Co, Residents near Disposal Site

Prepared in Sep. 2005

Narrative Summary	Objectively Verifiable Indicators	Means of Verification	Important Assumptions
Overall Goals 1. Nuuts/MUB will implement sanitary landfill operation at NEDS.	Evaluation by the monitoring committee for NEDS.	Interview survey to the monitoring committee for NEDS	
Project Purposes 1. Nuuts/MUB will implement controlled landfill operation at UCDS.	Evaluation by the monitoring committee for the UCDS	Interview survey to the monitoring committee for the UCDS	
Outputs 1. To establish a control and management system of collected waste	Database of incoming waste, truck registration, actual waste amount	Weighbridge records	
2. To dispose of the waste at the designated area of the UCDS	Incoming waste is disposed of at designated place	Site inspection	
3. To rehabilitate completed landfill area of the UCDS	Completed landfill area is covered with soil	Site inspection	
Activities 1. Construction of a new control building 2. Installation of Weighbridge 3. Establishment of boundary of the UCDS 4. Prevention of UCDS from expansion of Ger area 5. Construction of Enclosing bank and dam 6. Improvement of on site road. 7. Cleaning waste along access road 8. Installation of gas removal facilities. 9. Construction of storm water drain 10. Installation of leachate treatment facility 11. Construction of warm garage 12. Construction of medical waste pit 13. Rehabilitation of completed landfill area 14. Construction of green belt 15. Construction of Sorting Yard 16. Construction of fair trading center	**Input** **Study JICA ST** **Human Resource** • Expert **Equipment and materials** • Improvement of UCDS: US140,000$ • Weighbridge and data management : US50,000$ • Green belt construction US4,800$ • Sorting Yard construction US10,000$ • Fair trade center US11,000$	**MUB** **Human Resource** • Staff **Equipment and materials** • Access Cleanup : US 7,000$ • Rehabilitation of completed landfill: US60,000$ • Pavement of access road US250,000	**Pre-condition** MUB will allocate budget for soil cover

6.2.5 Closure of Ulaan Chuluut Disposal Site (UCDS)

a. Design Concept

The UCDS is approaching its capacity limit, and it will cease landfill operations in a few years. It is necessary for MUB to formulate a closure plan in order to demonstrate the appropriate closure of UCDS.

The key elements for the formulation of the closure plan of the UCDS are shown in the following table.

Table 6-9: Key Elements of the UCDS Closure Plan as of year 2005

Item	Unit	Qty
The area of disposal site	ha	17.0
Old Working Face (Western half): A1	ha	8.0
Existing Working Face (Eastern Half) : A2	ha	9.0
Landfill Operation Period	years	3 years
Estimated Landfilling Volume		
• 2005	m^3	85,000
• 2006	m^3	108,000
• 2007	m^3	120,000
• 2008	m^3	132,000

b. Closure Plan

b.1 Landfill Operation Plan until Closure

b.1.1. Basic Idea

The area of the UCDS consists of old working face (hereinafter call A1) located in the western half and existing working face (hereinafter call A2) which is located in the eastern half. Since A1 was covered with soil and rehabilitated, the operation shall be conducted in A2.

b.1.2. Annual Disposal Amount

Annual disposal amount from 2005 onwards is shown as follows based on the record of Nuuts Co. and Study JICA ST estimation before installing weigh bridge..

Table 6-10: Final Disposal Amount

	Daily Disposal Amount	Annual Disposal Amount		Landfill Amount after Compaction	Accumulate Amount
	ton/day	ton/year	m3/year	m3/year	m3
2005	232.9	85,009	106,261	85,009	85,009
2006	295.4	107,821	134,776	107,821	192,830
2007	329.2	120,158	150,198	120,158	312,988
2008	362.5	132,313	165,391	132,313	445,300

b.1.3. Landfill Capacity

Landfill capacity at A2 is calculated as follows.

Table 6-11: Landfill Capacity at Eastern Half Section

	Area of Wastes	Average Area	Height of Wastes	Volume of Wastes	Volume of Dam	Total Volum	Accum. Volume
	m2	m2	m	m3	m3	m3	m3
original	0.0						
1st Fill	7,540.0	3,770.0	4.4	16,588.0	3,125.0	19,713.0	19,713.0
2nd Fill	10,210.0	8,875.0	2.5	22,187.5	4,125.0	26,312.5	46,025.5
3rd Fill	11,770.0	10,990.0	2.5	27,475.0	5,250.0	32,725.0	78,750.5
4th Fill	13,200.0	12,485.0	2.5	31,212.5	6,500.0	37,712.5	116,463.0

5th Fill	16,400.0	14,800.0	2.5	37,000.0	7,500.0	44,500.0	160,963.0
6th Fill	19,230.0	17,815.0	2.5	44,537.5	8,500.0	53,037.5	214,000.5
7th Fill	24,600.0	21,915.0	2.5	54,787.5	9,250.0	64,037.5	278,038.0
8th Fill	36,080.0	30,340.0	2.5	75,850.0	10,250.0	86,100.0	364,138.0
9th Fill	52,240.0	44,160.0	2.5	110,400.0	11,250.0	121,650.0	485,788.0

Based on the above calculation, UCDS can be used for three years until 2008. After then, appropriate closure operation will be required.

b.1.4. Final Shape of the UCDS

Final shape of the UCDS is as follows as a result of the above filling operation.

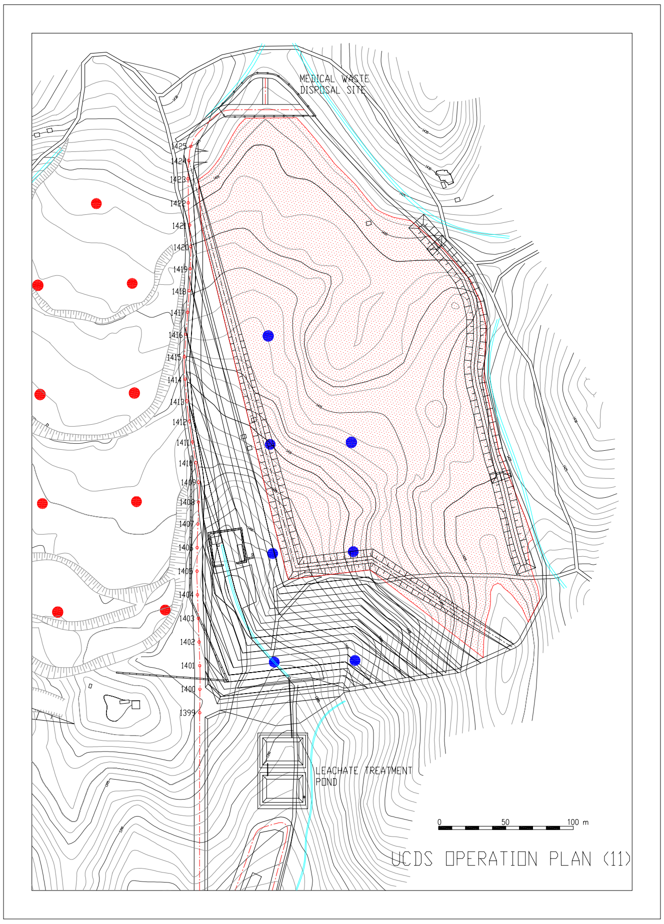


Figure 6-21: Final Shape of UCDS

b.2 Closure Plan

b.2.1. Final Soil Covering Plan

Soil shall be excavated and stockpiled in summer time for use in winter time.

It is possible for MUB to acquire the necessary soil for covering by excavated soil in its own land near UCDS. The thickness of soil should satisfy the following value.

- Flat part : 50 cm
- Sloping part: 50 cm

At the time of closure, the entire area of UCDS will be covered with soil. The amount of soil necessary for final soil covering is calculated as follows.

9 ha x 0.50 m thk = 45,000 m^3

Since the sloping part of the embankment dam shall be covered with soil during landfilling operation, the amount of the soil covering at the time of closure should be less than the above figures.

In order to save the amount of soil covering, the shaping by the bulldozer before soil covering will be essential.

b.2.2. Water Pollution Control

Leachate is collected through leachate collection facilities which were buried in the lowest area of original ground before landfilling is started. Then the collected leachate is stored in the leachate treatment pond which was constructed south of the embankment dam. The layout of the leachate collection facilities and leachate treatment pond is shown below.

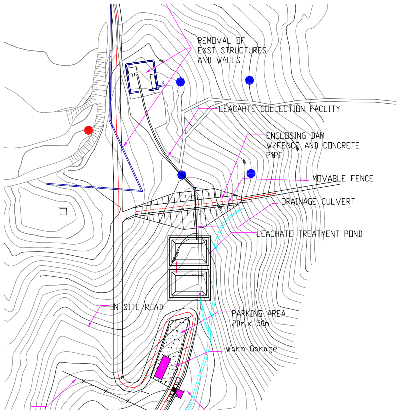


Figure 6-22: Layout of Leachate Collection System

b.2.3. Management Plan of Generated Gas

Generated gas is controlled by installing vertical gas removal pipes.

It is preferable to install vertical gas removal pipes according to the progress of the landfill operation. It is necessary for MUB to set up a vertical pipe at a planned spot before the landfill operation starts.

The installation plan of vertical gas removal pipes at A2 is shown below.

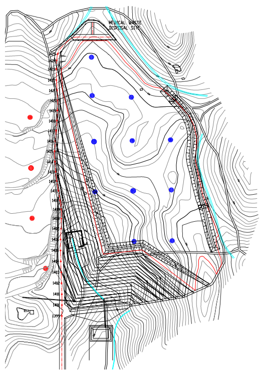


Figure 6-23: Installation Plan of Gas Removal Pipes in UCDS

b.2.4. Future Land Use Plan

A future land use plan shall be formulated and discussed among the relevant authorities. Since the closed UCDS is next to the future disposal site, which is NEDS, the use of this area as a buffer zone to the NEDS is strongly recommended. Necessary measures such as planting trees and fences shall be taken to prevent further expansion of ger towards UCDS.

b.2.5. Monitoring Plan

Monitoring shall be conducted after closure of the UCDS until the landfill area becomes stable. (it is normally around 15 years after its closure). The items of monitoring are shown in following table.

Table 6-12: Monitoring Plan of UCDS

Items	Facility	Frequency	Measuring Items
Appearance	Landfill area	once in a month	• Covering soil • Landfilled waste (subsidence, change of shape etc.) • Maintenance of drain • Others
Underground Water	Well nearby	twice in a year	Electric conductivity, CL^{-} pH
Leachate	Leachate Pond	in case of generation of leachate	Electric conductivity, CL^{-} pH
Landfill Gas	Gas removal pipe	four times a year	CH_4, CO_2, H_2O, Temperature
Settlement	Settlement board	four times a year	Settlement Level

6.2.6 Relevant Pictures


Weighbridge Operation


Weighbridge Control Building


Signboard and Fence


Enclosing Bank


Enclosing Dam and Working Face


Improvement of Access Road


Cleaning Waste dumped along access road


Gas Removal Facilities


Storm Water Drain


Leachate Treatment Facilities


Warm Garage for Heavy Machinery


Rehabilitation of Compacted Landfill Area by Soil Covering


Special Waste Pits


Movable Fence for Prevention of Waste Scattering

Prevention of Waste Scattering by Movable Fence

Conduct Waste Levelling and Compaction

Stop Expansion of Ger Area to the UCDS

Buffer Zone between Ger Area and Disposal Site

Establishment of a Monitoring Committee

Site Inspection by a Monitoring Committee

6.3 Thermal Recycling "RDF"

6.3.1 Project Outline

a. Background

Low quality papers and plastics, which are not recycled at all, will be collected and RDF will be produced by using these unused combustible wastes as raw materials. Produced RDF will be burned at the existing heating plant together with coal and necessary data will be obtained. Based on these experiments, feasibility of thermal recycle "RDF" will be examined through this pilot project (PP) in terms of technical and economic aspects.

This pilot project consists of two components, one is producing RDF and the other is burning produced RDF in the heating plant and takes a necessary data. Details are described below.

b. Location of Producing and Burning RDF

Production of RDF is contracted to a local company in Ulaanbaatar, TUV MORIT HANGAI Co., Ltd. The heating plant for mixed combustion test of RDF with coal was decided where MUB can control and take responsibility for the implementation of these experiments.

(1) Producing RDF : A local company in Ulaanbaatar
(2) Burning RDF : Nalaikh Heating Plant

c. Work Flow

Work flow of this PP is shown below.

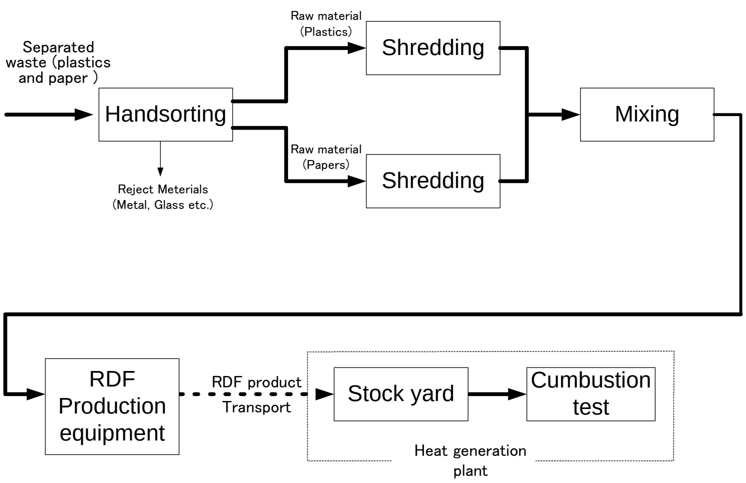


Figure 6-24: Work Flow of Pilot Project for Thermal Recycle "RDF"

6.3.2 Production of RDF

a. Outline

RDF can be produced by compacting and heating raw materials. Through this process, plastic contents of the raw material are melted and form a RDF. In case of using big RDF production machinery, this melting process is done by the heat generated by compacting process by itself and no further external heating will be required.

Under this PP, RDF was produced manually so that it is difficult to generate heat through compacting process. Simple apparatus was used and external heating was applied to melt plastics.

b. Methods

b.1 Collecting Raw Material

b.1.1. Plastics

Low quality plastics used as bags and packages, which are not recycled at present, was used as raw materials for RDF production. These materials were collected in UCDS by waste pickers and transported to the RDF production factory.

Plastics are separated into soft and hard. Hard plastics are not suitable for the production of RDF because they are difficult to melt.

Plastics made of Vinyl chloride are not suitable for RDF material because they will generate chloride gas during combustion. This material is normally used for water pipes, agricultural films, rapping films, construction boards (corrugated sheets), hoses, etc. Therefore, these products was excluded from raw materials.


Waste Plastic collected from UCDS


Waste Plastic as Raw Material for RDF

These materials were collected by waste pickers and sold to the RDF production company at the price of 70Tg/kg. It needs extra 20Tg/kg for transportation of these materials from UCDS to the factory.

b.1.2. Papers

Waste paper which used for RDF production is not from UCDS but from printing companies. Those papers are the cutting balance from their production process. In phase three of the study, waste paper from UCDS will be planned to use.


Waste Paper from factory

b.2 Pre Treatment of Raw Material

b.2.1. Plastic

Plastics shall be melted before feeding to the RDF production device.


Melting pot


Mixer

b.2.2. Papers

Papers were shredded before feeding to RDF production device in order to mix with melted plastics easily.

Waste Paper from Printing Company

Shredding Process

b.3 Production of RDF

Pre treated plastics and papers shall be mixed in a proportion of 75% to 25 % in weight basis. Generally, recommended mix proportion of plastics into RDF is range of 50% to 100%. Therefore medium proportion was adopted for this experiment.

Above materials were feed to the RDF production machine 1 (melting and mixing equipment) in above mix proportions and become one body and compacted.

Screw Conveyor of Machine 1

Machine 1 : Melting and mixing equipment

After shredded papers and melted plastics are mixed and compacted in RDF production machine 1, the mixed products were further feed to the RDF production machine 2 (pressing equipment) which forms designated diameter of the products. Then finally, this was cut into pieces and form a final shape of RDF.

Machine 2 : Pressing equipment

Manual Cutting for final shape

c. Production Record

c.1 Schedule

The work was contracted out to the local company "TUV MORIT HANGAI" in November 2005 and the contractor started fabrication and modification of RDF production machine. It took one month to complete this work and he started production of RDF in December 2005.

Machine was modified several times and finally 12 ton of RDF was produced. It took around 45 days for production of 12 ton of RDF. As a result, average production rate became 270kg per day and maximum production rate was 500 kg per day.

c.2 Cost Analysis

Following equipment was used to produce RDF.

	Name of the equipment	specification	No.	Explanation
1	Mixer	Heat the material, mix, and push	1	Designed
2	Press	Press and mould	1	Designed
3	Press (small)	Press and mould	1	Designed
4	Melting pot	Melt plastic	1	Owned previously
5	Melting and mixing equipment	Melt, mix, automatically spill out	1	Designed
6	Paper shredder	Shred paper and plastic	1	Modified to use
7	RDF cutter (manual)	Cut into right size	1	Designed

Following persons were employed for production of RDF.

Description of Work	person
Equipment design and repair	3
Melting Pot	3
Heating and mixing pot	1
Pressing and molding	1
Cutting	1
Paper shredding	1
Manager	1
Raw material preparing	1
Total	12

17.3 tons of plastics and 2 tons of paper were used for production of RDF.

Summary of cost for RDF production was shown as follows.

Table 6-13: Cost of RDF Production

Item	Unit	Quantity	Rate	Amount
Material				
Waste Plastic	ton	17.3	90,000	1,557,000
Waste Paper	ton	2	40,000	80,000
Machinery				
Modification	ls	1	680,000	680,000
Material, others	ls	1	1,649,000	1,649,000
Labour				
Labour	MM	24	120,000	2,880,000
Total				6,846,000

d. Lessons learnt

Followings are the findings during production of RDF.

- Main problem encountered during RDF production is that the melted plastic is quite sticky and easily become hard during cold conditions. Thus it was difficult to press by screw conveyor and caused stack at exit hole of the RDF production machine. In order to solve this problem, one more equipment is introduced, which is pressing equipment, to form the final shape of RDF.

- Since this technology is the first time in Mongolia, it took a long time to decide and modify equipment. At first, ready made Chinese plastic moulding machine was used for producing RDF. But due to the uneven quality of waste plastics, it was impossible to press and form a final shape and materials are frequently stacked inside the equipment. Therefore, we knew that specially designed equipment is necessary to produce RDF.
- In order to produce RDF more smoothly, obtaining of waste plastic is essential. In this case, waste plastics were collected at UCDS by waste pickers and transport to the RDF production factory by the truck. In case production of RDF is done at UCDS, the transportation cost can be saved and more stable supply of raw material can be achieved.

6.3.3 1st Mixed Combustion Test of RDF with Coal

a. Objectives

The proposed master plan (M/P) recommends that low quality papers and plastics, which are not recycled at present, will be collected and RDF will be produced by using these unused wastes as raw materials. The RDF produced will be burned at the existing heating and/or power generation plant as an alternative fuel to the coal. Consequently, the objectives of the RDF combustion test are:

Objective 1. To mainly investigate degree of negative impacts which may be caused by mixed combustion of RDF with coal at the existing heating plant;

Objective 2. To demonstrate citizens in MUB both negative and positive impacts of the mixed combustion of RDF with coal at the existing heating plant in order to obtain the consensus to implement the proposed M/P regarding thermal recycle "RDF"; and

Objective 3. To examine economic viability of the use of RDF at the existing heating and/or power generation plant

However, in order to pursue the above objectives, especially objective 3, it is preferable to conduct more than one week combustion test.

b. Negative Impacts

There are possibilities to have following negative impacts by the mixed combustion of RDF with coal:

- Generation of black smoke;
- Generation of dioxins;
- Damage to the internal furnace due to higher combustion temperature than pure coal combustion; and
- Generation of hydrochloric (HCl) gas.

In order to investigate the above-mentioned negative impacts as much as possible the following measures will be conducted in this combustion test:

1. The M/P proposes to use RDF at the existing power plants in which continuous and higher combustion of it will be able to be done in order to reduce adverse impacts.

2. Even if RDF is produced at maximum amount in the target year of F/S, i.e. 2010, the portion of RDF mixture to coal is less than 4 % in weight[2]. Calorific value of RDF is estimated as two times of that of coal. So mixing 4 % of RDF means 8 % in terms of calorific value.
3. Compare with the mixed combustion of RDF at the power plants, it at the Nalaikh heating plant may cause more serious negative impacts. It is, therefore, more convenient to conduct the combustion test at the Nalaikh heating plant.
4. Furthermore, since available RDF amount for the test is very limited, i.e. about 12 tons, mix proportion of RDF to coal is decided at 2 % and 4 % in weight (4 % and 8 % in terms of calorific value) in this test in order to observe more serious condition than it of F/S.
5. In the test RDF and coal will be mixed and burned in the furnace and to obtain combustion data, check equipment running condition and inspect combustion conditions visually.
6. There will be four kinds of combustion tests, 1. Preliminary test, 2. Baseline test for only coal combustion, 3. Mixed combustion of RDF (of 2 % in weight) with coal and 4. Mixed combustion of RDF (of 4 % in weight) with coal. In the preliminary combustion test, lower mixing rate will be applied first to carefully check the combustion conditions such as relevant equipment and exhaust gasses then, to increase mixing proportion gradually.
7. Mixed combustion tests of RDF (of 2 % and 4 % in weight) with coal will be carried out more than 12 hours continuously. Necessary data will be collected to investigate the negative impacts. In addition suitability of the equipment and economical aspects will also be examined.
8. It requires more than 12 hours operation during obtaining data for dioxin analysis.

c. Schedule of Combustion Test

The combustion test will be conducted from February 13 to 16, 2006 according to the following schedule.

February, 2006	12	13	14	15	16	17	18	19
	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun
1. Preliminary Test		■						
2. Baseline Test (Coal only burning)			■					
3. Mixed Combustion Test (RDF 2% Mixture)				■				
4. Mixed Combustion Test (RDF 4% Mixture)					■			
5. Occasional Date						■		

d. Items for Measurement

d.1 Exhaust Gas

d.1.1. Purpose

Measurement will be done in order to investigate impact on exhaust gas by mixed combustion of RDF with coal. Therefore, gas will be measured at three times as, 1) without

[2] No. 3 power plant has 13 furnaces and two of them are fluid type furnaces which will be able to burn particle type fuel like RDF. However, the other furnaces of the existing power plants uses powder coal which can not burn RDF without providing grades.

RDF (Baseline test), 2) 2 % mixture to the coal, 3) 4% mixture to the coal. Measurement schedule is shown in the following table. Location of measurement shall be at the exit of furnace in order to investigate exhaust gas treatment capacity.

Location of Measurement		Furnace
Coal Only		Test 1
RDF Mixture	2 % to coal	Test 2
	4 % to coal	Test 3

d.1.2. Items of Measurement

Items of measurement are shown below.

Item		Measurement
1	Emission Gas	Volume Temperature Moisture Contents Dust Oxygen Carbon Dioxide Carbon Monoxide Sulfur Dioxide Nitrogen Oxide Hydrogen Chloride Dioxin

d.2 Physical Composition of RDF

d.2.1. Purpose

Measurement of the physical composition of RDF will be utilized for design parameter for fuel feeding and spreading equipment. Calorific value will be measure for analysis of economical value of RDF alternative to the coal. Basic data for the coal will be obtained through a literature review.

d.2.2. Items and times of Measurement

items		Times No of samples	details
1	Physical Composition of RDF	x 4	Calorific Value
			Three Components （Moisture、Combustible、Incombustible）、Chlorine
			Particle Size（<5, 5-10、10-20、20-30、30-40, <40）
		Occasionally	Apparent Gravity, Shape

d.3 Physical Composition of Ash

d.3.1. Purpose

Three components analysis for ash will be done for comparison of with and without RDF mixture. This analysis will be used for obtaining basic data for designing type of furnace and relevant equipment. Apparent gravity of ash will be used for designing ash discharge device for furnace.

d.3.2. Items and times of Measurement

Items and times of measurement are shown below.

items		Times No of samples	details
1	Ash	x 4	Three Components （Moisture、Combustible、Incombustible）
		Occasionally	Apparent Gravity、Visual inspection

Note）Sampling will be done at the same time as combustion test. Sampling for apparent gravity and visual inspection will be done whenever necessary.

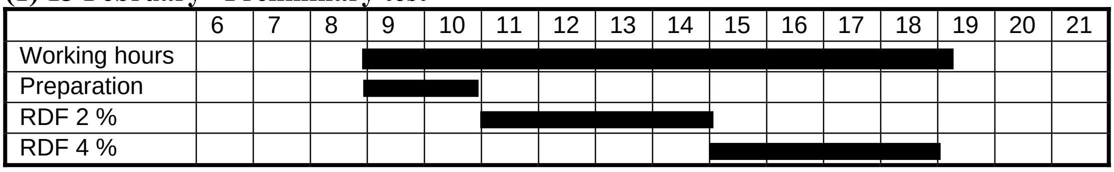
d.4 Basic Data of Heating Plant

Basic data which needs to be obtained from heating plant is as follows. These data is required for economical analysis using RDF alternative to the existing fuel.

- Feeding volume of coal
- Hot water supply volume and its temperature.

e. Time schedule

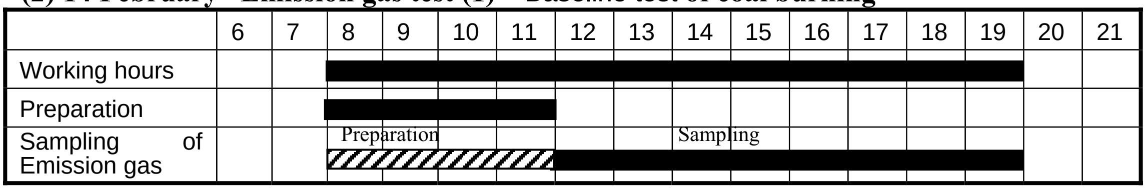
(1) 13 February "Preliminary test"



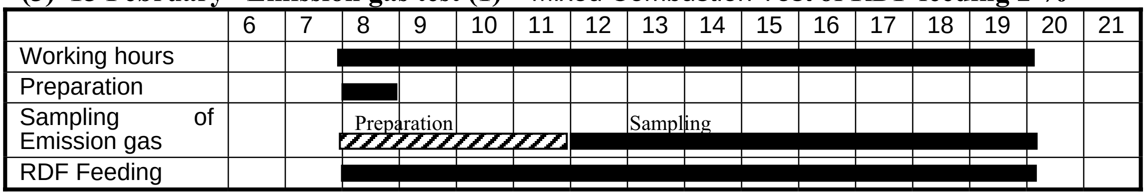
- RDF feeding amount 2 %
  → Nalaikh heating plant : 12,000 kg-coal / hour
  → Feeding amount 2 % : 12,000 kg-coal / hour x 0.02 = 240 kg
  → Plastic bag = 30 kg : 8 bags /hour

- RDF feeding amount 4 %
  → Nalaikh heating plant : 12,000 kg-coal / hour
  → Feeding amount 4 % : 12,000kg-coal / hour x 0.04 = 480 kg
  → Plastic bag = 30 kg : 16 bags /hour

(2) 14 February "Emission gas test (1) – Baseline test **of coal burning"**

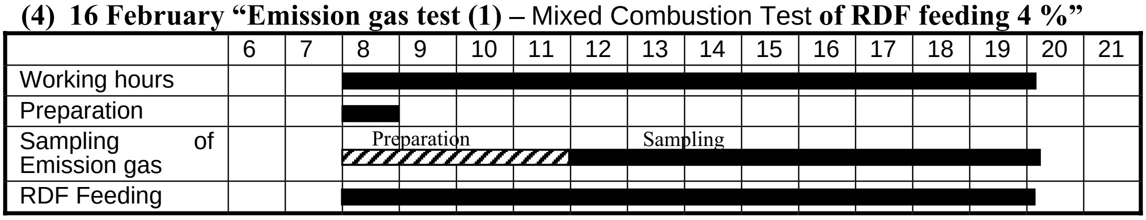


(3) 15 February "Emission gas test (1) – Mixed Combustion Test **of RDF feeding 2 %"**



- RDF feeding amount 2 %
  → Nalaikh heating plant : 12,000 kg-coal / hour
  → Feeding amount 2 % : 12,000 kg-coal / hour x 0.02 = 240 kg
  → Plastic bag = 30 kg : 8 bags / hour

(4) 16 February "Emission gas test (1) – Mixed Combustion Test **of RDF feeding 4 %"**



- RDF feeding amount 4 %

  → Nalaikh heating plant : 12,000 kg-coal / hour
  → Feeding amount 4 % : 12,000 kg-coal / hour x 0.04 = 480 kg
  → Plastic bag = 30 kg : 16 bags / hour

Since mixed combustion test of RDF with coal was carried out on 13 to 16 February 2006, the results of the test are not ready at the time of writing this report. Therefore, results and analysis will be described in the next report.

6.3.4 Results of the 1st Mixed Combustion Test

a. Preparatory Works

Prior to the 1st mixed combustion test of RDF with coal at the Nalaikh Heating Plant, the JICA study team conducted several preparatory works below.

a.1 Outline of Nalaikh Heating Plant Operation

The Nalaikh Heating Plant is a facility which generates hot water and supplies it to the apartment area in the Nalaikh district. The most important objective of the plant operation is a stable supply of hot water required by the users, i.e. sufficient amount and temperature of hot water.

The plant is operated based on the following correlation table which shows relation of Air temperature outside, Supply hot water temperature and Return water temperature coming from users. In order to follow the correlation table the following factors are handled:

- Amount of coal combusted (supplied)
- Amount of inlet water to the boiler
- Amount of boiler bypass water
- Amount of supply hot water
- Amount of exhaust gas sucked by fan
- Amount of air supplied by fan

For short term handling, the plant operation mainly controls the amount of coal supplied and the other factors are controlled for long term operation.

Table 6-14: Correlation of Air Temperature Outside, Supply Hot Water Temperature and Return Water Temperature

To	T1	T2	To	T1	T2	To	T1	T2	To	T1	T2
6	60	42	-6	68	47	-18	88	56	-30	106	65
5	60	42	-7	70	48	-19	90	57	-31	108	65
4	60	42	-8	72	48	-20	91	57	-32	110	66
3	60	42	-9	74	49	-21	92	58	-33	111	66
2	60	42	-10	76	50	-22	94	59	-34	112	67
1	60	42	-11	77	51	-23	96	59	-35	114	67
0	60	42	-12	78	52	-24	97	60	-36	116	68
-1	61	43	-13	80	52	-25	98	61	-37	117	68
-2	62	43	-14	82	53	-26	100	61	-38	119	69
-3	64	44	-15	84	54	-27	102	62	-39	120	70
-4	65	45	-16	85	55	-28	103	63	---	---	---
-5	66	46	-17	87	56	-29	105	64	---	---	---

To : Air temperature outside
T1: Supply hot water temperature coming from station
T2 : Return water temperature coming from users

a.2 RDF Spraying Test by Spreader

In order to know what extent RDF is spread in the furnace, a RDF spraying test by using existing spreader was conducted prior to the combustion test. In the test RDF was fed onto the conveyor through an inspection hole (size of it is 100mm x 100mm) manually. Then, RDF was sprayed by the spreader as shown in the Figure below. The followings are the findings of the test:

- Although the length of the furnace is 6.15m, RDF is sprayed at the range between 0.7-5m. The largest portion of RDF was spread at about 3m. Since RDF should be spread as far as possible for complete combustion, i.e. 6m, the result of the test did not satisfy the requirement.

- Regarding the width of the furnace (2.7m), RDF was almost equally spread. The results satisfied the requirement.

Coal Feeder（x 2）

Inspection Hole

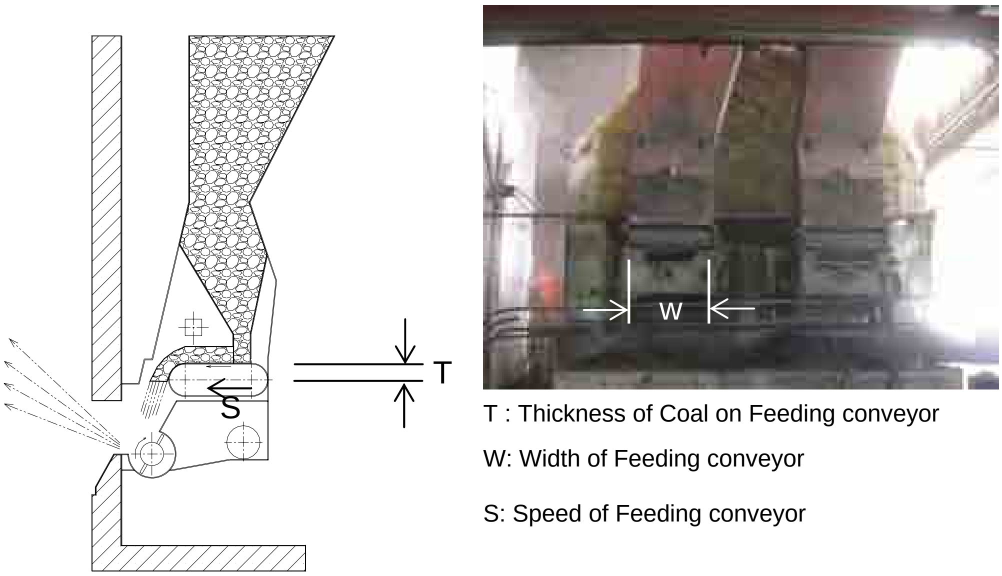
RDF Sprayed in the Furnace

a.3 Calculation of Coal Consumption (Fed Amount)

Amount of coal consumed for combustion (Q) is calculated based on operation data of coal feeder (spreader) as shown in the following formula:

Coal Consumption (Q) = (Speed of feeding conveyor (FC)) x (Width of FC) x (Thickness of Coal on FC) x ρ (Apparent density of Coal)

- Speed of feeding conveyor (FC): It is calculated by multiplying the diameter of the gear for the conveyor (20cm) by the number of revolutions of the gear.
- Width of FC: 60cm (effective width)
- Thickness of Coal on FC: 10cm (effective thickness)
- ρ (Apparent density of Coal): 0.86 (measured by the JICA ST)



T : Thickness of Coal on Feeding conveyor

W: Width of Feeding conveyor

S: Speed of Feeding conveyor

Figure 6-25: Coal Feeding System

a.4 Measurement of Retention Time

The speed of stoker in the furnace is controlled by handling the notch of operation panel in the electricity room. By analyzing the correlation between the notch and the speed of stoker, the JICA ST elaborated the following formula regarding retention time of fuel (coal and RDF) in the furnace:

Retention Time (min) = -5.3 x Number of Notch (0-10) + 65

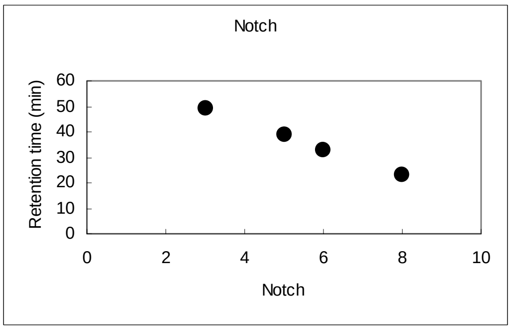


Figure 6-26: Relation between Notch of Operation Panel and Retention Time

b. Analysis of Air Pollutants in Emission Gas

b.1 Measurement of Air Pollutants in Emission Gas (excluding Dioxins)

The following table presents the results of the measurement of air pollutants in emission gas excluding Dioxins.

Table 6-15: Measurement of Air Pollutants in Emission Gas (excluding Dioxins)

			100% Coal	Mixed combustion test	
				RDF2% Mixture	RDF4% Mixture
	Furnace Number		No.3	No.3	No.3
	Examination date		14, Feb	15, Feb	16, Feb
1.	Amount of emission gas (Wet)	m^3N/h	103,440	103,370	103,270
2.	Amount of emission gas (Dry)*1	m^3N/h	96,000	94,000	94,800
3.	Temperature of emission gas	^0C	207.4	203.2	204.1
4.	Moisture	%	7.2	9.1	8.2
5.	Dust concentration	g/m^3N	0.228	0.245	0.216
	Dust concentration of conversion equivalent of O_2 12%	g/m^3N	0.315	0.431	0.380
6.	O_2	%	14.5	15.9	15.9
7.	CO	ppm	228	982	221
8.	CO_2	%	14.79	14.50	11.31
9.	SO_2	ppm	254.8	137.3	116.7
10.	NO_X	ppm	242.8	183.7	184.7
	NOx concentration of conversion equivalent of O_2 12%	ppm	336.2	324.2	325.9
11.	HCl	ppm	0.08	0.11	0.09
	HCl concentration of conversion equivalent of O_2 12%	ppm	0.11	0.19	0.16

Note : *1: Calculation value

b.2 Measurement of Dioxins in Emission Gas

b.2.1. Sampling Conditions

The emission gas volumes sampled for the analysis of dioxins are shown in the table below. As shown in the table, it must be noted that the emission gas volume sampled for RDF 4% was only about 13% of others, i.e. 100% coal and RDF 2%.

Table 6-16: Emission Gas Volumes Sampled for the Analysis of Dioxins

	100% Coal	Mixed combustion test	
		RDF2% (Mixture)	RDF4% (Mixture)
Furnace Number	No.3	No.3	No.3
Examination date	14, Feb	15, Feb	16, Feb
Amount of Sampling gas (m^3)	1.35	1.35	0.17

b.2.2. Results of Measurement

Concentration of dioxins in the emission gas (pg/g) which was measured by the laboratory analysis is presented in the table below. The table next to the table below shows the concentration of dioxins (pg/m^3N) which is converted into a unit emission gas (m^3N) and a standard condition (O_2 12%).

Table 6-17: Results of Emission Gas Analysis (Dioxins) – Actual data: Unit pg/g

		100% Coal	Mixed combustion test		Detection limit value
			RDF2% Mixture	RDF4% Mixture	
		pg/g	pg/g	pg/g	pg/g
PCDDs	2,3,7,8-TeCDD	N.D.	N.D.	N.D.	0.3
	1,3,6,8-TeCDD	7	320	39	0.3
	1,3,7,9-TeCDD	4	190	20	0.3
	TeCDDs	12	580	68	0.3
	1,2,3,7,8-PeCDD	N.D.	N.D.	N.D.	0.3
	PeCDDs	N.D.	350	52	0.3
	1,2,3,4,7,8-HxCDD	N.D.	N.D.	N.D.	0.6
	1,2,3,6,7,8-HxCDD	N.D.	N.D.	N.D.	0.6
	1,2,3,7,8,9-HXCDD	N.D.	N.D.	N.D.	0.6
	HxCDDs	9	310	41	0.6
	1,2,3,4,6,7,8-HpCDD	N.D.	37	6	0.6
	HpCDDs	N.D.	57	12	0.6
	OCDD	10	10	10	1.0
	Total PCDDs	31	1,307	183	-
PCDFs	2,3,7,8-TeCDF	N.D.	N.D.	4	0.3
	1,2,7,8-TeCDF	N.D.	4	4	0.3
	TeCDFs	N.D.	29	16	0.3
	1,2,3,7,8-PeCDF	N.D.	N.D.	3	0.3
	2,3,4,7,8-PeCDF	N.D.	N.D.	N.D.	0.3
	PeCDFs	N.D.	N.D.	3	0.3
	1,2,3,4,7,8-HxCDF	N.D.	N.D.	N.D.	0.6
	1,2,3,6,7,8-HxCDF	N.D.	N.D.	N.D.	0.6
	1,2,3,7,8,9-HxCDF	N.D.	N.D.	N.D.	0.6
	2,3,4,6,7,8-HxCDF	N.D.	N.D.	N.D.	0.6
	HxCDFs	N.D.	N.D.	N.D.	0.6
	1,2,3,4,6,7,8-HpCDF	N.D.	N.D.	N.D.	0.6
	1,2,3,4,7,8,9-HpCDF	N.D.	N.D.	N.D.	0.6
	HpCDFs	N.D.	N.D.	N.D.	0.6
	OCDF	N.D.	N.D.	N.D.	1.5
	Total PCDFs	N.D.	29	19	-
Total（PCDDs＋PCDFs）		31	1,336	202	-
Co-PCBs	3,4,4',5-TeCB （IUPAC#81）	N.D.	N.D.	N.D.	0.3
	3,3',4,4'-TeCB （IUPAC#77）	N.D.	N.D.	N.D.	0.3
	3,3',4,4',5-PeCB （IUPAC#126）	N.D.	N.D.	N.D.	0.3
	3,3'4,4',5,5'-HxCB （IUPAC#169）	N.D.	N.D.	N.D.	0.3
	Non-ortho PCBs	N.D.	N.D.	N.D.	0.3
	2',3,4,4',5-PeCB （IUPAC#123）	N.D.	N.D.	N.D.	0.6
	2,3',4,4',5-PeCB （IUPAC#118）	130	46	36	0.6
	2,3,3',4,4'-PeCB （IUPAC#105）	60	20	15	0.6
	2,3,4,4',5-PeCB (IUPAC#114）	N.D.	N.D.	N.D.	0.6
	2,3',4,4',5,5'-HxCB （IUPAC#167）	N.D.	N.D.	N.D.	0.6
	2,3,3',4,4',5-HxCB （IUPAC#156）	14	N.D.	N.D.	0.6
	2,3,3',4,4',5'-HxCB （IUPAC#157）	N.D.	N.D.	N.D.	0.6
	2,3,3',4,4',5,5'-HpCB （IUPAC#189）	N.D.	N.D.	N.D.	0.6
	Mono-ortho PCBs	204	66	51	0.6
Total（Co-PCBs）		204	66	51	-
Total（PCDDs +PCDFs +Co-PCBs）		240	1,400	250	-

IUPAC : International Union of Pure and Applied Chemistry

Table 6-18: Results of Emission Gas Analysis (Dioxins) – Converted value: ng/m^{3}N

		100% Coal pg/m^{3}N	Mixed combustion test RDF2% Mixture pg/m^{3}N	Mixed combustion test RDF4% Mixture pg/m^{3}N
PCDDs	2,3,7,8-TeCDD	N.D.	N.D.	N.D.
	1,3,6,8-TeCDD	2	129	14
	1,3,7,9-TeCDD	1	76	7
	TeCDDs	4	233	24
	1,2,3,7,8-PeCDD	N.D.	N.D.	N.D.
	PeCDDs	N.D.	141	18
	1,2,3,4,7,8-HxCDD	N.D.	N.D.	N.D.
	1,2,3,6,7,8-HxCDD	N.D.	N.D.	N.D.
	1,2,3,7,8,9-HXCDD	N.D.	N.D.	N.D.
	HxCDDs	3	125	15
	1,2,3,4,6,7,8-HpCDD	N.D.	15	2
	HpCDDs	N.D.	23	4
	OCDD	3	4	4
	Total PCDDs	9	525	65
PCDFs	2,3,7,8-TeCDF	N.D.	N.D.	1
	1,2,7,8-TeCDF	N.D.	2	1
	TeCDFs	N.D.	12	6
	1,2,3,7,8-PeCDF	N.D.	N.D.	1
	2,3,4,7,8-PeCDF	N.D.	N.D.	N.D.
	PeCDFs	N.D.	N.D.	1
	1,2,3,4,7,8-HxCDF	N.D.	N.D.	N.D.
	1,2,3,6,7,8-HxCDF	N.D.	N.D.	N.D.
	1,2,3,7,8,9-HxCDF	N.D.	N.D.	N.D.
	2,3,4,6,7,8-HxCDF	N.D.	N.D.	N.D.
	HxCDFs	N.D.	N.D.	N.D.
	1,2,3,4,6,7,8-HpCDF	N.D.	N.D.	N.D.
	1,2,3,4,7,8,9-HpCDF	N.D.	N.D.	N.D.
	HpCDFs	N.D.	N.D.	N.D.
	OCDF	N.D.	N.D.	N.D.
	Total PCDFs	N.D.	12	7
Total（PCDDs＋PCDFs）		9	537	72
Co-PCBs	3,4,4',5-TeCB （IUPAC#81）	N.D.	N.D.	N.D.
	3,3',4,4'-TeCB （IUPAC#77）	N.D.	N.D.	N.D.
	3,3',4,4',5-PeCB （IUPAC#126）	N.D.	N.D.	N.D.
	3,3'4,4',5,5'-HxCB （IUPAC#169）	N.D.	N.D.	N.D.
	Non-ortho PCBs	N.D.	N.D.	N.D.
	2',3,4,4',5-PeCB （IUPAC#123）	N.D.	N.D.	N.D.
	2,3',4,4',5-PeCB （IUPAC#118）	38	18	13
	2,3,3',4,4'-PeCB （IUPAC#105）	18	8	5
	2,3,4,4',5-PeCB （IUPAC#114）	N.D.	N.D.	N.D.
	2,3',4,4',5,5'-HxCB （IUPAC#167）	N.D.	N.D.	N.D.
	2,3,3',4,4',5-HxCB （IUPAC#156）	4	N.D.	N.D.
	2,3,3',4,4',5'-HxCB （IUPAC#157）	N.D.	N.D.	N.D.
	2,3,3',4,4',5,5'-HpCB （IUPAC#189）	N.D.	N.D.	N.D.
	Mono-ortho PCBs	60	27	18
Total（Co-PCBs）		60	27	18
Total（PCDDs +PCDFs +Co-PCBs）		71	563	89

IUPAC : International Union of Pure and Applied Chemistry

b.3 Physical Composition and Chlorinity of RDF

Physical composition and chlorinity of RDF which was used for the mixed combustion test was analyzed as shown in the table below.

Table 6-19: Physical Composition and Chlorinity of RDF

			Measurement value
Higher calorific value (HCV)		(kcal/kg)	5,820
Lower calorific value (LCV)*1		(kcal/kg)	5,290
Industrial chemical analysis	Moisture	(%)	8.3
	Combustible	(%)	86.0
	Non combustible (ash)	(%)	5.7
Chlorinity (Cl) (%)			0.29
particle size (%)	< 5 mm		2
	5 – 10 mm		3
	10 – 20 mm		5
	20 – 30 mm		8
	30 – 40 mm		15

	40 mm <		67
Apparent density*2		(ton/m^3)	0.41 (0.34-0.45)

Note *1: Calculation value
*2: Measurement value by Study team

b.4 Physical and Chemical Composition of Coal

Physical and chemical composition of the coal which was used for the mixed combustion test was analyzed as shown in the table below.

Table 6-20: Physical and Chemical Composition of Coal

			Measurement value	Literary data
Higher calorific value (HCV)		(kcal/kg)	3,875	2,905 – 4,257
Lower calorific value (LCV) *1		(kcal/kg)	2,470	-
Industrial chemical analysis	Moisture	(%)	31.3 (22.5-30.1 *2)	28.0 – 46.0
	Volatile matter	(%)	27.8	22.5 – 30.8
	Non combustible (ash)	(%)	8.8	6.1 – 17.0
	Fixed carbon	(%)	32.1	25.7 – 35.4
Total sulfur (S)		(%)	0.33	0.26 – 0.41
Chlorinity (Cl)		(%)	0.33	-
Apparent density *3		(ton/m^3)	0.86	-

Note *1: Calculation value
*2: Measurement value by JICA ST
*3: Measurement value by JICA ST

b.5 Physical Composition of Ash

Physical composition of ash which was generated by the mixed combustion test was analyzed as shown in the table below.

Table 6-21: Physical Composition of Ash

			100% Coal	Mixed combustion test	
				RDF2% Mixture	RDF4% Mixture
Industrial chemical analysis	Moisture	(%)	1.2	1.4	1.3
	Volatile matter	(%)	3.5	2.1	2.2
	Non combustible (ash)	(%)	92.2	93.8	94.1
	Fixed carbon	(%)	3.1	2.7	2.4
Apparent density		(ton/m^3)	2.2	2.0	2.0

c. Evaluation of Analysis Data

c.1 Emission Standard

In order to preserve environment each country has an environmental standard and emission standard. Purpose and use of them are outlined below.

<Environmental standard>

- In order to preserve environmental conditions each country sets its own standard. There is an environmental standard in Mongolia as shown in the table below.
- In Japan, the environmental standard are set regarding air pollution, water contamination, soil contamination and noise to protect health of human beings and preserve their living environment.

<Emission standard>

- Emission standard is the regulation (limit) value of pollutants emission from a generation source in order to maintain the environmental standard. Normally it sets allowable emission limit of pollutants.

- There is no emission standard in Mongolia.

Table 6-22: Environmental Standard on Air Quality in Mongolia (MNS 4585:1998)

Toxic substance	---	Tolerated amount
Sulfur dioxide (SO_2)	One time	500 μg/m^3
	Daily average	30μg/m^{3*1}, 70μg/m^{3*2}
Nitrogen dioxide (NO_2)	One time	85μg/m^{3*1}, 150μg/m^{3*2}
	Daily average	40μg/m^{3*1}, 60μg/m^{3*2}
Carbon monoxide (CO)	One time	8 mg/m^3
	Daily average	8 mg/m^3
Ozone (O_3)	One hour average	120 μg/m^3
Dust	One time	500 μg/m^3
	Daily average	30μg/m3^{*1}, 70μg/m^{3*2}
Lead (Pb)	Daily average	1.0μg/m^3
Benzpyrene	Daily average	0.001μg/m^3

Note : *1 Manual analysis
*2 Automatic analysis

c.2 Stockholm Convention

The Stockholm Convention on Persistent Organic Pollutants (POPs) is an international treaty designed to end the production and use of some of the world's most poisonous chemicals. The treaty was ratified by Mongolia. The treaty, however, does not provide an emission standard for exhaust gas.

- A11 of the chemicals targeted for action in the Stockholm Convention are Chlorinated chemicals. Most of these chemicals have been used to kill insects and other pests. Others were used as industrial chemicals, or were produced as a by-product of industrial processes including incineration. What they have in common is that they pose serious health risks to human populations and ecosystems. All POPs chemicals last for many years in the environment and can travel vast distances, transported by the air and water.
- The Convention targets twelve chemicals for action as shown in the table below. They include PCBs, Dioxins and DDT.
- The Convention end production and use of nine (9) chemicals as shown in the table below.
- The Convention allows countries to continue using DDT for malariacontro1, if necessary.
- The Convention asks reduction of four (4) by-products as shown in the table below.

Substance		Name
End production and use	1	Aldrin
	2	Chlordane
	3	Dieldrin
	4	Endrin
	5	Heptachlor
	6	Hexachlorobenzene
	7	Mirex
	8	Toxaphene
	9	PCB (Polychlorinated biphenyl)
Limit production and use	10	DDT (Dichloro-Diphenyl-Trichlioroethane)
Reduce By-product bof industrial processes including incineration	11	PCDD (Polychlorinated dibenzodioxins)
	12	PCDF (Polychlorinated dibenzofurans)
	6	Hexachlorobenzene
	10	DDT (Dichloro-Diphenyl-Trichlioroethane)

c.3 Evaluation Method of the Results of Emission Gas Analysis

As described above the Stockholm Convention does not provide an emission standard for exhaust gas and each state provides its own standard in USA. Therefore, the JICA study team evaluates the exhaust gas analysis data obtained by the 1st mixed combustion test with Japanese and European[3] emission standard.

c.4 Limit Values of Pollutants Other than Dioxins in Japan and EU

The limit values of other than dioxins in Japan and EU are presented in the following tables:

Table 6-23: Limit Value of Dust Emission in Japan and EU

Standard	Source of Emission Gas	Capacity of Incinerator	Conversion equivalent of O_2 (%)	Limit Value in Emission Standard (g/m3N)	
				Case of New Incinerator	Case of Existing Incinerator
Japan	Incinerator of Solid Waste	> 4 ton/hour	12	0.04	0.15
EU	Incinerator of Solid Waste	---	11	0.01	

Table 6-24: Limit Value of Sulfuric Oxide (SO_2) in Japan and EU

Standard	Source of Emission Gas	Capacity of Incinerator	Limit Value in Emission Standard
Japan	Incinerator of Solid Waste	> 4 ton/hour	K value
EU	Incinerator of Solid Waste	---	50 mg/m^{3}N

Table 6-25: Limit Value of Nitrogen Oxide (NOx) in Japan and EU

Standard	Source of Emission Gas	Capacity of Incinerator	Conversion equivalent of O_2 (%)	Emission standard
Japan	Incinerator of Solid Waste	> 4 ton/hour	12	250 ppm (513 mg/m^{3}N*1)
EU	Incinerator of Solid Waste	> 6 ton/hour	11	200 mg/m^{3}N

Note : *1 Calculation value

Table 6-26: Limit Value of Hydrogen Chloride (HCl) in Japan and EU

Standard	Source of Emission Gas	Conversion equivalent of O_2 (%)	Emission standard (mg/m^{3}N)
Japan	Incinerator of Solid Waste	12	700
EU	Incinerator of Solid Waste	11	10

c.5 Limit Value of Dioxins in Japan and EU

c.5.1. Toxic Equivalency Factor (TEF) and Toxic Equivalent (TEQ)

In order to evaluate emission gas on dioxins it is necessary to understand the Toxic Equivalency Factor (TEF) and Toxic Equivalent (TEQ) as fokkows:

<Toxic Equivalency Factor (TEF)>

- 222 kinds of dioxins are identified at present and they are broadly categorized into three groups, i.e. Polychlorinated Dibenzo-para-Dioxins (PCDDs), Polychlorinated Dibenzo-Furans (PCDFs) and Co-planar Polychlorinated Bipheyls (Co-PCBs).
- Among about 222 dioxins, 29 are identified as toxic and degree of toxicity differs each other. However, toxic or not of the other dioxins than 29 are not determined yet.

[3] Implementation of European Council Directive 2000/76/EC on the Incineration of Waste (August 2002, Paper 2002/24)

- Toxicity of each dioxins (isomer) is defined as TEF of which the strongest is 1 for 2, 3, 7, 8-TeCDD.

<Toxic Equivalent (TEQ)>

- Toxicity of dioxins is presented as Toxic Equivalent (TEQ) which is the sum of each toxic amount to be calculated by multiplying amount of each dioxin by each TEF of it.

c.5.2. Limit Value of Dioxins from Solid Waste Incinerator in Japan and EU

As for dioxins both Japanese and EU standards regulate emission limit value by TEQ (Toxic Equivalent). The table below presents the limit value of dioxins from solid waste incinerator in Japan and EU.

Table 6-27: Limit Value of Dioxins from Solid Waste Incinerator in Japan and EU

Standard	Source	Capacity of Incinerator	Emission standard (ng-TEQ/m^{3}N)	
			Case of New Incinerator	Case of Existing Incinerator
Japan	Incinerator of Solid Waste	> 4 ton/hour	0.1	1.0
EU	Incinerator of Solid Waste	---	0.1	

As shown the table below, the EU standard regulates only 17 types of TEF (Toxic Equivalency Factor) for PCDDs and PCDFs excluding PCBs while Japanese standard regulates 29 types of TEF for PCDDs, PCDFs and Co-PCBs. The Implementation of European Council Directive 2000/76/EC on the Incineration of Waste states that although Co-PCBs have similar toxicity with PCDDs and PCDFs, it could not regulates TEF and shall collect further information on toxicity of them.

Table 6-28: Equivalence Factors for PCDDs, PCDFs and Co-PCBs

			TEF	
			Japan	EU*1
PCDDs		2,3,7,8-TeCDD	1	1
		1,2,3,7,8-PeCDD	1	0.5
		1,2,3,4,7,8-HxCDD	0.1	0.1
		1,2,3,6,7,8-HxCDD	0.1	0.1
		1,2,3,7,8,9-HXCDD	0.1	0.1
		1,2,3,4,6,7,8-HpCDD	0.01	0.01
		OCDD	0.0001	0.001
PCDF		2,3,7,8-TeCDF	0.1	0.1
		1,2,3,7,8-PeCDF	0.05	0.05
		2,3,4,7,8-PeCDF	0.5	0.5
		1,2,3,4,7,8-HxCDF	0.1	0.1
		1,2,3,6,7,8-HxCDF	0.1	0.1
		1,2,3,7,8,9-HxCDF	0.1	0.1
		2,3,4,6,7,8-HxCDF	0.1	0.1
		1,2,3,4,6,7,8-HpCDF	0.01	0.01
		1,2,3,4,7,8,9-HpCDF	0.01	0.01
		OCDF	0.0001	0.001
Co-PCBs	Non-ortho PCBs	3,4,4',5-TeCB (IUPAC#81) *2	0.0001	-
		3,3',4,4'-TeCB (IUPAC#77)	0.0001	-
		3,3',4,4',5-PeCB (IUPAC#126)	0.1	-
		3,3'4,4',5,5'-HxCB (IUPAC#169)	0.01	-
	Mono-ortho PCBs	2',3,4,4',5-PeCB (IUPAC#123)	0.0001	-
		2,3',4,4',5-PeCB (IUPAC#118)	0.0001	-
		2,3,3',4,4'-PeCB (IUPAC#105)	0.0001	-
		2,3,4,4',5-PeCB (IUPAC#114)	0.0005	-
		2,3',4,4',5,5'-HxCB (IUPAC#167)	0.00001	-
		2,3,3',4,4',5-HxCB (IUPAC#156)	0.0005	-
		2,3,3',4,4',5'-HxCB (IUPAC#157)	0.0005	-
		2,3,3',4,4',5,5'-HpCB (IUPAC#189)	0.0001	-

Note : *1 Implementation of European Council Directive 2000/76/EC on the Incineration of Waste (August 2002, Paper 2002/24)

*2 IUPAC : International Union of Pure and Applied Chemistry

c.5.3. Dioxins Concentration of Emission Gas Analyzed (ng-TEQ/m^3N)

Dioxins concentration of emission gas analyzed is converted into TEQ in order to evaluate degree of pollutants as follows:

- There area two theories for the calculation of TEQ.
- Method 1: Based on calculation method of the Japanese and EU standard for an waste incinerator, the amounts of TEQ of emission gases for 100% coal, RDF 2% and RDF 4% are calculated at far less than 0.1ng (the strictest value of the emission standard).
- Method 2: Based on the strictest calculation theory – all 222 kinds of Dioxins are toxic – only 2% RDF mixture slightly over the strictest value of the emission standard in Japan.

Table 6-29: TEQ of Emission Gas Analyzed

Method	Standard	Emission Standard	100% Coal	Mixed combustion test	
				RDF2% Mixture	RDF4% Mixture
		ng-TEQ/m^3N	ng-TEQ/m^3N	ng-TEQ/m^3N	ng-TEQ/m^3N
Method 1	Japan	0.1 (New Incinerator) 1.0 (Existing Incinerator)	0.000008	0.000153	0.000172
	EU	0.1	0.000003	0.000154	0.000174
Method 2	Japan	---	0.004	0.388	0.045
	EU	---	0.004	0.318	0.036

c.6 Evaluation

The table below shows the results of the comparison of the exhaust gas analysis data obtained by the 1st mixed combustion test with Japanese and European emission standard.

The comparison table brings the following findings on the emission gas data:

- The emission gas data including 100% coal combustion over the limit values of Japanese and EU standard regarding total dust and NO_x.
- Although mixed combustion reduces concentration of SO_2, the emission gas data over the limit values of EU standard on it.
- Although mixed combustion increases concentration of HCl and dioxins, the emission gas data including mixed combustion are far less than the limit values of Japanese and EU standard regarding HCl and dioxins.

c.6.1. Dust

- No significant difference on measured values between 100% coal and RDF mixed combustion.
- The conversion values of both 100% coal and mixed with RDF over the limit value for the incinerator in Japan and EU.

c.6.2. Sulfuric Oxide (SO_2)

- The measured values of both 100% coal and mixed with RDF over the limit value for the incinerator in EU.
- The measured value shows mixed combustion improve emission gas on SO_2.

c.6.3. Nitrogen Oxide (NOx)

- The conversion values of both 100% coal and mixed with RDF over the limit value for the incinerator in Japan and EU.
- No significant difference on measured values between 100% coal and RDF mixed combustion.

c.6.4. Hydrogen Chloride (HCl)

- Although mixed combustion increases concentration, the emission gas data including mixed combustion are far less than the limit values of Japanese and EU standard.
- No significant difference on measured values between 100% coal and RDF mixed combustion.

c.6.5. Dioxins

- Since concentration of dioxins for mixed combustion are 1.04 – 5.83 times more than it of 100% coal, RDF mixed combustion impacts on generation of dioxins.
- However, TEQ value of RDF mixed combustion, according to the calculation method of the Japanese and EU standard for a solid waste incinerator, is less than 0.1 ng, the strictest value of the Japanese and EU emission standard. It is far below the regulation value set in the emission standards in Japan and EU for solid waste incinerators.
- Even if calculation based on the strictest calculation theory, TEQ of RDF mixed combustion is below the regulation value (1.0 ng-TEQ/m3N) set for the existing incinerator. However, it is slightly over the regulation value (0.1 ng-TEQ/m3N) set for the new incinerator.
- As for the concentrations of dioxins for 2% and 4% mixed combustion, the former (2% and less RDF) shows higher value. The reason of this results might be as follows:
  (1) Higher temperature caused by combustion of more RDF (4%) reduces generation of dioxins or facilitates thermal decomposition of them; or
  (2) Amount of emission gas sucked for 4% was 1/8 of 2% due to the trouble of the emission gas sampling machine.
- In order to confirm the results of the 1st mixed combustion test, the JICA study team will conduct the 2nd mixed combustion test including Emission Gas Analysis in October 2006.

Table 6-30: Comparison of Exhaust Gas Analysis Data with Japanese and European Emission Standard

Items	Limit value			Results of the 1st Mixed Combustion Test of RDF with Coal			
	Japan (Maximum)	EU[*4] (Daily average value)		100% Coal	Coal + RDF (2%)	Coal + RDF (4%)	Unit
Total dust	40[*1] mg/m^3N	10 mg/m^3N		315[*5]	431[*5]	380[*5]	mg/m^3N
Hydrogen chloride (HCl)	700 mg/m^3N	10 mg/m^3N		0.18[*5]	0.30[*5]	0.25[*5]	mg/m^3N
Sulphur dioxide (SO_2)	K value [*2]	50 mg/m^3N		255 (729) [*3]	137 (391) [*3]	117 (334) [*3]	ppm (mg/m^3N)
Nitrogen oxide (NO_x)	250 ppm (513)[*3] mg/m^3N	200 mg/m^3N		336 (690) [*3]	324 (665) [*3]	326 (669) [*3]	ppm (mg/m^3N)
Standard percentage oxygen concentration	12 %	11 %		---	---	---	---
Dioxins	0.1 ng-TEQ/m^3N	0.1 ng-TEQ/m^3N	Japanese Standard[*6]	0.000008	0.000153	0.000172	ng-TEQ/m^3N
			EU's Standard[*7]	0.000003	0.000154	0.000174	ng-TEQ/m^3N

Note
*1: Incineration capacity is more than 4ton/hour.

*2: Japanese standard regulates maximum concentration of SO_2 at certain point (it differs place.) departed from an emission source. K value is regulated according to the location with the range of 17.5-3.0.

*3: Although unit of limit value is set in ppm, we convert it in (mg/m^3N) for comparison.

*4: "Implementation of European Council Directive 2000/76/EC on the Incineration of Waste (August 2002, Paper 2002/24)"

*5: The figure is converted supposing that the concentration of oxygen is 12%.

*6: Calculation value base on Japanese standard

*7: Calculation value base on EU's standard

c.7 Operation Data of the Furnace used for Combustion Test

The operation data of the furnace used for combustion test are presented in the table below.

Table 6-31: Operation Data of the Furnace used for Combustion Test

	Total amount of network water	Total amount of network water coming out of furnace	Temperature of water going to user	Temperature of water coming from user	Amount of supplement water	Temperature of supplement water	Temperature of boiler effluent water	Temperature of heat exchanger effluent gas	Air temperature	Retention time of Fuel in the furnace	Feeding amount of the Coal	Feeding amount of the RDF
	ton	ton/h	oC	oC	t/h	oC	oC	oC	oC	min	ton/hour	ton/hour
14 Feb 100% Coal	529	240	80	53	25	30	117	NA	-14	19	15.3	-
15 Feb Coal + RDF(2%	530	240	83	56	25	27	116	NA	-16	36	10.6	0.24
16 Feb Coal + RDF(4%)	536	240	82	55	28	23	118	NA	-11	39	8.4	0.48

c.8 Physical Composition of Coal and RDF

The physical composition of coal and RDF used for the combustion test is presented in the table below. The table shows:

- Low calorific value of RDF is 2.1 times more than it of coal.
- Moisture of coal is considerably high, 31.3% (Literary data : 28.0 – 46.0%). In the combustion test we measured the moisture of coal. The moisture of coal in 1st and 2nd day was more than 40%. It decreased gradually and became 23-25% in the 4th day of the test (RDF4% mixture test day). The higher moisture of coal affects operation of coal feeder. In 1st and 2nd day the feeder was blocked at the scraper part several times. However in 3rd and 4th day there were observed very few blockage.
- Combustion rate of coal (Amount of fixed carbon/Amount of volatile matter) observed in the test was 1.2. This rate indicates the coal used for the test was low quality bituminous coal of which combustion rate is between 1 – 4. As for reference, the combustion rate of brown coal is less than 1 while it of anthracite coal is more than 4.

Table 6-32: Physical Composition of Coal and RDF

Physical composition			RDF	Coal		
Higher calorific value		(kcal/kg)	5,820	3,875		
Lower calorific value*1		(kcal/kg)	5,290	2,470		
Industrial chemical analysis	Moisture	(%)	8.3	31.3		
	Combustible	(%)	86.0	59.9	Volatile matter	27.8
					Fixed Carbon	32.1
	Ash	(%)	5.7	8.8		

Note *1: Calculation value

d. Examination of Material Balance and Heat Balance

d.1 Hot Water Supply System

In order to find out boiler efficiency the heat balance of the hot water system is examined. The hot water supply system of Nalaikh Heating Plant is presented in the figure below.

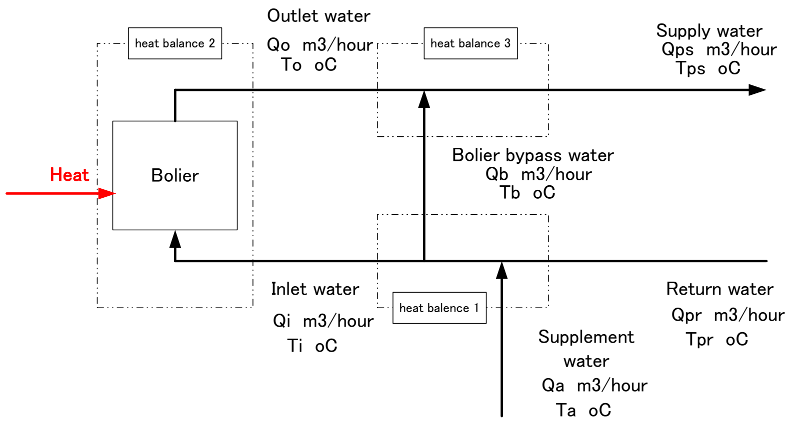


Figure 6-27: Hot Water Supply System of Nalaikh Heating Plant

d.2 Material Balance of Hot Water Supply System

d.2.1. Material Balance Table

Based on the data obtained the combustion test material balance of the hot water supply system on each combustion test is calculated and shown in the table below.

Table 6-33: Material Balance of Hot Water Supply System

Items			unit	100% Coal	Mixed combustion test		Note
					RDF2% Mixture	RDF4% Mixture	
Return water	Qpr	Amount	m^3/hour	504	505	511	Calculated value = supply water – supplement water
	Tpr	Temp.	°C	53	56	55	Actual value
Supplement water	Qa	Amount	m^3/hour	25	25	25	Actual value
	Ta	Temp.	°C	30	27	23	Actual value
Inlet water	Qi	Amount	m^3/hour	240	240	240	Actual value
	Ti	Temp.	°C	52	55	54	Calculated value
Boiler bypass water	Qb	Amount	m^3/hour	289	290	296	Calculated value =Return water + supplement water - Inlet water
	Tb	Temp.	°C	52	55	54	Calculated value
Outlet water	Qo	Amount	m^3/hour	240	240	240	Actual value
	To	Temp.	°C	117	116	118	Actual value
Supply water	Qps	Amount	m^3/hour	529	530	536	Actual value
	Tps	Temp.	°C	80	83	82	Actual value

d.2.2. Material Balance Diagram

Based on the above table, a material balance diagram is prepared and shown below.

<100% Coal>

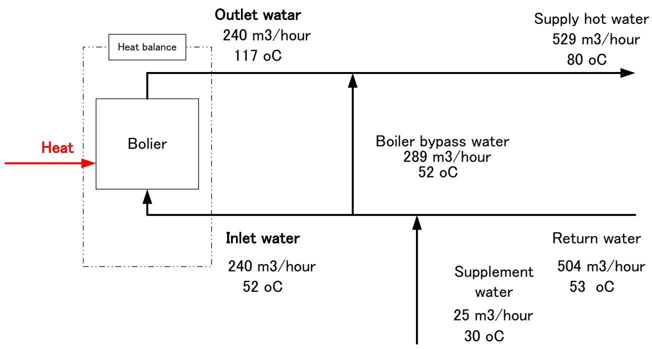


Figure 6-28: Material Balance Diagram of 100 % Coal Test

<Coal + RDF 2% Mixture>

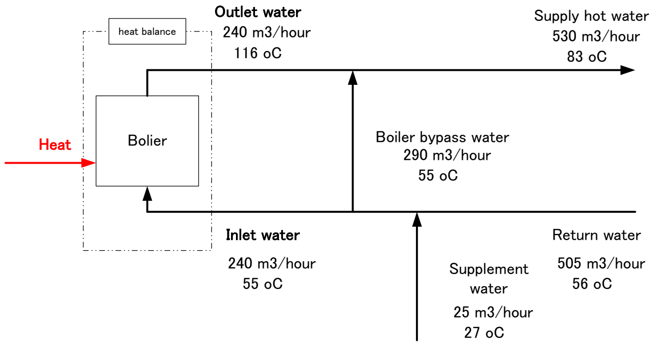


Figure 6-29: Material Balance Diagram of RDF 2% Mixture Test

< Coal + RDF 4% Mixture>

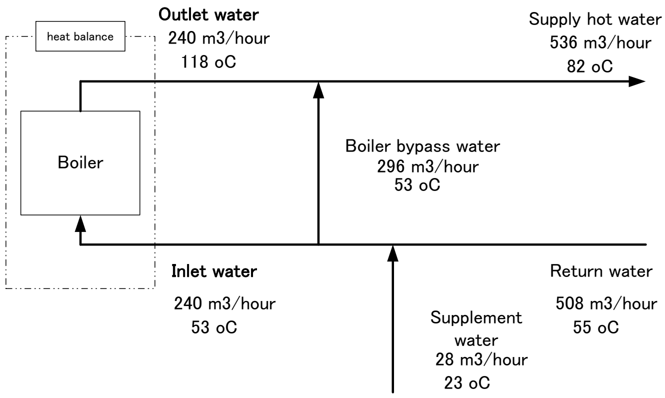


Figure 6-30: Material Balance Diagram of RDF 4% Mixture Test

d.3 Heat Balance of Hot Water Supply System

d.3.1. Heat Balance 1 (Return Hot Water System)

Heat balance of return hot water system is calculated as shown in the table below. The balance of heat in the table is made by the heat loss. Since the heat loss is small, i.e. only -0.7 – 0.6 % of heat input, the table indicates that we could rely on the data obtained regarding the amount or temperature of hot water measured in the supply system.

Table 6-34: Heat Balance 1 (Return Hot Water System)

Unit : 1,000 kcal/hour

		100% Coal	Mixed combustion test	
			RDF2% Mixture	RDF4% Mixture
Heat input	Calorific value of Return water	26,712	28,280	27,940
	Calorific value of Supplement water	750	675	644
	Total of heat input	27,462	28,955	28,584
Heat output	Calorific value of inlet water	12,480	13,200	12,720
	Calorific value of boiler bypass water	15,028	15,950	15,688
	heat loss (Balance)	-46	-195	176
	Total of heat output	27,462	28,955	28,584

d.3.2. Heat Balance 2 (Boiler)

Heat balance of boiler system is calculated as shown in the table below. In the table the loss of heat output is assumed 0% of heat input. Heat balance 2 provides calorific value received by the boiler water as follows:

Total calorific value received by the boiler water = Total calorific value of Outlet water – Total calorific value of Inlet water

Based on the calorific value we can calculate boiler efficiency of each combustion test.

Table 6-35: Heat Balance 2 (Boiler)

Unit : 1,000 kcal/hour

		100% Coal	Mixed combustion test	
			RDF2% Mixture	RDF4% Mixture
Heat input	Calorific value of Inlet water	12,480	13,200	12,720
	Calorific value received by the boiler water	15,600	14,640	15,600
	Total of heat input	28,080	27,840	28,320
Heat output	Calorific value of outlet water	28,080	27,840	28,320
	heat loss	0	0	0
	Total of heat output	28,080	27,840	28,320

d.3.3. Heat Balance 3 (Supply Hot Water System)

Heat balance of return hot water system is calculated as shown in the table below. The balance of heat in the table is made by the heat loss. Since the heat loss is small, i.e. only -0.5 – 1.8 % of heat input, the table indicates that we could rely on the data obtained regarding the amount or temperature of hot water measured in the supply system.

Table 6-36: Heat Balance 3 (Supply Hot Water System)

Unit : 1,000 kcal/hour

		100% Coal	Mixed combustion test	
			RDF2% Mixture	RDF4% Mixture
Heat input	Calorific value of Outlet water	28,080	27,840	28,320
	Calorific value of bypass water	15,028	15,950	15,688
	Total of heat input	43,108	43,790	44,008
Heat output	Calorific value of Supply hot water	42,320	43,990	43,952
	heat loss (Balance)	788	-200	56
	Total of heat output	43,108	43,790	44,008

d.3.4. Evaluation of Heat Balance Results

<Boiler Efficiency>

The boiler efficiency is calculated by the following formula.

Boiler efficiency = (Total calorific value of Outlet water – Total calorific value of Inlet water) / (Total calorific value of Fuel)

The results of calculation of boiler efficiency are shown in the following table.

Table 6-37: **Boiler Efficiency of the Combustion Test**

	100% Coal	Mixed combustion test	
		RDF2% (Mixture)	RDF4% (Mixture)
Boiler efficiency	41.3 %	53.3 %	67.0 %

- Mixed combustion of RDF with coal reduces coal consumption according to the JICA study team estimation.

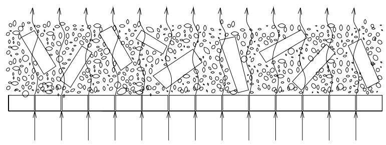
(1) 100% coal = 15.3 tons/hour
(2) 2% RDF (0.24 tons/hour) + coal (10.6 tons/hour)
(3) 4% RDF (0.48 tons/hour) + coal (8.4 tons/hour)

- According to the JICA study team calculation the Boiler efficiency is improved by the mixed combustion of RDF.

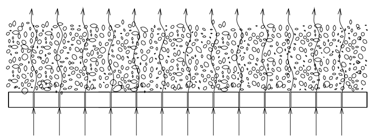
  (1) 100% coal = 41.3%
  (2) 2% RDF = 53.3%
  (3) 4% RDF = 67.0%

  ➢ Possible Reasons for the Improvement of Boiler Efficiency

  (1) 1. Mixture of RDF facilitates oxygen supply for combustion due to different size => It reduces the amount of unburned coal .



Case of RDF mixture



Case of 100 % Coal

  (2) Less water content => The water contents of coal for mixed combustion may be less than it for 100% combustion. => Less water content increase the LCV (lower calorific value of coal)

  (3) Higher speed of the feeding convey and high water contents may reduce the thickness of coal at the feeding convey. => The actual supply of the 100% coal combustion might be less than our calculation.

6.3.5 2nd Mixed Combustion Test of RDF with Coal

a. Objective

The results of the 1st mixed combustion test indicate mixed combustion of RDF with coal is effective regarding economic aspects. However the following aspects will be further examined in the 2nd mixed combustion test.

- Economical efficiency RDF mixed combustion of RDF with coal by a continuous combustion
- Confirmation of pollutants concentration of emission gas

It is one of the most important test items for the 2nd mixed combustion test to measure the actual coal supply capacity of coal spreader.

b. Test Plan

The 2nd combustion test was conducted according to following conditions.

(1) Mix proportion of RDF to the coal was 2% and 4%.

(2) Each mixed combustion test was conducted for continuous 2 days and the emission gas will be sampled in the period of the 2 days.

(3) The operation data of Coal 100% combustion was obtained for 2 continuous days of before and after the mixed combustion test.

c. Schedule

The 2nd mixed combustion test was conducted in the 7 days from 16 October to 22 October, 2006.

October , 2006	15	16	17	18	19	20	21	22	23
	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon
1.Preparation works		■							
1. Combustion test (Coal only burning)			■						
2. Combustion test (RDF 2% Mixture)				■	■				
3. Combustion test (RDF 4% Mixture)						■	■		

d. Items for Measurement

The measurement items is almost the same as the 1st combustion test.

- Emission Gas
- Physical Composition of RDF and Coal
- Physical Composition of Ash
- Basic Data of Heating Plant

e. Work schedule

October	16	17	18	19	20	21	22
	Mon	Tue	Wed	Thu	Fri	Sat	Sun
Operation	100% Coal		RDF 2%		RDF 4%		100% Coal
Measurement of Emission gas (exclude Dioxins)		Test 1 ■		Test 2 ■		Test 3 ■	
Measurement of Dioxins		■		■		■	
Physical Composition of RDF and coal				RDF, Coal ■	RDF ■	RDF, Coal ■	
Physical Composition of Ash				■		■	
Collection of Operation data	■	■	■	■	■	■	■

6.3.6 Results of the 2nd Mixed Combustion Test

a. Preparation Works

a.1 Measurement of Coal Consumption (Fed Amount)

The consumption amount of coal was measured by the revolution number of the gear of the main axle of the feeding conveyor. The weight amount of coal which were fed while the gear rotated around the main axle was 17.5kg/revolution. .

<Apparent density of Coal on the Feeding Conveyor>

Amount of coal consumed for combustion (Q) is calculated based on operation data of coal feeder (spreader) as shown in the following formula:

Feeding conveyor

- Speed of feeding conveyor (FC): It is calculated by multiplying the diameter of the gear for the conveyor (20cm) by the number of revolutions of the gear.
- Width of FC: 60cm (effective width)
- Thickness of Coal on FC: 10cm (effective thickness)
- ρ (Apparent density of Coal)

The apparent density of coal by the feeding conveyor is calculated using this formula.

Apparent density of Coal = (0.0175 ton)/(0.2m x 3.14 x 0.6 m x 0.1 m)
= 0.464 ton/m^3

<Weight of coal consumption by hour>

The weight amount of coal consumption per hour is estimated with the revolution number of the main gear as shown in the following equation.

Weight of coal per hour (ton/hour)

= (0.0175 ton/revolution x 60 sec/min x 60 min/hour) / (rotation speed/sec)

= 63 / (rotation speed) ton/hour

At the second combustion test, the weight amount of coal consumption was calculated by using this equation. The result of the test revealed that coal consumption amount was changed due to the moisture content of the coal and its particle size.

b. Analysis of Air Pollutants in Emission Gas

b.1 Measurement of Air Pollutants in Emission Gas (excluding Dioxins)

The following table presents the results of the measurement of air pollutants in emission gas excluding Dioxins.

Table 6-38: Measurement of Air Pollutants in Emission Gas (excluding Dioxins)

			100% Coal	Mixed combustion test	
				RDF2% Mixture	RDF4% Mixture
	Furnace Number		No.1	No.1	No.1
	Examination date		17, Oct	19, Oct	21, Oct
1.	Amount of emission gas (Wet)	m^3N/h	43,930	35,820	35,910
2.	Amount of emission gas (Dry)*1	m^3N/h	41,600	34,060	34,260
3.	Temperature of emission gas	^0C	130.8	153.7	141.3
4.	Moisture	%	5.3	4.9	4.6
5.	Dust concentration	g/m^3N	7.5	8.0	4.3
	Dust concentration of conversion equivalent of O_2 12%	g/m^3N	11.8	7.3	5.4
6.	O_2	%	15.3	11.2	13.8
7.	CO	ppm	1,069	504	687
8.	CO_2	%	5.8	9.2	6.8
9.	SO_2	ppm	209	333	110
10	NO_X	ppm	118	148	108
	NOx concentration of conversion equivalent of O_2 12%	ppm	186	136	135

Note : *1: Calculation value

b.2 Measurement of Dioxins in Emission Gas

b.2.1. Sampling Conditions

The emission gas volumes sampled for the analysis of dioxins are shown in the table below.

Table 6-39: Emission Gas Volumes Sampled for the Analysis of Dioxins

		100% Coal	Mixed combustion test	
			RDF2% (Mixture)	RDF4% (Mixture)
Furnace Number		No.1	No.1	No.1
Examination date		17, Oct	19, Oct	21, Oct
Amount of Sampling gas	(m^3)	2.208	3.312	3.480
Concentration of O_2	%	14.5	12.8	14.6
Concentration of CO	ppm	1,174	883	799
Temperature of Sampling gas	^0C	22	20	20

note: Concentration of O_2 and CO is the result of measuring dioxins measurement. （Intervals of about 30min）

b.2.2. Results of Measurement

Concentration of dioxins in the emission gas (ng/m^{3}N) which was measured by the laboratory analysis is presented in the table below.

Table 6-40: Results of Emission Gas Analysis (Dioxins) – 100% Coal (Particle + Gas)

		Actual value*1	Quantitation limit value	Detection limit value	Toxic Equivalency Factor	Toxic Equivalent (TEQ)
Unit		ng/m^{3}N	ng/m^{3}N	ng/m^{3}N	(TEF)	(ng-TEQ/ m^{3}N)
PCDDs	1,3,6,8-TeCDD	(0.006)	0.008	0.002	0	0
	1,3,7,9-TeCDD	(0.004)	0.008	0.002	0	0
	2,3,7,8-TeCDD	ND	0.008	0.002	1	0
	other-TeCDDs	0.010	-	-	-	-
	1,2,3,7,8-PeCDD	ND	0.008	0.003	1	0
	other-PeCDDs	(0.006)	-	-	-	-
	1,2,3,4,7,8-HxCDD	ND	0.02	0.007	0.1	0
	1,2,3,6,7,8-HxCDD	ND	0.02	0.007	0.1	0
	1,2,3,7,8,9-HXCDD	ND	0.01	0.004	0.1	0
	other-HxCDDs	ND	-	-	-	-
	1,2,3,4,6,7,8-HpCDD	ND	0.02	0.006	0.01	0
	other-HpCDDs	ND	-	-	-	-
	OCDD	(0.012)*1	0.03	0.009	0.0001	0
	Total PCDDs	0.039	-	-	-	-
PCDFs	1,2,7,8-TeCDF	0.021	0.007	0.002	0	0
	2,3,7,8-TeCDF	0.034	0.007	0.002	0.1	0.0034
	other-TeCDFs	0.19	-	-	-	-
	1,2,3,7,8+1,2,3,4,8-PeCDF	0.009	0.007	0.002	0.05	0.00045
	2,3,4,7,8-PeCDF	0.0073	0.0008	0.0002	0.5	0.00365
	other-PeCDFs	0.048	-	-	-	-
	1,2,3,4,7,8+1,2,3,4,7,9-HxCDF	ND	0.02	0.005	0.1	0
	1,2,3,6,7,8-HxCDF	ND	0.02	0.007	0.1	0
	1,2,3,7,8,9-HxCDF	ND	0.01	0.004	0.1	0
	2,3,4,6,7,8-HxCDF	ND	0.01	0.004	0.1	0
	other-HxCDFs	ND	-	-	-	-
	1,2,3,4,6,7,8-HpCDF	(0.003)*1	0.01	0.003	0.01	0
	1,2,3,4,7,8,9-HpCDF	ND	0.007	0.002	0.01	0
	other-HpCDFs	ND	-	-	-	-
	OCDF	ND	0.007	0.002	0.0001	0
	Total PCDFs	0.33	-	-	-	-
Total（PCDDs＋PCDFs）		0.37			-	-
Co-PCBs	3,3',4,4'-TeCB (#77)*2	0.067	0.01	0.003	0.0001	0.0000067
	3,4,4',5-TeCB (#81) *2	0.014	0.01	0.004	0.0001	0.0000014
	3,3',4,4',5-PeCB (#126)*2	ND	0.008	0.003	0.1	0
	3,3'4,4',5,5'-HxCB (#169)*2	ND	0.006	0.002	0.01	0
	Non-ortho PCBs	0.081			-	-
	2,3,3',4,4'-PeCB (#105)*2	0.5	0.007	0.002	0.0001	0.000050
	2,3,4,4',5-PeCB (#114)*2	0.028	0.004	0.001	0.0005	0.0000140
	2,3',4,4',5-PeCB (#118)*2	1.1	0.01	0.003	0.0001	0.00011
	2',3,4,4',5-PeCB (#123)*2	0.029	0.007	0.002	0.0001	0.0000029
	2,3,3',4,4',5-HxCB (#156)*2	0.12	0.01	0.004	0.0005	0.000060
	2,3,3',4,4',5'-HxCB (#157)*2	0.031	0.005	0.001	0.0005	0.0000155
	2,3',4,4',5,5'-HxCB (#167)*2	0.038	0.01	0.004	0.00001	0.00000038
	2,3,3',4,4',5,5'-HpCB (#189)*2	ND	0.01	0.003	0.0001	0
	Mono-ortho PCBs	1.9	-	-	-	-
Total（Co-PCBs）		2.0	-	-	-	-
Total（PCDDs +PCDFs +Co-PCBs）		2.3	-	-	-	-
Total TEQ						0.0078

*1 : It is shown that measurement value is between quantitation limit value and detection limit value. This analysis item does not calculate the equivalent of TEQ.
*2 : IUPAC : International Union of Pure and Applied Chemistry

Table 6-41: Results of Emission Gas Analysis (Dioxins) – RDF 2% Mixture (Particle + Gas)

		Actual value*1	Quantitation limit value	Detection limit value	Toxic Equivalency Factor	Toxic Equivalent (TEQ)
Unit		ng/m^3N	ng/m^3N	ng/m^3N	(TEF)	(ng-TEQ/ m^3N)
PCDDs	1,3,6,8-TeCDD	0.34	0.005	0.002	0	0
	1,3,7,9-TeCDD	0.23	0.005	0.002	0	0
	2,3,7,8-TeCDD	ND	0.005	0.002	1	0
	other-TeCDDs	0.074	-	-	-	-
	1,2,3,7,8-PeCDD	(0.004)	0.006	0.002	1	0
	other-PeCDDs	0.34	-	-	-	-
	1,2,3,4,7,8-HxCDD	ND	0.02	0.005	0.1	0
	1,2,3,6,7,8-HxCDD	(0.005)	0.01	0.004	0.1	0
	1,2,3,7,8,9-HXCDD	(0.006)	0.008	0.002	0.1	0
	other-HxCDDs	0.30	-	-	-	-
	1,2,3,4,6,7,8-HpCDD	0.033	0.01	0.004	0.01	0.00033
	other-HpCDDs	0.027	-	-	-	-
	OCDD	0.027	0.02	0.006	0.0001	0.0000027
	Total PCDDs	1.4	-	-	-	-
PCDFs	1,2,7,8-TeCDF	0.077	0.005	0.001	0	0
	2,3,7,8-TeCDF	0.091	0.005	0.001	0.1	0.0091
	other-TeCDFs	0.64	-	-	-	-
	1,2,3,7,8+1,2,3,4,8-PeCDF	0.027	0.005	0.001	0.05	0.00135
	2,3,4,7,8-PeCDF	0.019	0.0005	0.0002	0.5	0.0095
	other-PeCDFs	0.16	-	-	-	-
	1,2,3,4,7,8+1,2,3,4,7,9-HxCDF	(0.007)	0.01	0.003	0.1	0
	1,2,3,6,7,8-HxCDF	(0.005)	0.02	0.005	0.1	0
	1,2,3,7,8,9-HxCDF	ND	0.009	0.003	0.1	0
	2,3,4,6,7,8-HxCDF	(0.003)	0.009	0.003	0.1	0
	other-HxCDFs	0.023	-	-	-	-
	1,2,3,4,6,7,8-HpCDF	(0.005)	0.007	0.002	0.01	0
	1,2,3,4,7,8,9-HpCDF	ND	0.004	0.001	0.01	0
	other-HpCDFs	(0.003)	-	-	-	-
	OCDF	ND	0.005	0.001	0.0001	0
	Total PCDFs	1.1	-	-	-	-
Total（PCDDs＋PCDFs）		2.5	-		-	-
Co-PCBs	3,3',4,4'-TeCB (#77)*	0.20	0.007	0.002	0.0001	0.000020
	3,4,4',5-TeCB (#81)*	0.013	0.008	0.003	0.0001	0.0000013
	3,3',4,4',5-PeCB (#126)*	0.017	0.006	0.002	0.1	0.0017
	3,3'4,4',5,5'-HxCB (#169)*	ND	0.004	0.001	0.01	0
	Non-ortho PCBs	0.23	0.23		-	-
	2,3,3',4,4'-PeCB (#105)*	3.3	0.005	0.001	0.0001	0.00033
	2,3,4,4',5-PeCB (#114)*	0.21	0.003	0.0009	0.0005	0.000105
	2,3',4,4',5-PeCB (#118)*	7.2	0.007	0.002	0.0001	0.00072
	2',3,4,4',5-PeCB (#123)*	0.16	0.005	0.001	0.0001	0.000016
	2,3,3',4,4',5-HxCB (#156)*	0.62	0.008	0.002	0.0005	0.000310
	2,3,3',4,4',5'-HxCB (#157)*	0.15	0.003	0.0009	0.0005	0.000075
	2,3',4,4',5,5'-HxCB (#167)*	0.23	0.008	0.003	0.00001	0.0000023
	2,3,3',4,4',5,5'-HpCB (#189)*	0.010	0.007	0.002	0.0001	0.0000010
	Mono-ortho PCBs	12	-	-	-	-
Total（Co-PCBs）		12	-	-	-	-
Total（PCDDs +PCDFs +Co-PCBs）		15	-	-	-	-
Total TEQ						0.024

*1 : It is shown that measurement value is between quantitation limit value and detection limit value. This analysis item does not calculate the equivalent of TEQ.
*2 : IUPAC : International Union of Pure and Applied Chemistry

Table 6-42: Results of Emission Gas Analysis (Dioxins) – RDF 4% Mixture (Particle)

			Actual value*1	Quantitation limit value	Detection limit value	Toxic Equivalency Factor	Toxic Equivalent (TEQ)
Unit			ng/m^3N	ng/m^3N	ng/m^3N	(TEF)	$(ng\text{-}TEQ/m^3N)$
PCDDs	1,3,6,8-TeCDD		0.92	0.005	0.001	0	0
	1,3,7,9-TeCDD		0.65	0.005	0.001	0	0
	2,3,7,8-TeCDD		0.007	0.005	0.001	1	0.007
	other-TeCDDs		0.29	-	-	-	-
	1,2,3,7,8-PeCDD		0.022	0.005	0.002	1	0.022
	other-PeCDDs		1.2	-	-	-	-
	1,2,3,4,7,8-HxCDD		(0.019)	0.02	0.005	0.1	0
	1,2,3,6,7,8-HxCDD		0.033	0.01	0.004	0.1	0.0033
	1,2,3,7,8,9-HXCDD		0.028	0.008	0.002	0.1	0.0028
	other-HxCDDs		1.0	-	-	-	-
	1,2,3,4,6,7,8-HpCDD		0.15	0.01	0.004	0.01	0.0015
	other-HpCDDs		0.12	-	-	-	-
	OCDD		0.11	0.02	0.006	0.0001	0.000011
	Total PCDDs		4.6	-	-	-	-
PCDFs	1,2,7,8-TeCDF		0.078	0.004	0.001	0	0
	2,3,7,8-TeCDF		0.058	0.004	0.001	0.1	0.0058
	other-TeCDFs		0.91	-	-	-	-
	1,2,3,7,8+1,2,3,4,8-PeCDF		0.043	0.004	0.001	0.05	0.00215
	2,3,4,7,8-PeCDF		0.035	0.0005	0.0002	0.5	0.0175
	other-PeCDFs		0.35	-	-	-	-
	1,2,3,4,7,8+1,2,3,4,7,9-HxCDF		0.030	0.01	0.003	0.1	0.0030
	1,2,3,6,7,8-HxCDF		0.022	0.01	0.004	0.1	0.0022
	1,2,3,7,8,9-HxCDF		(0.003)	0.008	0.002	0.1	0
	2,3,4,6,7,8-HxCDF		0.021	0.009	0.003	0.1	0.0021
	other-HxCDFs		0.15	-	-	-	-
	1,2,3,4,6,7,8-HpCDF		0.040	0.006	0.002	0.01	0.00040
	1,2,3,4,7,8,9-HpCDF		0.009	0.004	0.001	0.01	0.00009
	other-HpCDFs		0.031	-	-	-	-
	OCDF		0.021	0.004	0.001	0.0001	0.0000021
	Total PCDFs		1.8	-	-	-	-
Total（PCDDs＋PCDFs）			6.4	-		-	-
Co-PCBs	3,3',4,4'-TeCB	(#77)*	0.13	0.007	0.002	0.0001	0.000013
	3,4,4',5-TeCB	(#81)*	0.009	0.008	0.002	0.0001	0.0000009
	3,3',4,4',5-PeCB	(#126)*	0.014	0.005	0.002	0.1	0.0014
	3,3'4,4',5,5'-HxCB	(#169)*	0.004	0.004	0.001	0.01	0.00004
	Non-ortho PCBs		0.16			-	-
	2,3,3',4,4'-PeCB	(#105)*	0.15	0.004	0.001	0.0001	0.000015
	2,3,4,4',5-PeCB	(#114)*	0.010	0.003	0.0009	0.0005	0.0000050
	2,3',4,4',5-PeCB	(#118)*	0.31	0.007	0.002	0.0001	0.000031
	2',3,4,4',5-PeCB	(#123)*	0.011	0.005	0.001	0.0001	0.0000011
	2,3,3',4,4',5-HxCB	(#156)*	0.034	0.008	0.002	0.0005	0.0000170
	2,3,3',4,4',5'-HxCB	(#157)*	0.0083	0.003	0.0009	0.0005	0.00000415
	2,3',4,4',5,5'-HxCB	(#167)*	0.012	0.008	0.002	0.00001	0.00000012
	2,3,3',4,4',5,5'-HpCB	(#189)*	(0.005)	0.007	0.002	0.0001	0
	Mono-ortho PCBs		0.54		-	-	-
Total（Co-PCBs）			0.69	-	-	-	-
Total（PCDDs +PCDFs +Co-PCBs）			7.0	-	-	-	-
Total TEQ							0.071

*1 : It is shown that measurement value is between quantitation limit value and detection limit value. This analysis item does not calculate the equivalent of TEQ.
*2 : IUPAC : International Union of Pure and Applied Chemistry

Table 6-43: Results of Emission Gas Analysis (Dioxins) – RDF 4% Mixture (Gas)

		Actual value*1	Quantitation limit value	Detection limit value	Toxic Equivalency Factor	Toxic Equivalent (TEQ)
Unit		ng/m^{3}N	ng/m^{3}N	ng/m^{3}N	(TEF)	(ng-TEQ/ m^{3}N)
PCDDs	1,3,6,8-TeCDD	0.008	0.005	0.001	0	0
	1,3,7,9-TeCDD	0.006	0.005	0.001	0	0
	2,3,7,8-TeCDD	ND	0.005	0.001	1	0
	other-TeCDDs	ND	-	-	-	-
	1,2,3,7,8-PeCDD	ND	0.005	0.002	1	0
	other-PeCDDs	0.018	-	-	-	-
	1,2,3,4,7,8-HxCDD	ND	0.02	0.005	0.1	0
	1,2,3,6,7,8-HxCDD	ND	0.01	0.004	0.1	0
	1,2,3,7,8,9-HXCDD	ND	0.008	0.002	0.1	0
	other-HxCDDs	(0.016)	-	-	-	-
	1,2,3,4,6,7,8-HpCDD	(0.004)	0.01	0.004	0.01	0
	other-HpCDDs	(0.004)	-	-	-	-
	OCDD	ND	0.02	0.006	0.0001	0
	Total PCDDs	0.057	-	-	-	-
PCDFs	1,2,7,8-TeCDF	ND	0.004	0.001	0	0
	2,3,7,8-TeCDF	ND	0.004	0.001	0.1	0
	other-TeCDFs	0.009	-	-	-	-
	1,2,3,7,8+1,2,3,4,8-PeCDF	ND	0.004	0.001	0.05	0
	2,3,4,7,8-PeCDF	0.0009	0.0005	0.0002	0.5	0.00045
	other-PeCDFs	0.004	-	-	-	-
	1,2,3,4,7,8+1,2,3,4,7,9-HxCDF	ND	0.01	0.003	0.1	0
	1,2,3,6,7,8-HxCDF	ND	0.01	0.004	0.1	0
	1,2,3,7,8,9-HxCDF	ND	0.008	0.002	0.1	0
	2,3,4,6,7,8-HxCDF	ND	0.009	0.003	0.1	0
	other-HxCDFs	ND	-	-	-	-
	1,2,3,4,6,7,8-HpCDF	(0.003)	0.006	0.002	0.01	0
	1,2,3,4,7,8,9-HpCDF	ND	0.004	0.001	0.01	0
	other-HpCDFs	ND	-	-	-	-
	OCDF	ND	0.004	0.001	0.0001	0
	Total PCDFs	0.024	-	-	-	-
Total（PCDDs＋PCDFs）		0.081	-		-	-
Co-PCBs	3,3',4,4'-TeCB (#77)*	0.012	0.007	0.002	0.0001	0.0000012
	3,4,4',5-TeCB (#81)*	ND	0.008	0.002	0.0001	0
	3,3',4,4',5-PeCB (#126)*	ND	0.005	0.002	0.1	0
	3,3'4,4',5,5'-HxCB (#169)*	ND	0.004	0.001	0.01	0
	Non-ortho PCBs	0.012			-	-
	2,3,3',4,4'-PeCB (#105)*	0.019	0.004	0.001	0.0001	0.0000019
	2,3,4,4',5-PeCB (#114)*	ND	0.003	0.0009	0.0005	0
	2,3',4,4',5-PeCB (#118)*	0.042	0.007	0.002	0.0001	0.0000042
	2',3,4,4',5-PeCB (#123)*	ND	0.005	0.001	0.0001	0
	2,3,3',4,4',5-HxCB (#156)*	(0.004)	0.008	0.002	0.0005	0
	2,3,3',4,4',5'-HxCB (#157)*	ND	0.003	0.0009	0.0005	0
	2,3',4,4',5,5'-HxCB (#167)*	(0.002)	0.008	0.002	0.00001	0
	2,3,3',4,4',5,5'-HpCB (#189)*	ND	0.007	0.002	0.0001	0
	Mono-ortho PCBs	0.068		-	-	-
Total（Co-PCBs）		0.080	-	-	-	-
Total（PCDDs +PCDFs +Co-PCBs）		0.16	-	-	-	-
Total TEQ						0.00046

*1 : It is shown that measurement value is between quantitation limit value and detection limit value. This analysis item does not calculate the equivalent of TEQ.
*2 : IUPAC : International Union of Pure and Applied Chemistry

Converted value (TEQ) of dioxins concentration of 1st and 2nd combustion test was shown following table.

Table 6-44: Results of Emission Gas Analysis (Dioxins) – Converted value: ng-TEQ/m^{3}N

Items	100% Coal	Mixed combustion test		
		RDF2% Mixture	RDF4% Mixture	
	Particle + Gas	Particle + Gas	Particle	Gas
	ng-TEQ/m^{3}N	ng-TEQ/m^{3}N	ng-TEQ/m^{3}N	ng-TEQ/m^{3}N
PCDDs	0	0.0003327	0.036611	0
PCDFs	0.00750	0.01995	0.0332421	0.00045
Co-PCBs	0.00026088	0.0032806	0.00152727	0.0000073
Total（PCDDs +PCDFs +Co-PCBs）	0.0078	0.024	0.071	0.00046

b.3 Physical Composition of RDF

Physical composition of RDF which was used for the mixed combustion test was analyzed as shown in the table below.

Table 6-45: Physical Composition of RDF

			Measurement value
Higher calorific value (HCV)*1		(kcal/kg)	3,320
Lower calorific value (LCV)		(kcal/kg)	3,200
Industrial chemical analysis	Moisture	(%)	0.9
	Combustible	(%)	74.9
	Non combustible (ash)	(%)	24.2
Apparent density*2		(ton/m^3)	0.43 (0.40-0.45)

Note *1: Calculation valu
Note *2: Measurement value by Study team

b.4 Physical Composition of Coal

Physical composition of the coal which was used for the mixed combustion test was analyzed as shown in the table below.

Table 6-46: Physical and Chemical Composition of Coal

			Measurement value
Higher calorific value (HCV)*1		(kcal/kg)	4,700
Lower calorific value (LCV)		(kcal/kg)	3,680
Industrial chemical analysis	Moisture	(%)	19.2 (19.8-23.8)*2
	Combustible	(%)	61.2
	Non combustible (ash)	(%)	19.6
Apparent density *2		(ton/m^3)	0.87

Note *1: Calculation value
Note *2: Measurement value by Study team

b.5 Physical Composition of Ash

Physical composition of ash which was generated by the mixed combustion test was analyzed as shown in the table below.

Table 6-47: Physical Composition of Ash

			Mixed combustion test	
			RDF2% Mixture	RDF4% Mixture
Industrial chemical analysis	Moisture	(%)	0.7	0.5
	Combustible	(%)	11.2	10.7
	Non combustible (ash)	(%)	88.1	88.8

c. Evaluation of Analysis Data

c.1 Difference between the First and Second combustion test

c.1.1. Quality of RDF and Coal

- Lower calorific value (LCV) of RDF for the 2nd combustion test far less than the 1st due to combustion at the production stage.
- On the contrary, LCV of coal for the 2nd combustion test much higher than the 1st due to less moisture.

Table 6-48: Physical Composition of RDF (Comparison of both results)

Physical composition			RDF		Coal	
			1st test	2nd test	1st test	2nd test
Higher calorific value (HCV)		(kcal/kg)	5,820	3,320	3,875	4,700
Lower calorific value (LCV)		(kcal/kg)	5,290	3,200	2,470	3,680
Industrial chemical analysis	Moisture	(%)	8.3	0.9	31.3	19.2
	Combustible	(%)	86.0	74.9	59.9	61.2
	Non combustible (ash)	(%)	5.7	24.2	8.8	19.6
Apparent density*2		(ton/m^3)	0.41	0.43	0.86	0.87

Note *1: Measurement value by Study team

<Combustion RDF at the Production Stage>


Pod for Plastics Melting


Inside of Pod

c.1.2. Mixture Rate of RDF and Coal

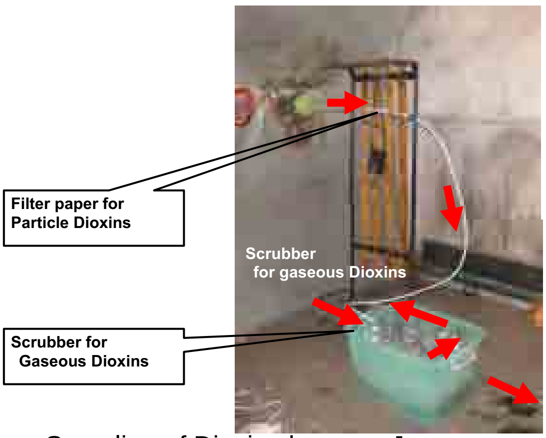
RDF mixture rate calculated from coal consumption was shown in the following table.

Table 6-49: Mixture Rate of RDF and Coal

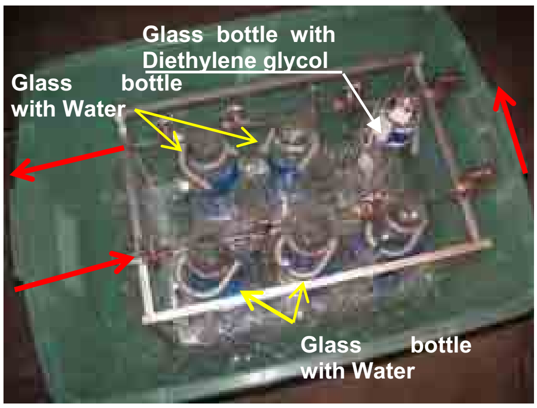
Target Mixture Rate	2.0 %	4.0 %
1st combustion test	2.3 %	5.7 %
2nd combustion test	2.5 %	4.6 %

c.1.3. Sampling of Dioxins

- The study team was worried about sampling of dioxins at the 1st combustion test.
- Sampling of Dioxins done by the Japanese Standard method.
- Gas suction instrument brought from Japan.
- Particle and gas dioxins were sampled in the 2nd combustion test.
- Dust, O_2 and CO were measured at the same time.



Sampling of Dioxins base on Japanese Standard (1)



Sampling of Dioxins base on Japanese Standard (2)
- Sampling for Gaseous Dioxins-

Sampling of Dioxins base on Japanese Standard (3)


Most of the sampling tools was brought from Japan for 2nd combustion test

c.1.4. Furnace Temperature

Temperature of Inside of Furnace was measured in the 2nd combustion test.

- Furnace temperature range between 644-855 °C.
- It did not create the dangerous temperature of dioxin generation (around 300 °C).
- Dioxins concentration of emission gas is under the standard.
- Japanese standard for waste incinerator sets higher temperature than 850 °C is preferable. Therefore, more stable temperature is preferable.

Table 6-50: Measured Furnace Temperature

	100% Coal	Coal + RDF (2%)	Coal + RDF (4%)
Number of Sampling	8	13	14
Average	727 °C	749 °C	744 °C
Maximum	769 °C	855 °C	819 °C
Minimum	690 °C	644 °C	650 °C


Thermocouple thermometer and Protection Cap (SUS316)


Installation of Thermometer

c.2 Evaluation

The table below shows the results of the comparison of the exhaust gas analysis data obtained by the 2nd mixed combustion test with Japanese and European emission standard.

The comparison table brings the following findings on the emission gas data:

c.2.1. Common

- Data obtained by 2nd combustion test is more than reliable because of gas suction instrument brought from Japan.

c.2.2. Dust

- No significant difference on measured values between 100% coal and RDF mixed combustion.
- The measured values far exceed the regulation value for the incinerator in Japan and EU.
- It is necessary to improve the dust precipitator of the furnace.

c.2.3. Sulfuric Oxide (SO_2)

- Measured value shows mixed combustion may improve emission gas on SO_2.
- The measured values exceed the EU emission standard.

c.2.4. Nitrogen Oxide (NOx)

- No significant difference on measured values between 100% coal and RDF mixed combustion.
- The measured values over the regulation value for the incinerator in EU.

c.2.5. Hydrogen Chloride (HCl)

- No significant difference on measured values between 100% coal and RDF mixed combustion.
- The emission gas satisfied the Japanese emission standard.

c.2.6. Dioxins

- Since concentration of dioxins for mixed combustion are 3.1 – 9.1 times more than it of 100% coal, RDF mixed combustion impacts on generation of dioxins.
- However, TEQ value of RDF mixed combustion, according to the calculation method of the Japanese and EU standard for a solid waste incinerator, is less than 0.1 ng, the strictest value of the Japanese and EU emission standard. It is below the regulation value set in the emission standards in Japan and EU for solid waste incinerators.
- The 2nd combustion test analyzed two state of dioxins in RDF 4% mixture test; i.e. of particle state and gaseous, which is commonly done in Japan. Based on the results, most of dioxins are in the particle state as follow.

  Particle state dioxins : 0.071 ng-TEQ/m^3N

  Gaseous dioxins : 0.00046 ng-TEQ/m^3N

- This indicates that good bag filter cound catch most of dioxins generated by the mixed combustion of RDF with coal.

Table 6-51: Comparison of Exhaust Gas Analysis Data with Japanese and European Emission Standard

Items	Limit value: Japan (Maximum)	Limit value: EU*4 (Daily average value)		Results of the 1st Mixed Combustion Test of RDF with Coal: 100% Coal	Coal + RDF (2%)	Coal + RDF (4%)	Results of the 2nd Mixed Combustion Test of RDF with Coal: 100% Coal	Coal + RDF (2%)	Coal + RDF (4%)	Unit
Total dust	40*1 mg/m^{3}N	10 mg/m^{3}N		315*5	431*5	380*5	11,800*5	7,300*5	5,400*5	mg/m^{3}N
Hydrogen chloride (HCl)	700 mg/m^{3}N	10 mg/m^{3}N		0.18*5	0.30*5	0.25*5	NA (HCl could not analyzed in Mongolia)			mg/m^{3}N
Sulphur dioxide (SO_2)	K value *2	50 mg/m^{3}N		255 (729) *3	137 (391) *3	117 (334) *3	209 (597) *3	333 (751) *3	110 (314) *3	ppm (mg/m^{3}N)
Nitrogen oxide (NO_x)	250 (513)*3 ppm mg/m^{3}N	200 mg/m^{3}N		336 (690) *3	324 (665) *3	326 (669) *3	186 (382) *3	136 (276) *3	135 (277) *3	ppm (mg/m^{3}N)
Standard percentage oxygen concentration	12 %	11 %		---	---	---	---	---	---	---
Dioxins	0.1 ng-TEQ /m^{3}N	0.1 ng-TEQ /m^{3}N	Japanese Standard*6	0.000008	0.000153	0.000172	0.0078	0.024	0.071	ng-TEQ /m^{3}N
			EU's Standard*7	0.000003	0.000154	0.000174	0.0075	0.020	0.070	ng-TEQ /m^{3}N

Note
*1: Incineration capacity is more than 4ton/hour.
*2: Japanese standard regulates maximum concentration of SO_2 at certain point (it differs place.) departed from an emission source. K value is regulated according to the location with the range of 17.5-3.0.
*3: Although unit of limit value is set in ppm, we convert it in (mg/m^{3}N) for comparison.
*4: "Implementation of European Council Directive 2000/76/EC on the Incineration of Waste (August 2002, Paper 2002/24)"
*5: The figure is converted supposing that the concentration of oxygen is 12%.
*6: Calculation value base on Japanese standard
*7: Calculation value base on EU's standard

c.2.7. Physical Composition of Coal and RDF

The physical composition of coal and RDF used for the combustion test is presented in the table below. The table shows:

- Low calorific value of RDF is 0.87 times less than it of coal. (1st combustion test :2.1 times)
- The moisture of coal was 19.2 %. (1st combustion test: 31.3)

Table 6-52: Physical Composition of Coal and RDF

Physical composition			RDF		Coal	
			1st test	2nd test	1st test	2nd test
Higher calorific value		(kcal/kg)	5,820	3,320*1	3,875	4,700*1
Lower calorific value		(kcal/kg)	5,290*1	3,200	2,470*1	3,680
Industrial chemical analysis	Moisture	(%)	8.3	0.9	31.3	19.2
	Combustible	(%)	86.0	74.9	59.9	61.2
	Ash	(%)	5.7	24.2	8.8	19.6
Apparent density*2			0.41	0.43	0.86	0.87

Note *1: Calculation value
*2: Measurement value by Study team

c.3 Operation Data of the Furnace used for Combustion Test

The operation data of the furnace used for combustion test are presented in the table below.

Table 6-53: Operation Data of the Furnace used for Combustion Test

	Total amount of network water*1	Total amount of network water coming out of furnace*1	Temperature of water going to user*!	Temperature of water coming from user*1	Amount of supplement water*!	Temperature of supplement water*1	Temperature of boiler effluent water*1	Temperature of heat exchanger effluent gas*1	Temperature of inside of furnace*2	Air temperature*2	Retention time of Fuel in the furnace*1	Feeding amount of the Coa*1	Feeding amount of the RDF*1
	ton	ton/h	^{0}C	^{0}C	t/h	^{0}C	^{0}C	^{0}C	^{0}C	^{0}C	min	ton/hour	ton/hour
100% Coal	443	235	58	43	17	17	72	245	727	8	49	3.4	-
Coal + RDF(2%	438	230	61	43	17	18	77	271	749	4	49	3.6	0.09
Coal + RDF(4%)	439	230	60	42	16	18	74	280	744	2	49	3.9	0.18

Note: *1 Number of Data : 44-48
*2 Number of Data : 8-14 (Day time only)

c.3.1. Examination of Material Balance and Heat Balance

(1) Material Balance Table

Based on the data obtained the combustion test material balance of the hot water supply system on each combustion test is calculated and shown in the table below.

Table 6-54: Material Balance of Hot Water Supply System

Items			unit	100% Coal	Mixed combustion test		Note
					RDF2% Mixture	RDF4% Mixture	
Return water	Qpr	Amount	m^3/hour	426	421	423	Calculated value = supply water – supplement water
	Tpr	Temp.	^{o}C	43	43	42	Actual value
Supplement water	Qa	Amount	m^3/hour	17	17	16	Actual value
	Ta	Temp.	^{o}C	17	18	18	Actual value
Inlet water	Qi	Amount	m^3/hour	235	230	230	Actual value
	Ti	Temp.	^{o}C	42	42	41	Calculated value
Boiler bypass	Qb	Amount	m^3/hour	208	208	209	Calculated value (=Return water + supplement water - Inlet water)

water	Tb	Temp.	°C	42	42	41	Calculated value
Outlet water	Qo	Amount	m^3/hour	235	230	230	Actual value
	To	Temp.	°C	72	77	74	Actual value
Supply water	Qps	Amount	m^3/hour	443	438	439	Actual value
	Tps	Temp.	°C	58	61	60	Actual value

(2) Material Balance Diagram

Based on the above table, a material balance diagram is prepared and shown in the figure below.

<100% Coal>

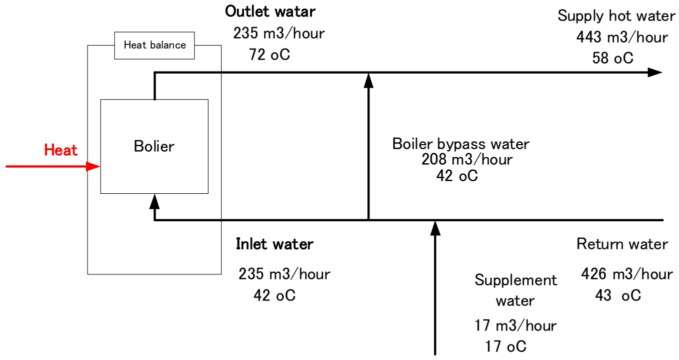


Figure 6-31: Material Balance Diagram of 100 % Coal Test

<Coal + RDF 2% Mixture>

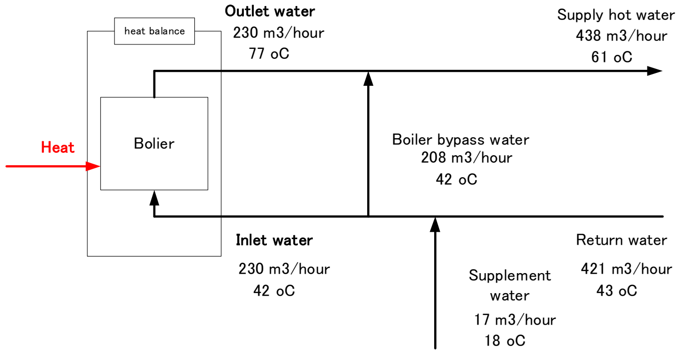


Figure 6-32: Material Balance Diagram of RDF 2% Mixture Test

< Coal + RDF 4% Mixture>

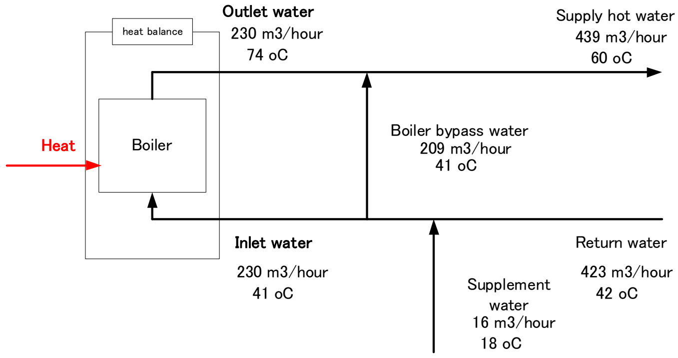


Figure 6-33: Material Balance Diagram of RDF 4% Mixture Test

(3) Heat Balance of Hot Water Supply System

- Heat Balance 1 (Return Hot Water System)

Heat balance of return hot water system is calculated as shown in the table below. The balance of heat in the table is made by the heat loss. Since the heat loss is small, i.e. only 0-0.3 % of heat input, the table indicates that we could rely on the data obtained regarding the amount or temperature of hot water measured in the supply system.

Table 6-55: Heat Balance 1 (Return Hot Water System)

Unit : 1,000 kcal/hour

		100% Coal	Mixed combustion test	
			RDF2% Mixture	RDF4% Mixture
Heat input	Calorific value of Return water	18,318	18,103	17,766
	Calorific value of Supplement water	289	306	288
	Total of heat input	18,607	18,409	18,054
Heat output	Calorific value of inlet water	9,870	9,660	9,430
	Calorific value of boiler bypass water	8,736	8,736	8,569
	heat loss (Balance)	1	13	55
	Total of heat output	18,607	18,409	18,054

- Heat Balance 2 (Boiler)

Heat balance of boiler system is calculated as shown in the table below. In the table the loss of heat output is assumed 0% of heat input. Heat balance 2 provides calorific value received by the boiler water as follows:

Total calorific value received by the boiler water = Total calorific value of Outlet water – Total calorific value of Inlet water

Based on the calorific value we can calculate boiler efficiency of each combustion test.

Table 6-56: Heat Balance 2 (Boiler)

Unit : 1,000 kcal/hour

		100% Coal	Mixed combustion test	
			RDF2% Mixture	RDF4% Mixture
Heat input	Calorific value of Inlet water	9,870	9,660	9,430
	Calorific value received by the boiler water	7,050	8,050	7,590
	Total of heat input	16,920	17,710	17,020
Heat output	Calorific value of outlet water	16,920	17,710	17,020
	heat loss	0	0	0
	Total of heat output	16,920	17,710	17,020

- Heat Balance 3 (Supply Hot Water System)

Heat balance of return hot water system is calculated as shown in the table below. The balance of heat in the table is made by the heat loss. Since the heat loss is small, i.e. only -0.1 – 2.9 % of heat input, the table indicates that we could rely on the data obtained regarding the amount or temperature of hot water measured in the supply system.

Table 6-57: Heat Balance 3 (Supply Hot Water System)

Unit : 1,000 kcal/hour

		100% Coal	Mixed combustion test	
			RDF2% Mixture	RDF4% Mixture
Heat input	Calorific value of Outlet water	16,920	17,710	17,020
	Calorific value of bypass water	8,736	8,736	8,569
	Total of heat input	25,656	26,446	25,589
Heat output	Calorific value of Supply hot water	25,694	26,718	26,340
	heat loss (Balance)	-38	-272	-751
	Total of heat output	25,656	26,446	25,589

c.3.2. Evaluation of Heat Balance Results

<Boiler Efficiency>

The boiler efficiency is calculated by the following formula.

Boiler efficiency = (Total calorific value of Outlet water – Total calorific value of Inlet water) / (Total calorific value of Fuel)

The results of calculation of boiler efficiency are shown in the following table.

Table 6-58: **Boiler Efficiency of the Combustion Test**

	100% Coal	Mixed combustion test	
		RDF2% Mixture	RDF4% Mixture
1st combustion test	41.3 %	53.3 %	67.0 %
2nd combustion test	56.3 %	59.5 %	50.8 %

- If the calorific value of RDF is higher than coal, mixed combustion of RDF with coal improve efficiency of boiler.
  => The calorific value of RDF (3,200 kcal/kg) used for the 2nd combustion test is lower than coal (3,680 kcal/kg) due to combustion when produced.
  => If RDF made by compaction method calorific value is much higher than it, i.e. more than 5,000 kcal/kg.
- It should be examined carefully whether increase of mixture rate of RDF may cause decease of efficiency or not.

6.4 Recycle Pilot Project: Movable Recyclable Collection System "Chirigami Kokan"

6.4.1 Project Outline

a. Justification

The percentage of recyclables in the waste discharged in the planned area is very high, more than 40% of the total waste, and this percentage has fallen in the average range of recyclable contents in developed countries. However, the activities to recover recyclable materials from waste at generation sources are not very active. It has resulted in the existence of many waste pickers not only in the disposal site but also in the town. Waste pickers at the disposal site have made the sanitary landfill operation difficult and they suffer from health risks under the unsanitary and dangerous working conditions. Waste pickers in the town scatter waste when they sort recyclables from the waste discharged. Therefore, the necessity of the establishment of a more systematic resource recovery system has been increasing.

One of the public opinion survey results is that one of the main causes of inactive separation of recyclables at generation sources is due to non existence of a convenient recovery system provided for residents. The existing method of recovery at generation sources is only through the buy back stations, which often use containers or rented rooms in apartment buildings as shops to buy recyclables. However, the buy back station system is not so convenient for common residents because it focuses on buying recyclables from waste pickers. This is the main reason why the present resource recovery rate is not high enough and the quality of recovered material is not so high.

In order to enhance the resource recovery activities at the generation sources, the most effective way is to provide residents with convenient access to the resource recovery route. The draft M/P, therefore, has proposed a few recyclable collection systems including "Chirigami Kokan" system which used to work in the whole country of Japan. In Chirigami Kokan system, which is a movable collection system of recyclables, the collector sometimes comes to residential and commercial areas and swaps recyclables from residents for toilet paper. The pilot project aims for the demonstration of this system in the planned area and examines its viability.

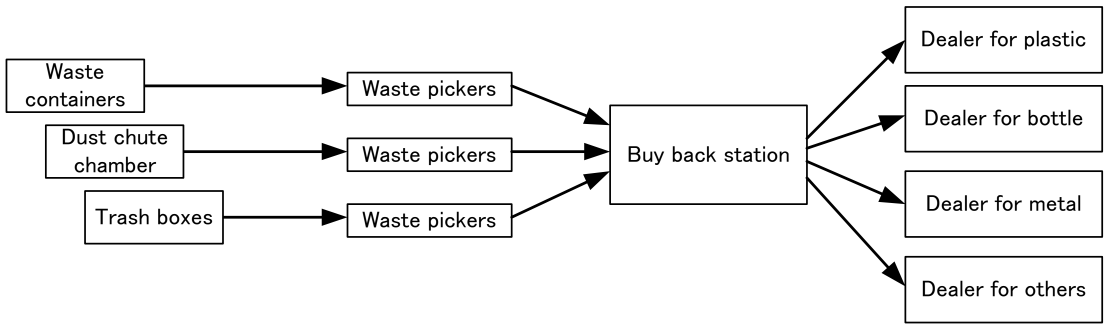
b. Project Design

b.1 Recyclable Stream Design

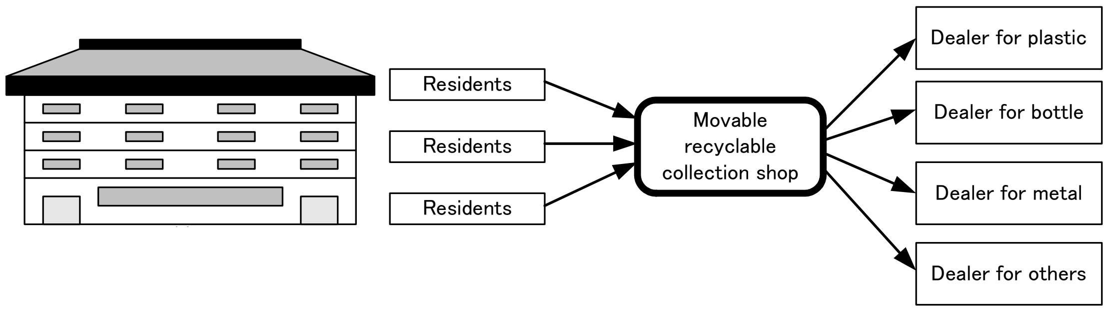
The present recyclable stream and the recyclable stream by the movable recyclable collection system are shown below. These figures show that the role of the buy back station is very similar to that of the movable recyclable collection truck.

The Chirigami Kokan system supplements the present recyclable stream by involving residents in recycling activities without replacing the present recyclable stream. Even though the Chirigami Kokan system is introduced, there will surely still be many people who will do the same without utilizing the Chirigami Kokan system. Therefore, the waste pickers' jobs will not be seriously affected by it.

Present Recyclable Stream



Recyclable Stream by Chirigami Kokan System



b.2 Project Site

Based on the site selection criteria, that the project site shall have a typical social feature in the study area, Khoroo 13 and 14 in Bayangol duureg were selected as the project sites. 1 week after the project started, Khoroo 12 was additionally included because the collection amount of recyclables in Khoroo 13 and 14 was too little.

Table 6-1: Social Data of Project Sites

Name of Khoroo	No. of Population*	No. of Households**	No. of Housing associations
12	10,649	2,200	4
13	6,125	968	4
14	5,902	1,083	10
Total	22,676	4,251	18

Sources: * Statistic Handbook for Ulaanbaatar, ** Interview from housing associations

100% of the project area is the planned area and 100% of residents live in apartment buildings which were developed in the 1970s. All of the target apartment buildings are equipped with a dust chute system as the waste discharge and storage system which tends to discourage residents awareness of the waste issue.

b.3 Measures to Improve the Project Sustainability

Although the continuity and sustainability of the project is not a main purpose and it is the demonstration and examination of the viability of the system, the following attentions were paid to improve the sustainability because the sustainability of the project is one of the most significant indexes of the project viability.

a) The buy back station operators have the highest potential to execute the Chirigami Kokan recycle system in future because their business style is the closest to the Chirigami Kokan recycle system. Therefore, one of the buy back station operators, UNDRAGA-OD, was selected as an executing body.

b) The Study team provides the executing body with only the use of a truck and goods to be swapped for recyclables and technical assistance without paying them any money. The Study team provided UNDRAGA with only 6000 goods for swapping, and UNDRAGA was obliged to buy more goods from their income to be gained from sale of recovered recyclables.

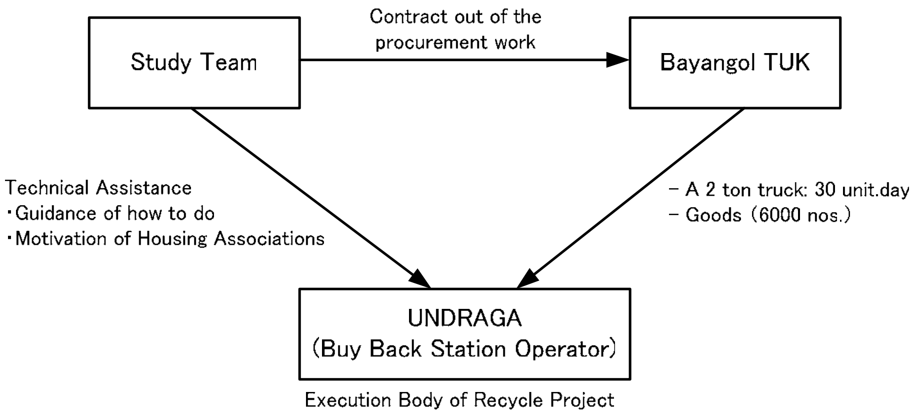


Figure 6-1: Relationship of Relevant Organizations for Implementation

c) UNDRAGA is able to learn how to do the system through the implementation of the project and examine the viability of the project. If they judge the viability of the project, they may continue by their own finance.

The Study team will examine the viability by using data obtained from UNDRAGA such as number of customers, the amount of resource recovered, and the amount of goods swapped for recyclables.

b.4 Promotion of Public Participation

According to the public opinion survey, the majority of residents cannot cooperate for recycling activities due to the lack of a convenient system, although they want to cooperate.

In fact, in some areas, waste pickers visit each household to collect recyclables. However, their methods of doing so are quite rude, such as disturbing residents by terribly knocking the door and giving a nuisance and unsafe feeling to the residents by wearing dirty clothes.

Besides, there are quite considerable numbers of buy back stations existing in the planned area. However, they are mentally uncomfortable and inconvenient for residents to use due to targeting waste pickers and poor people.

Therefore, the following attention was paid to facilitate residents to participate in the recycle activity.

1) Shortening the residents' hauling distance of waste by employing a mobile shop.

2) Protecting the residents' pride by differentiating residents from waste pickers by the introduction of swapping recyclables for goods instead of money.

3) Strengthening the residents' satisfaction for the cooperation with environmental protection by attaching a message card stating "Thank you for your contribution to environmental protection".

4) Playing comfortable music to inform residents of its arrival in spite of annoying residents.

5) Providing the executing body with the authorization of MUB so that residents can access without any worries.

6) No staff from the execution body enter the door and a lady carries out the operation so that residents are able to access comfortably.

7) Various options for swapping goods were prepared to meet people's different preferences. For example, toilet paper, toilet soap, laundry soap, kitchen gloves, kitchen sponges, pocket tissue paper, tooth brushes, shampoo, etc.

b.5 Public Education

1) There is no Mongolian word meaning "Recycle" and the foreign word "Recycle" is not known by people. What people can do in recycle activities is to sort recyclables from waste and separately discharge them. What people do in the Chirigami Kokan system is the same as the recycle activity to be done by people. Therefore, the project was named as "Recycle Project" in order to spread th e word "Recycle" to many people.

2) Within the project site, there are 22,600 residents and 18 housing associations. Housing associations employ guards who are responsible for the maintenance of public space such as stairs. The Study team, therefore, asked housing associations to distribute leaflets to all households by the guards.

3) People's participation to Recycle Project will gradually enhance their consciousness of environmental protection.

b.6 Roles of relevant organizations involved

- MUB: Responsible organization
- JICA: Sponsor. Planning. Technical support.
- Bayangol TUK: Provision of necessary equipment and materials
- UNDRAGA-OD LLC: Operator of the Recycle Project

b.7 PDMo

The project design matrix original (PDMo) is shown in the following page.

Project Design Matrix: PDMo

Name of Project: Recycle Project
Implementation Period : From Oct, 2005 to Jan. 2006.
Target Group: Seven TUKs

Prepared in Sep. 2005

Narrative Summary	Objectively Verifiable Indicators	Means of Verification	Important Assumptions
Overall Goals 1. The ways of private recyclable activities become diverse. (Citizens get many choices to participate in recycle.)		Recycle condition survey	
2. Residents' environmental awareness is enhanced.	Change of residents' attitude	Interview survey	
3. The collection amount of recyclables at generation sources increase.	The number of people who sort recyclables at home increase.	Recycle condition survey	
Project Purposes 1. The recyclable dealer learns the Chirigami kokan recycle method.	The number of assistances given by the Study Team.	Study team's record	
2. MUB staff understand the method.	Depth of understanding	Observation	
3. The applicability of the method to UB is examined.	Analysis result of actual implementation data	Recycle record sheets to be filled in by the operator	
4. Residents understand the importance of recycle.	Knowledge of the word "Recycle"	Interview survey	
Outputs 1. The Chirigami kokan recycle system is introduced.	The number of operation	Recycle record sheets	
2. Residents participate in the recycle.	The number of participants	Recycle record sheets	
3. The information of the actual collection amount of recyclables and the resource input data is obtained.	Collection rate of the actual recyclable collection data	Recycle record sheets	
Activities 1. Leaflets to residents are prepared. 2. Leaflets are distributed to residents. 3. The truck is arranged. 4. Goods to be swapped for recyclables are procured. 5. Gratitude message cards are prepared. 6. Recyclables are collected.	**Input** **Study Team** **Human Resource** • Expert **Equipment and materials** • A truck 24 unit/days • Goods to be swapped 6,000nos. • Leaflets 5,000sheets • Message cards 20,000cards	**MUB** **Human Resource** • Staff	**Pre-condition**

b.8 Procedure of Recycle Project

1) The leaflets to explain Recycle Project were distributed to target households.
2) UNDRAGA-OD LLC went around in the project site and swapped recyclable material for toilet paper to collect recyclable materials.
3) UNDRAGA-OD LLC sold recyclable materials.
4) UNDRAGA-OD LLC procured goods for swapping by using a part of income from selling recyclable materials.
5) UNDRAGA-OD LLC carried out Recycle Project operation every Wednesday and Sunday for 12 weeks.
6) The contractor shall prepare the financial report based on the information given by UNDRAGA-OD LLC. The report shall include the following data.

- Amounts of recyclable materials collected by item
- All expenditure spent by UNDRAGA-OD LLC.
- Number of materials UNDRAGA-OD LLC gave to residents during the project period.
- Etc.

b.9 Input by the Study Team

The Study Team provided the following resources.

No.	Description	unit	Quantity
1	Provision of a truck with a driver and fuel. The truck is equipped with a speaker system. • Preparation for 6 days and Operation for 24 days	days	30
2	Procurement of goods for swapping.	Nos.	6,000
3	Leaflets introducing Recycle Project	Nos.	5,000
4	Gratitude message cards	Nos.	20,000
5	Gratitude message sheet for toilet paper	set	1

Breakdown of the goods procured are as follows.

Items	Quantity	Unit Price	Amount (Tg)
Kitchen gloves	100	350	35,000
Cup & dish washer	30	350	10,500
Laundry soap (OK)	1,026	180	184,680
Kitchen sponge	100	120	12,000
Kitchen sponge (small)	200	80	16,000
OK detergent powder	80	70	5,600
Pocket tissue paper	110	110	12,100
Tooth paste (Jagar)	12	250	3,000
Tooth brush	40	120	4,800
Table napkin	50	100	5,000
Shampoo for single use	48	75	3,600
Shampoo for single use	108	70	7,560
Toilet paper (Locally made with used paper)	2,000	150	300,000
Toilet soap (GIV)	2,000	150	300,000
Total	5,904	-	899,840

b.10 Information materials used

A leaflet introducing Recycle Project

This leaflet was distributed all households, about 4300, in the project site.

9 September 2005

NOTICE FOR THE CHIRIGAMI KOKAN PROJECT

The project responsible organizations:

Responsible Organization:	MUB
Executing Agency:	Bayangol TUK
Sponsor:	JICA

Please cooperate for the improvement of the environment in Mongolia!

Please give us your used plastic pet bottles, glass bottles, aluminum cans, metal, etc. In return for them, we will give you toilet papers. These items are garbage if you throwaway. However, if you give us them, they will be utilized as resources for producing new goods. You can help not only to make the city clean but also to preserve the natural resources.

Let's improve the environment in Mongolia with your cooperation!

How you can cooperate with us!

1. The truck with playing music will come to near your apartment once or twice a week from October until December. Please accumulate your materials and bring your materials to the truck when it comes.

2. The required material amounts for a roll of toilet paper are shown below.
   - Plastic pet bottle (20 pieces)
   - Glass bottle
   - Other type of plastic waste
3. If your materials in mixed conditions exceeds the required amount for a toilet paper as a whole, it is OK for a toilet paper.
4. Also you may swap recyclables soap, shampoo, etc.
5. If you have large amount of recyclable materials other than the above mentioned items, please freely consult with us by the following telephone number (91613288).

c. Pictures during the Operation

Banners showing "Recycle Project" are fixed on both side plates and the roof so that people in Apartment can easily find it.
It plays music and announce for informing of its arrival to residents

Residents brought recyclables.

Recyclables can be swapped with various things. Their prices range from 70 to 180Tg

She swapped recyclables for toilet paper roll.

Toilet paper covers gratitude the customer for their contribution to the better environment.

Toilet soap is swapped for recyclables with a gratitude message.

d. Analysis of Implementation Records

d.1 Implementation period

The operation started on 2nd Oct. 2005 and was basically executed every Wednesday and Sunday except for a few weeks which could not be executed due to the truck problem mentioned previously. The period of non operation was between 24 Nov. and 13 Dec. The operation records until the 22nd operation are summarized below.

d.2 Type of truck

The type of truck used for the operation was a 2 ton open truck. However, in order to prevent the work from the cold weather, the carrier cover was fabricated. In addition, the speaker system was equipped with the truck in order to play music.

d.3 Number of Recyclables Collected

Mainly plastic pet bottles and glass bottles were collected. The glass bottles collected were only those which can be bought back by manufacturers of beverage such as beer bottles and vodka bottles; other bottles such as wine bottles and various bottles for whisky and cosmetics were not collected.

As for cans regardless of whether they are made of aluminum or metal, they were not collected because there was no local recyclable market available. This was caused by the present legal arrangement to prohibit the export of these materials.

The number of items collected during the 22 times operation was as follows.

Plastic pet bottles:	12,555 nos.
Glass bottles:	4,277 nos.
Can:	7 nos.

Figure 6-2 showing the number of recyclables collected per day found the following.

- Khuch Chadliin Us" Co., Ltd producing mineral water telephoned UNSRAGA and swapped more than 2000 plastic pet bottles for goods twice.
- The number of plastic pet bottle collected is more than that of glass bottles.

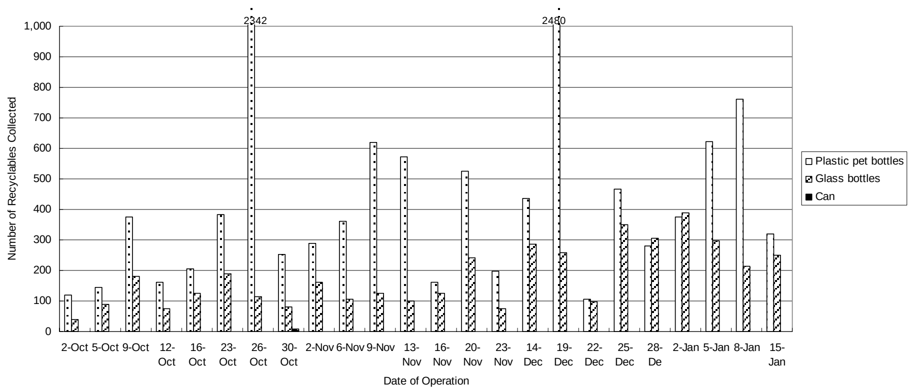


Figure 6-2: Number of Recyclables Collected Per Day

Figure 6-3 showing the total number of recyclables collected per day found the following.

- The number of recyclables collected per day in Dec. was around 750, while it was only around 300 in Oct.
- The number of recyclables collected is gradually increasing despite the colder weather. This fact implies that more people are getting familiar with the Recycle project and are participating in it.

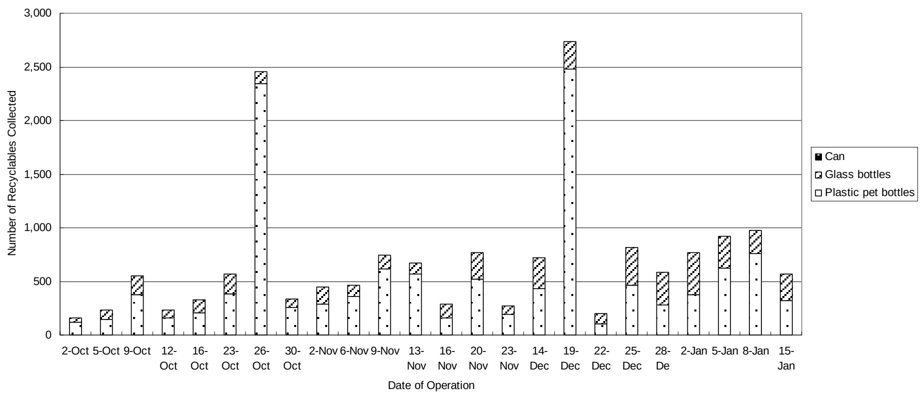


Figure 6-3: Total Number of Recyclables Collected Per Day

The total number of customers coming for 24 days' operation between 2nd Oct, 2005 and 5th Jan. 2006 was 621 people. Assuming every customer came once, the percentage of customers to the total household was 15%.

Around 35 to 50 customers came per day in Dec. and Jan. This number is equivalent to around 1% of the target households and it is increasing gradually despite the colder weather.

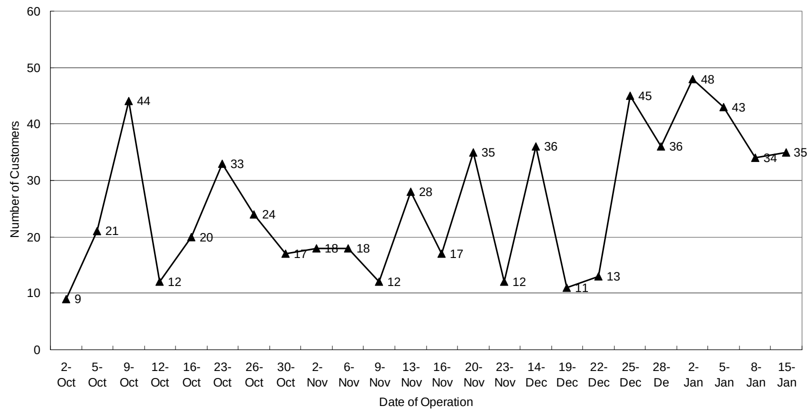


Figure 6-4: Number of Customers per Day

Figure 6-5 showing the accumulated quantity of goods swapped for recyclables found that laundry soap, toilet paper and toilet soap are the most preferred goods for swapping by people.

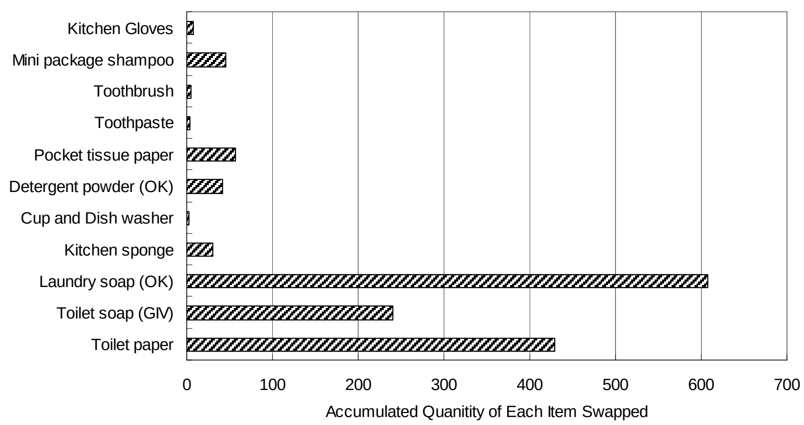


Figure 6-5: Accumulated Quantity of Goods Swapped for Recyclables

Comparing the collection efficiencies by collection days, Wednesday and Sunday, the collection quantity on Sunday was about 20% more than that on Wednesday.

e. Result of Interview Surveys

Various stakeholders' opinions to the project were interviewed.

e.1 Interview Survey to Housing Associations

		Total	%
Q1	Do you know that the Recycle Project was carried out?		
	I know.	15	88%
	I don't know.	2	12%
Q2	Did you see any impacts by the Recycle Project?		
	Yes	6	40%
	None	9	60%
Q2a	Comments		
	Residents highly support the project.	4	
	There is a conflict with the entrance keepers because they collect recyclables as well.	6	
	Entrance keepers highly support the project.	1	
	Residents are in trouble for cooperating because they don't know when the truck comes.	1	
	We strongly support the project.	1	
Q3	Do you think it is necessary to do the collection activity of recyclables by the private sector?		
	Very necessary	12	71%
	Unnecessary	1	6%
	I don't know	2	12%
	It doesn't matter. It is important for it to be collected t.	2	12%
Q4	Do you think the Housing Association can cooperate with the Recycle activity？		
	Yes	15	88%
	No	2	12%
	Don't know	0	0%
Q5	Any ideas for cooperation		
	We can cooperate for education of residents.	7	
Q6	Who should promote?		
	MUB	2	10%
	MoE	3	15%
	Duureg	3	15%
	TUK	7	35%
	NGO	0	0%
	Khoroo	1	5%
	Others	0	0%
	Unnecessary	4	20%
Q7	Did the project work to teach citizens the word "Recycle"?		
	Yes	1	6%
	No	9	53%
	I don't know	7	41%
Q8	Did the project work to teach citizens the importance of environmental protection?		
	Yes	4	24%
	No	6	35%
	I don't know	7	41%
Q9	Do you support the swapping of goods instead of money		
	Goods are OK	9	53%
	Money is better	6	35%
	It should suit people's preference.	2	12%
Q10	Do you think the project should continue?		
	It should continue.	17	100%
	It should stop.	0	0%
Q11	Suggestions		
	Plastic bags and paper should be collected.	5	
	Various types of bottles should be collected.	3	
	The recycle project should be done in Ger as well.	2	
	The project should cooperate with entrance keepers.	6	
	Educate residents of the separate discharge.	7	
	Saturday and Sunday are suitable for the project.	1	
	If weekday, the evening is suitable.	1	
	Fix the collection schedule.	1	
	Expand the project area.	1	
	More precise separate discharge should be done.	1	

e.2 Interview to MUB

1) MUB staff ha learnt the way of the Chirigami kokan recycle and has realized the necessity of the recycle activity carried out by the private sector.

2) MUB expects to improve the way and continue with JICA's assistance until the Chirigami kokan recycle activity will take off.

3) The general Manager of MUB appreciates the recycle project very much and strongly expects to continue and even expand the Chirigami kokan recycle project.

4) MUB explained the following impacts they have found during the project.

- In the governor meeting in Khan Uul held on 9th Jan. 2006, some of governors who knew the recycle project in Bayangol strongly request MUB to execute the Chirigami kokan recycle project in Khan Uul as well.

- Residents and housing associations in Khoroo No. 1, 2, and 3 in Chingeltei Duureg request MUB to execute the Chirigami kokan recycle project.
- Many residents in the current project site request the education to residents and fixing of the Chirigami kokan truck schedule.

5) MUB has realized that MUB should promote the private sector to do these kind of recycle activities, while they were opposed to that before the project started. As for the assistance method, MUB understands that it provides them with only technical assistance such as guidance of the method.
6) MUB has realized that the Chirigami kokan recycle project has environmental education effect to residents.
7) MUB has proposed the following two improvement measures.
8) To fix the collection schedule and inform it to the residents in advance.
9) To do it on Saturday and Sunday rather than weekdays.

e.3 Interview to UNDRAGA

1) UNDRAGA staff has learnt the way of the Chirigami kokan recycling.
2) UNDRAGA has realized the possibility of success of the project if the method is sufficiently improved.
3) UNDRAGA expect to do it by themselves without any assistance, however they understand the necessity of the assistance for several more months until more residents participate in the recycling.
4) UNDRAGA understand that the project teaches citizens the meaning of recycling and the importance of environmental protection.
5) UNDRAGA has found the following impacts by the project.
   - Residents very much appreciate this project, especially the point of swapping waste for useful things.
   - The number of residents sorting and keep recyclables at home for swapping is increasing because the recyclable waste in dust chute chambers decreased very much.
   - Waste pickers collecting recyclables in the project site complain to UNDRAGA for doing the project due to the decrease of the recyclables available for them. However, their resistance to them is not very active.
   - Housing associations and entrance keepers in particular are generally not cooperative with the project. They ignored the distribution of the leaflets for the project to the residents.

6.4.2 Interim Evaluation

a. Monitoring and Evaluation

The condition of the project as of 15th January 2006 was evaluated in terms of Relevance, Effectiveness, Efficiency, Impact and Sustainability.

Table 6-2: Evaluation Summary

<table>
<tr><th></th><th colspan="2">Relevance</th><th colspan="2">Effectiveness</th><th colspan="2">Efficiency</th><th colspan="2">Impact</th><th colspan="2">Sustainability</th></tr>
<tr><td>Overall Goal</td><td rowspan="2">▪ One of Japan's priority cooperation issues to Mongolia is the environmental protection
▪ The objective of SWM M/P is the environmental protection and the priority is 3 Rs.
▪ The waste minimization is one of the priority issues for both Mongolian government and MUB.</td><td rowspan="2">+
+
+</td><td></td><td></td><td></td><td></td><td rowspan="2">▪ Waste pickers in the site complained to UNDRAGA.
▪ Entrance keepers are generally not cooperative with the project because it disturbs their collection.
▪ The mineral water company periodically swapped thousands of plastic bottles.
▪ In the governor meeting in Khan Uul, some of governors requested MUB to execute the Chirigami kokan recycle project in Khan Uul.
▪ Residents and housing associations in Khoroo No. 1, 2, and 3 in Chingeltei Duureg request MUB to execute the Chirigami kokan recycle project.
▪ When the project ceased due to the truck problems, many people inquired to the operator.</td><td rowspan="2">+
+
+
+</td><td rowspan="4">▪ The project doesn't aim at sustainability and aims to judge the project sustainability.
▪ The number of customers and collection amount are increasing despite the colder weather.
▪ The collection amount of recyclables is not enough to make the project financially feasible.</td><td rowspan="4">+</td></tr>
<tr><td>Project Purpose</td><td rowspan="2">▪ The recyclable dealer has learnt the method.
▪ MUB staff understand the method.
▪ The data of the 24 times operation were obtained.
▪ Few people understood the word "Recycle".</td><td rowspan="2">+
-
+
-</td><td></td><td></td></tr>
<tr><td>Outputs</td><td></td><td></td><td rowspan="2">▪ The truck was fully used.
▪ About 2000 out of 6000 goods were swapped for recyclables.
▪ Most leaflets have been distributed.
▪ 1500 out of 20,000 message cards were distributed.</td><td rowspan="2">+
-
+
-</td><td></td><td></td></tr>
<tr><td>Activities</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

Table 6-3: Overall Evaluations

Criterion	Result	Basis	Justification for Basis
Relevance	Very high	▪ One of Japan's priority cooperation issues to Mongolia is environmental protection ▪ The objective of SWM M/P is environmental protection and the priority is 3 Rs. ▪ The waste minimization is one of the priority issues for both Mongolian government and MUB.	▪ Environmental protection is the priority issue for all stakeholders. The project aims to study the new method to minimize waste and therefore directly contribute to environmental protection.
Effectiveness	Progressing	▪ The recyclable dealer has learnt the Chirigami kokan recycle method and MUB staff understood the method. ▪ The data of the 24 times operation were obtained. ▪ Few people understood the word "Recycle".	▪ The project has generally achieved its purposes except the education of the word "Recycle" and the judging project viability. ▪ In order to judge the project viability, the project should be continued for several more months. ▪ In order to achieve environmental education, its activity should be strengthened.
Efficiency	High	▪ The truck was fully used. ▪ Most leaflets have been distributed. ▪ About 2,000 out of 6,000 goods were swapped for recyclables and 1,500 out of 20,000 message cards were distributed.	▪ The truck and leaflets have been fully utilized while many goods for swapping and message cards are still remaining due to fewer customers than expected.
Impacts	Various impacts	▪ Waste pickers in the site complained to UNDRAGA. ▪ Entrance keepers are generally not cooperative to the project because it disturbs their collection. ▪ The mineral water company periodically swapped thousands of plastic bottles. ▪ In the governor meeting in Khan Uul, some of the governors requested MUB to execute the Chirigami kokan recycle project in Khan Uul. ▪ Residents and housing associations in Khoroo No. 1, 2, and 3 in Chingeltei Duureg request MUB to execute the Chirigami kokan recycle project. ▪ When the project ceased due to the truck problems, many people inquired to UNDRAGA.	▪ All impacts except the conflicts with waste pickers and entrance keepers were positive impacts. ▪ The conflict with waste pickers should be carefully observed. ▪ The conflict with entrance keepers seem to be not serious because it can be expected that the Chirigami kokan recycle project has changed not so many residents' attitudes.
Sustainability	Very high	▪ The project doesn't aim at sustainability and aims to judge the project sustainability. ▪ The number of customers and the collection amount are increasing despite the colder weather. ▪ The collection amount of recyclables is not enough to make the project financially feasible.	▪ The project is strongly supported by most of stakeholders. However the introduction of the new recycle system leads the change of people's lifestyles and it takes some time to change these. It won't get enough cooperation from people until the system is rooted into their lifestyle. The peoples' participation has not achieved a sufficient level yet, but it is gradually increasing. In order to judge the project viability, it should be continued.

b. Lessons and Recommendations

b.1 Results

Most of the stakeholders such as residents, housing associations, MUB and the project operators appreciate the project very much and they strongly support to carry on the project with assistance. The method of swapping recyclable waste for goods instead of money, which is the first experience in Mongolia, is appreciated especially by middle income people. Middle and high income people who tend to feel humiliated for going to the recycle shop for money can participate in the Chirigami kokan recycle without feeling any remorse

Through the implementation, we found the present Chirigami kokan recycle system associated with the following problems.

- Residents` cannot notice the arrival of the Recycle truck even though music is playing loudly because the apartments are too large.
- It takes many minutes for residents to bring the recyclables from their homes because of the large apartment buildings and very cold weather.
- Very hard work for recycle dealers due to the coldness.

Considering the abovementioned problems, it is concluded that the Chirigami kokan recycle method used in Japan is not suitable for the society in Ulaanbaatar as it is. However, it is expected that the efficiency of the applicability of the system can be greatly improved by modifying some parts of the method.

The number of customers and the collection amount of recyclable waste is gradually increasing even though it is getting colder. It proves that the system is generally supported by residents and people are getting familiar with the system. It will take some more months for the system to become rooted into the society.

b.2 Recommendation

The project system and the implementation of the project are appreciated and supported by most stakeholders and the achievement is gradually increasing. The implementation of the project has made many stakeholders understand the Chirigami kokan recycle system and achieved the certain purposes, however there are still some original purposes which have not been achieved remained. Therefore, the project is recommended as follows.

a) The system should be modified to rectify the current problems identified.

b) The project should be continued.

c) The project area should be expanded.

d) The assistance to the project should be gradually decreased to make it sustainable.

e) The education of recycling should be executed at the same time.

b.3 Lessons Learnt

The implementation of the project has found the following lessons.

a) There are many people who want to swap recyclables for goods rather than money.

b) It is difficult to inform residents of the truck arrival only by playing music loudly and it takes many minutes for residents to bring recyclables to the truck due to the large apartment buildings and very cold weather. In order to minimize these problems, the collection schedule should be fixed and informed to residents in advance.

c) The collection efficiency of the operation on Sunday was higher than that on Wednesday by 20%. The weekend is more suitable for collection days.

d) Some people admit the project involves the education effect for environmental education, especially recycling. The project and education of recycling should be executed at the same time in order to improve the project achievement and .to educate people effectively.

e) The target area for a two ton truck should have a population of more than 20,000 .

f) In order to make the project sustainable, the pilot implementation for 3 months is insufficient because it takes more time for people to get familiar with the system and to adjust their lifestyle to the system.

b.4 PDM

Taking the recommendation into account, the PDMe of the pilot project for the Phase 3 was formulated as follows.

Project Design Matrix: PDMe

Name of Project: Recycle Project
Implementation Period： From Oct, 2005 to Mar. 2006. Twice a week. Total 24 days.
Target Group: Residents in Khoroo 12, 13, 14, 15, 17, 19 in Bayangol and Recycle dealer

Prepared in Feb. 2006

Narrative Summary	Objectively Verifiable Indicators	Means of Verification	Important Assumptions
Overall Goals 1. The ways of private recyclable activities becomes diverse. (Citizens get many choices to participate in recycle.)		Recycle condition survey	
2. Residents' environmental awareness is enhanced.	Change of residents' attitude	Interview survey	
3. The collection amount of recyclables at generation sources increase.	The number of people who sort recyclables at home increase.	Recycle condition survey	
Project Purposes 1. The recyclable dealer learns the Chirigami kokan recycle method.	The number of assistances given by the Study Team.	Study team's record	
2. MUB staff understands the method.	Depth of understanding	Observation	
3. The applicability of the method to UB is examined.	Analysis result of actual implementation data	Recycle record sheets to be filled in by the operator	
4. Residents learn the importance of recycling.	Knowledge of the word "Recycle"	Interview survey	
Outputs 1. The Chirigami kokan recycle system is expanded.	The number of operation	Recycle record sheets	
2. More residents participate in the recycle.	The number of participants	Recycle record sheets	
3. The information of the actual collection amount of recyclables and the resource input data is obtained.	Collection rate of the actual recyclable collection data	Recycle record sheets	
Activities 1. New target khoroos are selected. 2. Collection schedule is decided. 3. Leaflets to residents are prepared. 4. Leaflets are distributed to residents in all target Khoroos. 5. Chirigami kokan recycle is carried out in all target Khoroos.	**Input** **Study Team** **Human Resource** • Expert **Equipment and materials** • Provision of gasoline for a truck for doing Chirigami kokan operation. • Leaflets 10,000sheets	**MUB** **Human Resource** • Staff	**Pre-condition**

6.4.3 The 2nd Stage of the Project

a. Project Results

The project which started on 2nd Oct. 2005 finally stopped on 5th March 2006. The project implementation period could be divided into the following two stages in terms of the type of assistance by the Study Team.

- 1st stage, from 2nd Oct. 2006 until 15th Jan. 2006: The Study Team provided UNDRAGA with a truck including a driver and petrol required for the operation and the specified number of goods to be swapped with recyclables.
- 2nd stage, after 15th Jan. 2006: The Study Team provided UNDRAGA for only petrol required for the operation.

UNDRAGA stopped the operation due to the following reasons when all members of the Study Team were out of Mongolia.

- The only truck owned by UNDRAGA which was used for the Chirigami Kokan operation was broken down due to the traffic accident. It has not been repaired yet as of August 2006.
- The female manager of UNDRAGA who has been fully responsible for the operation got pregnant and her substitute could not be arranged.
- She judged the operation was not profitable due to the following reasons.
  - Maintenance cost of a truck including the rental of warm garage amounting more than 60,000 Tg. monthly is too expensive.
  - Boost of the gasoline price.
  - Lack of cooperation by residents in the khoroo15, 17 and 19 where the project extended in January 2006.

She summarized the lessons learnt through the implementation of the project as follows.

- Common residents very much appreciate the method of swapping recyclable for goods instead of money. This was supported by some residents' active participation to the project.
- Common residents appreciate the system that the truck comes near there homes to collect recyclables. It makes them convenient and comfortable to participate in the recycle.
- The system seems unprofitable due to especially the expensive required cost for the operation of a truck.
- To make the project success, the residents have to change their way of life and it takes for a few months. Therefore, the education to residents and the financial assistance for a initial few months are necessary.

The lessons learnt through the implementation of the project can be summarized as follows.

- Common residents more prefer the method of swapping recyclable for goods rather than for money while poor people prefer money. Swapping for goods makes them comfortable to participate in the recycle and the gratitude card attached with goods expressing "thanks for your cooperation to the environmental protection" encourages them for the participation.
- The movable system is inappropriate for the planned area, especially for high rise apartments because they need some time to carry recyclable down to the truck due to

wearing warm clothes and taking a lift, etc. The truck often has gone when they came down with recyclable to the truck.

- The using a truck makes the recyclable collection financially infeasible. The using a kiosk shop may be more feasible and convenient for residents in the developed area.
- In order to promote common residents to do the separation of recyclables for private recycle route, the environmental education should be given to the residents by the governmental organization such as MUB.

b. Implementation Records

b.1 Implementation period

Stage	Period	Project Khoroo	Operation Days
Stage 1	2nd Oct. 2005 till 5th Jan. 2006	12, 13, 14	Wednesday and Sunday
Stage 2	5th Jan. 2006 till 5th Mar. 06	12, 13, 14, 15, 17, 19	Saturday and Sunday

b.2 Type of truck

The type of truck used for the operation was 2 ton open truck. However, in order to prevent the work from the cold weather, the carrier cover was fabricated. In addition, the speaker system was equipped with the truck to play music.

b.3 Number of Recyclables Collected

Plastic pet bottles and glass bottles were mainly collected. Glass bottles collected were only those which can be bought back by manufacturers of beverage such as beer bottles and vodka bottles; and other bottles such as wine bottles and various bottles for whisky and cosmetics were not collected.

As for cans whichever they are made of aluminum or metal, they were not collected because of no local recyclable market available. This is caused by the present legal arrangement to prohibit the export of these materials.

The number of items collected during the 22 times operation were as follows.

Plastic pet bottles:	16,441 nos.
Glass bottles:	5,788 nos.
Can:	7 nos.

Figure 6-2 showing the number of recyclables collected per day and Figure 6-7 shows the number of recyclables collected per day in Khoroo 12, 13 and 14 where the project started in Oct. 1006. These show the followings.

- Khuch Chadliin Us" Co., Ltd producing mineral water telephoned UNSRAGA and swapped more than 2000 plastic pet bottles for goods twice.
- The number of plastic pet bottle collected is more than that of glass bottles.
- The collection amount of recyclables has been gradually increasing.
- The people's participation in Khoroo 15, 17 and 19 were very low.

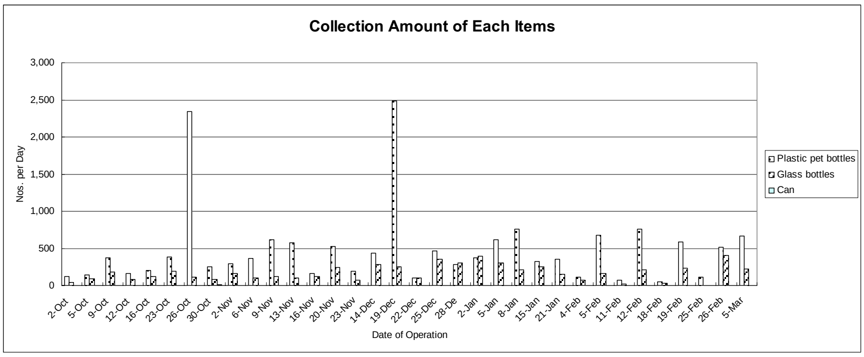


Figure 6-6: Number of Recyclables Collected Per Day

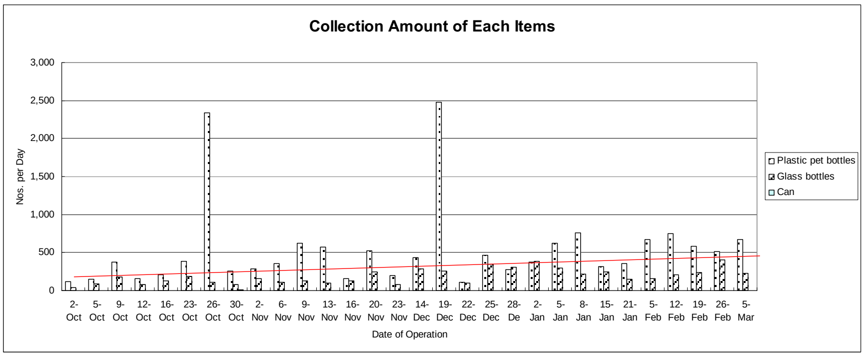


Figure 6-7: Number of Recyclables Collected Per Day in Khoroo 12, 13 and 14

Figure 6-3 showing the total number of recyclables collected per day and Figure 6-9 shows these in only Khoroo 12, 13 and 14.

The number of recyclables collected is gradually increasing despite the colder weather. This fact implies that more people are getting familiar with the Recycle project and are participating in it.

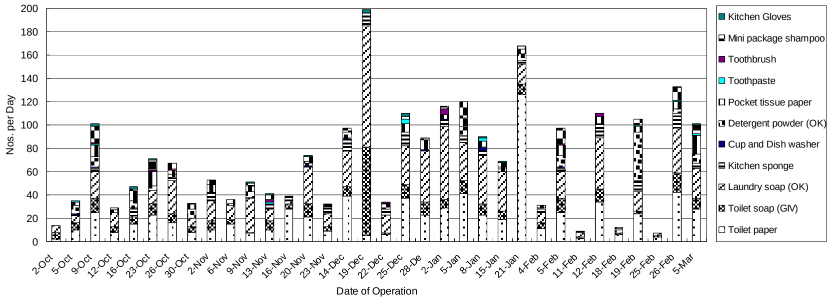


Figure 6-8: Total Number of Recyclables Collected Per Day

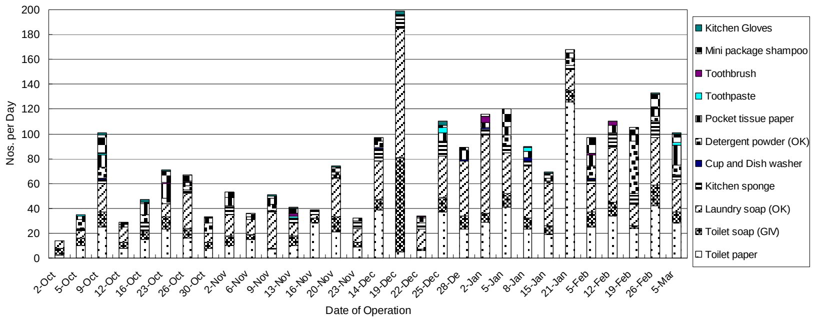


Figure 6-9: Total Number of Recyclables Collected Per Day

Total number of customers coming for 34 days' operation between 2nd Oct, 2005 and 5th Mar. 2006 was 924 people. In Khoroo 12, 13 and 14, around 40 to 50 customers came per day in Feb. and Mar. This number is equivalent around 1% of the target households and it is increasing gradually despite the colder weather.

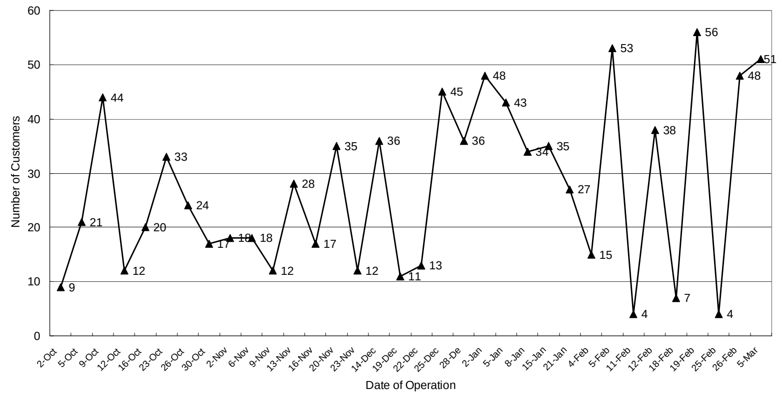


Figure 6-10: Number of Customers per Day

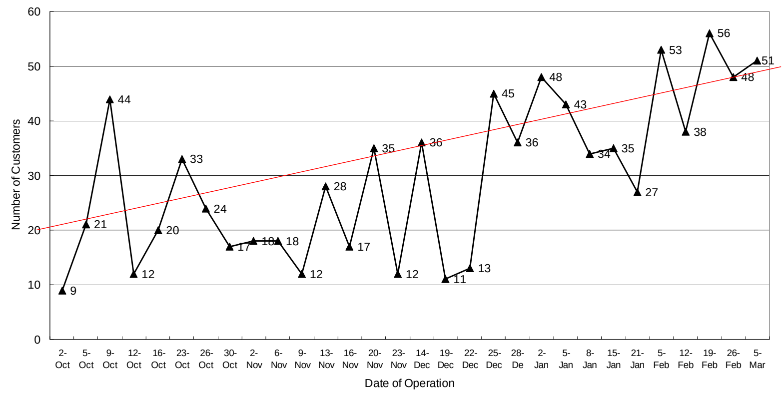


Figure 6-11: Number of Customers per Day in Khoroo 12, 13 and 14

Figure 6-5 showing the accumulated quantity of goods swapped for recyclables found that laundry soap, toilet paper and toilet soap are most preferred as goods for swapping by people.

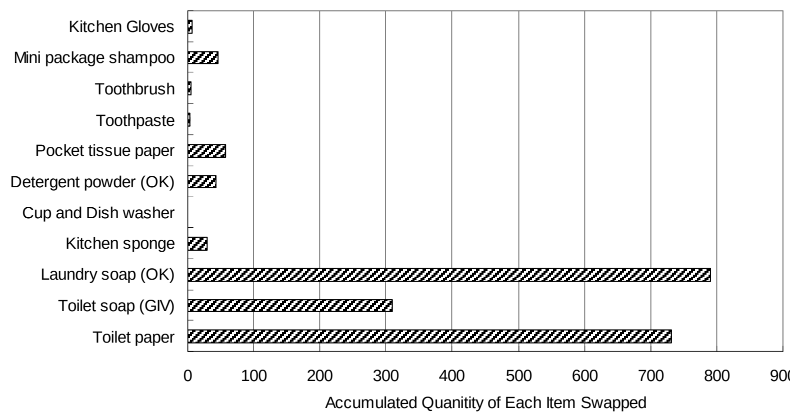


Figure 6-12: Accumulated Quantity of Goods Swapped for Recyclables

Comparing the collection efficiencies by collection days, Wednesday and Sunday, the collection quantity on Sunday was about 20% more than that on Wednesday.