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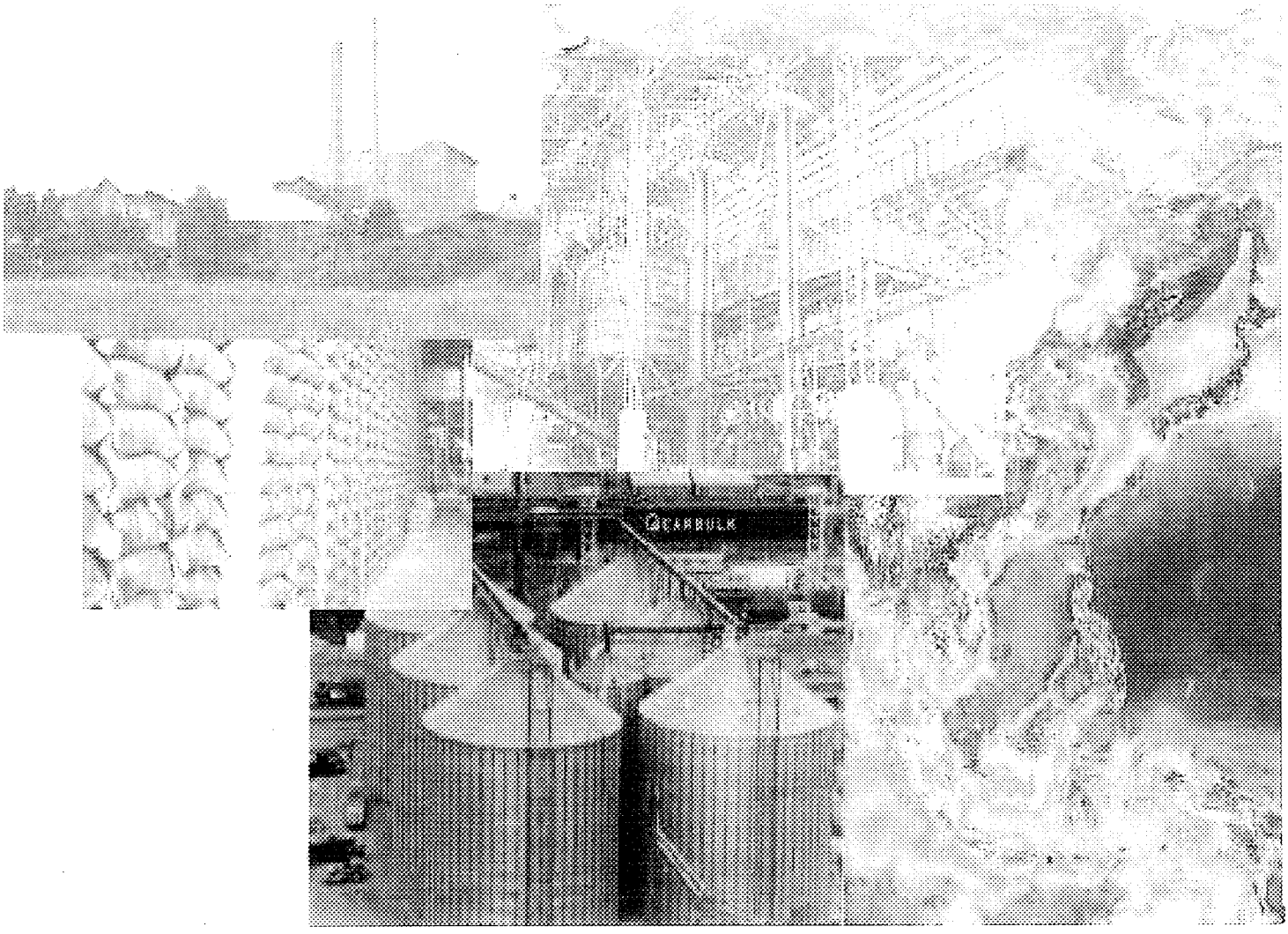
UNIDO CONTRACT No. 2000/058

PROJECT No. MP/ THA / 98 / 065

FINAL PROGRESS REPORT

ALTERNATIVES TO USE OF METHYL BROMIDE IN GRAIN STORAGE IN THAILAND



Acknowledgements

This Integrated Commodity Management Project - MP/THA/98/065 - has been funded by UNIDO as part of ongoing research in assessing alternative pest management options when methyl bromide is phased out of use under Montreal Protocol directives.

The Thai rice industry is one such food industry sector which is currently reliant on methyl bromide and the project team would like to thank Capital Rice Company Ltd. [CRC] for their strong support of the project. Without their moral and financial support the project would not have succeeded as it did in these initial developments of ICM strategies at their Samrong site in Samut Prakarn, Thailand.

We would particularly like to thank

Mr. Vorapong Pichpongsa,Chairman of STC Group and Managing Director of CRC
Mr. Sumeth Pichetpongsa, CRC Plant Manager
Mr. Sumit Sangburimtis and Mr. Suchart Wuthiwaropas , CRC Assistant Plant Manager

Thai Industrial Gases Public Company Limited [TIG] have also provided great assistance to this project as it was running in parallel with the ECO_2 Fume project on the same CRC site. TIG Speciality Gases manager -Ms Shanisa Chokprasop has provided invaluable assistance in co-ordinating the project and providing a center of communication for the International ICM consultant to communicate with the team. She has spent many long hours on site co-ordinating activities and has provided much of the practical report writing and liaison activities.

Plant Quarantine Service, Department of Agriculture Mr. Chamlong Lapasatukul, has provided strong technical support to the team and provided an invaluable liaison between the Department of Agriculture and the commercial rice industry. His fumigation skills and knowledge of the rice industry nationally was of great importance in the ICM planning and development.

John Wain Melville / International Expert in ICM
Werayut Tulvardhana / National Expert of Management in ICM

June 30 ,2001

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Executive Summary

Methyl bromide has been identified as an ozone depleting substance under the terms of the Montreal Protocol and as such its use has been targeted for phasing out in the near future.

Many industries currently rely solely on methyl bromide use to guarantee pest free status for their respective commodities and the Thai rice industry is one of these.
Thai rice mills use methyl bromide - often on a quarterly basis- to fumigate stored stocks of rice in bulk [bulk] bags . It is also used routinely for fumigation of export rice where it's use is a statutory requirement for export to certain countries as a regulatory control of insects.

There is an International need to identify effective alternative infestation control systems to replace methyl bromide fumigation. This project initially assesses the potential role of Integrated Commodity Management [ICM] approaches as part of this alternative approach.

Capital Rice Company Ltd. in Samut Prakarn, Thailand was selected as the experimental site for this demonstration project as the management are keen to participate in this proactive industry development.

This project ICM plan is restricted to the CRC site but in future it will be feasible to extend the work to other sites and include the entire rice pipeline from field production through rural rice mills and storages to export of quality clean rice from Thailand.

ICM involves a range of approaches and methods to reduce all forms of contamination, especially those associated with pest populations, in food commodities. These include physical, cultural and logistical management modifications designed to make process and storage sites less attractive to pests.
Use of low level Phosphine , both as a rice storage aid [$ECO_2Fume^{®}$] and as a direct replacement of methyl bromide for export rice was also evaluated on the CRC site in conjunction with the ICM project.

With any ICM development the critical long term success factor is gaining support from the participating company to the extent that they understand the benefits and take "ownership" of the project for the clear quantifiable benefits associated with it s operation.

Sites such as CRC are prone to infestation and attack from stored product pest insects SPP especially the Rust Red Flour Beetle [*Tribolium castaneum*] ,Saw Tooth Grain Beetle [*Oryzaephilus surinamensis*], Warehouse Moth [*Ephestia cautella],* Corn Moth [*Corcyra cephalonica*] and Rice Weevil [*Sitophilus oryzae*].
These insects will all cause seriously damage to rice stocks and methyl bromide is currently the key tool in their control.

Alternative controls for these insects is the focus of the ICM project which is designed to ultimately change the microenvironment within the mill which is currently highly conducive to SPP insects feeding and breeding.

ICM success is also dependent on identification and documentation of infestation and contamination risk areas and developing cost effective procedures to improve these issues.

Key areas were identified at CRC where significant improvements were needed:

Pest control [general lack of pest recognition and awareness, unsafe fumigation techniques, nil use of residual chemicals, no exclusion of birds or rodents, total reliance on methyl bromide for disinfestation, absence of insect monitoring and trapping]

Infestation awareness / monitoring [very low awareness of problems, nil monitoring]

Hygiene systems [Lack of cleaning procedures and poor equipment choice, heavy accumulation of residues and associated insects, malfunction of equipment causing spillage and product loss/ downgrade etc]

Management logistics [Poor stock rotation , lack of FIFO operation, poor sack and bulk bag storage and rotation, minimal communication of process problem issues between upper and lower management levels etc]

Record Keeping [Poor record keeping for some operations, some written quality procedures do not reflect the actual work processes etc]

All these issues were addressed through training and inputs from the ICM team on site and a new system for insect control and monitoring was established in conjunction with a much improved cleaning system which has removed many established pest harbourages on site.

Key improvements and changes include

- Establishment of high quality pest control systems through the mill for insects [including phosphine substitution of methyl bromide, residual spraying of floors and walls where sacks and rice are stored, secure boxed rodent baiting etc]
- Incorporation of a range of pest monitoring systems [including pheromone trapping of moths, physical trapping of Rust Red Flour Beetles and Flat Grain Beetles in light traps, regular sieve testing of rice in store etc.]
- Creation of cleaning schedules methods for all mill areas including time frames for routines and improvements in methods used [e.g. vacuum cleaners instead of blowers]
- Sealing of cracks and holes in walls to eliminate pest harbourages.
- Modification of equipment to eliminate spillage and wasted or downgrade rice.
- Improvement of lighting in Go Downs and painting of white 'no go' areas around wall edges to allow for better storage and access for cleaning behind rice stacks.
- Introduction of FIFO [First in First out] management of rice stocks and targeting a 3 month maximum storage time on site.
- Adoption of regular meetings and discussions to review operations and the direct involvement of all staff levels in these meetings via designated representatives.
- Improved bag cleaning and storage plus rapid rotation of aged stocks of jute sacks.
- Better checks of bags seals and ties to reduce insect infestation.
- Introduction of 4 new cyclones to remove rice dust to the collectors from the plant.
- Improved safety operations including face mask use and safety barriers etc

Work to date has resulted in greatly improved pest awareness on site and there have been significant cost savings associated with the logistical changes in particular.

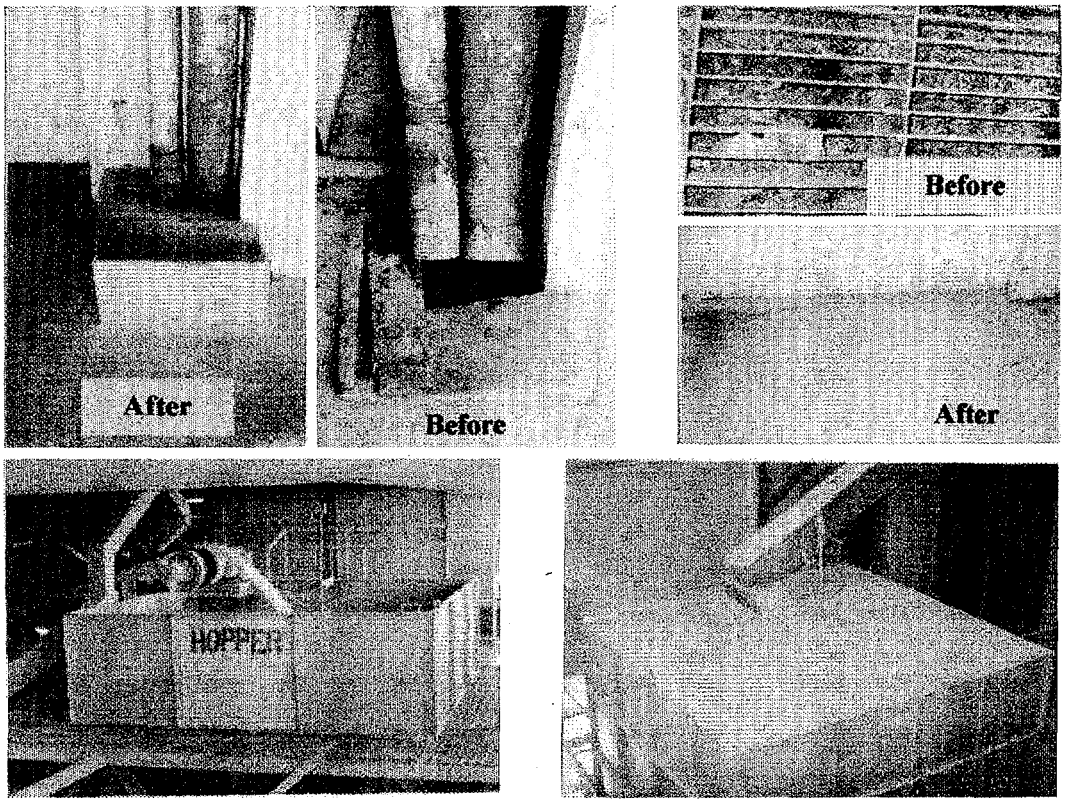
Non quantitative benefits are also important and these include improved staff morale, better cleaner and safer workplace conditions as well as improved long term sales options resulting from key market buyer visits to the showpiece site.

The 2 site trial options of ICM and ECO_2Fume operating in conjunction are thus initially seen to have strong prospects as replacement options to use of methyl bromide in Thailand which is soon to be discontinued .

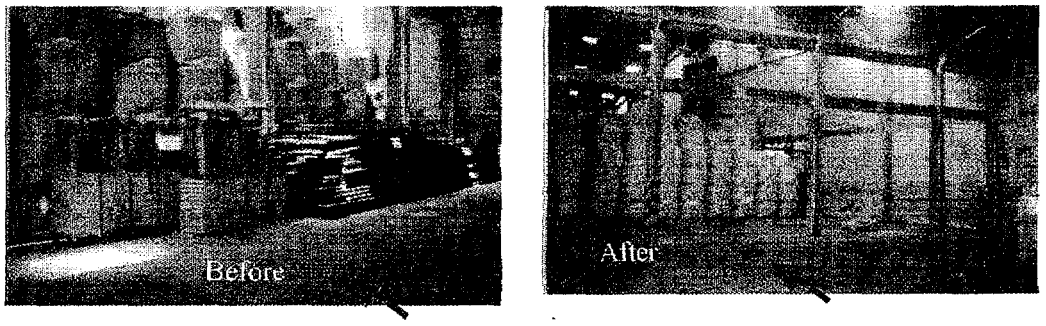
More work is needed to ensure that this initial ICM work continues to develop positively on site. The ultimate aim will be to ensure benefits can be fine tuned and the key concepts ultimately passed on to all the rest of the food processing and export industries in Thailand who currently rely on methyl bromide use

ICM Activities Examples

<u>Activities : Reduce Insect Harbourages</u>

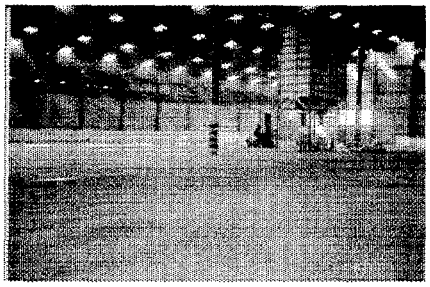


Closed the top of hopper to reduce dust and insect harbourage

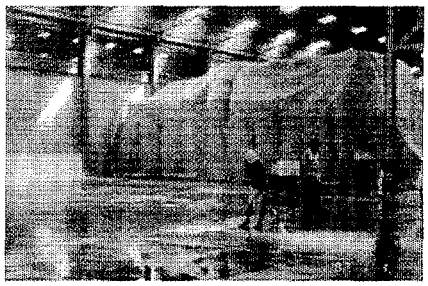


Clear unused stuffs out of Go downs

Activities : Cleaning and Leveraging High Sanitation Standard

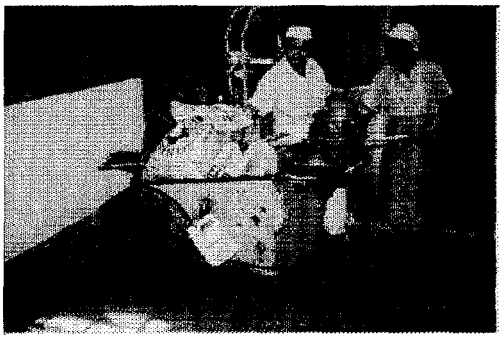


Before



ICM Implement

Currently view

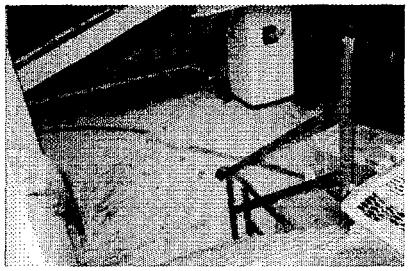


Before

After

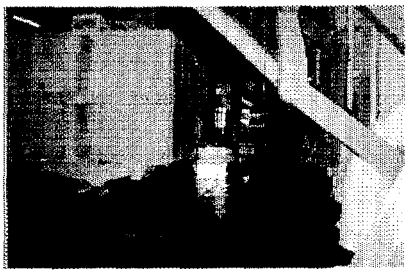
Introduce new cleaning tools to suit the workplace

<u>Activities : Reduce staffs workload but achieve the cleaning level target</u>

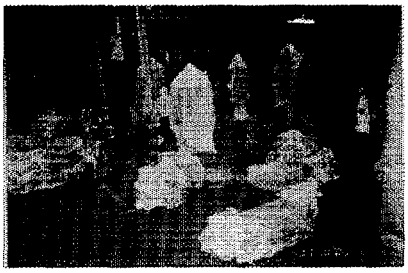


Dust from inside cyclone blown out during pre-cleaning the 25 % white rice (inside M/H)

Install multi-cyclone to improve dust collection during pre-cleanning



To reduce cleaning staff workload and to get clean floor

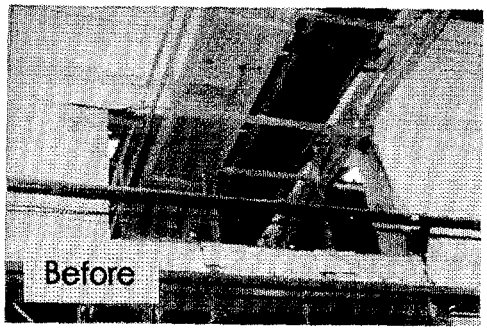


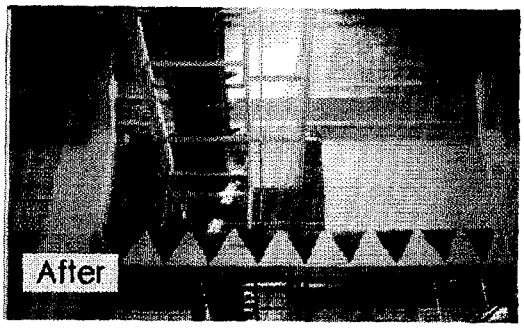
Before

After

Reduce 4-5 staff workload & reduce accumulated residue from bag cleaning inside Godown to cleaning point outside with suitable tools such as broom and air jet gun by 2 staffs only.

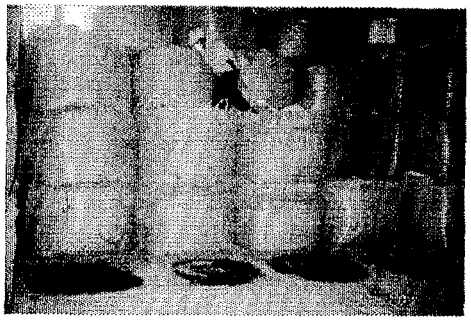
Activities : Outside Pest Control

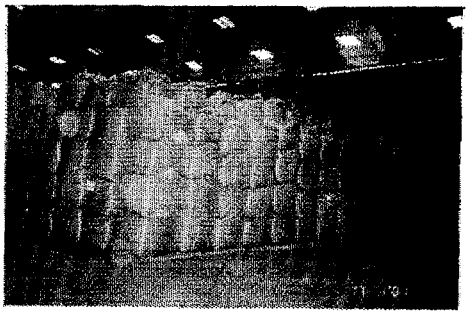




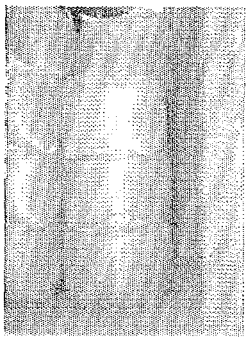
Closed bird access

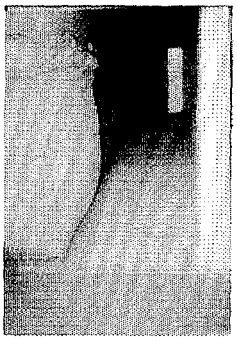
Activities : Stock Management





Implementation FIFO Concept

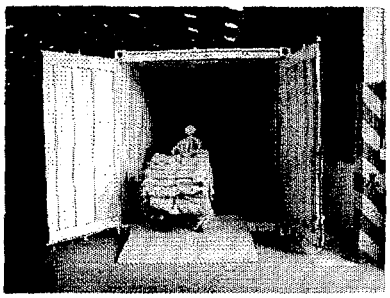




Before After

Monitoring Access around Go-down wall

Before



After

Keeping resale jute bag stock in fumigation container

Chapter 1

Project Introduction

1.1 UNIDO Project Aims

As methyl bromide [MeBr] has been identified as an ozone-depleting substance under the Montreal Protocol, targets have been set for its reduction and phase out.
Methyl bromide is predominantly used for controlling stored product insect pests, commonly referred to as "SPP" in the agricultural industry world wide and its removal will have profound significance for the Thai rice industry where it is utilised on a daily basis for dis-infestation of export rice and for regular bulk sack fumigation of bagged rice in store.

Procedures and criteria are being developed in many countries for emergency and critical use exemptions. The prime basis for this exemption rationale is the assertion that there are currently no technically and economically feasible alternatives to methyl bromide use.

Development and adoption of a cost effective ICM strategy for a selected rice milling and storage site may provide part of a viable alternative to facilitate methyl bromide replacement industry wide in Thailand.

Capital Rice Company Limited Mill [CRC] in Samut Prakarn Province was selected for this ICM project and also for the initial trials of ICM / ECO_2fume® rice storage integration.
The mill is deemed one of the biggest and most proactive in quality terms in the Thai export rice industry. This selection has been justified over the course of the project and CRC has proven to be strong supporter of project ideas and has implemented many of the ICM factors at its own cost to date.

1.2 ICM & IPM Definitions and Concepts

The term **Integrated Pest Management [IPM]** has been developed in field crop pest management over many decades whilst the term Integrated Commodity Management [ICM] has been more recently applied to food storage and processing operations.

IPM can be defined as the practice of combining all the best available strategies and pest control methods that apply to a given problem created by the activities of pests.

A more specific definition is the practical manipulation of pest populations using sound ecological principles to keep pest populations below a level causing economic injury. The measure of this threshold is a vital component and is variable for specific commodities.

With some food commodities there is a 'nil live insect' acceptance level so treatment is mandatory. In other situations there is scope for some degree of pest tolerance as the cost of eliminating the problem is not justified by the return.

IPM is most frequently applied to field situations where it is specifically linked to management and solution of pest problems. When the concept of applying a range of management options to food processing and storage areas the term **ICM – Integrated Commodity Management** is more appropriate.

Whilst both terms have similarities and place emphasis on pest management; ICM encompasses a broader range of commodity quality issues when compared to IPM which is technically limited to cover pest management issues only.
ICM addresses physical contamination [e.g. dust, dirt or glass], biological contamination [animal excreta, hairs, feathers bacteria, mould, rancidity], chemical contamination [e.g. from poor pesticide application or careless cleaning methods] plus other "best management practices" such as rapid stock rotation including FIFO [First in , First out] reduction of product loss through spillage and quality downgrade in process operations.

ICM is closer to "Total Quality Management" in concept and requires strictly controlled and documented operational procedures to maintain the highest long term quality parameters for the commodities being protected
ICM is co-reliant on the highest levels of hygiene to be successful.

The rationale for implementing ICM is thus:

- To reduce production costs through reducing energy and time inputs and to increase profits from improved quality, better sales / stock control and reduced stock losses.

- To reduce environmental and commodity contamination through the carefully controlled use of pesticides. [In case of CRC it is aimed at creating alternative options for the current routine use of methyl bromide for rice dis-infestation before export].

- To allow for maximum utilization of cultural practices, physical and [possibly] biological methods for SPP Control rather than rely on Methyl bromide solutions to problems.

The key components of ICM programs in stored ecosystems are ;
management and logistical controls; chemical, biological, physical and mechanical methods of pest control , all of which are supplemented by regulatory control.

In a storage ecosystem, hygiene and good warehouse management are essential factors in minimizing risks from contamination. They provide the base framework for other supplementary ICM and pest infestation control methods.

An effective ICM system would therefore supplement high level sanitation and good warehousing procedures with a combination of factors including:

- Improved quality inspection of inbound raw materials and rejection of infested produce.
- Training and awareness for staff to enable effective input to industry problem solving.
- Judicious use of residual insecticides eliminating risk of product contamination.
- Replacement of methyl bromide fumigation with more acceptable fumigants (PH_3).
- Use of ambient aeration, and refrigerated aeration [cooling reduces insect breeding].
- Equipment and packaging modification to enhance product protection .
- Thermal disinfestation techniques [very high or low temperatures].
- Irradiation or microwave techniques.
- Insect resistant or repelling packaging use.
- Insect growth regulators IGR's: e.g. methoprene or hydroprene to prevent pest breeding.
- Biological controls (parasites, predators and pheromones).
- Storage management and optimum stock rotation e.g. First In – First Out (FIFO).
- Adequate grain cleaning and contaminated residue dumping at storage sites .
- Fully documented cleaning procedures, methods and schedules.
- Internal and external QA audits to guarantee acceptable documented quality standards.
- Contamination and pest monitoring of adjacent plants and immediate surroundings.

Some of the above factors may be inappropriate for rice mill situations in Thailand at this early stage of ICM implementation but may well become viable economically as the systems develop and quality parameters are raised.
Others still including issues such as development of pest resistant rice varieties are much further down the track and beyond the scope of this study.

1.3 CRC Project Objectives

The overall aim of ICM in the current situation at Capital Rice Company Ltd. mill [CRC] in Samutprakarn, Thailand is to protect the integrity of rice quality through the CRC process ands storage pipeline to provide a better quality product via a cost effective and environmentally appropriate system.

This will be principally achieved with improved hygiene standards on site and implementation of selected ICM methods backed up by long term phosphine aided storage [$ECO_2fume^{®}$] and reduction of the current methyl bromide reliance .

This combined approach of an environmentally friendly fumigant for disinfestation plus methods to minimise background infestation is seen as a viable cost effective replacement option for the current routine methyl bromide fumigation once this is Internationally phased out under the conditions of the Montreal Protocol.

Specific project aims are to:

- Identify the points where rice quality is compromised through the process / storage pipeline [modified form of HACCP - Hazard analysis critical control point -review]
- Assess the primary contributory factors producing these risks [pest control practices, hygiene, housekeeping, proofing, logistics and stock management practices etc]
- Identify all potential alternative practices and methods to improve the situation and reduce the associated risk to rice stock quality.
- Initiate selected improvements and trial management systems in conjunction with CRC management
- Provide monitoring, review and modification of methods to ensure successful implementation of ICM methods
- Provide training and awareness programs to the company to support the ICM project methods selected for trial.
- Provide cost benefit assessment of work implemented to date and forecast future benefits which can also accrue[some of these may be non-quantifiable for some years but are of significant importance nonetheless].
- Ultimately develop a 'nil tolerance' of pest infestation on site and to raise awareness of the significance of such infestations to the quality and value of finished product
- Provide long- term management options and recommendations for development of the project vision at CRC specifically and for the Thai rice industry in general.

ICM benefits noted during the progress of this project can be passed on directly and immediately to other mills and storages within the STC Group of companies of which CRC is an affiliate.

Further dissemination of ICM strategic information to the rest of the rice export community of Thailand and to other food industry process and storage sites is also viable but remains a longer term goal of the project.

1.4 Scope of Work

Rice is grown in rural sites in central Thailand, harvested, then sold to rural rice mills which store it as paddy – i.e. husked rice which is principally infestation free due to its natural protective coating.
When an export mill such as CRC requires rice for further process to edible rice format – it is ordered from the rural mills and received in jute bags or in bulk format via trucks from the various mills. Rural sites will mill the rice to remove the outer protective husk and then bag or bulk load to trucks and ship to CRC.

Rice is shipped to CRC in jute bags or in bulk trucks in its five basic varieties viz. brown rice [cargo rice] white, fragrant, glutinous and par boiled and in a variety of quality standards varying from 50% to 100% whole grains - vs. broken grains - in the load.

Inspections were carried out at rural rice mills during March 2000 and again in April 2001 to assess conditions [Refer Appendix 6 for examples]. These sites store all rice as husked paddy until ordered by process mills such as CRC.
All were noted to be similar in standard with high pest infestation levels but only rudimentary or non existent pest management. Minimal levels of hygiene and cleaning were in place with many mills apparently having no cleaning whatsoever.

Rice processed in these rural mills is thus always going to pose a certain risk being to the final storage and process sites but there is currently no external management which can be applied through project resources to modify these practices.

In a full ICM program –the finished product quality management should include management of that commodity through all stages of production and process.
This would include all aspects of field preparation, rice growing, harvesting, transport to the rural rice mills and storage as paddy rice until required for final milling in Bangkok.
ICM should also theoretically cover the quality of transport and storage of the rice from the point of leaving the CRC site to the time when it is purchased by the consumer

This is too extensive an aim for the current project and the scope of the current work only encompasses the rice pathway from arrival at Bangkok CRC site to the shipping of finished product to local or overseas markets from there.

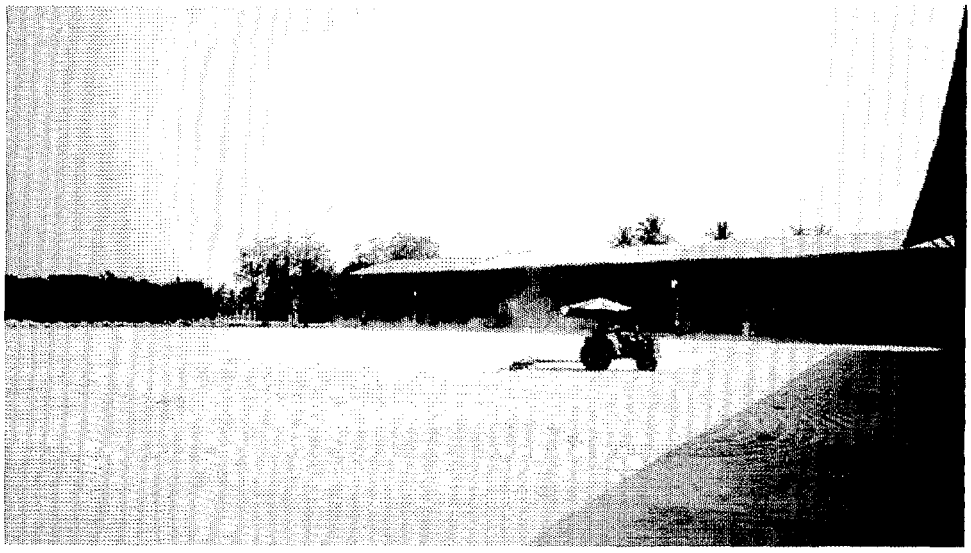
If the project scope were to be extended at a later date, then field management issues such as development of pest resistant crops and rural mill operations would be included.

It should also be stressed that ICM is a dynamic and flexible process intended for constant review and modification over many years and it is seen to be impossible to provide full economic benefit to any participating company over the course of a single year.
ICM allows incorporation of changing product inputs, increased client quality demands and changing storage requirements. Improved understanding of the causes of infestation, contamination and product damage will also necessitate changes to the remedial approach.

At this stage of implementation at CRC a wide variety of beneficial changes have been implemented on site and some of these are already showing benefits in economic terms.
Others will take longer to become quantifiable e.g. improved sales following positive client visits. Some methods assessed have not proven to be economically viable in this situation.

This project has however provided the groundwork for CRC to continue the site improvements for achievement of full ICM potential with continued input from internal and external advisers.

Rural Thailand Rice Harvesting



Drying of Paddy – Rural Thailand

1.5 Project Team

Project Member	Key Roles
Mr. John Wain Melville International Expert in Integrated Commodity Management **[IE]** **Education** - M.Env.Sc Monash University, Australia - B.Sc[Hons:Ecology] Liverpool University, UK - Post Graduate Certification in Education **Key Experience** - ICM Development and Implementation in Food Industry Consulting, Auditing, Training, QA and HACCP assessments - Organic Food Industry Inspection and certification requirements - Australia and SE Asia - Pesticide residue analysis in environmental samples. **Working Period : 6 weeks (April,1 2000 to May, 30 2001)**	1. CRC and rural mill site Audits, HACCP and ICM planning 2. Initial establishment and modification of working guidelines for National Expert. 3. Technical advisor to project and advice on final report compilation
Dr. Somchai Isichaikul National Expert in Integrated Commodity Management 1 **[NE]** **Education** - Ph.D (Insect Ecology), Ehime University, Japan - MS. (Entomology) , Kasetsart University, Thailand - B.Sc.(Agriculture) , Kasetsart University, Thailand **Experience** - Training and demonstrating crop protection and integrated pest management in cereal crops and soybean field. - Research on efficacy of insecticides - Research into natural enemies of corn and sorghum. **Working Period : 25 days (April 1, 2000 to October 1,2000)** **Resigned role on October 1, 2000 , replaced by Werayut Tulvardhana**	1. Training of site staff to raise awareness of pest problems and their influencing factors 2. Implementation of project design & guidelines from International Expert. 3. Undertaking of trials and collection of project data on stored product pests. 4. Development of baseline cleaning programs and documentation of hygiene systems
Mr. Werayut Tulvardhana National Expert of Management in Integrated Commodity Management 2 **[NE]** **Education** - MBA, National Institute of Development Administration (NIDA) - Certificate of Defense Resources Management - BA.(International Relations) , Ramkhamhaeng University, Thailand - B.Sc.(Marine Engineer), Naval Academy, Royal Thai Navy, Thailand **Experience** - Production Management and Logistics in Industry - Lecturer in Small & Medium Size Shipyard Management - Hygiene &House Keeping & Logistic Management **Working Period : 155 days (September 15, 2000 to May 31,2001)**	1. Site audits and ICM development on site 2. Implementation of working procedures from the initial IE guidelines 3. Supervision and education of CRC staff to meet the new hygiene and sanitation standards. 4. Collection and collation of project data and correlation of cost / benefit aspects of the project. 5. Cooperative work with CRC management to ensure continued input and support

Chapter 2

Infestation Assessment at CRC - pre ICM

There is a nationally high tolerance of pests on rice milling sites especially the stored product insects [SPP] which are generally viewed as very small and thus inconsequential to the profitability of the operation.
The tolerance of pests can be directly related to the total industry dependence on methyl bromide fumigation to solve all pest problems. Most rice mills and export sites have no other pest management strategy than a regular 3 – 4 monthly mass fumigation of infested stock in hand with methyl bromide.
This reliance will cease when methyl bromide is removed from use so efforts must be made to identify viable alternatives before this occurs.

Accurate and easily replicable methods for measurement of SPP activity on site are vital to demonstrate the baseline levels of infestation present on site and the variance in pest populations when influenced by ICM practices.

2.1 Site Audits [Appendix 1]

Various inspection reports and investigations have been carried out to determine the infestation levels on site including detailed audits of site by John Melville – Project International Expert in ICM [March 2000, Sept 2000 and May 2001].

Audits covered the main mill itself [sometimes referred to as the "Machine house"] and the warehouses adjacent - termed "Go Downs" in Thailand. Additional comparative audits were carried out in rural rice mills as well as large open storages in Bangkok where bulk rice is piled up to 20 metres in height in Go Downs up to 200 m long.
These latter piles are heavily infested with Corn moth [*Corcyra cephalonica*] and staff are paid to rake off the thousands of moth cocoons accumulating on the heaps on a weekly basis.

Audits detailed in Appendix 1 show consistent reduction in SPP populations and distribution of stored product insects across the Samut Prakarn CRC site over the project study period.
The consistent improvement of hygiene and cleaning coincides over this period with significant reductions in visible insects across the site.

March 2000 audit indicates the situation before any work was done on site whilst the May 2001 audit indicates the current situation at the time of this report.

The dominant stored product pest insect [SPP] species which are causing infestation at the CRC site are :–

Rust red flour beetle	[*Tribolium castaneum*]
Rice weevil	[*Sitophilus oryzae*]
Flat grain beetle	[*Cryptolestes pusillus*]
Warehouse moth	[*Ephestia cautella*]
Corn moth	[*Corcyra cephalonica*]
Lesser grain borer	[*Rhizopertha domenica*]
Saw toothed grain beetle	[*Oryzaephilus surinamensis*]
Cadelle	[*Tenebriodes mauritanicus*]
Booklice	[*Psocid sp.]*

Hazards associated with these pests and notes on their habitat choice and ecology plus damage potential; are given in the initial audit report March 2000 .

All of the above pests can create significant economic damage and as such their presence should be recognised and appropriate control measure be initiated when a risk is ascertained.

As well as direct damage to stocks – one of the commonest pests on site -the Rust red flour beetle [*Tribolium castaneum*] -has been associated with flavour tainting to product which can affect palatability, quality and ultimately sales.

Psocids indicate the presence of mould and fungus which insects upon-thus indicating a significant quality problem with the rice.

Fumigation of heavily infested stocks will not remove this chemical taint and the best control method is to avoid heavy contamination by Psocids and / or Red flour beetle in the first place.

Other pests such as mice, rats and birds were noted along with their associated damage and management methods.
Rats, mice and birds may create damage to stored rice in sacks and bulk bags.
The opening of storage bags creates secondary problems through invasion of insect pests which feed and breed in the spilled rice then invaded the bags themselves.

2.2 Pheromone Trapping – *Ephestia cautella* sp. moths [Appendix 2]

Given the high populations endemic on the site, it is considered invalid to attempt grid networks of monitors until such time as there is a very low population of moths on site and a need to pinpoint sites where they are most actively breeding and harbouring.

Initially it had to be accepted that they were widespread and in high numbers so the simple aim is to see if there is a reduction in general counts with time over the course of the project.

Warehouse moth is not the most significant pest species on site but moths are readily caught on the pheromone lure traps as the males search for mates. The species was chosen as an "indicator" of general pest infestation on site as it shares common habitat and food with the beetles and weevils which are more significant pests on site.

Sticky boards were placed in delta traps with the *Ephestia sp* pheromone lure added to the trap. This lure also contained the Indian meal moth – *Plodia interpunctela* pheromone so served as an attractant for both pest species.
Changes of pheromone occurred 6 weekly as per the manufacturers instructions and a large number of moths were caught at the initiation of the work indicating a high baseline population.

Traps were placed as noted in Appendix 2 and counts made weekly and recorded by site staff acting under instruction and supervision from the initial national ICM expert Dr Somchai.

The initial set of results from July 2000- September 2000 were highly variable and inconsistent and it was clear that the methods needed modification. Variation in results were due to the following factors:

- Rapid accumulation of rice dust on the sticky boards in the warehouses and machine room which in turn reduces the catch on the boards over time.

- Indications that the UK produced pheromone lures could be losing their attraction in the extremely high temperatures and humidity levels noted in the stores .

- Delegation of monitoring responsibility to junior staff by the National expert without adequate training for those staffs in recognizing experimental problems and modifying methods to suit the conditions.

{NB : It should be noted that the national expert Dr. Somchai resigned from the project team in October 2000 due to inability to commit the required time to the project. he was replaced by Mr. Werayut Tulvardana which improved communication, awareness and training standards for site members}

Pheromone stock ran out in November. New stocks were replaced by the International adviser with a subsequent change in approach which involved placing lures into the Machine rooms and Go Downs on Saturday following close of operations and then collection of the lures and board on Monday before work restarted.

This gives 2 nights of monitoring per week without heavy dust loads in the air and also ensured pheromones were placed in the fridge between monitoring events which preserves the pheromone potency and extends the effective life of the boards.

Results are shown in Appendix 2 and indications are still inconclusive with peaks of activity and catch numbers being noted in early February and early April.
Activity in December and January was low but numbers peaked at the above times for no apparent reason.

It should be noted that large numbers of warehouse moth are visible after nightfall in the exterior areas of the sites e.g. in the car parks and near road dumps.

This indicates a large population in the general site area - possibly associated with a neighbouring rice mill which does not follow ICM hygiene practices.

Moths move easily into the warehouses through open doors and are commonly found outside in the loading areas and the laneways between the adjacent rice mill and the Go Downs of CRC.
This ease of movement is adding to the confused records and it is not likely that the counts are directly related to endemic populations inside the storages being monitored.

Whilst there is still benefit in the trapping program to maintain a background understanding of moth movement, there is little practical ICM information that can be drawn from the counts to date.

Continued data collection over longer periods of time and relating this data to other activities in the ICM program is required to gain more meaningful information.

2.3 SPP Populations- Machine House Residues[Appendix 3]

Following the major clean downs of the mill and machine room areas in particular. The numbers of beetle and weevil SPP insects declined dramatically .

In October and November the average numbers counted in residues accumulated in rubbish ducting, spilled rice residues and wall holes etc. was over 1000 individuals per sample count.

The counts declined to less that 200 individuals per count from March this year and reached a low during the recent count at 74 individuals over the 6 floors of the machine house [main mill] on April 24th .

This a good result and clearly indicates a reduction of insect pests which can be directly related to removal of rubbish from the mill ducts and floors where the insects live and breed. These insects do not move readily from their harbourages unlike moths which move frequently as conditions change.

With continued cleaning and attention to residual accumulations – the ongoing risk from infestation will be much reduced through the mill.

2.4 Sieve Results – varied rice type & quality [Appendix 4]

There are 5 primary rice types stored on site [white, fragrant, glutinous, brown and par-boiled] and these are usually in 3 grades - 100%, 75% and 50% whole grain [with the rest of the stock as broken grains to complete the 100% volume in the latter 2 categories]
Brown rice is stored in very small volumes and is not considered due to lack of data.
Glutinous rice is only ever able to achieve 90% whole grain status.
Rice is stored for varied periods of time in the Go Downs ranging from 1 to 12 plus months depending on client demands and purchases.

Results indicate a preference for the parboiled rice stocks with broken grains in them and a higher level of infestation in long stored goods due to extended opportunity for insects to invade and breed.
There appeared to be little difference in insect preference for the other rice types but glutinous showed slightly higher levels of activity than others.
This is backed by observations from site staff over many years but there is no rice type that is resistant to infestation and thus all stocks must be protected and treated with equal care.

Points of note include the presence of very high numbers of dead insects in some of the parboiled stocks with a 9 months storage period [> 200 per kg sample of rice taken and sieved].
This is due to the stocks having been routinely methyl bromide fumigated at some point in the storage period – possibly twice.
NB Rice stocks are all inspected 3-4 monthly and if 5 live insects are located – the stock is fumigated with methyl bromide to kill the insects present.

New rice stocks stored adjacent to very old and infested rice will become cross infested more rapidly than the same rice stored in a clean and un-infested environment.
Infestation management cannot be based on preferential treatment of any identifiably susceptible rice type.

Other experiments were carried out attempting to relate infestation with vertical position in a stack. Rice bulk bags are often stacked in piles 4-5 high and insect numbers were examined in the bottom top and all intermediate levels of storage.

Saw tooth grain beetles and Rust red flour beetle infestations were checked in a series of experiments and these showed both top and bottom bulk bags to have highest levels of attack.
The top bulk bags offer easy access for flying insects landing on the large exposed surface areas often have unsealed ties at the top. Bags on the base level are the first to be contacted by crawling insects moving over the floor and thus can be invaded directly from this level.
Attacks at the base level are often associated with tears to the bags. Some of these are structural splits whilst others are created by rodent attack which allow insects access to rice

Highest levels of infestation are associated with open top bags and damaged rice bulk bags.
The fact that base level bags are attacked provides a management option in treating the floor with residual chemical to kill crawling insects which attack from the ground level.
NB: Fogging may offer some level of protection to upper level bulk bags as the chemical will settle on the upper surfaces of the bags and kill invading insects.

Bags in the middle sections [level 2-4/5] are effectively sealed by the bag above so that even if the bulk bag ties are open there is no access to the rice via the bag top.
The key points are that all rice types are susceptible to insect pest attack after hulling and placing into bulk bags for storage regardless of stack placement position.
The level of infestation is most likely to be related to storage time and position in the Go Downs relative to other aged infested stocks.

2.5 Initial Comparisons- GD 4 Infestation / Adjacent Mill

This was carried out during May 2001 following high counts of moths and Rust red flour beetles in the lane-way between the CRC Go Downs 3 / 4 and the adjacent Puay Heng Long mill at the Samut Prakarn site.

This was a limited investigation using 6 pheromone traps placed in the adjacent mill compared to 6 similar lures placed in Go Down 4 of CRC mill.

The levels of cleaning in this mill are extremely low and it would appear that there has never been any cleaning at all.
Crawling insects are visibly obvious in the thick residues all areas and a more detailed inspection would have been useful but was considered discourteous given the competitive nature of the respective operations and our "invited visitor" status with the adjacent mill.

Results showed an average of 9 warehouse moths [*Ephestia cautella*] per trap taken in the Puay Heng Long mill compared to average 2 in the GD 4 traps.

Pheromone lures were from a different manufacturer to those used in prior experiments in CRC sites so there is no real comparison between these result and other pheromone lure results.

There is an indication of higher moth activity in the adjacent mill and observation made of Saw tooth beetles, Red flour beetles and Cadelle all indicate that this site is going to provide cross infestation source for the CRC site over time.

Other pheromone lures placed in the loading bays and wharf areas all also showed high moth activity overnight. One trap placed in the packing line outside GD 4 collected 61 moths which may have come from next door, from the Go Down line itself or from other surrounding areas.

There is clearly a high level of activity in the wharf loading area in general but the source of the moths cannot be precisely identified.

No lure inside any of the CRC Go Downs or machine rooms has ever caught this number of moths over one night and it is clear that there is a large population of mobile moths which forage outside the Go Downs and the mill buildings.

2.6 Light Trapping at night using UV vacuum traps [Appendix 5]

There was commenced in January 2001 to supplement insect monitoring with pheromones which has been problematic due to changes in the national expert input on site and other technical problems with the traps and pheromone capsules themselves.

Results here indicate that regular capture of Rust red flour beetles [*Tribolium castaneum*] and Flat grain beetles [*Cryptolestes pusillus*]can be achieved using these light traps. Light traps set up in the Go Downs and in exterior laneways and wharf loading areas indicate high catches of both these insects but there has been no segregation of individual species caught in the traps – results are for both species combined.
Whilst it would have been interesting to have the species segregated from the start – they are both problematic and the value of the UV traps has been proven in monitoring.

Moths are caught regularly on the pheromone lures but have not been trapped at all in any of the light traps showing their aversion to light .Saw tooth grain beetles and Weevils can also fly but are also not attracted to or caught in the traps.

Most stored product pests are strongly photo-negative for the majority of their life spans and are only occasionally UV light attracted-usually when looking for a mate.
Following mating the insects become photo-phobic again and shun light – preferring the dark of cracks , crevices and product masses where they lay eggs and feed.

Whilst the adjacent rice mill is heavily infested and dirty by comparison with CRC – the light trap captures in the laneway between the 2 companies have not been consistently high to date. Cross contamination and infestation could occur from this site but it initially appears that the laneway is not a high insect traffic area.
It could however be significant that the UV trap is placed in the ECO_2fume® phosphine gas cylinder compound for security and low levels of gas leaking from the cylinders may be creating localised repellence –thus negating any attraction from the light unit.
Future trials should include setting UV units in the lane – well away from the phosphine gas

The numbers of caught insects per day shows steady decline with time and this is undoubtedly related to the reduction in residues on site from upgraded cleaning activities.

Individual trap counts indicate high activity associated with traps number s 2,4 and 5 plus the exterior trap placed on the wharf outside GD 4 indicating higher activity of the 2 beetles in Go Downs 5 and 6 as well as outside where the pheromone lures have also been picking up high levels of moth activity.
It is highly unlikely that any SPP will be emerging from the wood piled for export packing in containers so these beetles must be flying nightly outside the CRC buildings or must be emerging from the external overhead conveyors at night.

Go Down 3 and 4 results show relatively low levels of infestation and results have again been declining since the commencement of monitoring in January 2001.
Go Downs 4 and 3 have been the subject of intense management and cleaning during the course of the project resulting in the observed decline in insects compared to 5 and 6.
GD 5 and 6 results have also been declining but remain higher than those for 3 and 4.

Results indicate some measure of control for some SPP insects as part of the ICM program.
The use of standard blue UV light traps is of no value in controlling moths although a new type of light trap utilising a broader spectrum of "green light" may have management options for later consideration

Chapter 3

Baseline Pest Management Systems - Pre ICM [April 2000]

3.1 Fumigation

Fumigation with methyl bromide has always been the number one tool for pest management on site and the total reliance on this method is the biggest hurdle to overcome in getting full management support behind the ICM project.
Infestation has traditionally been allowed to run to high levels whilst rice is in storage and when required for sale / export is physically cleaned through the mill to remove most of the problem pests and the signs of their damage.

As heavy SPP infestation is known to reduce rice quality and volume in storage it is considered useful in the industry to inspect stocks every 4 months and then to fumigate if heavily infested [> 5 live insects per kg].
This is a general rule of thumb and not always carried out on rice storage sites.

The adjacent Puay Heng Long mill however carries out full phosphine/methyl bromide fumigation of all of its huge stocks of rice every 4 months at a significant cost.
Re- infestation occurs almost immediately from the structure of the mill and the heavy residues in the equipment itself so the approach is essentially a band aid method to reduce rice losses but does not address the real problem associated with SPP infestation.

When clean rice is packed quickly into bags for shipping it is traditionally fumigated with methyl bromide. This occurs as a reasonably well managed operation in export shipping containers or in a highly dangerous and ad hoc manner in lighters filled with rice bags as they move down the river to deliver rice to local or marine based markets.

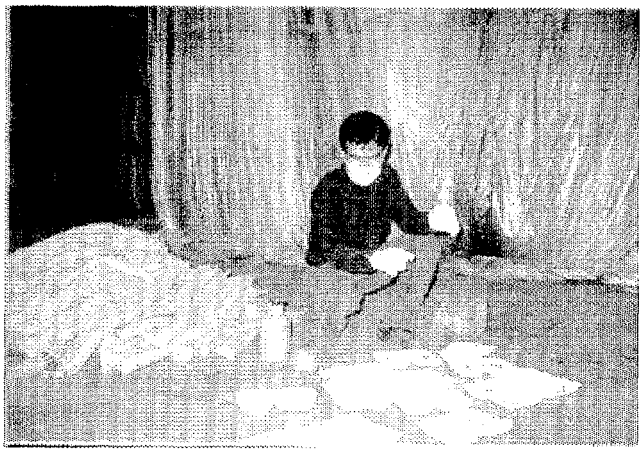
Fumigation inside the Go Downs was observed to be unsafe with unsealed polythene sheeting covers thrown over rice and methyl bromide gas released underneath for varying time periods.

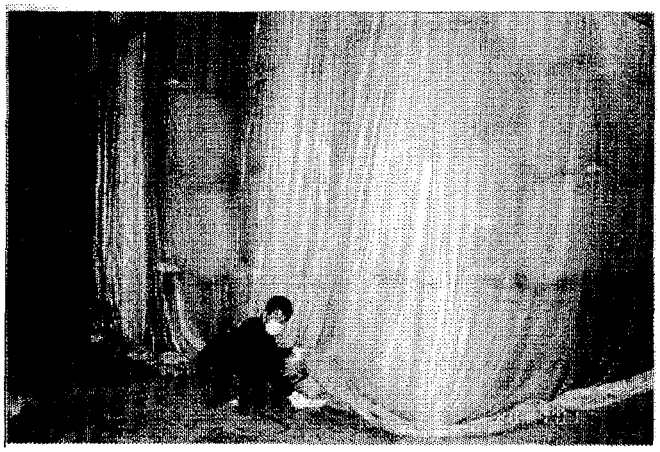
There are no safety or warning signs on such stacks and they are not shielded with protective barriers to prevent staff from moving the sheets of even going inside the fumigation stack to work. Fumigation workers wear no protection at all but were stated to wear a dust mask if questioned about safety issues.
This provides no protection whatsoever as a filter against phosphine or Methyl Bromide.

The real efficacy of fumigations cannot be ascertained – particularly with the lighter fumigation as there is no calculation of gas application or any possible assessment of the gas escape from the ships holds as they move down river.
It is highly possible that most gas will leak out very fast and will not penetrate the bags to any effect but until such time as rice is returned to the suppliers with heavy levels of infestation in it – the practice is deemed very acceptable.

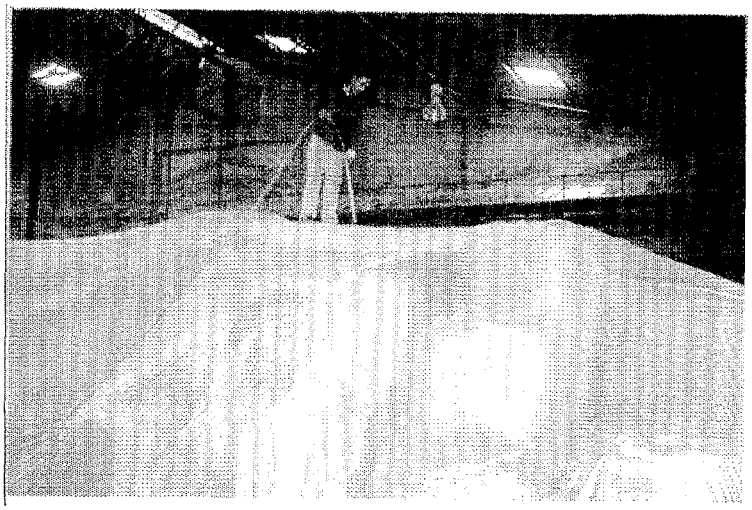
Changes in the use of fumigant gasses i.e. removal of Methyl bromide from use will clearly change this hazardous and ineffective operation in future and hopefully ICM practices plus ECO_2fume® storage will serve to minimize the perceived need for this anyway.

There are legal regulations involved in fumigation as well which must be overcome including the quarantine need for fumigation of rice going to certain countries e.g. Australia which requires a fumigation certificate prior to allowing rice to enter the country from Thailand.
The avoidance of such regulations is outside the scope of this study but is one which must be addressed prior to the removal of methyl bromide from the pest management arsenal.





Preparation for PH_3 fumigation
(Note : Dust Mask Only !!!)



Methyl Bromide Use. (Note : Dust Mask only !!)

3.2 Insect Control in Storage

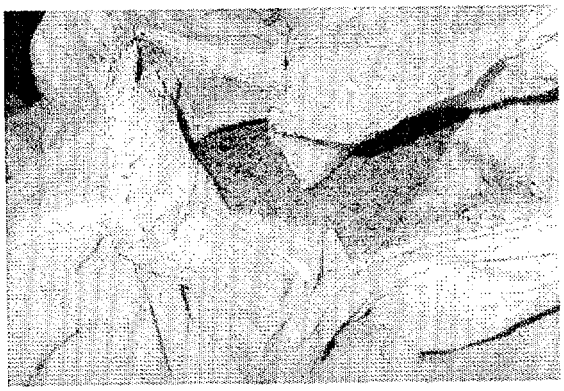
Other than the above noted fumigation with methyl bromide or phosphine on a 4 monthly basis – there is virtually no pest control carried out on site via fogging and / or spraying of chemical barriers to kill insects or reduce insect attacks.

Given the size of the Go Downs and the cost of fogging plus the lack of penetration of bagged rice stocks to kill insects already inside the rice bags – this type of control is considered to be a waste of time in its own.
Traditionally applied chemicals will not enter the bags to kill insects already deeply buried in the rice mass.
Moth larvae are known to penetrate up to 30 cms into bagged food commodities and the natural photo-negative behaviours of SPP insects means that they will normally be located in deep harbourages where fogged or gaseous forms of chemical treatment cannot reach them. They will effectively remain away from the chemical contact zone unless they fly or crawl to exterior surfaces to migrate, pupate or feed.
This limited exposure time corresponds to limitations in overall control efficacy.

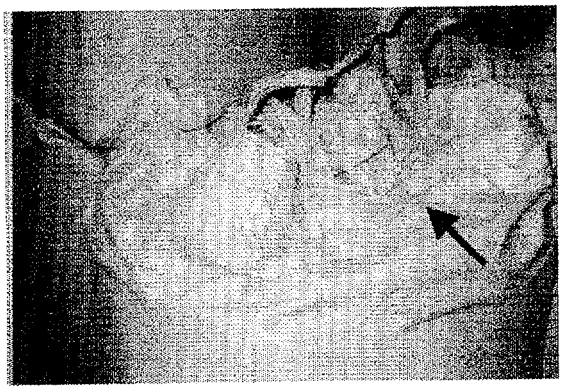
Fumigation with methyl bromide will of course kill the insects and their life cycle stages and this is indeed the common tool used for control in the Go Downs but of course this is the tool which ICM is looking to minimize or ultimately replace!

Conventional chemical usage as a residual treatment could however be considered as a valuable *component* of an ICM plan in the future to kill exposed SPP on bags ,walls, floors and ceilings.

Care must be taken to avoid excess use of any chemical near or on food commodities as this can produce chemical residue problems in the food which are more of a concern than the SPP



Insects in exposed rice.



Insects on the lid of "Bulk" bag.

An insects harbourage : damaged bulk bags

3.3 Rodent Control

Rodents are not well controlled on site and there is no professional rodent baiting program in place. If rats and or mice are noted to be a major problem in specific areas there is scope for use of sticky boards with baits placed on them.

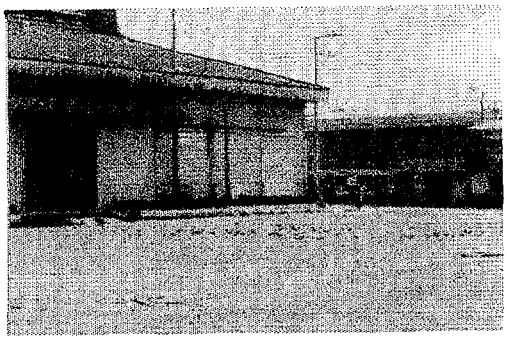
The rule is to tolerate issues rather than to manage the pests before they become significant problems and create serious damage.
Rats are commonplace down the river banks and will invade regularly over time.
Total exclusion is considered impossible but a management system was considered relatively straightforward to set up.

Baits must be selected so as to kill rodents without posing any risk from spillages which may contaminate the rice on site.
Baiting choices must take into account

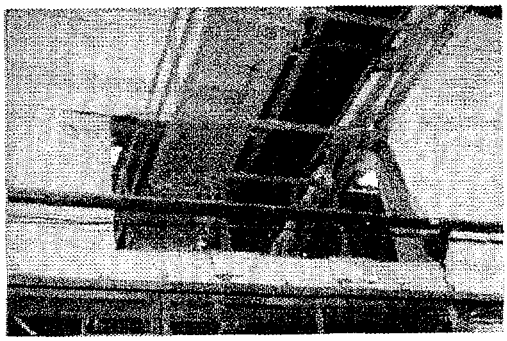
- Formulation e.g. blocks or loose grain type [blocks give lower contamination potential]
- Active ingredient reversible anticoagulant action or single shot high toxicity.
  [anticoagulant baits have an antidote if accidental poisoning occurs]
- Bait station design - covered and tamperproof to avoid spillages even if knocked [block baits can be securely fixed inside these stations]
- Bait station placement for maximum effect and maximum safety e.g. along wall edges to either side of entry doors but not on ledges over open silos]
- Station recording - map positions, activity records, changing and cleaning regimes etc.

3.4 Bird Control

Again this has been non existent in the past and birds are common invaders of the Go Downs. Feathers and droppings are easily located and these will create health hazards for rice in storage – especially if droppings get into rice being bagged.
Rice moving through the mill process will be cleaned and some control of bio-contamination will be achieved through this physical cleaning process. Birds are still accessing retail packed rice and tearing bags in the Go Downs so there is a significant contamination hazard in place.



Pigeons in truck loading yard



Conveyor access between Go-downs

3.5 Monitoring & Record Keeping

Monitoring of pest activities and stock losses from infestation etc were non existent prior to the study team becoming involved in CRC and setting up the basics of the ICM project.

There are a great many changes in this area of accountability which need initiation and modification over the course of the project.

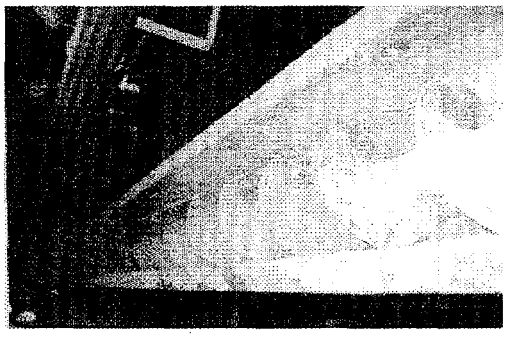
Chapter 4

Hygiene & Housekeeping - Pre ICM [April 2000]

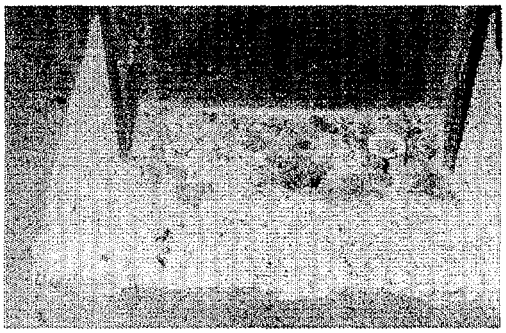
4.1 Baseline Hygiene Assessment

The levels of hygiene and housekeeping applied to all areas of the CRC facility and to every factor of the quality management process from recieval of milled rice to export shipment has been assessed. Summary findings are:-

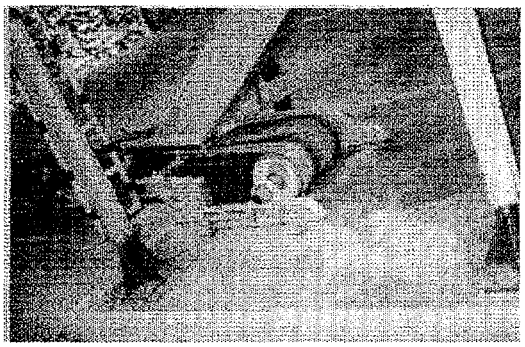
- Residual refuse material from rice processing is abundant in all areas.
- Floors, walls and equipment are cleaned very infrequently.
- The interior of bins are not inspected, cleaned and repaired when empty.
- Quantifiable standards for assessing acceptable cleanliness on site are absent.
- There are no cleaning schedules or procedures available.
- There is no current management accountability for cleaning.
- No space is provided between Bulk bags and walls to enable cleaning and correct inspection of milled rice.
- Lighting is inadequate in all areas to facilitate inspection and cleaning.
- Raw material and product spillage with attracts rodents and birds and serves as a breeding site for insects can be found inside and outside the plant.
- Process and cleaning equipment in machine house are not inspected and cleaned.
- Water spills are countered by using rice bran as an absorbent material but this is highly edible to insects when flushed into the many floor gaps. It also provides mould contamination.



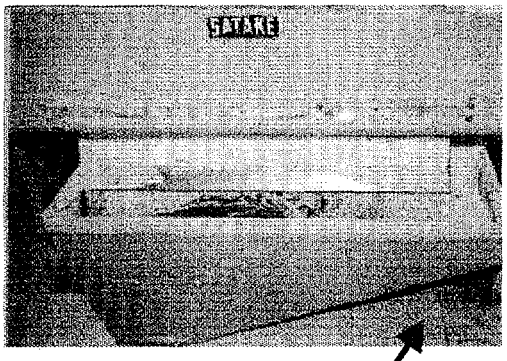
Accumulated residue in old auger



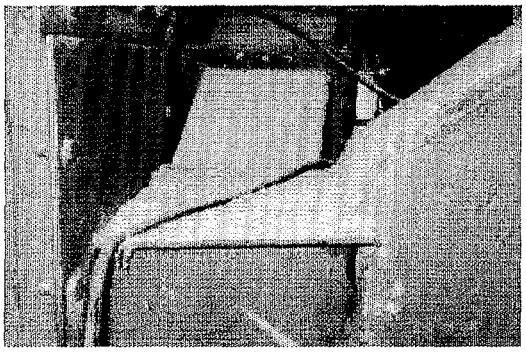
Residue by silos column in main mill areas



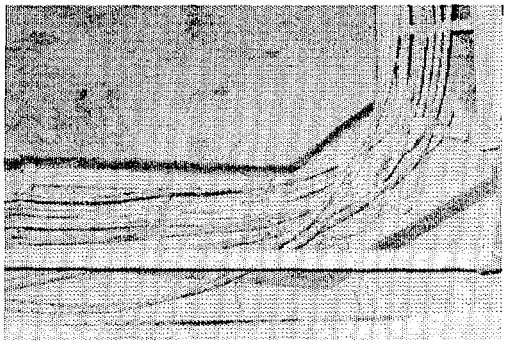
Rice spills under pulley



Rice spills on the floor from color sorters

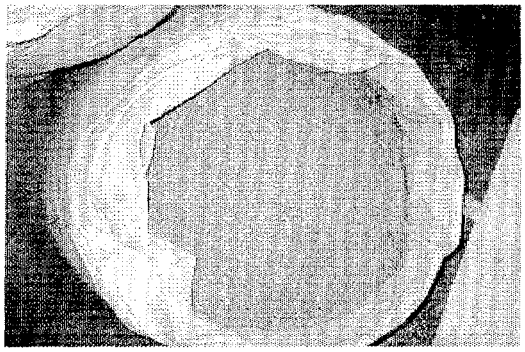


Spillage accumulation on the pipeline Junction

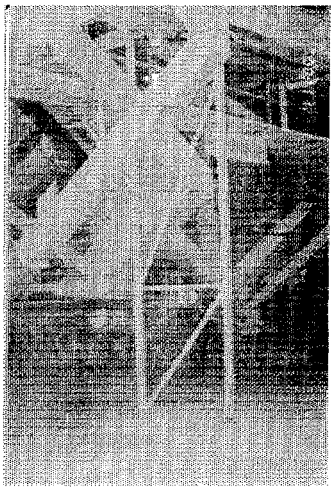


Cable tray spillage

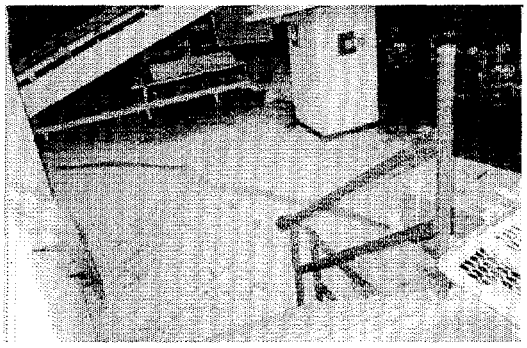
Untidy house keeping



Very dirty spillage rice



Heavy residue build up



Dust spreading during production process

4.2 Cleaning Methods

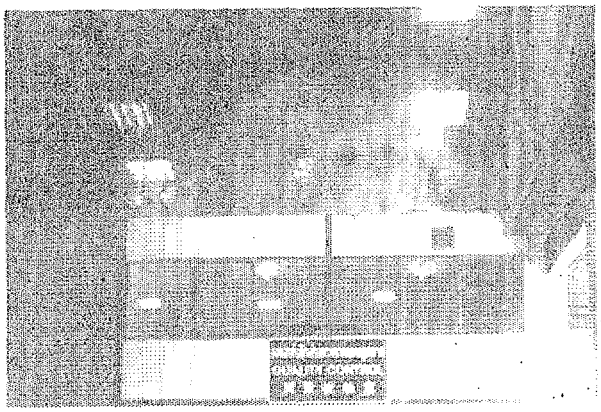
CRC receive a great variety of products from suppliers including 25% white rice from the central government warehouses organization. This contains only 75% whole grain rice and is considered low standard as it is in highly broken condition and raises high levels of airborne dust.

CRC staffs use only compressed air for blowing down dust residues and brooms for cleaning which are inadequate for removing residues – serving only to spread the problems.
There is minimal use of vacuum cleaners on site and these are considered vital acquisitions for the future management of cleaning at CRC. Large industrial cleaners and smaller back pack units are needed for high ledges.
The latter units may not be available in Thailand but are known to be available in Australia and could be exported readily.
There is one industrial vacuum cleaner in place in the machine house building which is used on upper floors e.g. in the grading rooms. This was noted to be dirty inside and it must be enforced that all such units be cleaned regularly to avoid accumulation of SPP inside the structure of the cleaners themselves.

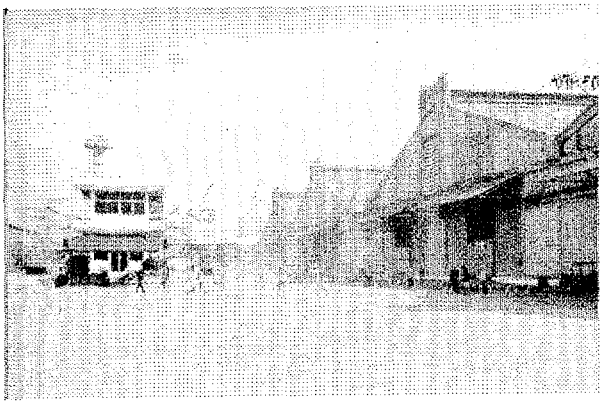
Dust collection systems and aspirators had not been installed pre ICM which also added to dust production and heavy residues on ledges etc.

Cleaning tools are ineffective, not designed for the tasks and not kept in clean condition themselves.

CRC "clean" used Bulk Bags with brooms under the hoppers in Go Down's 5 and 7 causing dust and infestation to spread into the Go Downs. Bags are left for long storage periods occupying over 80 m2 with these poor quality and infested bags.



Dust spread with blowers



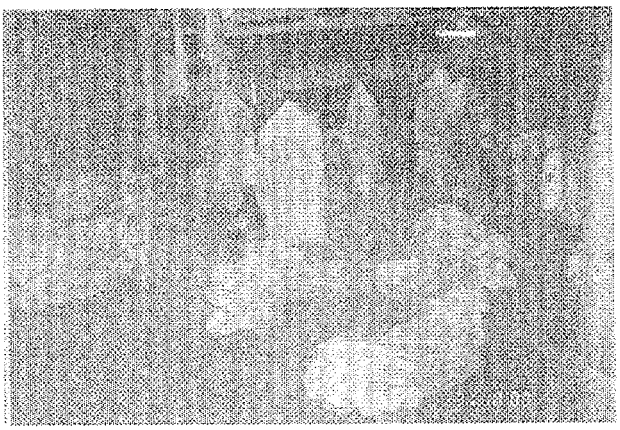
Dust spreads around Go down areas.

4.3 Record Keeping

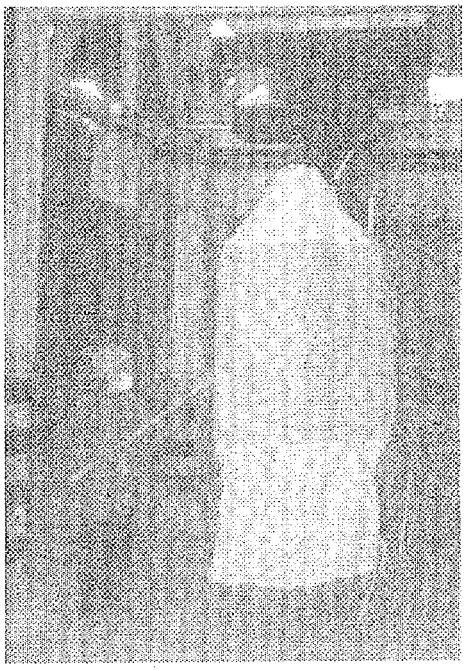
Records are generally poor and there are no procedures for cleaning in place and as noted there is no senior management ownership of the hygiene planning and maintenance.

Quantitative measurements recorded by the ICM team include such factors as manpower involvement in cleaning. These figures are vital in assessing the cost effectiveness of ICM methods over time as efficiency increases - man power costs should be reduced. Refer to Section 10.2 for further information.

- Bulk bag cleaning rate is 28 Bulk bags / hour with 3 staff.
- 7 cleaning staff were operating in the main mill [machine house.]
- 6 cleaning staff were utilised in Go downs 5 and 7



Bulk Bags Cleaning Under Hopper in Go Downs



Chapter 5

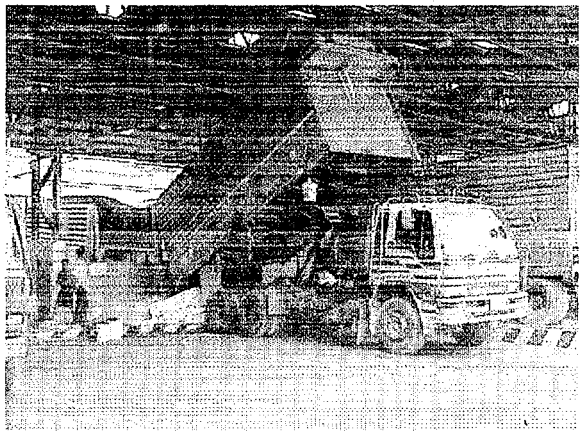
Storage Logistics - pre ICM [April 2000]

5.1 Receival System

Raw materials are received at the initial road dump hopper C1-C3 by truck. 60% of receival volumes are in bulk trucks and the remainder is via 100 kg jute bags. Incoming material is not critically inspected for insect pests and mould etc before unloading.

There is a theoretical procedure for rejection of infested rice but in practice most rice arriving is taken into the site. This is especially noticeable when rice arrives from government supply Go Downs and in cases when rice is sought for immediate export demands.

Rice in the latter 2 categories is often infested but as it is intended for very rapid rotation through the plant and then shipping out – the infestation factor is often overlooked.
There is a strong inherent belief that the milling process and fumigation eliminates the problem but this fails to recognize the problem of bringing pests into the plant structure in the first place.



Bulk rice format being dumped to road dump

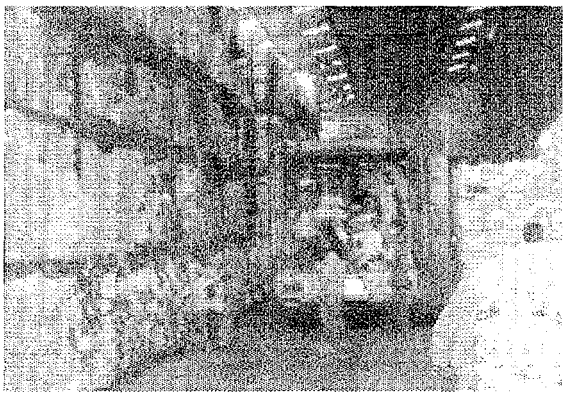
Bag rice format being dumped to road dump

5.2 Storage Methods

Bulk rice is stored in Silos with a total capacity of 30,000 tons and other stocks are stored in Bulk bags [Bulk bags] which each hold 1 ton of rice.
These are kept in 7 warehouses or Go Downs which have totally capacity of 300,000 tons.

Sacks such as the woven retail bulk sacks and bags for shipping of rice are stocked on pallet racking in Go Down 3.

Sacks are frequently placed against the exterior walls allowing for no cleaning or inspection around the stack perimeter and also preventing access to older rice for sale before new stocks which are placed to the front of the stacks on arrival.



Retail bag stock section

Old bulk bag storage

5.3 Stock rotation

This aspect is vital in minimizing insect population growth in the Go downs.
There is a clear and logical correlation between stock age and insect attack so it is also clear that old stock should theoretically be moved out before new stock of the same type to restrict the infestation levels which will accumulate on site.

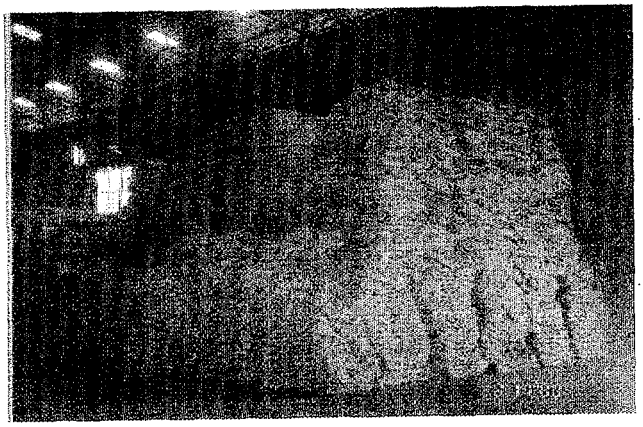
This does not regularly happen in practice and there is little management control of stock rotation.This factor is hard to control due to flexibility of order systems but in many cases there is no conformance to standard FIFO
(First In ; First Out) practices.

Old rice may stay in store whilst orders for certain rice types are filled with new rice in stock which is easier to access logistically e.g. to the front of the rice stock piles having been received last. Some old stocks are now over 12 months old and this is one of the key problem elements in the warehousing management.

Old rice tends to be covered in cobwebs and when stored for long periods can develop moulds and other taints.
High level insect activity will raise the temperature of the rice body and this creates quality problems in its own right. Aged rice stored in humid condition has a tendency to go rancid and produce off tastes. This is another key reason to speed stock movements.

Another problem noted in the Go downs is the storage of large volumes of old , used and dirty jute sacks from rice receivals. These are stock piled until such time as they are considered saleable and are then moved out. Storage can be for over 6 months and the old bag storage site represents a threat to stored rice as there are large populations of both SPP insects and rodents which use the area as a harbourage and feeding site.

Old used bulk bags [Bulks] are also stored in large numbers until they are re-used. This again poses the same infestation threat and there is a need to improve management logistics in the bag storage system



Large stock of used jute bags.

Huge amount of rice stock in Go Downs

5.4 Record Keeping

Records are provided and kept but as noted do not specify FIFO operation.
HACCP plans and procedural records are also kept and these will be modified over time to include all the successful aspects of ICM implemented over the course of the project.

Records are of course kept for all sales and dispatch transactions.
Locations of rice stacks can also be accessed for aged stock assessment on computer records but when rice is moved out for sale the older rice is not always targeted in the data outputs.
As a result much aged rice remains inaccessible - in positions to the rear of the stores and against the walls.

Areas occupied in storage of bags are as follows - 90 m2 for 35,000 poly sacks and bags in Go Down 3 and 40 m2 for keeping unused Bulk sacks in Go Down 6

Chapter 6
ICM Plan

6.1 Key Factors

The following improvements were considered viable for short term establishment at CRC.

Pest Management

- Improve all practical methods used on site for insect , bird and rodent control..
- Set higher standards for record keeping to follow pest population trends.
- Establish procedures for phosphine fumigation of aged stocks of rice and ensure fumigated rice goes to clean areas of the Go Down to avoid cross contamination.
- Integrated use of residual chemicals for insect management.
- Utilize ECO_2fume® rather than methyl bromide for storage fumigation.
- Set up training to raise awareness in pest management issues and hold meetings to encourage staff involvement in programs.
- Introduce trapping of rodents and insects as an integrated control tool as well as a monitoring method.
- Increase proofing of Go Downs to exclude birds to a higher degree.
- Initiate **safe** fumigation techniques for compulsory methyl bromide use for export.

Hygiene and Housekeeping

- Improve all aspects of cleaning methodology and raise hygiene standards across the site.
- Raise awareness of infestation and contamination issues associated with poor practice.
- Reduce air blower use and replace with vacuum removal of residues.
- Identify and eliminate dead spots in equipment and remove old disused equipment.
- Seal holes in walls and floors where residues accumulate.
- Remove covers from equipment and clean interior sections of equipment.
- Set procedures and schedules for cleaning all areas of the site [daily, weekly monthly etc].
- Set standards and methods for cleaning bulk bags.
- Designate team leaders to hold responsibility for work zone cleaning.
- Incorporate training to raise hygiene awareness for staffs.
- Move rice stocks away from walls in Go Downs to allow inspection and cleaning access.
- Addition of covers for exposed rice through the system e.g. conveyor covers, silo tops etc.
- Increase light penetration to Go Downs via installation of overhead skylights.
- Cease use of rice bran for water spill absorption.

Logistics

- Introduce FIFO methods for rice rotation and set up ICM focussed auditing across the site.
- Reduce old stock over 6 months of age from the site and target a 3 month turnover period.
- Improve stock inspection methods at receival to reject infested rice.
- Improve equipment operation to reduce product spills and wastage / downgrade of rice.
- Ensure jute bags and bulks are cleaned and sold quickly rather allowed to accumulate.
- Improve storage systems for bulk bags in a clean managed environment.
- Improve truck movements in the forecourt are to avoid congestion and speed delivery.
- Provision of improved aspiration equipment within the main mill [machine house].
- Provide feed back to staff on benefits from the ICM methods adopted including external positive feedback e.g. from visiting buyers, Government inspectors etc.

6.2 Review and Modification Process

All ICM systems must rely strongly on support from the organization involved in the project. Without positive feedback from the project team during the early period of ICM introduction there will be no real understanding of the project aims. CRC management must have direct involvement in the decision making processes to ensure that the long term benefits will survive and develop without constant external influences.

ICM systems must ultimately be developed with the intention of handing the long term management responsibility back to the client who must be fully aware of the aims and objectives of the modified ICM management methods.

ICM systems are flexible, and must remain so for the course of their existence.
Review processes must be regular and must involve elected staff members from all facets of floor operation and management.

CRC management should ultimately demonstrate "ownership" of the program and be fully committed to its achievement.

If this single basic criterion is not met overall – then the project as a whole will fail so it is imperative that the required time be spent on this aspect of the establishment phase.

As a result of these considerations there is a need for very regular open and positive meetings with all site staff to ensure they are kept informed of progress and feel able to contribute to the ICM development over time.

Initially this was a difficult hurdle to overcome and there was confusion over the outcome and feasibility of the entire plan. This was mainly due to the new concept of ICM and difficulty in visualizing its outcome and benefits.

This attitude was changed over many months through intensive work led by NE,Werayut and comprised meetings with senior management as well as with process staff to allow all levels of CRC employees to make a significant input to the achievement of the project aims.

6.3 Outcome Measurements

There are a number of measurement parameters to judge success of the project – both quantitative and non-quantitative.

Quantitative measures include

- SPP insect numbers and population counts located throughout the site and in rice itself
- Costs of ICM methods compared to costs of prior activities [including product losses and direct labour costs]
- Rice volumes in store covering a range of aged stocks
- Fumigation costs [methyl bromide disinfestation vs. phosphine storage]
- Costs of pest control on site
- Storage costs – bags / long term rice storage
- Volumes of rice spilled and downgraded
- Volumes of dust and dirt collected
- Total volumes of rice fumigated for disinfestation purposes [as against regulatory fumigation volumes which are not controllable]

Non- Quantitative methods include:

- Improved hygiene and working conditions for staffs.
- Healthier, safer and dust free workplace.
- Improved staff morale resulting from their direct involvement in the total site management plan.
- Raised " Quality profile " of the CRC site in the eyes of potential new buyers and government.
- Improved communication from senior management - now walking around the site daily to communicate with workers on wide ranging issues relating to ICM and work quality.
- Utilization of ICM records to achieve other targeted achievements such as ISO 9002 and HACCP accreditation

Chapter 7

ICM Implementation -Pest Management

7.1 Fumigation - methyl bromide

A key aim of the project is to assist with the transition from total reliance on methyl bromide fumigation on site for pest management before it is removed through legislative means in the coming years.

It is currently impossible to totally eliminate usage because of the quarantine needs of certain countries like Australia which demand a fumigation certificate prior to receival of any rice from Thailand.
Other counties requiring this type of fumigation guarantee are

Nigeria	Africa	Iran	Singapore
Ivory Coast	Dubai	Jordan	Indonesia
Malaysia	Spain	Senegal	Mozambique
Saudi Arabia			

There is a possibility of phosphine replacement of the commodity prior to export but this requires longer fumigation times and is currently logistically impractical.
Phosphine storage and subsequent provision of certificates based on this are to be looked into for the relevant countries import declarations.

Whilst methyl bromide fumigation is to done on site it must now consistently be done with full safety considerations in place. These are :

- Safety warning signs placed on stacks and containers
- Secure seals for tarpaulins and adequate taping of container doors.
- Name of the responsible fumigation company [currently "Thai Fumigation Company" and date of fumigant insertion and degassing date placed on the stack / container.
- Use of full face masks for de gassing and full safety options to exclude and protect other site staff at this stage
- Logistic management of fumigation operations to ensure all feasible work with a serious risk associated [gassing and de-gassing] is done over weekends or at times when few staff are on site.

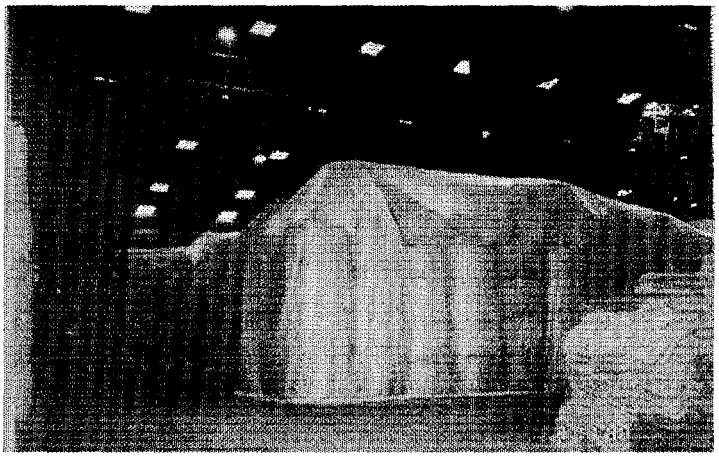
Current volumes of rice being fumigated for storage only i.e. not under legislated requirements are shown in Appendix 7. These indicate slow reduction in volumes of rice fumigation and thus cost reduction over the period measured in quarterly estimates.

June – August 2000	Average fumigated per month	5,943 T
September – November 2000	"	5,526 T
December 2000 – February 2001	"	2,917 T
March 2001 – April 2001	"	2,794 T

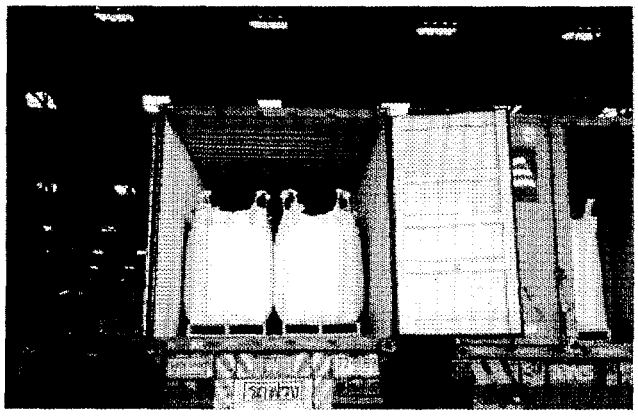
This is not completely conclusive evidence especially as the last result is an average of 2 not 3 months but the trend is clearly to show reduction in volumes of infested rice being fumigated and thus reduction in cash outlay for this fumigation.

Methyl bromide is still in use for local market rice and this must be applied incorporating the same safety procedures as export.

Sealing stack with sand snake
before applying fumigant



Stock Fumigation for storage purpose



Container being filled for fumigation

7.2 Fumigation – phosphine

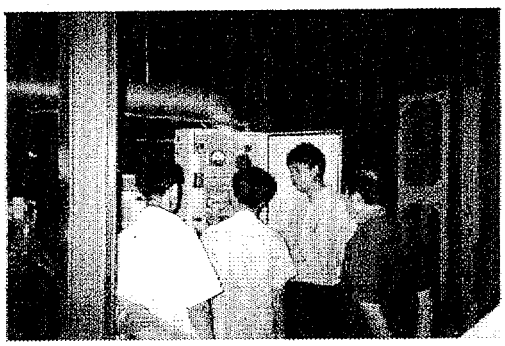
Rice in silo storage is being protected by phosphine gas at low concentrations and the gas is also being used to fumigate bulk aged rice in the main stores themselves.

Silo rice treatments are carried out using the $ECO_2Fume^{®}$ under trial at CRC.
The gas is used at low concentrations at 70 ppm. PH_3 controllable with Sirocirc® and Siroflo® systems within the silos and protects rice over long storage periods.
The results collated to date show a high level of success with 100% mortality for all stage of Stored Product Pests.

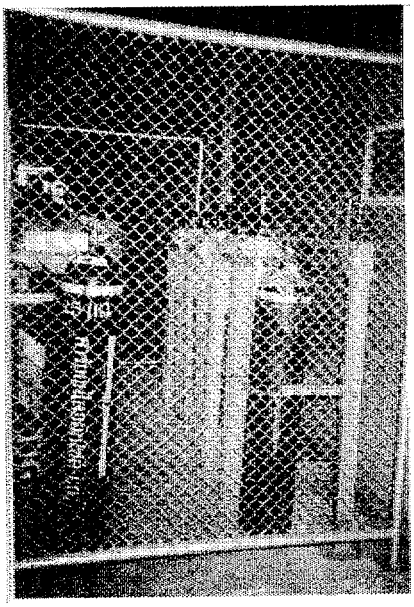
Phosphine is now currently being used by Thai Fumigation Company on site instead of methyl bromide at a standard application rate of 2 Aluminium phosphide tablets for 5 days per ton rice under the plastic blankets. This is equivalent to 1,600 ppm PH_3 on the 2nd day after applying the fumigants.

Results again show very good kills of all insect stages with the only drawback being the longer time exposure needed for fumigation when compared to methyl l bromide.

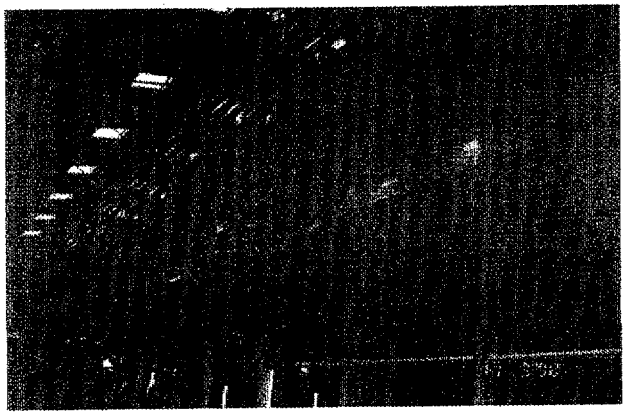
Storage Fumigation



Phosphine Concentration Controller used for ECO_2Fume



ECO_2Fume ® Phosphine Cylinders



Silo for ECO_2Fume ® Fumigation

7.3 CRC - Insect Controls

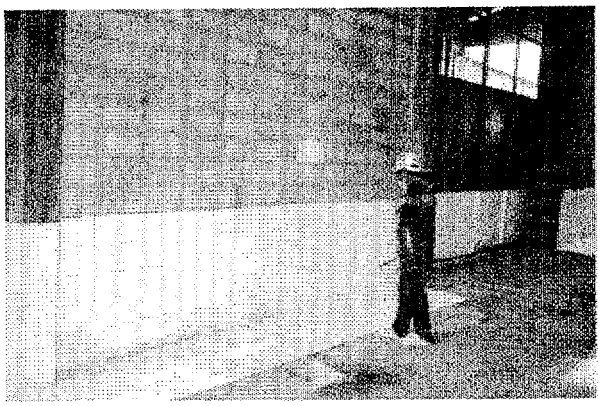
7.3.1 Chemical

Residual chemical use has also been in situations such as wall floor junctions, floors where bulk bags have been removed and cleaning has taken place, equipment bases and gaps under lines, refuse collection bins–exterior [interiors when opportunity arises] and on structural and silo walls.
Chemical used is Actellic® [pirimiphos methyl] which is a residual organophosphate with good insecticidal properties in various conditions.

To best ensure efficacy and avoid resistance development in insects – a rotation of chemicals is recommended for this use.

These will include synthetic pyrethroids - SP's - such as permethrin, cyfluthrin and cypermethrin plus organophosphates - OP's - such as Azamethiphos [Alfacron ®] or chlorpyrifos methyl [Reldan ®] used in monthly or quarterly rotations.

Rotation of chemicals can reduce the chances of insects gaining resistance to certain common chemicals. It is recommended that the groups be rotated as well as the types within the groups eg OP 1 month one SP 1 month 2, OP 2 month 3 and SP 2 month 4 etc.



Chemical Spraying with Actellic®

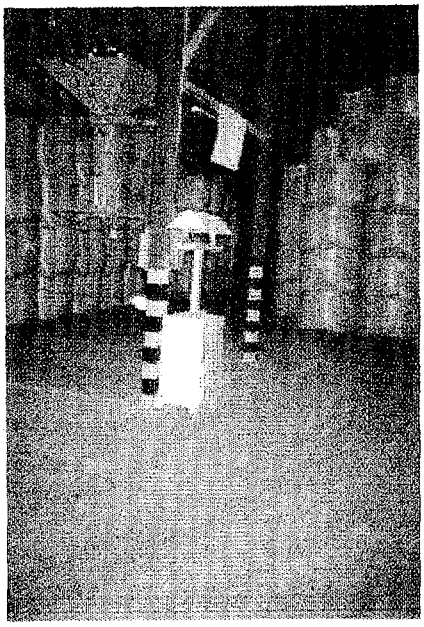
7.3.2 Physical

Light trapping using the vacuum UV light units has demonstrated the ability to capture both red flour beetles [*Tribolium castaneum*] as well as the flat grain beetle [*Cryptolestes pusillus*] see Appendix 6.

Light traps are thus considered viable for longer term monitoring of these insect pests but as the catches can be relatively high more than 200 / 300 per night, there is some degree of positive control also associated with the use of the traps.

Future work with Green light "Insect-a-matic ®" units with greater capacity for SPP attraction will be valid and these may be a valuable part of future controls on sites in Thailand.
These green units supply light in the range of 490 - 550 nm. as well as the standard light output wavelengths of 350 - 370 as found in blue light outputs.
Different species of insects are attracted to different light wavelengths so the combination of both ranges gives added attraction to a greater range of species.

NB: A factor or more than 30% greater attraction for SPP insects has been claimed by the manufacturers of the Green light units and this would be significant in all Go Downs and the main mill areas.
Some units are designed for use in dusty environments working on low voltage grids - avoiding duct explosions and are thus very safe in a variety of work places.



UV Light Traps

7.3.3 Pheromone Use

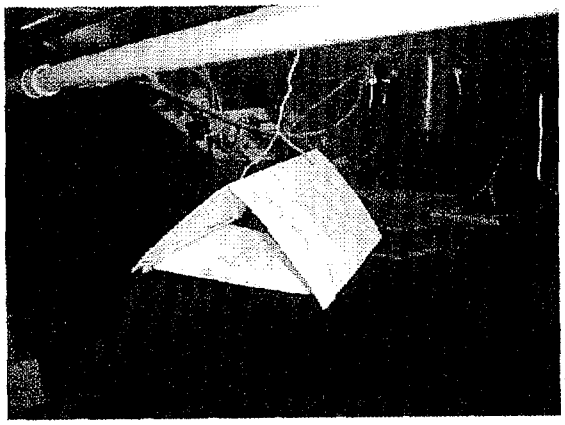
Pheromone trapping of male beetles and moths will remain valid as a monitoring system to indicate problem sites or hot spots within the bounds of the buildings but is seen to offer very limited value in any control program.

Monitoring will be better when the overall populations are much reduced and there is very tolerance of any insects on site.
It is in these conditions that pheromone monitoring is at its optimum value and careful grid placement of pheromone lures will indicate clear "hot spots" breeding and feeding areas of SPP pests.

With this information and an understanding of the ecology of the pests involved – the hot spots can be identified, cleaned and treated. Subsequent monitoring will demonstrate the removal of the problem site as counts drop down to zero.

Other controls can be initiated in closed buildings involving pheromone disruption strategies. This strategy involves placing huge numbers of pheromone lures in closed buildings which cause the male moths to become disoriented and unable to find a female for mating.
Population control is due to this inability to reproduce but this is not currently viable in the CRC mill due to its size and open nature.

[NB Large amounts of pheromone moving in the air can actually cause attraction to moths outside the buildings – making the situation worse!]



Pheromone Stations

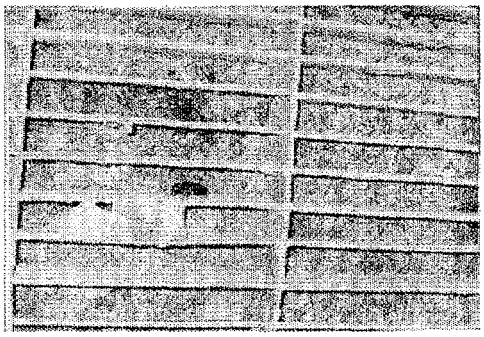
7.3.4 Removal of insects with rice dust and residues

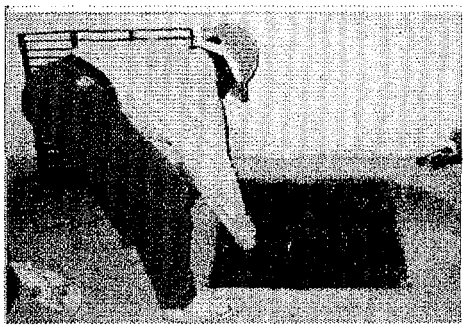
This is a key part of the reduction of risk from insects as well as the reduction of dust contamination to the products.

Improved cleaning has removed a huge insect population from the site and all the other cleaning measures have enhanced the result.

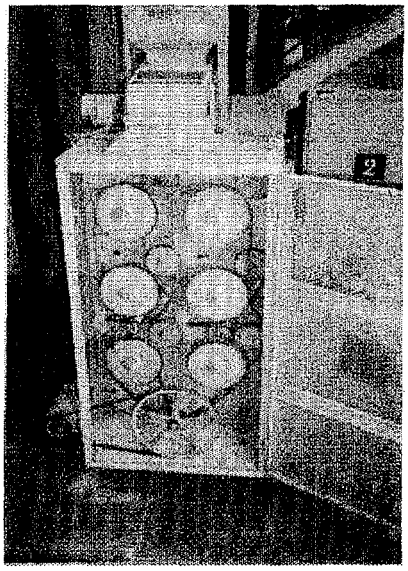
Addition of the 4 cyclones to the main mill and fitting of the residue removal ducting on each floor has improved the rubbish removal efficiency from the mill again reducing the insect population.

Sealing of dead spots and removal of the disused equipment on site has created a reduction in harbourage availability and residue accumulations.





Sealing of dead spot



Remove the accumulated residue

7.4 Biological Controls

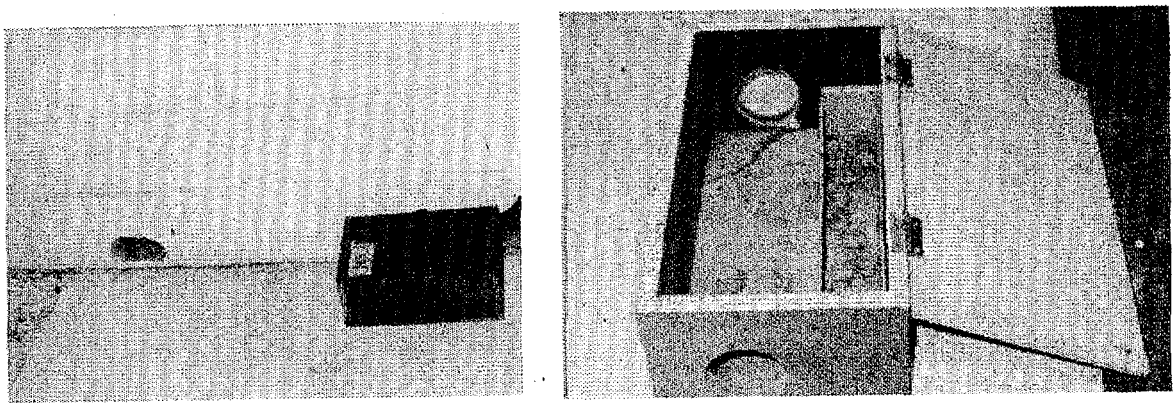
No biological controls have been initiated on site to date but there is possible consideration of some bio-controls in the future e.g. use of *trichogramma sp* wasps which predate the larvae of the moths such as the corn moth and warehouse moth.
This type of control is only possible however if the standard chemical controls are removed as the chemical applications will destroy the predator populations as well.

Investigations of the rice in storage has already demonstrated the presence of predator bugs *Xylocoris sp* but these are having minimal impact on the resident SPP insect populations.

7.5 Rodent Control

Rodent stations have been established through the mill and Go Downs and these are numbered and marked on a map.
Baits are changed monthly and in situations where there is high level activity e.g. wharf and loading docks – there is scope for use of sticky boards.

- Baits are to be replaced monthly and boxes cleaned inside to eliminate rice residues
- Baits are to be rotated monthly using anticoagulant based block baits which cannot be spilled as easily as the loose grain baits or pellets.
- Sticky boards when used must be changed at least twice weekly and dead rodents removed from the boards to prevent odours and fly breeding
- All dead rodents to be removed on discovery
- No stations to be placed on upper ledges to minimize spill and contamination potential
- Snap traps are to be considered for fixing to upper ledges and these are to be emptied daily when a rodent has been caught.



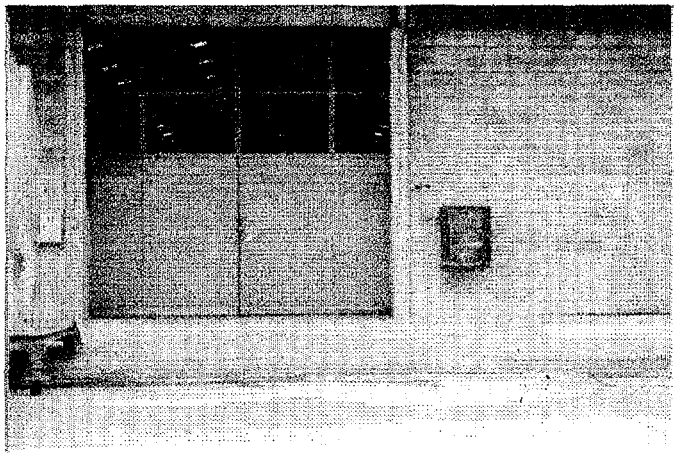
Rodent Station in Place

7.6 Bird Control

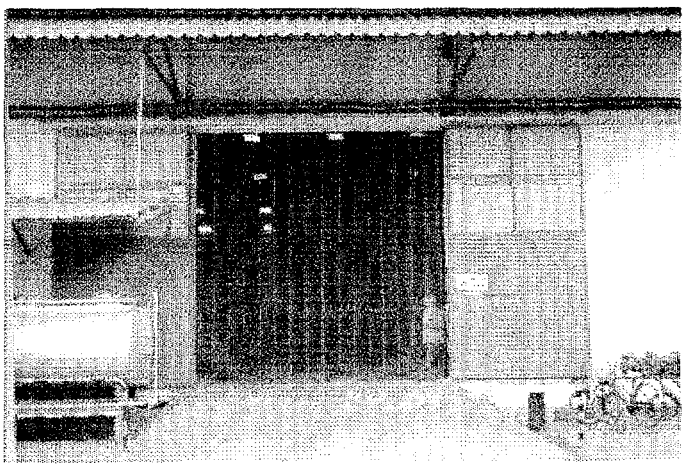
CRC has sealed all upper levels of the Go Downs with bird mesh to eliminate bird access points. Go Downs also have good bird netting weighted with chains across the doors which is a good flexible means of eliminating pest birds from the site. Screens can be pulled across on sliding runners to allow trucks and forklifts to access the Go Downs then closed to exclude birds.

One problem however is that the bird species inside the buildings are sparrows which have been born on site and have great skills in invading carefully sealed buildings. They will wait by doors until they open and then hop in for example so it is worth considering further controls to reduce the population permanently.

The Main mill is however still open and the method or temperature control involving opening windows is constantly going to produce bird access points..
External fitting of bird mesh to windows to enable opening is a good option when money is allocated. Birds will contaminate product readily with feathers and droppings and so this type of issue is worth spending time and money on in the future.



Keep Go down's gate closed



Bird Netting-Closed

7.7 Monitoring

Monitoring has been set up and will continue using the following methods;

- Pheromone lures for moths [*Ephestia sp* and *Plodia interpunctella*]
- Sieve assessments of rice in storage to build data on age stock infestation and relative insect proportions in commodity type.
- Sieve tests on residues removed from mill and Go Down ledges and equipment. Both these latters methods involve direct, comparable counts of SPP insects and can show specied distribution on site.
- Monitoring of rodent activity will enable better placement of traps and stations.

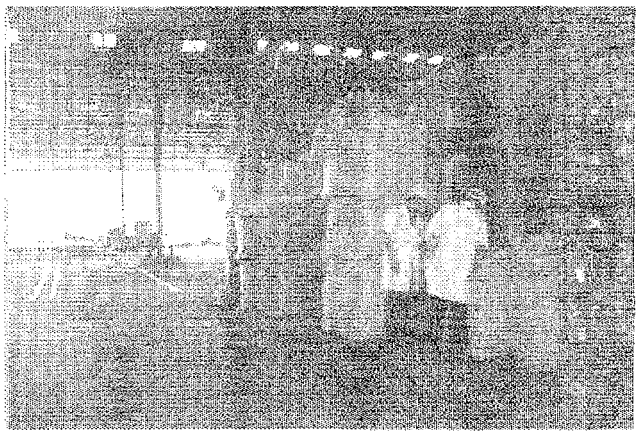
7.8 Audits

Audits of the site will be done by ICM team members still involved in the project in the longer term and by internal QA staff at the mill.

Training for the audit process and formats has been provided by the National ICM advisor in conjunction with the International Advisor.

CRC will undertake their own audits and these will be placed on record to give a historical document of progress and improvement over time.

Bi-weekly Internal Audit



Monthly External Audit by ICM Team

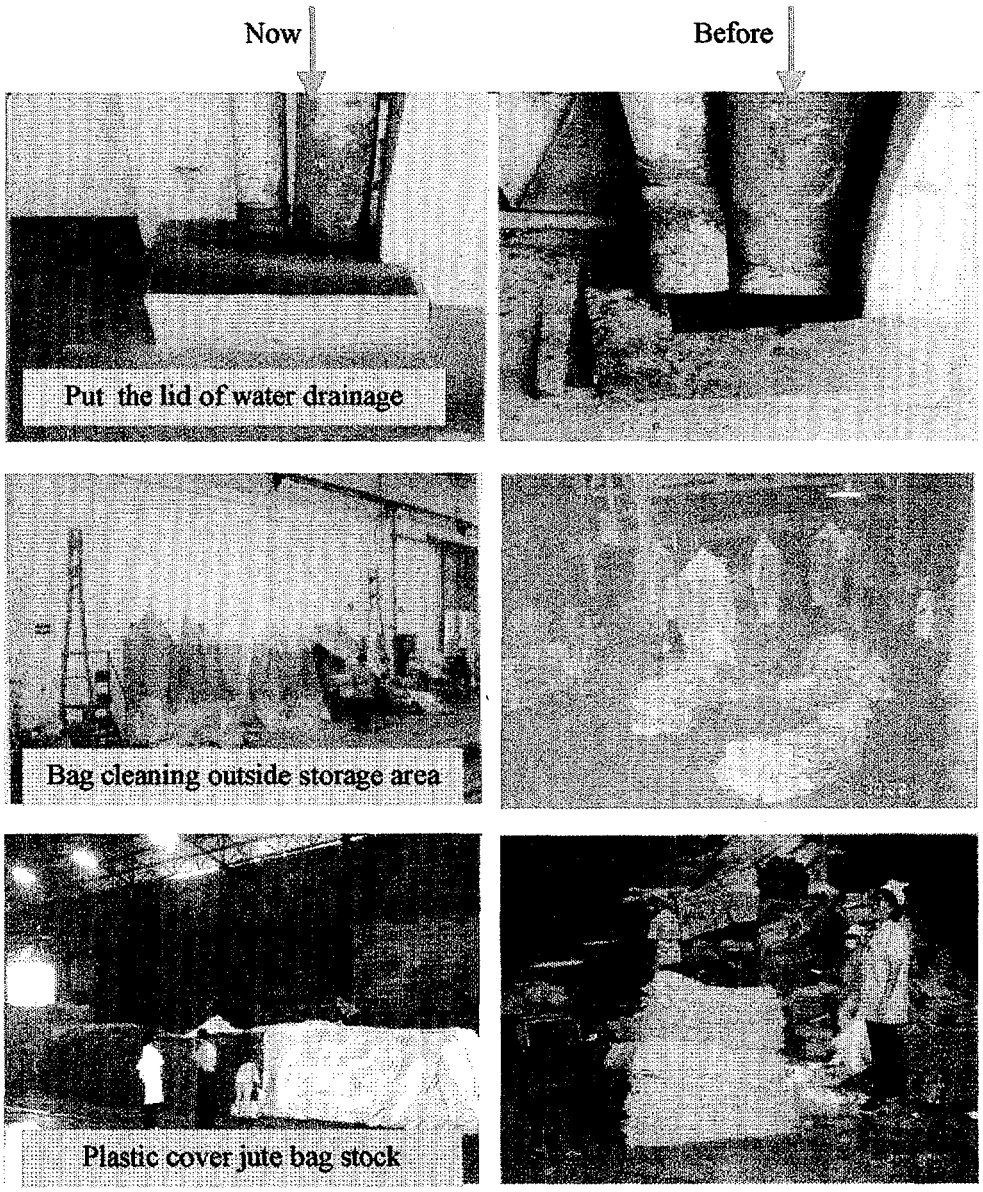
7.9 Photo records

These have proven invaluable in defining the required standards for the mill and Go Downs for CRC as many lower level site staff relate better to pictorial instructions rather than to written ones.

ICM team has provided procedure documents, stage by stage methodology diagrams, flow charts and QA documents all using photographs to define the required 'good' and 'bad' situations on site.

Examples of these are provided in Appendix 8 and others will be modified over the coming year by CRC staff using the same technology [digital camera shots and scanned images to computer]

After implementation the workspace sanitation plan

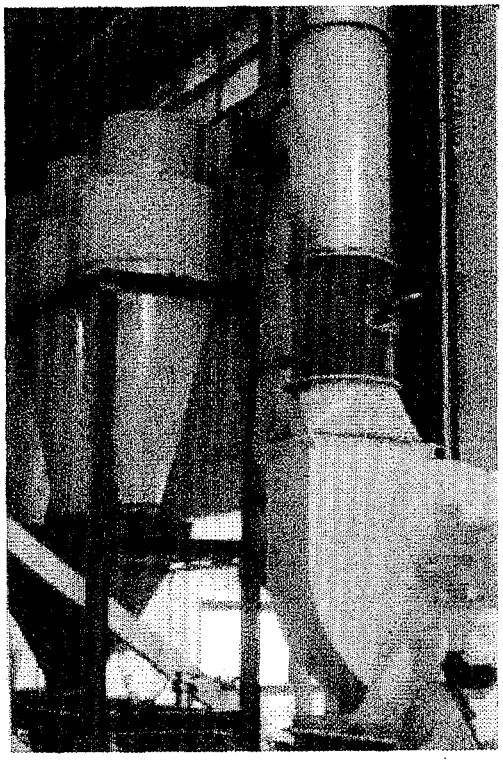


Chapter 8

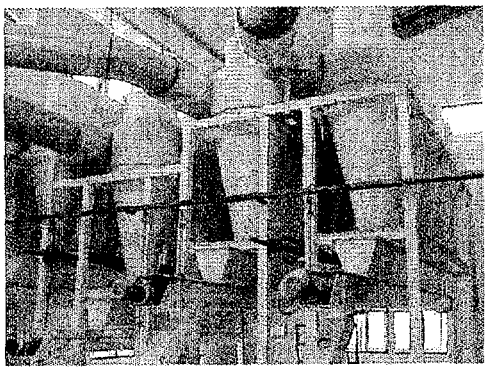
ICM Implementation - Hygiene & Housekeeping

8.1 Mill Equipment Improvements

- Cyclones [Dust extraction units] Installed on 3rd and 5th floor in Main mill
- Back filters installed in grain sorter room on 2nd floor.
- Filled cavities and crevices all floors with cement and steel plates
- Repair of Leakage in Pipeline process
- Bag filling process was noted to produce spills to the tops of bulk bag bags during the filling process which was measured as 60 gms per bulk bag filled. This results in huge stock losses and was rectified with changes in closure of the bin slide to prevent this type of spill
- Modification of the blower equipment for cleaning the silos and bins



Cyclones [Dust extraction units] Installed 3rd floor



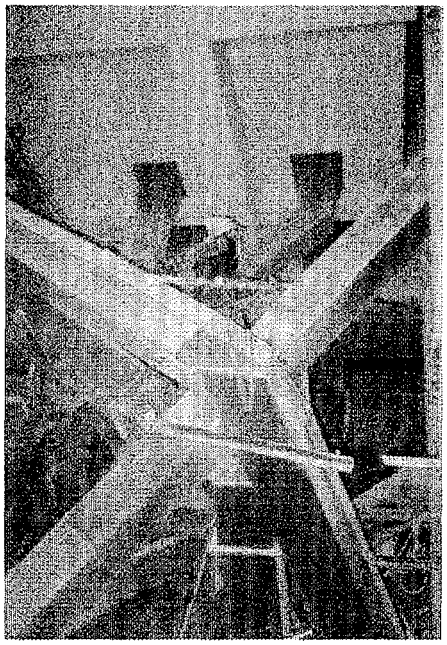
Cyclones [Dust extraction units] Installed 5th floor

Blower equipment for cleaning the silos and bins

8.2 "Best Practice" Procedures

To enforce staff keeping the warehouse clean which is the foundation of Integrated Commodity Management (ICM), a set of Best Management Practice [BMP] procedures was drawn up to integrate with existing CRC operations as follows:-

1. Best practice for plant and equipment design.
2. Best practice for good sanitation.
3. Best practice for inspection and monitoring
4. Best practice for storage and fumigation of bagged grain.

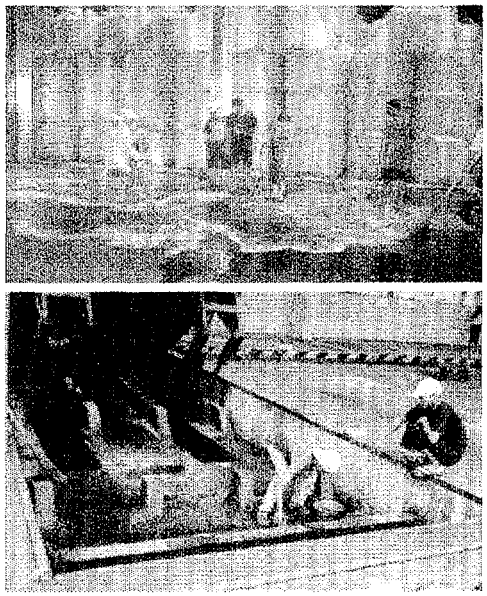


Cleaning all hidden areas to diminish insect harbourages

8.3 Cleaning demonstrations

As some of CRC cleaning staff lack higher level education it is essential to demonstrate the cleaning techniques and have them follow the lead shown by trained staff in cleaning logistics. A team of trained people were brought on to the site in September 2000 to provide this demonstration and following the demonstration a series of photographic representations were provided in poster format for the staff to relate to over future cleans for which they are responsible. Refer to Appendix 9 .

Vacuum usage



Floor cleaning

8.4 Cleaning schedules

Draft cleaning schedules have been set by ICM National Advisor in consultation with CRC staff. Review of these documents occurs monthly and examples provided in Appendix 8 & 9

8.5 Record keeping

All records have been upgraded and record keeping is now a standard part of the cleaning and stock rotation system. Examples are provided in Appendix 8 and 9
Other factual and quantitative records are kept now including Rice volumes by age – appendix 7 and Rice volumes fumigated by month for storage purposes only. The quanlity of the recording keeping initiated by ICM implementation has provides CRC with an easy road to HACCP and ISO 9002 accreditation this year. Favourable comments were received from both these external certifiers in this regards.

Staff location and responsibility is recorded and monitored regularly.

- cleaning staff allocated to the machine house
- cleaning staffs in Godowns 5-7
- cleaning staff for cleaning Bulk bags at a cleaning rate at 40 Bags / hr

8.6 Monitoring and review methods

The monitoring methods include:-

- Establishment of achievable and quantifiable targets with designated action points.
- Schedules for placing and checking pheromone traps and UV light traps.
- Daily check of inbound raw material and outbound of finished goods.
- Bi-weekly internal audit by QA. staff at CRC.
- Finally monthly external audit by National ICM Expert.

8.7 Lighting improvements

450 Skylights have been installed over all Go downs plus an additional 90 units in the Machine House. This has added high levels of light to walls and floor interfaces providing cost savings on electrical lighting and easy access for inspection and cleaning.

In addition there have been 250 compact fluorescents installed in Machine House and in Go downs 3 & 4 – which are key focus storage areas of the ICM project .

Skylight & wall/Floor painting

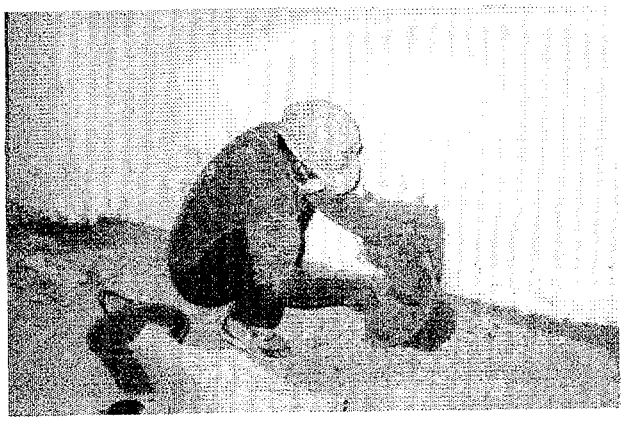
8.8 Inspection and cleaning access

This is enhanced by the addition of lighting and the provision of procedures for inspection and cleaning. Staff awareness is very high currently and backed strongly by management at CRC.

The white lines painted along the wall floor interface in the Go Downs are to be regarded as Exclusion areas for rice storage i.e. no rice to be placed on the white painted areas in storage to ensure the access remains available.
These areas give a minimum access of 1 metre all round the walls for cleaning and inspection purposes.

8.9 Proofing and Sealing of harbourages

Flat surface, cracks, crevices and cavities in floors, wall, ceiling and equipment have been sealed with concrete or otherwise repaired.
There is still work to do in closing windows in the main mill during the day but there is better control of door closing in the mill and Go Downs when not in use.
Refer to Section 10.2 for cost estimation.



Sealing the cavity

8.10 Contamination Protection –exposed rice

Plastic covers are now in place over all conveyors in the plant and Go Downs to prevent dust and bird contamination of the rice in transit.

Rice in bins and hoppers is protected by closing the lids of these when not being accessed directly and there is a huge reduction in dust in the air and thus a reduction of contamination from this aspect.

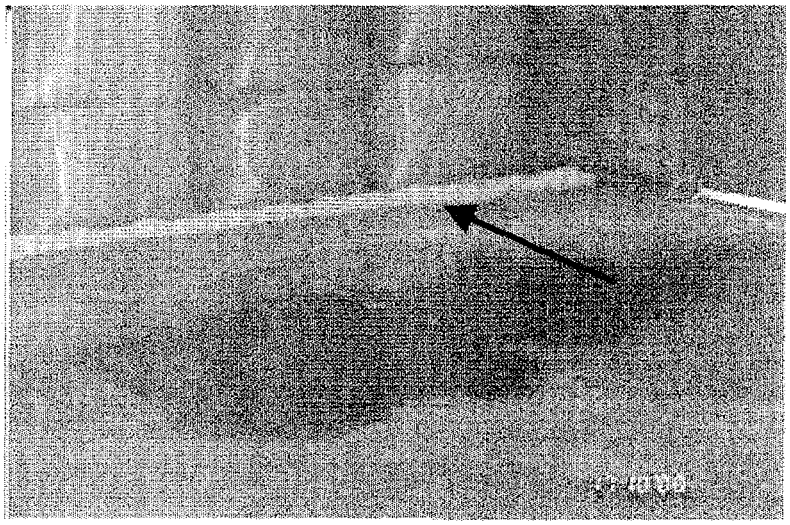
Spills of rice are quickly noted and any equipment malfunction is rapidly repaired to prevent further spillage and downgrading of quality of the rice.

NB : All spilled and thus exposed rice becomes downgraded so this represents a great cost saving through proactive management.

Covered conveyer

8.11 Water spill management

- Leaks in pipes are quickly identified and repaired.
- Roof drainage must be in good shape and debris removal is often required on the top of Machine House to prevent water accumulation
- Mops, sand and rags are used to collect water spills and there is no further use of edible material such as rice bran for this purpose.

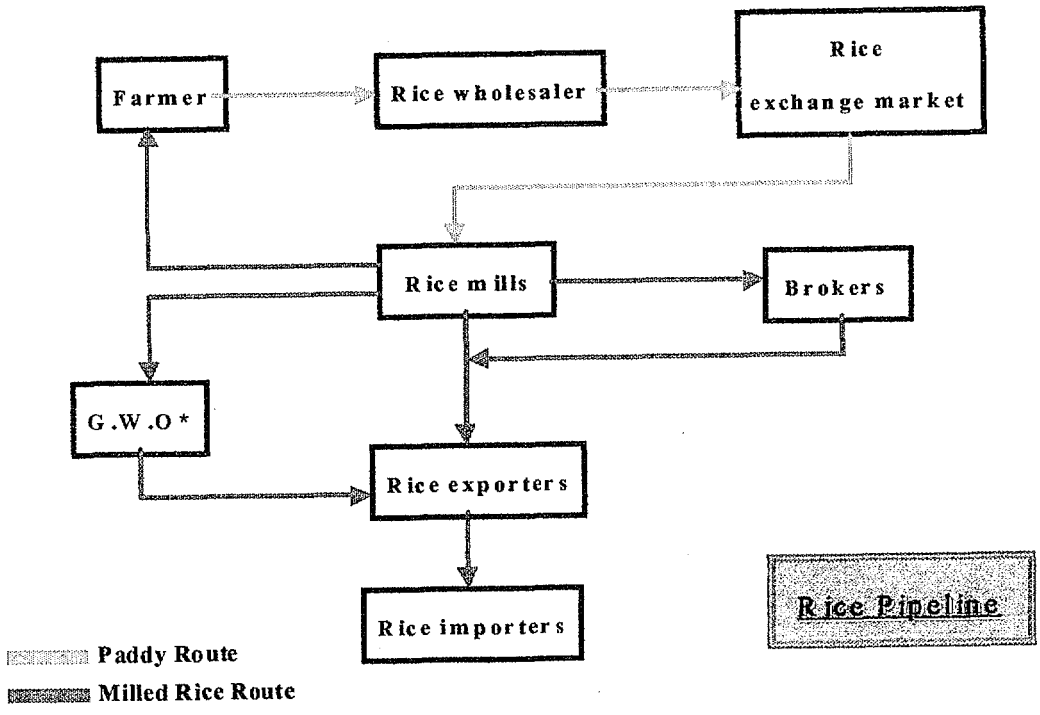


Chapter 9

ICM Implementation - Management Logistics

9.1 Rice Receival

The unloading area must be clean and free of contamination. The milled rice is inspected before unloading if necessary. Refer to the diagram



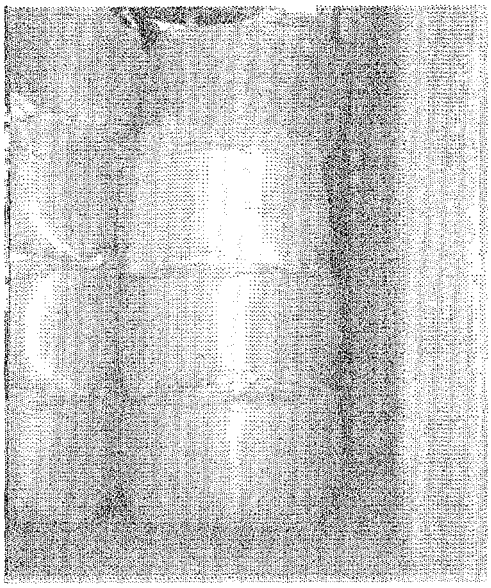
G.W.O* = Government Warehouse Organization

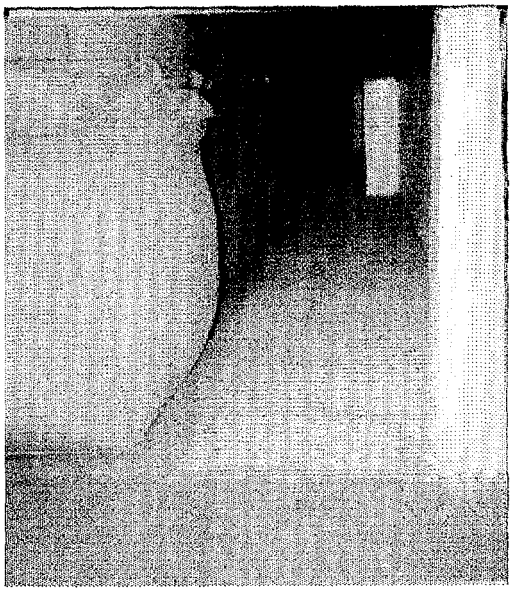
9.2 Mill Storage Logistics

CRC will maintain reduced stock inventory and create faster rotation of stocks by closely coordinate with marketing and procurement division.

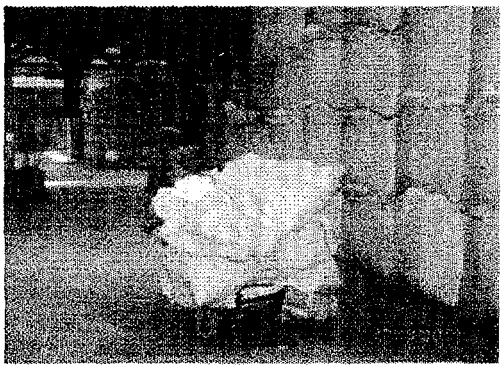
Rice will not be stacked against walls and the white painted exclusion zones will assist with this management factor. [refer Appendix 11 – Best Practice for ICM]

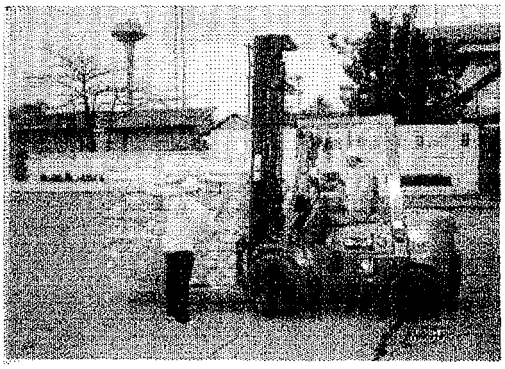
When rice is to be stored for over 6 months the rows of bulk bags shall not be more than and placed in separate rows comprising no more than 12 in number to enable quick and easy access for inspection and fumigation if deemed necessary.





Rice will not be stacked against walls and the white painted exclusion zones.

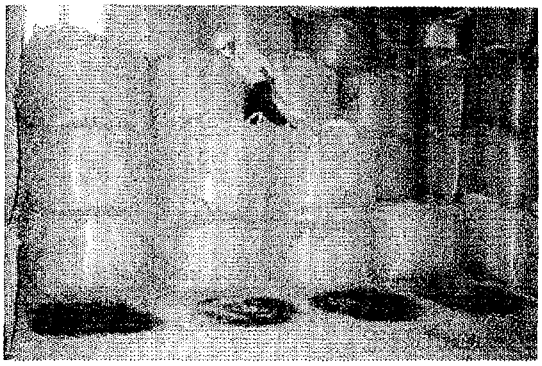




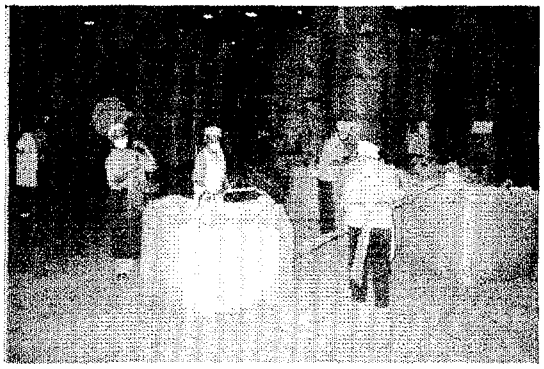
Forklifts are used for movement of bulk bags instead of trolleys which improves efficiency.

9.3 Rice storage periods [FIFO]

This first in first out [FIFO] method must be employed whenever possible at CRC and management are currently working on improvement of storage to allow for older stocks to be accessed for process before newer stocks are run.
FIFO management will become an integral part of the CRC logistic planning in the coming year and although difficult to implement in this situation will prove to be an invaluable logistics option.



Removal of very old stock for inspection.



Cleaning down and inspecting old stocks.

9.4 Stack management

- Before bags are filled for storage in any area they must be checked for cleanliness. See Bulk bag cleaning procedure.
- The bulk bags will not be stacked more than 6 metres high.
- Minimum gap between stack of bags and walls must be retained at 1 metre and floor painted white as a no store exclusion area allowing for easy cleaning & inspection.
- Weekly inspections must be made to locate infestation of grain in poor condition [mouldy, infested or rancid]

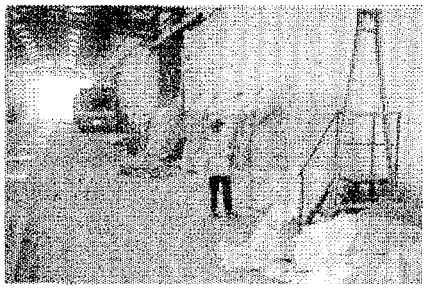
Weekly inspections

The bulk bags will not be stacked more than 6 metres high.

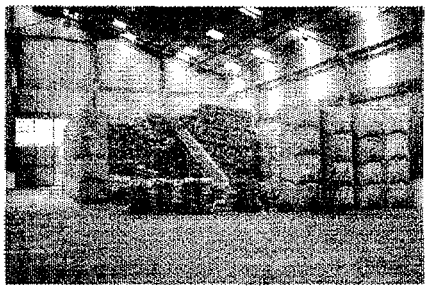
9.5 Rice Bag cleaning

All of the used bulk bag are cleaned in the designated area which is the corridor between GD6 and GD7. This is fitted with a hanger for 10 Bulk Bags to be treated at any one time and is equipped with 4 air compressed gun. 3 staff members are trained to follow the procedure

- Repair the broken bags [stitch and tape as needed].
- Exterior cleaning of bags with a broom.
- Inside cleaning with compressed air.
- Fumigation of those bags with phosphine fumigant in conjunction with storage fumigation in the Go Downs.
- Storage for reuse in a designated area of GD 7 on a floor area treated with Actellic® .
- All cleaning equipment should be fumigated once per month minimum.



Bulk bag cleaning



Preparing used bulk bag before fumigation

9.6 Bag coding

The milled rice which has passed QA inspection will be packed in Bulk bags colour coded and designated to vary rice types viz:

Blue	Fragrance rice,
Yellow	Parboiled rice
Green	White rice
Red	Spilled white rice [downgraded quality commodity]

This coding makes it easier to visibly assess rice placement in the storage and will give guidance in future for assessing rice susceptibility to attack.
Whilst the ultimate aim is to achieve this coding for all bags – there is currently a mix of colour bags for the same commodity due to occasional shortages of some colours when needed for filling. This will be rectified overt the coming months.

Colour coding of bags

9.7 Bag Storage

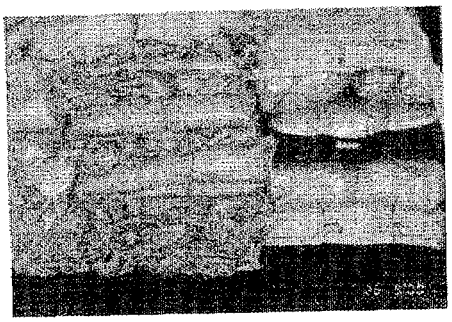
The bag storage is separated into 3 parts

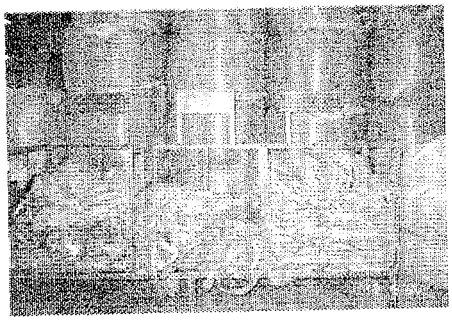
1. the bulk bags which will be reused on site
2. the use jute bags which will be sold back to suppliers
3. the retail bags in Go Down 3.

Bulk bag storage is now restricted to the corner of the Go Down 7 where floors are treated with pesticide and bag heaps are protected with a plastic cover.

Jute bags will be accumulated in Go Down 5 again covered with a protective plastic cover. Jute bags in stock that would normally be held for long periods until the bag price is high or the volume of bags held is unwieldy - will now be disposed of at regular price to reduce the infestation risk emerging from this harbourage.

Trials of fumigation of old bags in situ-covered with poly or placed inside a sealed poly bag with a dichlorvos strip insert will be trialled over the coming year and this may offer a cost effective storage system for used bags on site.



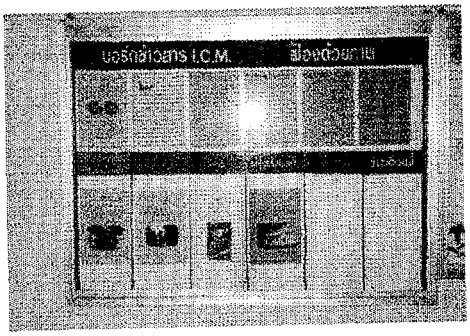


Improved bulk bag storage

9.8 Management coordination and communication

ICM is flexible system so the ICM team must always take the concerns of the CRC management into consideration in planning options for the achievement of the ICM principles.

Meeting are held to discuss options on a weekly basis with action points and completion deadlines ensured by mutual cooperation.
Other informal meeting between site staff representatives and ICM team and or CRC Management are also held to discuss issues of concern to floor staff including health and safety issues and cleaning routines.



ICM Board

Informal Meeting

Chapter 10

Project Evaluation

10.1 Overview

The initial aim of restricting work to the Bangkok CRC process and storage site rather than attempt to include ICM for all aspects of rural supply mills is justified given the complexity of work required to date.
If ICM quality standards are maintained through the system at Samut Prakarn – there should be good control over finished goods rice quality relating to infestation and contamination issues.
Future extension of the work scope to initially include other STC group mills - such as the mill at Bang Pa In - is justified given the experience now accumulated by CRC.

With the combination of ECO_2Fume in storage silos – there should be demonstrable controls over infestation and this is in turn will reduce the need for fumigation of rice stacks in storage and in export.

Work is still required to gain support for this alternative system from the countries requiring methyl bromide fumigation certificates pre export.

Extension of ICM to farm level is not considered to impact on the current system but should be part of the long term aim of ICM initiation in the rice industry in Thailand

10.2 Quantitative Review of ICM Improvements

The current adoption of a wide range of techniques on site has shown many benefits to date but these must be seen in context as part of a long term plan.
Many high costs accrued this calendar year e.g. the installation of cyclones for dust removal will show benefits into the future and the initial cost of installation must be spread and not fully amortized into year one.

All tabulated costs and benefits have been assessed by the National Expert in Management and are based on the assumption that the improvements are key to the ICM operation. The cost saving in labour following hole sealing is only justified if there is an initial total commitment to cleaning on site. NB Rural mills would currently not clean at all thus the savings noted here would actually be seen as an *increased* cost rather than a saving!
Other costs such as those from saving rice from downgrade after spillage and reduction in rice losses from infestation are clearly economic benefits in any operation

Activity	Cost US$	Quantifiable benefit	Other benefits
Skylight installation	$5,147	Electric Lighting cost saving $ 4,217 per annum (base on cost of electricity at 5.7 cent / unit)	• Ease of inspection • Improved appearance • Reduction of humidity
New bag storage in GD 3	No cost	Release of storage space 90 m2 - saving area rental $1,536	• Improved efficiency and removal of dead stock
Stock rotation / Maintain low inventory improvement	No cost	1. Reduced production loss due to rice deterioration $ 27,766 2. Fragrant rice weight loss duet to SPP destroyed saving $ 29,262 [produced at 30,000 tons/years at cost 82 cent/ tons rice.]	• Reduce insect cross contamination • Efficiency gains
Filling of holes and cracks in floors and walls	$970	Reduction in labour time and costs for cleaning $7,560 by reducing overtime (OT) payment from 4 hrs/day 200 days/year to 50 days/ year. (at 73 cent / hrs)	• Improved dust control and healthier work environment

Activity	Cost US$	Quantifiable benefit	Other benefits
Installation of bulk bags and jute bags cleaning equipment and improved sack use rotations Bag recycling after cleaning	$230	1. Labour cost saving $2,094 from reducing 2 staff and OT payment from 200 days at 4 hrs a day to 50 days. 2. New bag purchase saving $11,110 from purchase of only 2500 bags instead of 10,000 bags. 3. Increase in available storage space $1,365 by releasing rental area 75m2 @ $1.50/m2/month	• Improved efficiency of operation
Installation of dust removal cyclones	$47,321	Reduction in labour time and labour cost.	• Healthier work environment • Harbourage and insect elimination
Improved procedures for packing bulk bags and unpacking jute sacks	No cost	1. Re -process saving $5,107 (spilled rice lost from damaged processing equipment and pipeline leakage at an average rate 0.18% of 1.2 M.ton at $2.36 / ton. 2. Rice standard downgrade reduction $109,000 (downgraded rice after process will decrease in value $50 / ton.) 3. Labour cost saving $4,320 in reducing cleaning staff from 3 to 2 persons. . 4. Savings on maintenance equipment $2,140 (1% of maintenance cost / year)	• Reduced spillages , improved efficiency

10.3 Non Quantitative Benefits

Items which are recognized as benefits to CRC and which arise directly from this ICM project are as follows. These currently have no direct costs or benefits applicable to them but in future most could be quantified as data is gained.

- *Healthier work environment* – Lower dust and dirt in the workplace with management committed to efficient management with improved safety measures.
  These improvements include safety barriers inside the mill, protective dust masks for staff and safer stack management to reduce collapse.
  Reduction of insect and rodents on site enhances site hygiene.
  Improved safety leads to higher staff morale and better workplace stability.
  Staff have a higher self esteem and increased pride in their workplace following the improvements to the plant and their positive involvement in the decision making process.
  Senior management now also take an additional interest in the day operations and have closer understanding of the needs of the production and cleaning staff.

- *Improved efficiency of operation* – Streamlining of operations with removal of very old stocks of rice, elimination of 'dead 'stocks of bags and associated freeing up of storage space plus items like the colour coding of bags and introduction of FIFO ideas has led to improved efficiency of the CRC operation. Management is better able to concentrate of more urgent issues as a result of this system modification.

- *Improved business opportunity* – The site is now unique within Thailand in its hygiene and efficiency management. This will be clear to potential buyers when they visit the site and will give clear advantages to CRC when the quality of the production system is compared to competitors mills. Countries with high quality standards such as USA and Japan will be more inclined to buy from CRC than competitors for this reason alone in the coming period.
  The successful involvement of CRC in such an ICM project could be used in advertising material produced for marketing purposes and a flyer addition to the corporate brochure would be a great benefit in this regard.
  Marketing and sales advantages are presented here but increased sales may take time to be realised and quantified.

Chapter 11

Recommendations for Continued ICM Development

It should be accepted that the current stage of development represents the starting phase of ICM adoption and the overall development and achievement of full ICM status will take many years.
Processes in place already and showing success must be retained and modified to best suit any changes to conditions as during the past 12 moths but new innovations are also required.
These include items in the following categories

11.1 Pest Management

- Upgrade rodent control to include monthly rotations of bait type and recorded notes on activity in the various stations aimed at identifying access and activity points for further attention.Placement of extra stations proofing may be indicated.

- Rotate chemical use in the Go Downs to minimise risk of insect resistance to particular pesticides. Actellic® should be rotated with synthetic pyrethroids and - possibly Alfacron ® fenitrothion of chlorpyrifos methyl on a monthly basis. Records must reflect this rotation.

- Extended use of silos adapted to Eco_2Fume low level fumigation must be considered and if viable should be costed for installation over the coming year.

- Phoshine fumigation of bagged or sack stored goods should also be considered as an alternative to methyl bromide fumigation but will full safety requirements in place.

- Alternatives to fumigation of rice stocks should be researched and followed e.g. irradiation and heat disinfestation techniques which are currently costly but experimentally available. They may also have limitations in volume handling capacity.

- Full western safety standards must be incorporated into fumigations on site and it is recommended that Thai Fumigation Company supply training to site management in these safety responsibilites so that CRC is fully aware of the dangers of fumigation and can in turn ensure staff safely on site.

- Light trap units should be retained in the Go Downs and new units using Green light [Insectomatic units should be considered for installation to improve catch of target insects – rust red flour beetles and flat grain beetles and possible increased the range of SPP insects being trapped.

- Pest Control is everyone's responsibility and regular meetings should take place for pest control / hygiene discussions where staff ideas can be incorporated to management schemes.
  Nil tolerance of pests is the target and this should be regularly reinforced.

- Visually clear insect pest identification charts should be displayed on site – to be supplied by International ICM Advisor.

11.2 System Monitoring

- Pheromone trapping is to continue in all current sites but with modification of the type of lure used to include the combined pheromones supplied by Insects Limited [USA] for monitoring of 5 key insect species rather than the single species currently monitored. nightly monitoring between Saturday night and Monday morning is recommended and additional monitors are required to give a minimum of 6 per Go Down.

- Regular audits from internal QA staff and external staff e.g. National ICM adviser are recommended along with regular CRC feedback and ICM modification meetings.

- Sieve testing of stored rice is to continue and results used to determine effects of ICM on insect populations in rice of different quality, variety and with different storage times.

- Exterior areas and laneways between existing Go Downs must be monitored for pest activity and if there is a clear indication that there is cross contamination occurring from the adjacent unclean mill – additional measures to prevent insect movement into Go Down 3 must be implemented [e.g. closing of all doors in this laneway , full sealing of roof line , installation of UV light control units inside the GD 3 wall etc]

System monitoring feedback

11.3 Hygiene and Housekeeping

- Cleaning procedures to be constantly upgraded and checked to ensure the current high levels of cleanliness are retained after the official close of the ICM project.

- Use of air blowers to be discontinued and replaced with vacuums to eliminate dust rather than blow it to other areas where it creates further problems . Use and availability of back pack vacuum cleaners to be investigated.

- Continued sealing of floor and wall gaps to be initiated following each audit from internal and external ICM staff.

- Cleaning staff should be responsible for their own areas and leading hands must be retained for each work team. Regular hygiene meetings should be held to discuss relevant issues and worker concerns in achieving targets.

- Cleaning competitions should be considered and a cleaning achievement against target chart should be set up with a prize / recognition of achievement award provided monthly to the most proactive and successful team.

- Cleaning of bags must be continued and improved through sealing of cleaned bags into large poly bags or another sealed bulk bag until needed for use. These storage bulk bags can be sealed with inverted poly bags which can be taped around the bulk bag base and recycled after use.

- Storage bulk bags like this can be experimentally sealed won with a dichlorvos strip inside them to provide spot fumigation for the bags and to guarantee disinfestation of bags pre filling with rice. This method has been suggested before but not carried out in trials as yet and would be a cost effective method of storing bags for long periods before reuse.

- All bulk bags should be gradually replaced with double tie topped bags with a fine tight weave which allows minimal chance of insect invasion. To further seal these bags they can be covered with inverted poly bags which can be taped round the base of the bulk bag to reduce any insect invasion. This is to happen **immediately** after milling with rice going into clean sacks.

- Use of the inverted plastic pallecon liners is possible using items imported from Australia if not available locally in Thailand . These are noted to cost ~2$ Australian per unit but can be re-used and will serve to protect rice from invasion by insects and will also serve to withhold any current infestation inside the bags.

- Consideration to be given to replacing all bulk bags with the Japanese style close weave poly sacks which are less likely to tear and reduce the pest invasion factor.

- Target all future rice recievals to be in bulk truck rather than in jute sacks to eliminate the need for storage of sacks and the problems associated with bag strips and string etc getting into the delivery lines . Consider a bonus payment for bulk rice to encourage this delivery format.

11.4 Management Logistics

- Target all future rice receivals to be in bulk truck rather than in jute sacks to eliminate the need for storage of sacks and the problems associated with bag strips and string etc. getting into the delivery lines. Consider a bonus payment for bulk rice to encourage this delivery format.

- Target a constantly reducing volume of long term storage rice in bulk bags and try to ensure long term store commodities are placed in silos where phosphine can be added to retain the quality in storage. Initial target could be to have over 75% of rice under 3 months of age with that target reducing monthly to approach the ideal 100%.

- Assess FIFO application methodology and ensure old rice stocks can be accessed for this aim. If this involves additional bulk bag movement it should be considered as a vital operation to maintain low stocks of old rice.

- Identify rice spillages and target the source immediately to reduce losses of product to downgrading and dumping. Equipment repair is to be ongoing and should be the role of all staff to assist with the identification of such problem sites in the mill and Go Downs.

- Methods to improve the quality of rice on recieval should be identified including

    - Routine rejection of poor quality infested rice.
    - Establishment of minimal recieval standards in compliance with ICM.
    - Planned audits of suppliers as part of a "vendor assurance" scheme.
    - Invitations to rural mill managers to the CRC site to inspect facilities and show what can be done to raise standards of hygiene and pest management.
    - Government visits to demonstrate CRC quality standards on site.

- All bulk bags should be correctly colour coded by end of 2001 and all bags should be clean, well marked and without any physical damage or tears noticeable.

- Increased awareness of hygiene and health and safety aspects of mill operation to be increased including supply of ear plugs to staff working in the main mill areas where noise pollution is extreme. These are to be supplied to visitors also.

11.5 Communication

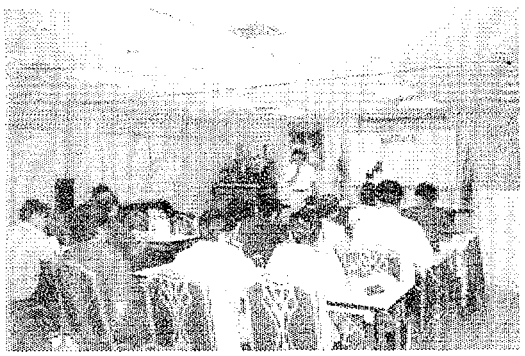
- Regular meetings should be planned for ICM management discussions of infestation and hygiene issues. These should include representatives from all aspects of the mill operation and include designated team leaders or representatives of cleaning and pest control staff. Such meetings are recommended to occur weekly for middle management but also incorporating a senior management meeting on a monthly or at least quarterly basis. Progress to ICM targets [stock age and rotations, infestation notifications] and to designated cleaning targets must be discussed and targets and deadlines set.

- All such quantifiable targets should be publicly displayed and success can be measured by the achievement of set targets. Targets initially should be achievable but become increasingly challenging [but still rationally achievable!] as competence increases.

- It would be recommended that due to the developing nature of ICM on site that the current team be allowed to continue with the work of improving and modifying the program on site for at least another 6 months. This will ensure maximum benefit and maintain the communication level which is currently high between CRC / National ICM advisor.

- Establish basic occupational health and safety standards for staff and have continuous awareness campaigns for safety improvements on site. Regular meeting with site staff representatives to discuss options will be of great importance here. All unsafe practices, equipment and structures must be identified and sequentially eliminated from site. Supply ear plugs to staff and visitors as a first option.

Insect Ecology Trainning



Regular training in hygiene & sanitation

Appendices

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Appendix 1 : CRC Site Audits March 2000

Site: Capital Rice Company [Samrong Mill] , Samutprakarn, Thailand

Executive Summary

No coordinated pest control has occurred on site to date. Strong reliance is placed on dis-infesting product at the end of the line with methyl bromide rather than on eliminating pests along the production and processing pipeline to avoid the need for continual fumigation of finished product.
This process will have to cease with the removal of methyl bromide from use in coming years.

Direct replacement of the fumigant with phosphine is a partial solution but an integrated management system for pests is considered a more appropriate for of holistic control for the site. Reduction of pest populations at all stages of transport, storage & process reduces ultimate dependence on fumigation.
Current fumigation practices undertaken by CRC staff appear to be lacking in safety when compared to Australian fumigation standards and must be upgraded through training and correct method application.

Whilst all damaging pests including rodents, birds and mammals such as cats are to be included in this assessment [March 22 –23], the principal group of pests requiring control is the stored product group of insects such as the flour and grain beetles, weevils and moths.

In general the pest situation is better than would be normally expected in such an attractive environment for insects [high temperatures, abundant food and ample harbourage] but there are significant pest populations in existence.
Rust red flour beetles, saw tooth grain beetles along with warehouse and rice moths provide the major control challenges and all these can inflict severe economic losses if unmanaged. Other stored product pest insects encountered are flat grain beetles, rice weevils, psocids and mealworm beetles.
Ants are commonly located and could pose an accidental threat to product as they forage for rice fragments and insects .

Large volumes of insects are removed from the rice during the early cleaning stages of the process . Residues collected in Hopper 2 from the pre-cleaning units in the mill are severely infested indicating the entire line from precleaning units to the residue collection hopper is also infested
Much of the product is stored in tightly packed bulka bags which appear to be reasonably impervious to pest attack. Bins and hoppers are relatively open to infestation and bin / silo tops show insect activity. Old used bulka bags in store are dirty and often infested with moth and beetles.

Cleaning is of good standard and this is the major factor in maintaining a relatively low level of infestation but there is room for great improvement in cleaning systems and disposal of residues. Correct cleaning of residues and immediate disposal of these residues is the most important pest control method to be implemented on site. Elimination of pest breeding and feeding harbourages through sealing and cleaning is equally vital.
Cross infestation risk is enhanced in the mill as the majority of pest insects noted are strong fliers.

Appendix 1 : CRC Site Audits March 2000

Site: Capital Rice Company [Samrong Mill] , Samutprakarn, Thailand

An Integrated Pest Management will be established in the coming months and monitoring of numbers of the above pests will serve to demonstrate efficacy of the system. Improvements to logistics, storage conditions and cleaning will be incorporated with a low hazard chemical treatment schedule.
Pheromone traps for a target moth [Ephestia sp] and sieve sample estimates for beetles will be undertaken prior to commencement of pest control activities and weekly counts will be done to check population fluctuations. This will ultimately reflect the success of the system.
New reporting formats will be developed to ensure pest problems and responses are fully documented in line with HACCP requirements

Other safety issues were identified and barriers need placing at high levels in the mill eg adjacent to the grain sorting room level 2 where barriers are missing in 2 areas. Whilst these issues are not related to pest management, they are critical to upgrading the overall quality assurance and safety standards of the mill.

Appendix 1 : CRC Site Audits March 2000

Site: Capital Rice Company [Samrong Mill] , Samutprakarn, Thailand

Infestation		Site	Risk Value			Comment & Action Required
			1	2	3	
1.	Rust red flour beetle [*Tribolium castaneum*]	Through the entire plant and warehouses system in accumulations of residues especially prevalent in:- • Pits below the main silos • Sacks of rice sweepings eg on top of holding bins in Go Down 3 • 600 MT Silo tops • Conveyor line carrying waste from pre cleaning machinery to hopper 2 in Go Down 4. • Around the road dump	X			Rust red flour beetles are active fliers and represent one of the commonest pests in the grain industry world wide. Apart from obvious product damage – they can produce a taint in food produce rendering it inedible. Populations can increase 70 fold in a month and optimum life cycle is 20 days at 35 celsius and 80% rh. Pest control must be established to minimize this pest population
2.	Saw tooth grain beetle [*Oryzaephilus surinamensis*]	Very high numbers found in hopper number 2 and a few individuals in hopper 1 adjacent.	X			Major pest of stored grain products capable of 50 fold population increase in a month. Optimum life cycle is 20 days at 33 celsius and 80 % rh. Pest spreads rapidly via flying and walking. Pest control must be established for control of this insect
3.	Rice weevil [*Sitophilus oryzae*]	Distribution similar to the red flour beetle but lesser in number	X			Common primary pest of many grain products and is a strong flier. Capable of population increase 25 fold per month and has a maximum lifecycle of 25 days at 30 celsius and 70%rh.

Risk Value 1 – Significant risk to product urgent attention requested ; 2 – Some associated risk – attention required ; 3 - Observation only – no immediate risk

Appendix 1 : CRC Site Audits March 2000

Site: Capital Rice Company [Samrong Mill] , Samutprakarn, Thailand

Infestation		Site	Risk Value			Comment & Action Required
			1	2	3	
4.	Warehouse moth [*Ephestia elutella*]	Widely distributed but very common:- • Go Down 5 & 6 adjacent to used bag storage • Pits under 600 MT silos • Grain sorting room • Length grading room • Top of silos	X			Moth is common and can create major problems in rice storages. Moths are attracted to pheromone lures and can be monitored using these devices. Most active at night and capable of 60 fold population increase in 1 month , optimum lifecycle is 28 days at 30 celsius and 80rh.
5.	Rice moth [*Corcyra cephalonica*]	Commonest in silo pits and larvae noted in refuse rice bags at the top of holding bins in packing area , Go Down 3. In bags collecting FB Rice for animal feed.	X			Not a high population at present but the pest represents a potential hazard on site. Population dynamics similar to that of the *Ephestia sp* moths.
6.	Flat grain beetle [*Cryptolestes ferrugineus*]	Residues under conveyors and in silo pits		X		Not a major problem currently but populations can increase 55 times in a month. 23 days is the maximum lifecycle for this pest.

Risk Value 1 – Significant risk to product urgent attention requested ; 2 – Some associated risk – attention required ; 3 - Observation only – no immediate risk

Appendix 1 : CRC Site Audits March 2000

Site: Capital Rice Company [Samrong Mill] , Samutprakarn, Thailand

Infestation		Site	Risk Value			Comment & Action Required
			1	2	3	
7.	Lesser meal worm [*Alphitobius sp*]	In bran resides in hopper 1 Go Down 4 and in residue accumulations in silo pits and silo tops.		X		Population increase is much lower than Tribolium at ~ 30 times. Life cycle is generally slower as well – 46- 50 days at 32 celsius and >90% rh.
8.	Drugstore beetle [*Stegobuium paniceum*]	Localised small populations in residues in silo pit and under the delivery conveyors from road dump.		X		Beetles prefer other commodities thus it represents a lesser risk than the other beetles noted. Population increase is maximised at 30 celsius and life cycle is ~ 40 days.
9.	Paper mites [Psocid sp]	Commonly found in damper areas where meals and residue rice for stock feed is stored		X		Not a problem in good quality dry rice but their presence indicates mouldy conditions If they should be found on bags etc it is indicative that the quality of the rice will be affected by the damp conditions. NB Psocids feed on moulds not on the product itself.
10.	Flies	Found at the southern end of the plant where damp conditions prevail.			X	Not a major pest of rice which is in good condition but germs can be spread by flies landing on good rice after feeding on garbage. Removal of damp and mouldy residues from the southern section of the mill will be beneficial.

Risk Value 1 – Significant risk to product urgent attention requested ; 2 – Some associated risk – attention required ; 3 - Observation only – no immediate risk

Appendix 1 : CRC Site Audits March 2000

Site: Capital Rice Company [Samrong Mill] , Samutprakarn, Thailand

Infestation		Site	Risk Value			Comment & Action Required
			1	2	3	
11.	Ants Unknown species	Many small red brown ants are noted crawling over rice in bags and in sacks of residue rice.			X	These can be classed as casual intruders and appear to be foraging for rice fragments and possibly for insects. Reduction in insect numbers will reduce the accidental contamination of the product by these insects.
12.	Minute mould beetles [Corticaria sp?]	ID to be confirmed by Thai experts within next month. Found in bulkas collecting FB/ MB rice on ground floor		X		If ID is correct – mould feeders with no significant problems attached to sound grains or rice. Presence indicates damp conditions and poor quality grain or residues. NB Nominated bulkas are collecting animal feed materials.
13.	Birds – sparrows [*Sturnus vulgaris*] and pigeons.	Through plant and Go Downs. Pigeons seen at the top of silos entering via roof line and sparrows in significant numbers in all Go Downs and in plant itself.		X		Proofing has been carried out to exclude pigeons from most plant areas but there are many access points for the birds including roof line over silos, all open doors and windows and via the dock side which is completely open. Movement between Go Downs and plant is easily done via conveyor lines through walls. Gaps under sliding doors in Go Downs also allows for sparrow access.
13.	Cat	A single black cat was noted at the southern end of the plant feeding on food residues from a bin			X	Feral dogs and cats should be excluded from the site or caught in humane traps and removed permanently. They can create serious fouling of packaged and bulk product.
14.	Rodents	Rat and mouse tracks found in residues and dust especially on lower levels of the mill.		X		These pests can create high levels of damage and contamination to packaged and bulk product. A pest control system is to be developed for control of rodents in the factory and Bioterm will assist in this planning.

Risk Value 1 – Significant risk to product urgent attention requested ; 2 – Some associated risk – attention required ; 3 - Observation only – no immediate risk

Appendix 1 : CRC Site Audits March 2000

Site: Capital Rice Company [Samrong Mill] , Samutprakarn, Thailand

Hygiene		Site	Risk Value			Comment & Action Required
			1	2	3	
1.	Heavy residue accumulations of dust and rice were noted in the following areas.	• Beneath external road delivery ramps • In silo pits • Under conveyors in silo pits, to rear of QA lab and from road dump • Under cable tray housings • Around lids of silo hatches • In and between bulka bag and sack storage in GoDown 5 & 6 • Along high ledges of mill itself • Under plywood floor covering in colour sorting room • In delivery truck floors between boards • Under stitched seals of bulkas and inside old bulkas in storage in GoDowns • Under equipment lines where access is difficult	X			Residual accumulation usually indicates difficulty in accessing the sites for regular cleaning and whilst the main factory and warehouse units are very clean it is still quite easy to find areas where cleaning is incomplete. In some cases where cleaning has occurred correctly – the residues have been bagged and left in situ – creating a severe hazard and a haven for pests to live and breed in. This is exemplified in the sacks of rice on top of the holding bins in the packing area – full of insects. Residue accumulations are the single biggest cause of pest infestation in plants such as this and a high level cleaning and hygiene plan is required to remove the pests food and safe breeding grounds.

Risk Value 1 – Significant risk to product urgent attention requested ; 2 – Some associated risk – attention required ; 3 - Observation only – no immediate risk

Appendix 1 : CRC Site Audits March 2000

Site: Capital Rice Company [Samrong Mill] , Samutprakarn, Thailand

Hygiene		Site	Risk Value			Comment & Action Required
			1	2	3	
2.	Storage of infested old bags in close proximity to bulk goods	Go Down 5 & 5	X			Cross infestation can easily occur from this co – storage system and care should be taken to isolate any infested goods from clean newly packaged goods. Bags should be cleaned and disinfested by fumigation prior to storage in GoDowns.
3.	Cleaning methods	Main mill		X		Blowing down residues from high ledges is not a good system of residue removal as it simply spreads the problem. Use of vacuums to collect dust is a better option and residues collected must be disposed of to a closed bin outside the plant after every cleaning event.
4.	Animal feed collection	Ground floor mill and Go Down 4	X			The animal feed is usually low grade material with high levels of infestation associated with it. The material coming out of the precleaning machine and going into hopper 2 in GoDown 4 is highly infested and as most of these pests can fly – it represents a principal source of infestation for the entire mill. This should be bagged, sealed and removed from site daily.
5.	Proofing of building	Main mill and GoDowns		X		A good deal of time and money has been spent on bird proofing but this is not very effective given that sparrows are the key pest onsite and they will get through a very small gap indeed. All main doors are fully open all day and gaps in the proofing are common eg at roof level above silos, where conveyors pass through walls and under sliding doors on Go Downs. Access for the wharf tot he main mill is fully open and birds will use these access points without any hinderance. Exclusion is going to be expensive and trapping or baiting may be a better option.

Risk Value 1 – Significant risk to product urgent attention requested ; 2 – Some associated risk – attention required ; 3 - Observation only – no immediate risk

Appendix 1 : CRC Site Audits March 2000

Site: Capital Rice Company [Samrong Mill] , Samutprakarn, Thailand

Pest Control Operations		Site	Risk Value			Comment & Action Required
			1	2	3	
1.	Lack of any coordinated Pest Control operation in general	All areas	X			Risk has already been recognised and the main aim of this project is to establish a suitable integrated management program for the site. This should be done by suitable fully licenced operators in compliance with Thai safety and pesticide use regulations.
2.	Fumigation by internal staff	All areas	X			Current fumigation practice is considered hazardous due to the following points noted • Fumigation stacks are poorly sealed at the base – fumigants will escape quickly to the surrounding area. CH4Br is deadly and odourless – it presents a significant health risk. Sand snakes or wet sand is required to seal the base. • Stacks are placed through the work areas and there is no clearly marked exclusion zone [6 metres is required for safety] and the stack should be fenced eg with cyclone fencing to enforce the exclusion zoning. • Stacks are not marked with warning / danger signs to prevent staff from opening and going inside. • Stacks are not signed or dated to give clear indication of time and date of gassing and of gas release – training is required for staff in all aspects of the work. • Fumigation is done in areas where degassing can present a health risk and there is no positive venting of methyl bromide after de-sheeting occurs. • The mask available to staff for degassing is an organic vapour [half mask] exclusion type only and will allow passage of fumigants to the wearer. A full face mask is needed with appropriate filters • Fumigation should be consolidated to a certain well ventilated area e.g. the wharf loading area and this site should be designated to fumigation for the future.

Risk Value 1 – Significant risk to product urgent attention requested ; 2 – Some associated risk – attention required ; 3 - Observation only – no immediate risk

Appendix 1 : CRC Site Audits March 2000

Site: Capital Rice Company [Samrong Mill] , Samutprakarn, Thailand

Pest Control operations		Site	Risk Value			Comment & Action Required
			1	2	3	
3.	HACCP reporting paperwork	All areas		X		Current documents do not adequately cover pest infestation management and whilst the ideas are essentially good – there is a need to create an insect free environment and an increased awareness of associated problems in staff. Currently the paperwork covers observation of pests but there is no appropriate response procedure to eliminate the risk if problems are noted. This will be solved with the establishment of an integrated management system where appropriate responses are documented as SOP's.
4.	Receivals procedures	Receival area and QA lab		X		Standards are required for assessment of inbound goods for insect infestation and there should be a quantifiable standard for rejection of inbound rice. Sieves, magnifiers and pest identification training must be provided to receivals operators.
5.	Risk assessment from insect observations	All staff and management		X		Genuine risk assessment is required for QA and management staff in production areas. Finding of 'insects' as noted in HACCP plans is insufficient information to act upon. Staff must clearly differentiate between stored product pests and accidental occurrences of eg field insects or others attracted to lights in the mill etc. Stored product pests are a genuine risk whilst accidental intruders are not!

Risk Value 1 – Significant risk to product urgent attention requested ; 2 – Some associated risk – attention required ; 3 - Observation only – no immediate risk

Appendix 1 : CRC Site Audit - September 2000

Site: Capital Rice Company [Samrong Mill] , Samutprakarn, Thailand

Executive Summary

The mill management have been extremely accommodating in their assistance with the ICM program development to date but there is a real need to commence to initiate real changes now. This must be done stage wise in achievable sections and each segment of work must be accompanied by result discussion with the CRC management. Positive reinforcement of these changes and proven benefits must be seen.

Some work to date has been completed well including the installation of overhead lighting via skylights and an attempt to segregate animal feed materials from good quality rice in storage.

Cleaning has improved and the frequency of the cleaning rounds is now double. There is a need to clean the hidden areas however and this issue has not yet been addressed although the open accessible areas of the mill and Go Down are extremely clean now.
Initial discussion on this visit have created the option of implementing Clean storage areas in Go Down 3 and 4 and then to measure the insect pests in these areas over time compared to other areas.
Creation of a clean area will entail

- The removal of return rice from trade [infested]
- Re siting of pre cleaning material collection bins in Go Down 4
- Elimination of current high level residues from adjacent machine room and silo base areas
- Improvement of cleaning in both Go down areas
- Removal of infested damaged bags and old rice [3 months plus] for fumigation prior to restoring stocks in store
  [NB If Organic rice is fumigated it immediately returns to conventional status and cannot ever be sold as organic in the future]
- Good monitoring establishment in both Go Downs
- Feedback to CRC staff on impacts of this work
- Establishment of a pesticide free environment for organic rice protection and integrity

Insect pests are still commonly found through the plant and there has been no significant drop in the numbers or species located.

The main issues for attention over the coming period are improvements to cleaning, training storage logistics and monitoring of insect pests.

Appendix 1 : CRC Site Audit - September 2000

Site: Capital Rice Company [Samrong Mill] , Samutprakarn, Thailand

Infestation		Site	Risk Value			Comment & Action Required
			1	2	3	
1.	Rust red flour beetle [*Tribolium castaneum*]	Through the entire plant and Go Down system in accumulations of residues especially prevalent in:- • Machine room sections below the main silos and mill • Conveyor system equipment and interior ledges on top of bins in Go Down 3 • 600 MT Silo tops • Conveyor line carrying waste from pre cleaning machinery to hopper 2 in Go Down 4. • Hopper 2 in Go Down 4 • Sack store areas Go Down 5 and 6 • Go down 7 and 8 [especially jute sacks in 8 – not CRC property]	X			Rust red flour beetles are active fliers and represent one of the commonest pests in the grain industry world wide. Apart from obvious product damage – they can produce a taint in food produce rendering it inedible. Populations can increase 70 fold in a month and optimum life cycle is 20 days at 35 celsius and 80% rh. Red flour beetles are currently as widespread as they were last time and there has been no apparent influence from the increased cleaning frequency for example. Identification of key cleaning areas was repeated directly with CRC staff and it is hope that the situation will improve over coming months now it has been made clear what the needs are. Incorporation of cleaning schedules and point scoring for hygiene in defined areas will assist in improving efficiency over time.

Appendix 1 : CRC Site Audit - September 2000

Site: Capital Rice Company [Samrong Mill] , Samutprakarn, Thailand

Infestation		Site	Risk Value			Comment & Action Required
			1	2	3	
2.	Saw tooth grain beetle [*Oryzaephilus surinamensis*]	Very high numbers found in hopper number 2 and a few individuals in hopper 1 adjacent. Widespread in rice storages especially in SMTC Go Down and Go Down 7 and 8 Large numbers in animal feed collection areas and in sacks of residues stacked on floor 3 of the mill and upper ledges of floor 2 colour sorting room.	X			Major pest of stored grain products capable of 50 fold population increase in a month. Optimum life cycle is 20 days at 33 celsius and 80 % rh. Pest spreads rapidly via flying and walking. Go Down 8 is shared with another ice company and this company uses jute sacks for storage. These bags are heavily infested with all beetles and weevils and from here they can easily access adjacent stocks of CRC rice in 8 Due to the widespread distribution of this insect and its potential damage – it is the chosen insect for estimation of success of ICM practices in the rice stacks.
3.	Rice weevil [*Sitophilus oryzae*]	Distribution similar to the red flour beetle but lesser in number	X			Common primary pest of many grain products and is a strong flier. Capable of population increase 25 fold per month and has a maximum lifecycle of 25 days at 30 celsius and 70%rh. Found in many products especially in returned stocks from trade – organic brown varieties especially in Go Down 3 and through the screenings. Weevils also noted in display pack of fragrant rice in the company cabinet.

Risk Value 1 – Significant risk to product urgent attention requested ; 2 – Some associated risk – attention required ; 3 - Observation only – no immediate risk

Appendix 1 : CRC Site Audit - September 2000

Site: Capital Rice Company [Samrong Mill] , Samutprakarn, Thailand

Infestation		Site	Risk Value			Comment & Action Required
			1	2	3	
4.	Tropical warehouse moth [*Ephestia cautella*]	Widely distributed but very common:- • Go Down 5, 6 ,7 and 8 adjacent to used bag storage • Pits in underground machine room area • In bags of screenings • Length grading room • Top of silos • Go Down 3 in cleaning bin collector	X			Moth is common and can create major problems in rice storages. Moths are attracted to pheromone lures and can be monitored using these devices. Most active at night and capable of 60 fold population increase in 1 month , optimum lifecycle is 28 days at 30 celsius and 80rh. Moths are undergoing trapping with pheromone lures currently to evaluate their distribution and relative numbers across the site. Trapping is not easy due to heavy dust accumulations and what is suspected to be a lack of potency and longevity of the lures themselves but this is the chosen indicator insect of the mill system over the period of the ICM project
5.	Rice moth [*Corcyra cephalonica*]	Commonest in machine room underground pits and in cleaning residues in animal feeds area. Go Down 3 returns area is also infested but the moths can be found individually everywhere on site.	X			Not a very high population at present but the pest represents a potential hazard on site especially in the dark and uncleaned area of the machine room. Population dynamics similar to that of the *Ephestia sp* moths.
6.	Flat grain beetle [*Cryptolestes ferrugineus*]	Residues under conveyors and in machine room In residues under and in rice stored in Go Downs.		X		Not a major problem currently but populations can increase 55 times in a month. 23 days is the maximum lifecycle for this pest.

Appendix 1 : CRC Site Audit - September 2000

Site: Capital Rice Company [Samrong Mill] , Samutprakarn, Thailand

Infestation		Site	Risk Value			Comment & Action Required
			1	2	3	
7.	Lesser meal worm [*Alphitobius sp*]	Go Down 4 and in residue accumulations in silo pits and silo tops. Old resides in Go Down 6,7 and 8 and also in SMTC warehouse		X		Population increase is much lower than Tribolium at ~ 30 times. Life cycle is generally slower as well – 46- 50 days at 32 celsius and >90% rh.
8.	Drugstore beetle [*Stegobuium paniceum*]	Localised small populations in residues in silo pit and under the delivery conveyors from road dump.		X		Beetles prefer other commodities thus it represents a lesser risk than the other beetles noted. Population increase is maximised at 30 celsius and life cycle is ~ 40 days.
9.	Booklice [Psocids]	Commonly found in damper areas where meals and residue rice for stock feed is stored. All areas where moist rice residues are found .		X		Not a problem in good quality dry rice but their presence indicates mouldy conditions If they should be found on bags etc it is indicative that the quality of the rice will be affected by the damp conditions. NB Psocids feed on moulds not on the product itself. These are now visible in Go Down 7 where the wall floor junction is painted white – thus this is a good practice for other Go Downs.
10.	Flies	Found at the southern end of the plant where damp conditions prevail. Also noted in damp residues in the machine room subfloor section.			X	Not a major pest of rice which is in good condition but germs can be spread by flies landing on good rice after feeding on garbage. Removal of damp and mouldy residues from the southern section of the mill will be beneficial.

Appendix 1 : CRC Site Audit - September 2000

Site: Capital Rice Company [Samrong Mill] , Samutprakarn, Thailand

Infestation		Site	Risk Value			Comment & Action Required
			1	2	3	
11.	Ants Unknown species	Many small red brown ants are noted crawling over rice in bags and in sacks of residue rice.			X	These can be classed as casual intruders and appear to be foraging for rice fragments and possibly for insects. Reduction in insect numbers will reduce the accidental contamination of the product by these insects.
12.	Predator bug [Xylocoris sp]	In rice stocks in jumbo bags			X	This may have some impact on the pest species in long term storage – over 6 months – but in general they are simply responding to high levels of food [beetles]. Not considered a pest themselves but still undesirable in any food commodity.
13.	Birds – sparrows [*Sturnus vulgaris*] and pigeons.	Through plant and Go Downs. Pigeons seen at the top of silos entering via roof line and sparrows in significant numbers in all Go Downs and in plant itself.		X		Proofing has been carried out to exclude pigeons from most plant areas but there are still some access points for the birds including roof line over silos, sliding doors to Go Downs [bases and hand holes for reaching the release catch]and via the dock side which is often completely open. Movement between Go Downs and plant is easily done via conveyor lines through walls. Gaps under sliding doors in Go Downs also allows for sparrow access. Bird proofing has improved since March and will continue to do so.
14.	Rodents	Rat and mouse tracks found in residues and dust especially on lower levels of the mill. Rat damage to stored rice noted in Go Down 6 – torn spilled sacks		X		These pests can create high levels of damage and contamination to packaged and bulk product. Opened packaging allows for secondary insect infestation which is the biggest single problem with the rodents.

Appendix 1 : CRC Site Audit - September 2000

Site: Capital Rice Company [Samrong Mill] , Samutprakarn, Thailand

Hygiene		Site	Risk Value			Comment & Action Required
			1	2	3	
1.	Heavy residue accumulations of dust and rice were noted in the following areas.	• Beneath external road delivery ramps • **In underground areas of machine room** • **Under conveyors in machine room on top of bins in Go Down 3 to rear of QA lab and from road dump to machine room** • Under cable tray housings and all electrical conduits • Around and under lids of silo hatches • In and between jumbo bag storages in all GoDowns • Along high ledges of mill structure itself and in colour sorting rooms • Under stitched seals of jumbos and inside old jumbos and sacks in GoDowns • Under equipment lines where access is difficult	X			Residual accumulation usually indicates difficulty in accessing the sites for regular cleaning and whilst the main factory and warehouse floor areas are very clean it is still easy to find areas where cleaning is incomplete despite the previous audit and detailing of specific areas for cleaning. This is a complex issue and takes time to reach the required standards. Effort is being placed on cleaning but this effort needs regular direction from project managers in Thailand. In some cases where cleaning has occurred correctly – the residues have been bagged and left in situ – creating a severe hazard and a haven for pests to live and breed in. This is exemplified in the sacks of residue rice in Go Down 7,8 and SMTC and at the bases of the main silos. Sacks of heavily infested rice sweepings were also noted in Go Down 3,4 and on floors of the main mill –levels 2,3 and 5 Residue accumulations are the single biggest cause of pest infestation in plants such as this and a high level cleaning and hygiene plan is required to remove the pests food and safe breeding grounds. To further this aim it is recommended that the company investigate the purchase of back pack vacuum cleaners for staff to use. Blowing residues everywhere with airhoses is not the best way to clean and simply spreads the problem.

Appendix 1 : CRC Site Audit - September 2000

Site: Capital Rice Company [Samrong Mill] , Samutprakarn, Thailand

Hygiene		Site	Risk Value			Comment & Action Required
			1	2	3	
2.	Storage of infested old bags and product in close proximity to bulk goods	Go Downs especially 5/6 and 3 where infested returned goods from trade are housed adjacent to good jumbos	X			Cross infestation can easily occur from this co storage system and care should be taken to separate and isolate all infested goods from clean newly packaged goods. Bags should be cleaned and disinfested by fumigation prior to storage in Go Downs.
3.	Cleaning methods	Main mill		X		Blowing down residues from high ledges is not a good system of residue removal as it simply spreads the problem. Use of vacuums to collect dust is a better option and residues collected must be disposed of to a closed bin outside the plant after every cleaning event. This should be initiated very soon as a trial in Go Downs 3 & 4.
4.	Animal feed collection area	Ground floor mill and Go Down 4	X			The animal feed is usually low grade material with high levels of infestation associated with it. The material coming out of the precleaning machine and going into hopper 2 in GoDown 4 is highly infested and as most of these pests can fly – it represents a principal source of infestation for the entire mill. This should be bagged, sealed and removed from site daily. This observation was made in March and is reiterated here. Conveyors carrying the screenings etc are also infested and it should be ensured that overhead conveyors carrying infested screenings do not transit over good clean store areas especially at night. Animal feeds are now being segregated to some extent and stored outside in a separate area which is a great step forward.

Appendix 1 : CRC Site Audit - September 2000

Site: Capital Rice Company [Samrong Mill] , Samutprakarn, Thailand

Hygiene		Site	Risk Value			Comment & Action Required
			1	2	3	
5.	Proofing of building	Main mill and GoDowns		X		A good deal of time and money has been spent on bird proofing but this is not very effective given that sparrows are the key pest onsite and they will get through a very small gap indeed. All main doors are fully open all day and gaps in the proofing are common eg at roof level above silos, where conveyors pass through walls and under sliding doors on Go Downs. Access for the wharf tot he main mill is fully open and birds will use these access points without any hinderance. Exclusion is going to be expensive and trapping or baiting may be a better option.
6.	Lighting of building	Go Down 6 and 5		X		Skylights have been fitted to allow more light to enter the building and help with inspection and cleaning especially to the rear of the rice stacks in Go Downs
7.	Bag splits and spillage	All Go downs	X			Bags will get split in the normal course of events – especially from forklift damage. When this occurs it is best to remove the damaged bags and repack the rice or to seal the damaged units completely with tape. Latter option is not likely to have long term benefits and repacking should be done regularly to save product. Split bags noted in Go Down 3 and 4 –organic rice – were heavily infested with rice moth and weevil with the greatest level of insects in the hole created by a forklift.

Appendix 1 : CRC Site Audit - September 2000

Site: Capital Rice Company [Samrong Mill] , Samutprakarn, Thailand

Pest Control Operations		Site	Risk Value			Comment & Action Required
			1	2	3	
1.	Lack of any coordinated Pest Control operation in general	All areas	X			Risk has already been recognised and the main aim of this project is to establish a suitable integrated management program for the site.This should be done by suitable fully licenced operators in compliance with Thai safety and pesticide use regulations. There will be a planned misting operation of selected Go Downs over the month of October but it is necessary to co-ordinate this activity with cleaning and fumigation if required. Assessment of effectiveness of treatments used will be incorporated into future work. Sieve tests for live insects will take place after fumigation and misting has taken place to determine the effectiveness and penetration of these methods.
2.	HACCP reporting paperwork	All areas		X		Current documents still do not adequately cover pest infestation management. Currently the paperwork covers limited observation of pests but there is no appropriate response procedure to eliminate the risk if problems are noted. There is still a need for establishment of an integrated management system where appropriate responses are documented as Standard Operating Procedures [SOP's]
3.	Fumigation of 3 month old stocks	All areas		X		Whilst being a good idea in theory, it is hard to actually get this to occur in any appropriate manner and avoid cross contamination from old and already infested stocks. The volume of 3 month age + stock is ~ 52,000 T and it is impossible to fumigate this and return to clean storage before cross infestation can occur.
4.	Receivals procedures	Receival area and QA lab		X		Standards are required for assessment of inbound goods for insect infestation and there should be a quantifiable standard for rejection of inbound rice. This has been initiated to a partial extent but it is not considered a major issue so is not practically valid.

Risk Value 1 – Significant risk to product urgent attention requested ; 2 – Some associated risk – attention required ; 3 - Observation only – no immediate risk

Appendix 1 : CRC Site Audit May 2001

Site: Capital Rice Mill, Samut Prakan, Bangkok, Thailand , 14/5/2001

Infestation		Site	Risk Value			Comment & Action Required
			1	2	3	
1.	Warehouse moth [*Ephestia cautella*]	Sample storage room [2] Go Down 3 [2] Go Down 4 [1] Go Down 5 [3] Go Down 7 [4]	X			This is a very good result. The number of moths visible during the day even when carrying a pheromone in clothing is minimal compared to the previous 2 audits. This is presumed to be due to the vast improvement in stock rotation and general plant hygiene.
2.	Red flour beetle [*Tribolium castaneum*]	Widespread but in lower numbers than noted in previous audits. Beetles are noted on outside of bulk in ones and twos and also in dust extraction samples and feed grade rice. **Still relatively easy to locate on the top of rice bulk which have been left partially open and not tied correctly.**	X			Rust reds are flying beetles which can fly for long distances when disturbed. Flight is intensified at dusk when light conditions are deteriorating. These beetles are being successfully caught in the UV light traps set up as trial controls through the plant. This is probably a useful extra control but the insects are only known to be strongly light attracted at those short periods when looking for a mate. This should mean that the UV light is only attractive for short times – but still it is a useful weapon in the ICM system. [Green light units may be better as they have a much wider spectrum of attraction for insects especially spp insects.] Insects being noted on top of open topped rice bulk is understandable as the insects can easily get into open bags without any problem. Reduction of rice spillages on bagged rice stocks is reduced and the sighting of live insects outside bags is also reduced
3.	Rice weevil [*Sitophilus oryzae*]	Occasional insects noted on exterior of bulk – especially those over 3-4 months old and also in feed quality rice stocks.	X			Still to be regarded as a significant pest in the mill and store but again apparently reduced in number from previous inspections. These insects fly but are not known to be light attracted and thus are not found in the light traps. Hygiene and stock rotations are the best controls of these pests and the current operations should be continued.

Risk Value 1 – Significant risk to product urgent attention requested ; 2 – Some associated risk – attention required ; 3 - Observation only – no immediate

Appendix 1 : CRC Site Audit May 2001

Site: Capital Rice Mill, Samut Prakan, Bangkok, Thailand , 14/5/2001

Infestation		Site	Risk Value			Comment & Action Required
			1	2	3	
4.	Flat grain beetle [*Cryptolestes sp*]	Widespread but in ones and twos for the most part. Old stocks of rice held in partially open topped bulk seem to be infested rapidly.	X			These are very small and can be a problem if numbers get too large but currently this is not the case. Stock recycling and hygiene are critical controls. These insects are noted to be attracted to the light traps and are found in relatively large numbers in some units. Use of such traps may provide a measure of control of the insects and the continued use of the units is justified .
5.	Saw tooth grain beetle [*Oryzaephilus surinamensis*]	Inside residue collection bins and animal feed rice stoocks	X			Still a problem on site due to prolific damage and breeding potential but reduced in distribution and visibility on site. The insect appears to be prevalent in dust and residues which are now in turn reduced in volume on site. The insect has been recorded in numbers in the light traps but on inspection there were none in the trapped insect collections held on site. It is unknown whether these insects will be attracted to light traps and thus the use of the traps as a monitor or control is unknown
6.	Corn moth [*Corcyra cephalonica*]	Machine room – 6 individuals noted under bucket elevator bases and under the conveyor ex road dump. Occasional moth cases on top surfaces of old rice especially 6 months plus old.	X			Reduction in numbers again from last inspection and the problem looks to be almost under control especially in the machine room and subfloor equipment areas and elevator bases. These are not attracted to the pheromones being used on site and have to be visually located. With the removal of residues from the elevator pits, electrical conduits and wall ledges etc – the population has decreased.
7.	Sparrows	In Go Downs 4,5,6 and 7	X			Bird proofing has been much improved and there is good reinforced netting over the door to GD 5 but birds are still getting in to the plant. These are resident populations and should be controlled by baiting, trapping or shooting to eliminate from the site.

Risk Value 1 – Significant risk to product urgent attention requested ; 2 – Some associated risk – attention required ; 3 - Observation only – no immediate

Appendix 1 : CRC Site Audit May 2001

Site: Capital Rice Mill, Samut Prakan, Bangkok, Thailand , 14/5/2001

Hygiene		Site	Risk Value			Comment & Action Required
			1	2	3	
1.	Rice storage bags [bulka/ jumbo; jute sacks and retail poly bags] stored in clean conditions	Retail poly bag store in Go Down 3 – now fitted with steel pallet racks to keep bottom level bags off floor.			X	This is a good development and will prevent residues accumulating under the bags and eliminate rodent harbourage. Bags are clear of the floor and any insects invading must do so by flying in.
		Jute bags from rice recieval ex truck now stored on poly sheets in GD 5 .			X	Jute bags are creating a problem in the road dump area as bits of hessian are coming loose and getting into the product lines to storage. Options are to go to bulk delivery only [expensive for many small mills] or possibly to replace the hessian with recyclable woven poly sacks. Bag storage is good and turnover rapid.
		Clean bulk stored in GD 7 on floor but covered with tarpaulin.		X		This is good but can be improved by placing bulk in clean sealed poly sacks after cleaning and fumigating - to fully protect from dust and insects. Poly sacks can even be spot fumigated in these bags before recycling which will eliminate the need for floor covering and tarpaulin use.
2.	Conveyors covered	All Go Downs, external wharf conveyors and all conveyors in the mill itself			X	All conveyors are now covered to eliminate bird contamination and also to minimize dust spread. This is a very good initiative and will assist in maintaining the overall quality of the product.
3.	Four new Cyclones fitted to reduce dust	Main mill			X	Another good innovation to minimize dust and to segregate the poor quality and frequently infested residues and feed grade rice from the good rice for human consumption.

Risk Value 1 – Significant risk to product urgent attention requested ; 2 – Some associated risk – attention required ; 3 - Observation only – no immediate

Appendix 1 : CRC Site Audit May 2001

Site: Capital Rice Mill, Samut Prakan, Bangkok, Thailand , 14/5/2001

Hygiene		Site	Risk Value			Comment & Action Required
			1	2	3	
4.	Floor and wall edges clean and visible due to paint work	All Go Downs and mill itself.			X	The wall edges are accessible for inspection and there is no sign of the levels of residue located during other inspections. Paint has been used to good effect in most areas to create a clean looking "no store area" and a very visible clear space round wall edges. This is excellent and should be maintained at all times.
5.	Floor and wall edges sealed with concrete	Most areas – ongoing work but obvious in GD 3 and 4 and along silo room /GD4 wall edge.			X	All this is excellent and serves to reduce the harbourage for insects on site. Cleaning is easier and there are no food residues for insects in these key areas.
6.	Bulk bag filling points now utilize tied and sealed bag tops to reduce insect movement and dust accumulation	GD 4 and all exterior feed and split collection points.		X		This is a very good management option but must ensure the bag is sealed totally to eliminate dust. Some bags when examined were shown to be slightly open and insects / dust can still escape. Improvements to the filling operation removes the former spillage of rice estimated at 60 gms per bulk bag filled.
7.	Colour coding for bulk now in place [not completely infallible but certainly improving]	All site areas			X	Pink / red Broken downgraded white rice Green White rice Yellow /white Parboiled rice Blue Fragrant These categories will assist in managing rice stocks and keeping susceptible stocks in easily accessible places. Split rice for example contains rice dust and will attract a wide variety of insects whilst whole white rice will not be as attractive.

Risk Value 1 – Significant risk to product urgent attention requested ; 2 – Some associated risk – attention required ; 3 - Observation only – no immediate

Appendix 1 : CRC Site Audit May 2001

Site: Capital Rice Mill, Samut Prakan, Bangkok, Thailand , 14/5/2001

Hygiene		Site	Risk Value			Comment & Action Required
			1	2	3	
8.	Dust masks are now required and there is jewelry, glass ban in the mill and stores	All areas			X	Good initiative again but it must be policed totally if it is to be considered a useful quality enhancement measure. We were not advised that this was an issue and carried out the audit with rings and watches exposed. It would be a good idea to include ear plugs in the safety equipment as there is a very loud siren signal in the mill which could easily damage hearing if exposed to long and or very loud blasts.
9.	Vacuum cleaners are inadequate for cleaning of all mill and Go Down areas	All areas		X		Good back pack units are available in Australia as are good floor units. These are to be investigated by JM and information sent to Capital Rice Mill
10.	Inverted poly cover sheets to be investigated for bulka covers	All areas			X	These are used to great effect in Australia and will be costed for Capital Rice Mill. These are clear covers which fit over the top of clean filled bulk and prevent dust and insect contamination of stored product. They also contain any insects emerging from the interior of the product mass but if all other aspects of ICM are operating well – this internal emergence should be at a minimum.

Risk Value 1 – Significant risk to product urgent attention requested ; 2 – Some associated risk – attention required ; 3 - Observation only – no immediate

Appendix 1 : CRC Site Audit May 2001

Site: Capital Rice Mill, Samut Prakan, Bangkok, Thailand , 14/5/2001

Pest Control Operations		Site	Risk Value			Comment & Action Required
			1	2	3	
1.	Rodent boxes – sometimes have residues and insects inside	Main mill all floors	X			A common problem with open ended boxes such as these. Rice residues get into and underneath the rodent stations but are not cleaned in normal cleaning operations . As a result- beetles can breed inside the boxes and then emerge to cause infestation of clean areas overnight.Ensure these are cleaned every visit and rodent baits are replaced every visit. Also ensure boxes are not sited where they can be spilled and preferably ensure that the rodent blocks are secured inside the box with wire.
2.	Use of residual chemicals	All areas post cleaning		X		As the mill and store is now much cleaner than before – it is worth considering the regular application of some residual chemicals to floor spaces, walls and elevator boots etc. A chemical such as Alfacron® or a synthetic pyrethroid such as deltamethrin would be appropriate on a monthly basis to kill any insects moving into these areas. This would be very useful in the screening collection areas such as the yellow box in GD4 adjacent to the lab where insects are bound to accumulate.
3.	Bag fumigation and storage	Go Downs	X			After use and after basic cleaning and dust removal - bulk should be stored inside a poly bag for fumigation.This fumigation can be done safely within a small controlled space using dichlorvos strips. Millspot® liquid or phosphine tablets could also be used but safety would be an issue here. The bags must be sealed down and safely quarantined for example in a lockable shed or shipping container depending on volume of bags to be cleansed and disinfested.

Summary

The site has moved on well with the ICM system and levels of hygiene are very much improved thanks to inputs from ICM team especially Khun Werayut and with the continued support of Capital Rice management. Insect numbers are much reduced and there is clear improvement in cleaning and proofing. Stock rotations are better and there is minimal aged , infested and dusty stock on the floor of any GD. This will give a high level of confidence to buyers visiting the site with regard to QA and HACCP Management. [Refer to UNIDO final report on ICM project for additional information.]

Risk Value 1 – Significant risk to product urgent attention requested ; 2 – Some associated risk – attention required ; 3 - Observation only – no immediate

Appendix 2 : Moth Trapping with Pheromone Lures
December 2000 - April 2001

	2000			2001							2001								
Trap No./ Locations	Dec.4	Dec.12	Dec.18	Jan.8	Jan.22	Jan.29	Feb.5	Feb.12	Feb.19	Feb.26	Mar.5	Mar.12	Mar.19	Mar.26	Apr.2	Apr.9	Apr.14	Apr.23	Apr.30
1 : Bag/Packing store area in G3	2	0	0	2	5	3	0	13	0	0	9	6	0	1	2	65	23	19	3
2 : Bottom of holding bins in G3	6	1	0	17*	3	0	0	0	7	5	20	22	2	12	21	13	28	11	5
3 : Under Conveyor in G3	0	4	1	13	0	0	0	2	0	15	14	10	6	8	21	3	11	12	1
4 : Top of holding bins in G3	9	4	0	2	0	0	0	0	3	0	15	11	2	0	1	33	26	16	1
5 : Organic Rice Packing Area in G3	6	3	4	2	0	0	0	0	1	32	38	17	8	2	5	7	16	13	0
6 : Border line between G3 & G4	0	0	0	0	2	0	1	0	7	0	24	12	0	1	2	7	20	9	2
7 : Front of Central column in G4	0	0	0	0	0	0	0	0	10	2	45	26	11	6	3	40	10	7	2
8 : Back of Central Column in G4	1	2	1	9	6	3	0	1	73	16	41	21	6	4	8	11	21	4	1
9 : Animal Feed Storage near main mill	1	1	1	0	0	0	0	0	9	0	0	0	0	0	0	16	16	6	0
10 : Middle-Left of 1st floor area of 600T Si	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	13	11	5	0
11 : Back-left of 1st floor area of 600T Silo	4	2	0	1	3	1	0	0	13	6	0	0	0	0	0	8	8	3	4
12 : Front-right of 1st floor area of 600T Sil	2	3	1	4	0	0	0	0	0	0	0	0	0	0	0	26	6	6	0
13 : Back-right of 1st floor area of 600T Sil	0	0	1	0	2	0	1	0	0	0	0	0	0	0	0	0	5	8	0
14 : Top-back of 600T Silos	6	5	2	19*	1	2	3	0	21	6	0	0	0	0	0	0	8	4	1
15 : Top-middle of 600T Silos	0	0	0	3	2	0	0	0	23	9	0	0	0	0	0	14	7	9	0
16 : Top-front of 600T Silos	10	0	3	4	2	0	0	0	12	0	0	0	0	0	0	10	12	10	3
17 : Under Hopper 5A in G5	0	0	0	6	1	0	0	1	7	3	2	0	0	1	5	2	12	11	2
18 : Under Hopper 5B in G5	1	0	0	19*	4	1	2	0	18	0	6	1	3	3	3	9	14	6	4
19 : Under Hopper 5C in G5	0	1	0	7	0	0	0	13	66	12	7	2	0	7	9	3	6	7	6
20 : Under Hopper 6A in G6	0	1	1	1	0	0	0	2	3	0	4	0	0	4	5	0	11	9	1

Appendix 2 : Moth Trapping with Pheromone Lures
December 2000 - April 2001

	2000			2001							2001								
Trap No./ Locations	Dec.4	Dec.12	Dec.18	Jan.8	Jan.22	Jan.29	Feb.5	Feb.12	Feb.19	Feb.26	Mar.5	Mar.12	Mar.19	Mar.26	Apr.2	Apr.9	Apr.14	Apr.23	Apr.30
21 : Under Hopper 6B in G6	2	3	2	26*	4	0	1	2	10	0	2	0	0	5	3	3	18	12	3
22 : Under Hopper 6C in G6	1	0	0	1	3	0	0	0	12	10	0	0	1	3	2	15	6	14	1
23 : The Left-Side Gate in G7	3	0	0	41*	13	3	0	0	40	17	10	6	2	8	26	3	9	1	0
24 : The Right-Side Gate in G7	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	6	6	1
25 : Under Hopper 7A in G7	0	0	0	8	4	0	0	3	18	3	0	0	0	0	5	10	16	3	5
26 : Under Hopper 7B in G7	2	0	0	8	2	0	0	1	22	6	9	0	0	1	2	6	16	5	3
27 : Under Hopper 7C in G7	1	3	0	2	3	0	0	0	10	0	0	0	0	0	0	0	19	0	0
Total Trapped Insect per day	58	34	18	73	61	13	8	38	382	142	246	134	41	66	123	317	361	216	49

Note :-

1. February 18, 2001 : Changing new pheromone with glued board.
2. Explosure time : at 9.00 AM every Saturday to at 9.00 AM every Monday

Appendix 3 : Insect Number - Machine House October 2000 - April 2001

		2000						2001								
Fl	Location	Oct.12	Oct.28	Nov.11	Nov.28	Dec.12	Dec.29	Jan.11	Jan.27	Feb.3	Feb.17	Mar.3	Mar.17	Mar.31	Apr.14	Apr.28
Ground	Under Hopper C1,C2 & C3	67	67	30	42	0	0	1	2	0	1	0	0	0	0	0
1	DRUM SIEVE Duct from 6th. Floor	20	18	20	12	0	0	1	0	0	0	1	3	1	2	1
	Bran Duct.	0	0	1	0	0	0	0	0	1	2	2	0	1	1	1
	Broken Rice Hopper	150	18	30	0	0	0	0	1	2	0	0	0	2	1	1
	Animal Feed Hopper	22	4	12	6	8	6	10	4	9	5	4	6	3	2	3
	Spilled Rice	7	3	5	6	8	10	12	12	5	5	3	2	2	1	1
	Floor + Wall Holes	200	3	0	5	7	6	8	7	5	3	3	1	1	0	0
2	Rubblish Duct.	0	0	0	0	0	0	1	5	5	2	2	1	1	1	1
	Spilled Rice.	57	0	3	0	0	0	2	4	3	0	0	0	2	1	0
	Floor + Wall Holes	125	0	20	1	0	3	10	8	10	8	5	0	0	0	1
3	Rubblish Duct.	20	30	22	60	216	120	20	9	6	5	6	5	3	2	2
	Spilled Rice.	20	30	15	8	0	6	12	7	3	2	11	10	11	6	2
	Floor + Wall Holes	130	10	5	70	100	50	30	15	17	15	12	9	8	6	1
4	Rubblish Duct.	16	100	55	120	383	60	25	28	25	25	20	21	19	8	5
	Spilled Rice.	200	500	200	60	6	10	15	14	13	10	11	10	8	5	3
	Floor + Wall Holes	25	58	40	20	26	15	10	13	15	13	9	5	4	3	1
5	Rubblish Duct.	10	0	3	0	0	2	5	0	0	0	0	0	3	2	2
	Spilled Rice.	2	0	5	0	0	1	3	2	1	0	0	1	2	2	1
	Floor + Wall Holes	30	0	0	0	0	1	2	6	5	0	0	3	0	1	3
6	Rubblish Duct.	200	500	250	350	500	100	80	120	100	86	89	75	85	42	35
	Spilled Rice.	3	34	20	12	9	3	17	19	20	15	13	12	10	10	5
	Floor + Wall Holes	22	0	300	280	333	90	30	28	25	10	10	8	7	7	5
	Total SPP's Insects Counted	1326	1375	1036	1052	1596	294	483	294	304	270	201	172	173	103	74

Appendix 4 : Sieve Results from Stored Rice Varieties and Standard

Combined results from 3 sampling days [October 2000, April 2001 and May 2001]
Average numbers of live insects in samples

Rice Type	1 month	3 months	6 months	9 months	Mean	Type Mean
White 100%	1	6.3	14	33	13.6	
White 75%	8	7	#	8.5	7.8	10.4
White 50%	10.4	3.6	11.8	13.5	9.8	
Fragrant 100%	0	19.7	14	11.8	11.4	
Fragrant 75%	1	5.5	#	35	13.8	13.5
Fragrant 50%	17	9.4	18.4	16	15.2	
Glutinous 90%	13	8.5	3	8	8.1	
Glutinous 75%	#	6	#	8	7	16
Glutinous 50%	#	#	33	#	33	
Par boiled 100%	5	3.4	38	14	15.1	
Par boiled 75%	2	7.7	109.4	248	91.8	39
Par boiled 50%	5	9	17	10	10.2	
	6.3	7.8	31.7	34.8		

Notes

1 Minimum accepted sample size for mean estimates in table is 3 results per category.

2 # sign indicates when results could not be measured in the 1 kg samples taken.

3 Large numbers of dead insects [> 200] were recorded in parboiled rice in both 50% and 75% quality standards.

4 All rice stocks are inspected and fumigated if more than 5 live insects are found in 1 kg samples taken at 4 months of age in store.

5 % figures relate to the percentage of whole rice grains in the sample with the remainder being broken grains.

6 All live SPP are recorded and there is no attempt at species selectivity of rice type.

Appendix 5 : Insects Caught in UV Light Traps at CRC site

Period of Monitoring : January 17, 2001 to April 30, 2001

Location of Placing UV light traps

Position	Location
5A	Under Hopper 5A in Godown 5
5C	Under Hopper 5C in Godown 5
6A	Under Hopper 6A in Godown 6
6C	Under Hopper 6C in Godown 6
7A	Under Hopper 7A in Godown 7
7C	Under Hopper 7C in Godown 7
G3	In Godown 3 near new plastic bags stock.
S59	Under Silo S59 in Godown 4 near main mill
G3LP	Local Packing Area in G3
Wood	Loading area which was kept packing material adjacent to mill
4A	Under Hopper 4A near the broken rice duct in Godown 4
Extension	Laneway between GD4 & Neighbour rice mill.

Trapped Method

1. Turn on the power of UV light traps from 5.00 PM to 8.00 AM everyday.
2. Counted caught insects every day.

Most of trapped insects are Rust Red Flour Beetles (Tribolium castaneum)

Appendix 5 : Insects caught in UV Light Traps at CRC site

Date	5A	5C	6A	6C	7A	7C	G3	S59	G3LP	wood	4A	Extension	Trapped insects per day
17/1/44	515	40	948	850	735	200	n/a	n/a	n/a	n/a	n/a	n/a	3,288
18/1/44	188	100	178	130	40	40	n/a	n/a	n/a	n/a	n/a	n/a	676
19/1/44	50	20	160	110	60	40	n/a	n/a	n/a	n/a	n/a	n/a	440
20/1/44	70	70	215	120	50	20	n/a	n/a	n/a	n/a	n/a	n/a	545
22/1/44	33	38	183	145	34	13	n/a	n/a	n/a	n/a	n/a	n/a	445
23/1/44	33	38	183	145	34	13	n/a	n/a	n/a	n/a	n/a	n/a	445
24/1/44	33	38	183	145	34	13	n/a	n/a	n/a	n/a	n/a	n/a	445
25/1/44	33	38	183	145	34	13	n/a	n/a	n/a	n/a	n/a	n/a	445
26/1/44	50	110	100	178	60	50	80	110	15	200	0	185	1,138
27/1/44	10	20	25	15	10	10	70	60	20	247	0	50	537
29/1/44	60	20	150	140	40	45	20	10	5	125	0	65	680
30/1/44	60	20	150	140	40	45	20	10	5	125	0	65	680
31/1/44	180	20	90	120	110	40	30	60	110	400	0	120	1,280
1/2/44	50	10	70	230	60	10	18	15	25	80	0	35	603
2/2/44	30	20	80	110	20	10	22	15	15	60	0	45	427
3/2/44	80	40	50	70	20	10	60	12	30	284	0	67	723
5/2/44	112	15	170	228	37	8	60	12	30	284	0	67	1,023
6/2/44	90	10	87	53	10	9	15	3	7	71	0	17	371
7/2/44	90	10	87	53	10	9	15	3	7	71	0	17	371
8/2/44	90	10	87	53	10	9	15	3	7	71	0	17	371
9/2/44	90	10	87	53	10	9	15	3	7	71	0	17	371
10/2/44	78	18	85	40	42	17	37	16	28	128	0	33	522
12/2/44	183	73	77	348	40	28	27	11	50	480	0	30	1,347
13/2/44	53	12	117	273	58	40	27	11	50	480	0	30	1,151
14/2/44	102	14	70	119	77	8	105	8	60	212	0	50	825
15/2/44	86	22	110	227	54	12	39	12	25	260	0	46	893
16/2/44	78	31	90	256	60	9	17	25	17	184	0	34	801
17/2/44	20	20	87	112	48	17	46	21	22	120	0	22	535
19/22/44	42	12	117	87	10	15	81	28	38	198	0	35	663
20/2/44	75	10	68	69	10	-	32	16	19	210	0	72	581

Appendix 5 : Insects caught in UV Light Traps at CRC site

Date	5A	5C	6A	6C	7A	7C	G3	S59	G3LP	wood	4A	Extension	Trapped insects per day
28/3/44	7	105	31	36	3	-	3	35	28	29	17	6	300
29/3/44	2	50	36	71	2	-	4	20	17	87	12	6	307
30/3/44	5	31	17	63	0	-	7	13	8	81	5	9	239
31/3/44	6	58	16	32	1	-	2	10	2	47	0	8	182
2/4/44	4	116	29	109	2	-	3	22	0	42	1	12	340
3/4/44	7	37	17	42	0	-	0	18	4	90	3	17	235
4/4/44	13	87	46	35	3	-	2	10	3	36	4	6	245
5/4/44	3	70	21	23	4	-	3	26	5	126	1	6	288
7/4/44	8	90	28	30	6	-	19	63	70	218	33	12	577
9/4/44	11	11	44	32	0	-	15	27	-	121	3	39	303
10/4/44	13	51	14	27	0	-	3	10	-	109	21	16	264
11/4/44	15	40	256	163	63	-	23	18	-	145	126	12	861
12/4/44	135	69	122	58	26	-	8	23	-	145	126	12	724
17/4/44	12	45	16	26	3	-	4	10	26	185	15	36	378
18/4/44	28	5	56	14	9	-	9	7	0	86	13	15	242
19/4/44	13	8	25	23	3	-	8	4	0	64	10	36	194
20/4/44	13	5	28	8	5	-	7	7	0	38	16	29	156
21/4/44	15	16	12	9	10	-	5	10	2	36	11	28	154
22/4/44	24	12	16	16	6	-	3	15	3	26	4	13	138
23/4/44	12	14	18	12	4	-	9	5	4	23	0	14	115
24/4/44	16	41	29	15	6	-	13	6	0	25	0	34	185
25/4/44	28	29	18	26	7	-	6	12	2	27	0	36	191
26/4/44	23	35	23	12	16	-	22	16	4	32	0	16	199
27/4/44	13	32	19	36	12	-	16	14	4	34	0	19	199
28/4/44	14	26	30	19	3	-	19	12	2	26	0	26	177
29/4/44	18	20	19	22	5	-	23	14	1	22	0	26	170
30/4/44	16	25	46	24	3	-	18	8	1	36	7	38	222

Appendix 6 : Rural Rice Mill - Quatitative Assessment

Mill name :New Thai Rung Ruang Mill, Nakhon Pathom **Date: 4/4/2000**
By : John Melville

Assessment Criteria	Score 5	Score 4	Score 3	Score 2	Score 1
Live SPP					
Flour beetles					X
Weevils					X
Moths				X	
Psocids					X
Cleaning					
Scheduling quality					X
Floors / walls					X
Equipment					X
Residues removed					X
Frequency					X
Exterior				X	
Trucks				X	
Storage areas					X
Bags / bulk clean?					X
Proofing					
Presence					X
Efficacy					X
Logistics					
Overall management				X	
Brief storage time				X	
Record Quality				X	
Unit Scores				12	12
			Sum total		24

Score 5 - Maximum [Excellent] – 1 Minimum [Unacceptable / Very poor]
Maximum score 90 , Minimum score 18

Appendix 6 : Rural Rice Mills – Quantitative Assessment

Mill name : Suphan buri Rural rice mill **Date: 31/3/2000**
By : John Melville

Assessment Criteria	Score 5	Score 4	Score 3	Score 2	Score 1
Live SPP					
1 Flour beetles					X
2 Weevils				X	
3 Moths				X	
4 Psocids					X
Cleaning					
5 Scheduling quality					X
6 Floors / walls					X
7 Equipment					X
8 Residues removed					X
9 Frequency					X
10 Exterior					X
11 Trucks					X
12 Storage areas					X
13 Bags / bulk					X
Proofing					
14 Presence					X
15 Efficacy					X
Logistics					
16 Overall			X		
17 Brief storage			X		
18 Record Quality		X			
Unit Scores		4	6	4	13
		Sum total			27

Score 5 - Maximum [Excellent] – 1 Minimum [Unacceptable / Very poor]

Maximum score 90 ; Minimum score 18

Appendix 7 : Rice Volume Fumigated – Storage only

Year	Month	Fumigated Rice	Fumigation Cost (0.3 USD/ tons)	Quarterly Average (Tons)
2000	June	6,900	2,070	6,533
	July	5,400	1,620	
	August	7,300	2,190	
	September	8,100	2,430	5,353
	October	2,754	826.2	
	November	5,204	1,561.2	
	December	3,300	990	2,917
2001	January	1,355	406.5	
	February	4,046	1,213.8	
	March	3,500	1,050	2,794
	April	2,089	626.7	
Total		49,999 Tons	$ 14,999.7	$\bar{X}$ = 4,545 Tons

Appendix 8 : Cleaning Procedure Example

STC GROUP

CAPITAL RICE CO., LTD.

Work instruction for Stack Storage Procedures (WI-QC-003)

Copy no. : .....

เอกสารต้นฉบับ

Prepared by : .....

(นางสาวสมพร ตั้งเกษม)
หัวหน้าแผนกวิเคราะห์

Date : 17 / 11 / 43

Approved by : .....

(นายสุชาติ วุฒิวโรภาส (วิเคราะห์))
ผู้ช่วยผู้จัดการฝ่ายคลังสินค้าและโรงงาน

Date : 17 / 11 / 43

1.0 Operator

1.1 Fork lift driver

2.0 Safety equipment

2.1 Personal dust cover

3.0 Equipment & Tool

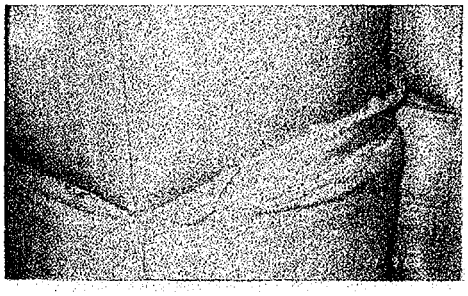
3.1 Forklift

4.0 Reference document

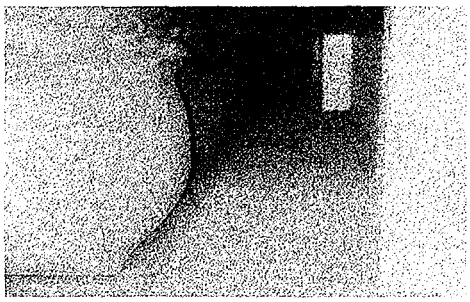
Nil

5.0 Working procedure

5.1 Before bags are stored in any area, it should be cleaned of all debris and long grain.

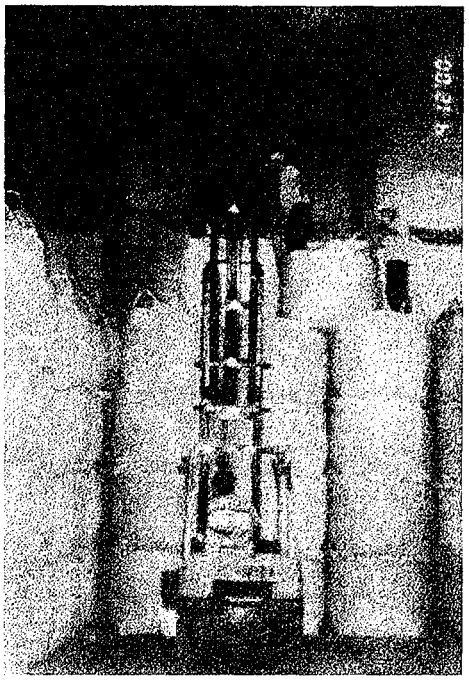


5.2 Minimum gap between stacks and well column should be 1 meter.

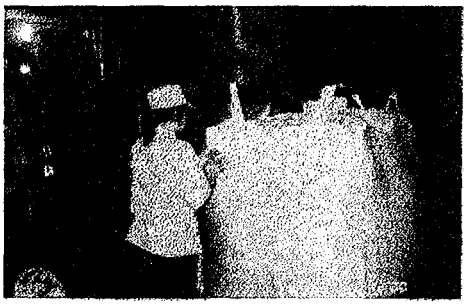


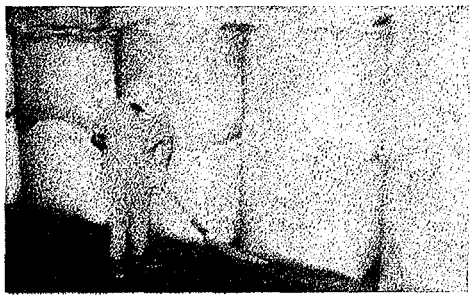
5.3 Minimum gap between stacks for gangway should be 2 meters.

5.4 Stack should be no more than 6 meters high.



5.5 Broken bags should be repaired and spills cleaned up as soon as found.





5.6 Where market demands permit, the oldest stock should always be shipped first.

5.7 Stock that can no longer be sold at regular prices and is more of an insect attractant than a value should be disposed of at the least possible loss. Destruction may still be more profitable than keeping the material and increasing treatment costs.

5.8 Weekly inspections should be made to locate possible infestation or grain that is no longer in good condition.

Appendix 8 : Cleaning Procedure Example

STC GROUP

CAPITAL RICE CO., LTD.

Cleaning Procedures (WI-PD-024)

Copy no. : .....

เอกสารต้นฉบับ

Prepared by : .....
(.....
หัวหน้าแผนกวิเคราะห์)

Date : 17 / 11 / 43

Approved by : .....
(.....
ผู้ช่วยผู้จัดการฝ่ายคลังสินค้าและโรงงาน)

Date : 17 / 11 / 43

CAPITAL RICE STC GROUP	Cleaning Procedures Example		WORK INSTRUCTION
	Date : 17/11/00 Revision : 0 Issue : 1	Approved by : ..... Assistant Plant Manager	WI-PD-024 Page 1 of 3

1.0 Operator

1.1 Cleaning staff

2.0 Safety equipment

2.1 Personal dust protection

3.0 Equipment & Tool

3.1 Broom
3.2 Clean cloth
3.3 Detergent
3.4 Mop
3.5 Water basket
3.6 Air compressor hose
3.7 Brush

4.0 Reference document

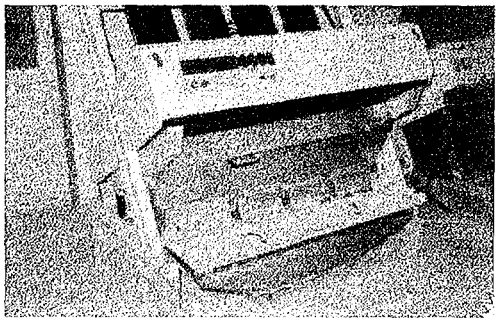
Nil

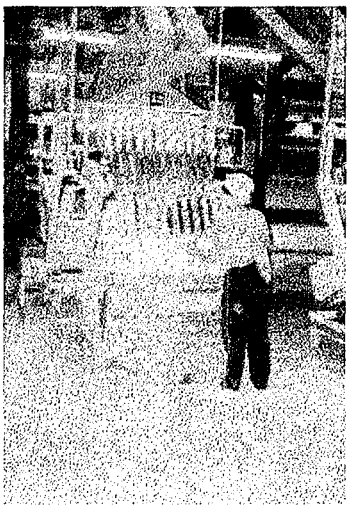
5.0 Working procedure

5.1 Every hour.

Used A small brush to remove spill rice on Grain sorter

5.2 Every 2 hours.





Grain sorter are cleaned with cloth and floors are cleaned with dust Collector

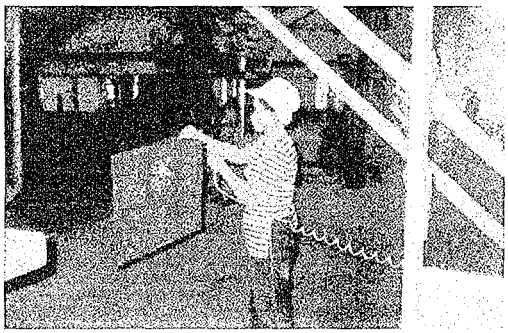
5.3 Every 6 hours.

Windows both inside and outside Grain sorter room are cleaned with detergent and cloth

5.4 Every 7 hours.

A compressed air blower is used to remove dust inside corners of ceiling, a broom used to all areas.

5.5 Every 8 hours.



After completion of cleaning in Grain sorter room, a mop is used to clean all areas again and a Compressed air blower is used to remove dust in filter conditioners.

6.0 Precautions /Hazards.

6.1 Eye irritation from dust exposure.
6.2 Eye irritation from detergent.
6.3 Danger from Electric shot circuit.

Appendix 9

Capital Rice Company Co.,Ltd.	Cleaning Internal Audit in Machine House at 1st Floor.		
	Revised Edition :	Page :	Document Code :

Date .....

Time	Location / Area										Remedy Action	Auditor
	1A	1B	1C	1D	1E	1F	1G	1H	1I	1J		
08.00 A.M.												
09.00 A.M.												
10.00 A.M.												
11.00 A.M.												
12.00 A.M.												
01.00 P.M.												
02.00 P.M.												
03.00 P.M.												
04.00 P.M.												
05.00 P.M.												
06.00 P.M.												
07.00 P.M.												
08.00 P.M.												
09.00 P.M.												
10.00 P.M.												
11.00 P.M.												
12.00 P.M.												
01.00 A.M.												
02.00 A.M.												
03.00 A.M.												
04.00 A.M.												
05.00 A.M.												
06.00 A.M.												
07.00 A.M.												

Appendix 9

Cleaning External Audit in ..... Division.....

Section	Location			Date		
Accummulate Activities	No.of Job					
	Production Department			Maintenance Department		
	Planned	Actual	incomplete	Plan	Actual	incomplete
1st Floor						
2nd Floor						
3rd Floor						
4th Floor						
5th Floor						
6th Floor						
7th Floor						
Go down 3 – 4						
Go down 5 – 6						
Go down 7						

2. Inaccessible areas and future access / date/ person responsible

2.1 _____

2.2 _____

2.3 _____

2.4 _____

2.5 _____

3. Supervisor Comments

4. Head of Department Comments

Auditor Signature _____

Appendix 9

Area / Equipment	Cleaning Schedule Production Division		
	Revised No. :		Document Code : SD-PD-002
	Issued Date :	Authorized by:_____	
	Issued No. :	Position : _____	Page :

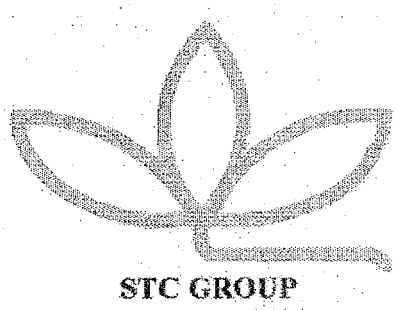
Location	1 hr.	2 hrs.	8 hrs.	Every week	Every 2 weeks	Every 1 month	Every 3 months	Every 6 months	Every 1 year	Operator
Floor		1								Cleaning Operator
Ceiling				3						Cleaning Operator
Window / Window glass					6					Cleaning Operator
C 32			8							Cleaning Operator
C 34 A			8							Cleaning Operator
C 34 B			8							Cleaning Operator
C 34			8							Cleaning Operator
PC 1			8							Production Operator
ST 1			8							Production Operator
ST 2			8							Production Operator
ST 3			8							Production Operator
ST 4			8							Production Operator
GD 1			8							Production Operator
GD 2			8							Production Operator
E 13			12							Cleaning Operator
Lamp cover				4						Cleaning Operator
Stairs / Stairs case		1								Cleaning Operator
Water Cooler				4						Cleaning Operator
Dust Collector										Cleaning Operator
Spilled rice bins		10								Cleaning Operator

Cleaning Method

1. Cleaning by soft broom / mob.
2. Cleaning by hard broom.
3. Cleaning by long broom.
4. Rub with wetted cloth.
5. Washing by detergent.
6. Cleaning by window cleaning agent.
7. Cleaning by jet water gun.
8. Cleaning by airhose.
9. Cleaning by vacuum cleaner and suitable equipment.
10. Pour out into small bin.
11. Dust collector in bulk bag.
12. Cleaning by air hose and rub with dry cloth.
13. Cleaning by small brush.
14. Cleaning by air hose and rub with wetted cloth.

Appendix 10 : Rice Volumes in Storage by Age
During June 2000 - April 2001

	Jun 2000	Jul 2000	Aug 2000	Sep 2000	Oct 2000	Nov 2000	Dec 2000	Jan 2001	Feb 2001	Mar 2001	Apr 2001
LT 3 month	37,202	45,193	41,908	33,799	17,705	24,787	39,058	20,751	14,562	18,970	39,884
3-6 month	4,262	4,126	9,655	21,264	5,861	4,850	4,561	4,016	6,731	5,440	5,731
6-9 month	4,446	3,458	2,876	1,641	1,551	2,171	2,379	2,504	2,013	1,870	842
9-12 month	1,046	1,657	1,119	1,586	923	1,622	712	947	-	485	1,304
>12 month	1,608	585	506	-	561	-	-	1,014	233	250	330
Total stock > 3 month	11,362	9,826	14,156	24,491	8,896	8,643	7,652	8,481	8,977	8,045	8,207



CAPITAL RICE CO.,LTD

Best Practices for ICM

Copy No :.....

Prepared by :

Date ...../...../.....

Authorized by : .....

Date : ...../...../.....

Preface

To raise CRC staff awareness in helping to keep the warehouse clean and good hygiene, which are the foundation of Integrated Commodity Management (ICM), Best practice, a set of principles and procedures is set as follows

1. Best practice for plant and equipment design.
2. Best practice for good sanitation.
3. Best practice for inspection and monitoring
4. Best practice for storage and fumigation of bagged grain.

By follow the best practice, the milled rice enhances and improves the efficiency of its operations in terms of product quality, productivity and cost management to satisfy the growing demand of their customers, which consequently lead to continuous improvement. It has helped CRC a sustainable competitive edge by providing high quality products at lower cost, bringing direct benefits to all customers.

1. Best practice for plant and equipment design.

1.1 Materials, construction and layout of the building and equipment should avoid creating surfaces and cavities where dust, food material, insects and rodents can collect.

1.2 Flat surfaces that can collect dust should be avoided, especially in locations that are hard to reach.

1.3 Cracks, crevices and cavities in floors, walls, ceilings and equipment should be avoided.

1.4 Open ends of conduits should be sealed. Seams on ductwork should be sealed, especially in areas with grain-based products.

1.5 Insulation must be sealed off to prevent insects from colonizing there.

1.6 Cavities should either be completely sealed or made completely accessible.

1.7 All parts of the plant and equipment are accessible for easy cleaning. Tight spaces not only collect dust and provide harbourage for insects, but they are also difficult to clean.

1.8 There must be adequate space around, under and over equipment, supports and beams for cleaning.

1.9 Service lines should be laid out so as not to block access to equipment or create difficult cleaning problems.

1.10 Equipment and ductwork must have access ports to remote areas for cleaning and inspection, particularly on long horizontal sections.

1.11 Equipment must also be elevated from the floor for effective cleaning.

1.12 Dust collection systems should be easy to clean.

1.13 Floors, walls, ceilings and equipment surfaces must be made from a material that is appropriate to the use of the area and is easy to clean.

1.14 The equipment should be compatible with treatment methods such as gas or heat, and the plant should be structurally sound to accommodate and retain controlled atmospheres, gases and heat. Any equipment that is not compatible with treatments should be mobile or easily isolated.

1.15 The building and surrounding grounds should be free of harbourage sites for rodents. Trees and shrubs should not be grown next to the building and those known to attract insects should be avoided.

1.16 Exterior lighting with sodium vapor lights can reduce the numbers of insects attracted, and lights can be shielded above to avoid attracting high-flying insects.

1.17 Doors and windows need to be closed or screened with proper seals to keep out pests and night-lights should not be directly over doors.

1.18 Entryways for trucks and railcars need special attention.

1.19 Ventilation intakes should be designed to keep out birds and insects.

1.20 Particular attention is needed to seasonal insect problems. Where there may be release or spill of material from exhaust vents, the surrounding area must be amenable to clean up.

2. *Best practice for good sanitation.*

2.1 The facility should be operated to minimize the opportunity for pests to become established. Cleaning and sanitation, therefore, requires utmost priority.

2.2 Cleaning must be conducted thoroughly, regularly and frequently, with written procedures identifying cleaning methods.

2.3 The length or frequency of the cleaning cycle should be adapted to specific buildings and equipment, however, it should be appropriate to maintain a high level of control.

2.4 Known trouble spots should be inspected and cleaned more frequently, and the cleaning cycle shortened if necessary.

2.5 Cleaning tools must be effective, designed for the task, and must themselves be kept clean.

2.6 Air hoses should generally not be used for cleaning, unless areas are not accessible for vacuum cleaners.

2.7 In addition to cleaning, the generation and accumulation of dust should be prevented.

2.8 Leaks in pipes should be avoided, and when they occur quickly identified and repaired.

2.9 Dust collectors and seals on equipment should be cleaned and maintained in good working order.

2.10 It is important to keep dust, flour, insects or other material from reaching areas that are inaccessible for cleaning, treating and inspecting.

2.11 Opportunities for pests to become established should be minimized by removing food sources and pest harbourages.

2.12 Product should be kept away from walls and in pest-proof packaging.

2.13 Maintaining reduced inventory and faster rotation of stock ca also reduce establishment of pests.

2.14 Sanitation is also needed outside the plant to reduce food sources.

2.15 The importance of cleaning and sanitation must be emphasized to all staff. In particular, cooperation among cleaning crews, quality control officials, and a pest control service will be beneficial.

2.16 Regular and preventative maintenance is important. Holes and cracks in floors, walls, ceiling, roofs, doors and windows allow access for vermin and allow dust to collect, and therefore must be fixed.

2.17 Roof drains must be in good shape and debris removal is often required on top of buildings to prevent vegetation growth, accumulation of water that can attract birds, and collection of decaying organic matter.

2.18 Interior attractors, such as food and harbourage sites, must be eliminated using techniques such as storing idle equipment on racks off the floor and covering food and waste containers.

3 ***Best practice for storage and fumigation of bagged grain***

3.1 Stacks should be no more than 6 meters high
3.2 Minimum gap between stacks and wall or columns should be 1 meter.

3.3 Minimum gap between stacks for gangways should be 2 meters.

3.4 Before bags are stored in any area, it should be cleaned of all debris and loose grain.

3.5 All sweepings should be fumigated or immediately destroyed to avoid harboring an Infestation.

3.6 Floor cracks should be filled with cement or hard filler

3.7 Floors need spraying with a good residual pesticide to discourage insect migration for storage.

3.8 Floors should dry before any material is placed in the area.

3.9 Walls should be checked for holes or cracks that could retain old grain.

3.10 Moth webbing and old grain should be brushed clean and all holes and cracks should be filled with cement.

3.11 Wall spraying with residual pesticides, of or appropriate type and formulation could be considered when practical to do so.

3.12 Overhead areas should be cleaned of dust and moth webbing and sprayed with residual insecticides
3.13 Storage should be segregated: Old and new stock, Good and bad stock, Different moisture levels, and Different grains or varieties

3.14 Incoming grain should be checked for insect infestation and treated of infested. A regular programmed of inspection maintenance and sanitation should be implemented.

3.15 All grain should be inspected on arrival and fumigated if infected.

3.16 Insects will live in spilled grain next to bags and along walls. This must be swept up daily and fumigated or destroyed.

3.17 Insects can live in grain dust on ledges and ceiling beams. These must be kept clean enough to discourage this infestation.

3.18 Tailings and siftings from equipment will contain many live insects. This should be fumigated or destroyed each day.

3.19 Weekly inspections should be made to locate possible infestation or grain that is no longer in good condition.

3.20 Where market demands permit, the oldest stock should always be shipped first.
3.21 Applications of residual insecticides should be made to the walls and other insect resting area at least once per month.

3.22 All used bags should be fumigated before reuse.
3.23 All cleaning and bagging equipment should be fumigated once per month minimum.
3.24 Stock that can no longer be sold at regular prices and is more of an insect attractant than a value should be disposed of at the least possible loss. Destruction may still be more profitable than keeping the material and increasing treatment costs.

3.25 Broken bags should be repaired and spills cleaned up as soon as found.
3.26 A rodent trapping or poisoning program should be maintained wherever rodents are a problem.
3.27 Bird infestation in the go downs should be discouraged through use of hanging strips at doorways and other mechanical deterrents.
3.28 Floor drains should be kept clean and treated to discourage cockroach infestations, which can affect the odor and flavor of rice.

4. Best practice for inspection and monitoring

4.1 It is considered a prerequisite that the inspector has a working knowledge of the insect species that are commonly occurring in the produce with which he is dealing.
4.2 In a stack of bags which is to remain in position, It is only possible to sample the top layer. Since most insects are found in the outer bags, including the top layer, the selected sample units shall always included the from corner bags since there are especially prove to infestation.

4.3 It is important to realize that after adopting a thorough inspection programme, the inability to find any insect infestation does not automatically preclude their absence, and especially in the humid tropics of Southeast Asia, the presence of low level populations now (i.e. 1 insect per 100 kg.), will result in damaging population densities developing within four months. Continuous monitoring is therefore the essence of preventing serious deterioration of grain in storage.

4.4 General inspection may involve checking grain held at storage facilities for any obvious infestation without drawing grain samples or it may involve looking for sources of residual infestation within the fabric of the storage structure or the immediate surrounds.

4.5 Because of the time-consuming nature of an inspection, the initial phase should concentrate on observing places where insects if present are likely to congregate.

4.6 During an inspection, a few bags should be opened at random and the folds of sacking and bag corners examined. Some bags should be at least lifted and set aside and the exposed surfaces of neighbouring bags quickly examined for adults and more carefully for larvae and pupae: such as for Ephestia cautella.

4.7 Localized rises in grain temperature or moisture within a bagged stack or grain bulk are most important indicators of insect activity.

4.8 Nearly all storage insects are more easily found in dark premises because they are more active in the dark than in the light. They also lay eggs more readily in the dark. Therefore, the inspector should examine dark places, the conical tufts of sprouting grain under leaks in the roof, the wet surfaces of bags and areas of produce known or thought to be wetter than the rest, and the tops of stacks especially those under metals roofs.

4.9 The monitoring program should include establishment of targets and action levels, and schedules for placing and checking traps or other techniques. Methods of trapping can include pheromone traps, glue boards and light traps for flying insects.

4.10 Zone mapping can be used to establish different inspections, pest thresholds and control procedures for different parts of the facility, related to the level of risk for the product.

4.11 Traps can be arranged in a grid pattern throughout the facility following manufacturers' guidelines for placement and spacing. Generally, moth traps attract insects from a wider area and fewer may be needed than for beetle traps that do not attract insects from as large an area.

4.12 When the traps are in place, they should be checked on a regular basis and the numbers and species of insects carefully recorded. Traps should also be replaced on a regular interval.

4.13 The number of insects caught is determined by several factors; trap placement, temperature, duration of sampling and condition of pheromone lure, that can be unrelated to the number of insects in the building. The interpretation of trap data is difficult because it is a relative, not an absolute measure of insect populations. The best approach is to look for trends in trap catches. Low or no traps catch followed by a sudden increase in numbers is an indication of a developing infestation. If this happens, traps can be concentrated in the areas where traps catch the most insects. As the search area is reduced, it is often possible to pinpoint infestations and to deal with them without treating the entire facility.

4.14 Light traps must be strategically located, so they do not attract flying insects from outside. The light traps need to be cleaned regularly to prevent secondary infestation from occurring.

4.15 Portable black light or ultraviolet light can be used to detect evidence of rodent activity.

5. *Best practice for use insect trap in a warehouse.*

5.1 A tool to determine the presence or absence of potentially harmful pest insects is needed where stored commodities are held for extended lengths of time. Pheromone-baited traps are excellent tools for this purpose. It is important to recognize that there is not always one type of trap that is best to use in a pest- monitoring program in warehouses. It is important to match the specific trap to the environmental conditions in each particular situation. Some examples of this would be: 1) dusty areas vs. areas that are not dusty, 2) hot vs. cold temperatures, and 3) outdoors vs. indoor use. All pheromone-baited traps were not created equal. Traps for moths may act differently than beetle traps. One cannot treat all stored-product pests the same when it comes to recommending an effective trapping program. Long-lived insect adults (e.g., flour beetles) tend to be less attracted to pheromone-baited traps than short-lived insect adults.

5.2 Too much dust can cause sticky traps to be ineffective. In this situation, alterations to the sticky trap can prevent an excessive build-up of dust or a pitfall-type trap could be incorporated.

5.3 Dusty warehouses offer challenges for conventional sticky glue traps. In these extreme conditions, a sticky trap may become useless after several days, or even after several hours. The selection of a trap that can deflect the dust or a pitfall-type trap that does not include glue as the entrapment mechanism will need to be implemented.

5.4 Placement of traps will depend on the temperature in the warehouse. As the temperature gradients in the warehouse change during the summer months, the harsh conditions near the top of these facilities may hinder the capture of insects in a monitoring program.

5.5 There is no exact number of traps that should be placed in a warehouse to detect the presence or absence of pest insects. The number of traps needed can change according to several factors determined by the trained person implementing and re-evaluating program.

5.6 A common misconception in a strategy used to manage grain, bulk commodities, and bagged products using pheromone-baited traps is that there is a set numerical threshold for action or reaction. There is no magic number for determining action. A trained pest management inspector must weigh all factors before making a decision. The key to interpreting trap catch is to look for increases in numbers of insects from one trapping period to the next.

5.7 Pheromone-baited traps have some limitations in the management of grain, bulk commodities, and bagged products. These traps are very sensitive to the target insects being monitored. However, other insects often are present and go undetected because of a lack of effective or efficient trapping systems.

Appendix 12 : Timetable of ICM Work

No.	Activities	Work Progressive Period										Remarks
		Sep 00	Oct 00	Nov 00	Dec 00	Jan 01	Feb 01	Mar 01	Apr 01	May 01	Jun 01	
1.	**Rice protection from contamination through a process**											
	Development of isolation system for residues and screenings											
	1.1 Develop a 'clean' environment for Go Downs 3 and 4	Sv	C	N	I	Maintain Sanitation Level						Note. 1
	1.2 Removal of damp and moldy residues from	Sv	C,N	I	Maintain Sanitation Level							
	• The southern section of the mill	/	/	/	/	/	/	/	/	/	/	Note.2
	• Machine room sections below the main silos and mills	/	/	/	/	/	/	/	/	/	/	Note.3
	• Conveyor system equipment and interior ledges on top of bins in Go Down 3	/	/	/	/	/	/	/	/	/	/	Note.1
	• 600 MT Silo tops	/	/	/	/	/	/	/	/	/	/	Note.3
	• Conveyor line carrying waste from pre cleaning machinery to hopper 2 in Go Down 4	/	/	/	/	/	/	/	/	/	/	Note.4
	• Machine and going into Hopper 2 in Go Down 4	/	/	/	/	/	/	/	/	/	/	Note.4
	• Sack store areas Go Down 5 and 6	/	/	/	/	/	/	/	/	/	/	Note.5
	• Go Down 7 and 8 (especially jute sacks in 8)	/	/	/	/	/	/	/	/	/	/	Note.6
	1.3 Make cleaning schedules and cleaning standard through the entire plant and Go Down system	Sv	C	N	N	I	Maintain Sanitation Level					Note.7
	1.4 Carry out to exclude pigeons from most plant area	Sv	C	C	N	I	Maintain Sanitation Level					Note.7
	1.5 Making a high level cleaning and hygiene plan to remove the pests food plant and save breeding grounds (by using back pack vacuum cleaners)	Sv	C	C	C	C	I	Maintain Sanitation Level				Note.7
	1.6 Bird proofing of building in main mill and Go Downs	Sv	C	N	N	I	Maintain Sanitation Level					Note.7
	1.7 Remove the damaged bags and repack	Sv	C,N	I	Maintain Sanitation Level							Note.6
	1.8 Eliminate a potential hazard on site especially in the dark and uncleanness area of the machine room	Sv	C,N	I	Maintain Sanitation Level							Note.3
	1.9 Residues collected and remove from site	Sv	C,N	I	Maintain Sanitation Level							Note.2

Sv = Site Survey , C = Concept , N = Negotiate , I = Implementation , PF = Problem found , PS = Problem solved.

Appendix 12 : Timetable of ICM Work

No.		Activities	Work Progressive Period										Remarks
			Sep 00	Oct 00	Nov 00	Dec 00	Jan 01	Feb 01	Mar 01	Apr 01	May 01	Jun 01	
2.	**Rice protection from contamination through stored pipeline**												
	2.1	Review logistics of rice cleaning and movement in the mill pipeline	Sv	Sv	C	N	I	Maintain Sanitation Level					Note.8
	2.2	Pre cleaning overhead conveyors	Sv	C,N	I	Maintain Sanitation Level							Note.3
3.	**Rice protection from infestation through a process**												
	3.1	Improve bag closures and seals	Sv	C	N, I	Maintain Sanitation Level							Note.9
	3.2	Separate and isolate all infested goods from clean newly package goods	Sv	C	N, I	Maintain Sanitation Level							Note.10
	3.3	Remove a principal source of infestation for the entire mill by bag, seal and remove from site	Sv	C,N	N, I	Maintain Sanitation Level							Note.3
	3.4	Install sieves and insect ID chart at weighbridge	Sv	C	N	N	I	Maintain Sanitation Level					Note.11
	3.5	Identify all dead spots and seal	Sv	C,N	I	Maintain Sanitation Level							Note.12
	3.6	Eliminate old disused equipment	Sv	C,N	I	Maintain Sanitation Level							Note.12
	3.7	Identify all spills in the pipeline and repair equipment	Sv	C	N	I	Maintain Sanitation Level						Note.12
	3.8	Reshuffle upper bag vs lower bag infestation	Sv	C	C	N	I	Maintain Sanitation Level					
	3.9	Fumigation of 3 months old stock	Sv	I	Maintain Sanitation Level								Note.12
4.	**Rice protection from infestation through stored pipeline**												
	4.1	Trial Dichlorvos tablets or hangers within Jumbos for long-term storage protection	← Unmatched with CRC Situation →										
	4.2	Establish predator pest dynamic experiment	← Unmatched with CRC Situation →										
	4.3	Clean and fumigate used bag and sack prior to storage in Go Down	Sv	C ,N	I	Maintain Sanitation Level							Note.7
	4.4	Remove heavily infested material such as hopper 2 collections	Sv	C,N	I	Maintain Sanitation Level							Note.7

Sv = Site Survey , C = Concept , N = Negotiate , I = Implementation , PF = Problem found , PS = Problem solved.

Appendix 12 : Timetable of ICM Work

No.	Activities	Work Progressive Period										Remarks
		Sep 00	Oct 00	Nov 00	Dec 00	Jan 01	Feb 01	Mar 01	Apr 01	May 01	Jun 01	
5.	**Monitoring and Report**											
	5.1 Internal audit		C	N	N	I	Maintain					Note.13
	5.2 External audit	I				I	I	I	I	I	I	Note.13
	5.3 Documented, analyzed and transmitted for insect activities to TIG and IE										I	Note.13
	5.4 Develop strategy for influencing rice quality supply from all rural mills	C	C	C	N	N	N	N	N	I	I	Note.11
	5.5 Undertake a cost assessment of fumigation and fogging	C	C	Implementation								Note.13
	5.6 Cost out and plan trial work with Dustinex in a Go Down to compare to nil treatment and fogging options	Not implementation because of high cost										
	5.7 Develop and document Best Manufacturing Practices (BMP) for cleaning at each and every mill areas	C	C	C	Implementation							Note.7
	5.8 Establish a stored product insect reference library						I					
	5.9 Prepare QA manual document						I					Note.7
	5.10 Meeting and review all features of ICM development	I	I	I	I	I	I	I	I	I	I	Note.13

Sv = Site Survey , C = Concept , N = Negotiate , I = Implementation , PF = Problem found , PS = Problem solved.

Appendix 12 : Timetable of ICM Work

Note	Topic	Activity
1.	Clean G 3 -4	
PF.	• Identify space utilization. • Identify all dead spot areas	Found the stocks of returned products , Unused bags , old equipment , residue , pile of empty bags , Infested bran from sieve , residue beneath machine, old stocks.
PS	- Clear unused bags from stocking shelves	Find new area for keeping them while await for sales.(Building cost~ 30KB by CRC)
	- Keep the returned products out of Godown - Old equipment	- Share CPT container.Use the blanket cover for fumigation. - Sold unused equipment.
	- Pile of empty bags	- Set 1 cleaning point with the specific staffs (location between G6-G7 road path).JB cleaning productivity increase 40%. (Investment cost ~ 10 KB paid by CRC). - Reduce the residue from cleaning and insect harborage.
	- Old stocks	Fumigation (~ 80 KBaht paid by CRC), Stocked rotation.
	- Residue beneath machine	- Educate cleaning staffs. Prepare photo-cleaning work procedure. - Have a big cleaning days every month.
2.	Residue the main mill	
PF	• Identify space utilization. • Identify all dead spot areas	Found heavy residues and insect infestation , holes
PS	- Heavy residues	- Train cleaning staffs and preparing cleaning schedule for them. - Cleaned by both air injection, Sweep and vacuum cleaner.
	- Heavy residue in the cable tray	- Cleaned by both air injection, Sweep and vacuum cleaner. - Covered clean cable by aluminium covered lid.
	- Hole	Cleaned, Closed holes all 7 floors in Machine House (cost ~ 100 KB).
	- Insect Infestation sources	- Installed vertical drainage pipeline both of residues and dirty water from cleaning activity from each floor through drainage vessels at ground floor. Reduce cleaning staff-workload. - Installed spilled rice drainage pipeline from 7th floor to ground floor in order not keep those material on each floor.

Appendix 12 : Timetable of ICM Work

3.	Residue and spillage in M/H	
PF	• Identify space utilization and Identify all dead spot areas	Found spillage from machine , Blown out residue from cyclone , Huge dump of processing rice drop out from conveyor (10 tons/day)
PS	- Residue blown out from cyclone	Prevent the blown out by installation ducts which will convey dust from cyclone to storage outside M/H. (Estimated cost installation ~ 500 KB by CRC.)
	- Spillage from machine	- Find out causes of spillage - Install rice guard to protect the spilled for every machine (2 KB) - Repair the machine, Set preventive maintenance schedule.
	- Huge dump of processing rice drop out from conveyor	- Find out causes. - Checking the electrical circuit & repair causes of equipment mal-function.
4.	Insect infested residue from sieving step (near Q.C. room)	
PF	• Identify space utilization. • Identify all dead spot areas	Found many insects inside the vessels hold residue from sieve.
PS	- Working procedure to get rid of insect in the residue on sieving machine	- Tight the cover of holding vessels. - Install tank storage for residue from sieve outside of M/H.
5.	Moldy residue & Sack storage in Godown 5 – 6	
PF	• Identify space utilization. • Identify all dead spot areas	Found old jute bags storage , old bulk bags storage , no cleaning and no fumigation inside Godown. Old stock , Spilled rice from packing rice from and pouring rice to hopper and conveyor.
PS	- Old jute bags storage - New jute bags	- Sold all old jute bags stock (gain ~ 50 KB) - Holding short period (< 0.5 months) and will sell every 10,000 PCs.
	- Old JB storage - Empty JB stocks but no cleaning and fumigation	- Sold all. - Cleaning bulk bag from 500 pcs/day to 2000 pcs./days and set the procedure of use bulk bags. (Use only cleaned and fumigated bulk bag for keeping stock). - Stocking the clean bulk bag in containers
	- Old stock	Set direction for stocks which is keeping over than 3 months and infested will fumigation.
	- Spilled rice from Packing and Pouring	- Identify causes. - Set the working procedure for both packing and pouring. - Repair some hydraulic valve.

Appendix 12 : Timetable of ICM Work

Note	Topic	Activity
6.	Moldy residue & Sack storage in Godown 7 - 8	
PF	- Identify space utilization. - Identify all dead spot areas	Found infested rice stock in jute bags in Godown 8 , spilled rice from packing and pouring , no access area for monitoring , heavy dust on floor , stock of damaged JB
PS	- Infested rice stock in Jute bags	- Fumigated. - Move out the stock from G8 to SMTC Godown.
	- No access area for monitoring around the wall - Heavy dust on floor - Damaged JB	- Move out all stocks in G7 and sold all damage JB stock. - Cleaning floor by water jet and white coloring on the 1.0 meter width accessing area . - Fumigated the infested stocks which keeping older than 3 months. - Fumigated the empty stock (25,000 pcs.) in G 7.
7.	Make cleaning schedules and cleaning standard	
PF	- Identify all cleaning activity	Found hard working but still dirty (thick residues on floor and the top of Silo)
PS	- Training staff	- Training staffs - Prepare cleaning Schedule to all cleanign staffs (M/H first) - Provided suitable cleaning tools.
	- Sources of problems	- Find out & Investigated - Solve by co-operate with CRC's engineering
	- Prepare Best Practice Manual	Start with the BMP of cleaning in M/H
8.	Review logistic of cleaning rice in house pipeline	
PF	- Identify processing route and pre cleaning overhead conveyors	- Build plastic overarching cover the conveyor line in order to prevent dust and rice spillages spread out during transferring rice to the production process.
9.	Working procedure of bag closures and seal	
PF	- Identify steps of work and records	Collecting the data of present operation Monitoring by reference test. (collecting insect found data every 2 weeks)
PS	- Set reference test (~ 30 JB / set)	- Set reference pile in Godown 7 and 6 - Test result is not showing trend to support the theory because it did not ensure that the reference is free of insects before test.

Appendix 12 : Timetable of ICM Work

Note	Topic	Activity
10.	Separate and isolate infested good from clean newly package goods in G3.	See in note. 1
11.	Install sieve and insect ID at weight bridge.	
PF	- Identify insect infestation from sources of milled rice before CRC keeping in their stock	Monitoring Results found no insect from sample except milled rice from government.
	- Insect ID	
12.	Identity all dead spot and seal	See Note.1-Note.10
13.	Monitoring & Report	
	- Recording insect numbers in stocks kept over 3 month	After the confirmation that stocks kept over 3 months will have a pervade infestation. Stop keeping these records.
	- Recording insect numbers in the reference test for bag closure and seal	Record every 2 weeks.
	- Recording insect numbers from pheromone trapping	Record every weeks
	- Recording insect numbers from the residues entire plant	Record every month
	- Spilled rice from machine in M/H	Daily records.
	- Weight loss from insects	Some batch
	- Weight loss from equipment malfunction.	Some batch

1. Introduction

Mehtyl Bromide is widely used as a fumigant in agriculture and pest control in structures, stored commodities and quarantine treatments. It is active against a diverse variety of organisms at low concentration, including mammals and many insects, mites, nematodes, fungi , weeds, bacteria and viruses. Although it is clearly a most useful tool in specific instances but it was listed as an ozone-depleting substances by the fourth meeting of the parties to Montreal protocol on substances that deplete the ozone layer in Copenhengen in November 1992 which have led countries to impose restrictions on its use.

In the year 2000 Thailand consumed 487 tons of methyl bromide. Approximately 96.5% of this amount was used on the quarantine control of durable export commodities like rice, tapioca , maize ,pulses. The rest were used mostly in storage fumigation and a small amount in soil fumigation.

1.1 UNIDO Project Aims

As methyl bromide has been identified as an ozone-depleting substance under the Montreal Protocol, and targets have been set for reduction and phase out. The reduction of methyl bromide used is to find out the possibility of both technical and economical aspect of alternatives fumigation treatment. There are 2 alternatives demonstrated in this project which are

1.1.1 Fumigation with Phosphine in the form of :-

1.1.1.1 Cylinderised Liquid Phosphine ECO_2fume with SIROCIRC® and SIROFLO®

1.1.1.2 Phosphine Tablets / Tablets for bagged rice and tapiocca tablets in Barges.

1.1.2 Introduce and implement the integrated commodity management (ICM) concept to the rice warehouses.

1.1.3 Compare the efficacy and cost of these treatment with the current use of methyl bromide (MeBr).

1.1.4 Disseminate the results of the project to related industries

1.2 Background

MeBr is an effective fumigant and widely used in disinfestation of agricultural commodities. It is widely used because of the short time exposure period and its properties to penetrate quickly and deeply into sortive material at normal atmospheric pressure and its vapours dissipate rapidly, non-flammable or explosive under normal fumigating condition.Its exposure period to reach $LD_{\geq 99}$ is less than 24 hours which mean that the stored keepers could handle their works easily. Comparing to phosphine fumigation that would take longer expopsure period.

Anyhow these demonstrations were the samples that can be used in the normal practice and its need a little effort to arrange the works so that fumigation can be run properly without the problem of the failure of fumigation.

Table 1. – Dosage and exposure time of fumigants normally used in Thailand

Fumigant	Exposure period	Dosage (g. / cu.m.)	Normal Condition
MeBr	24 hrs	32	Atmospheric temperature
Phosphine	3 - 5 days	2 - 5	Atmospheric Temperature

1.3 Alternative technologies demonstrated

This project will compare the pest control efficacy of phosphine(PH_3) in 2 forms, solid metal phosphide and liquid PH_3 referenced by methyl bromide fumigation.

Solid metal phosphide is the PH_3 gas generated from the chemical reaction of the aluminium or magnesium phosphide with surrounding moisture releases hydrogen phosphide gas, or phosphine. Fumigation demonstration on bag stack fumigation and barge fumigation. Stack fumigation will be demonstrated under sealed gas proof sheet and the traditional application.

Liquid PH_3 is the PH_3 gaseous mixture, $ECO_2fume^{®}$,developed and patented by BOC Gases Group that can be ready to kill the pests in the enclosure. This can be used as an alternative to the generation of phosphine from metallic phosphides.
Fumigating demonstration in Silos.

1.4 Fumigation Demonstration

There were two commodities in the fumigation demonstration,

1.4.1 Rice fumigation were done at Capital Rice Co., Ltd. warehouse at Sarong, Samutprakan.

1.4.1.1 Silo Fumigation: $ECO_2Fume^{®}$ VS. MeBr.
1.4.1.2 Sealed Stack Fumigation: PH_3 tablets VS. MeBr.
1.4.1.3 Bagged Rice Fumigation under gas proof sheet: PH_3 tablets VS. MeBr.

1.4.2 Tapioca chip fumigation was done at Asia Pellet Co., Ltd. at Sampran, Nakorn Pathom

1.4.2.1 Lighter Fumigation for Tapioca : PH_3 tablets VS. MeBr.

The efficacy of fumigation was monitored by two factors:

Gas concentration.

Gas concentration was monitored during fumigation by using Gastec detector tubes. Methyl bromide concentrations were read one hour after applying the gas and every 3 -6 hours until the end of the exposure period.
Phophine tablet fumigation, gas concentration was read 3 hours after applying the tablets and every 12 hours until the fumigation was terminated.

$ECO_2Fume^{®}$ fumigation, gas concentration was read on 9.00 A.M. and 3.00 P.M. with SILOCHECK, PH_3 electronic gas detector.

Bioassay with tested insects.

Bioassay was used to evaluate the effectiveness of the fumigation in addition to monitoring gas concentration. Live insects were placed in the silos and stacks prior the apply of fumigant. Then after treatment, number of each species of insect were counted to determine the dead and alive. Immature stages of rice weevil, *Sitophilus oryzae* were counted 3 weeks after to determine the immature to become adult stage.

Insects that were used in the test were Rice weevil, *Sitophilus oryzae* both adult and immature stages, saw-tooth grain beetle, *Oryzaephilus surnamensis*, flour beetle, *Tribolium* spp. and book lice, *Liposcelis* spp.

1.4.1.1 Silo Fumigation : $ECO_2Fume^{®}$ VS. MeBr.

1. Fumigation was done in steel silo with the rice capacity of 120 tons.

    - 2 bins for $ECO_2fume^{®}$ with the recirculated system, SIROCIRC® at 70 ppm. for 15 days.
    - 2 bins for $ECO_2fume^{®}$ with the non-circulated system, SIROFLO® at 70 ppm. for 15 days.
    - 1 bins for MeBr 24 hours

2. Gas tightness was tested before fumigation was performed.
3. Placed each tested insect in the cloth bags and tied them in to 3 levels inside the bin, with the structure inside the bin. Insects were place at the bottom, middle and on the top of the rice.
4. Sealed all the outlets of the bin.

5. Applied Selected Fumigants.

    $ECO_2Fume^{®}$

    - Applied $ECO_2Fume^{®}$ from gas tank mixed up with air blown from the bottom of the bin at 4.26 liters /min. to reach PH_3 concentration of 70 ppm. continuously along 15 days with recirculating gas from upper of the bin.
    - Applied $ECO_2Fume^{®}$ from gas tank mixed up with air blown from the bottom of the bin at 4.26 liters /min. to reach PH_3 concentration of 70 ppm. continuously along 15 days flow through the ventilation pipeline.
    - Measured concentration at 8 hour after apply the gas and 9.00 A.M. and 3.00 P.M everyday until the end of the exposure period.
    - Ventilated the remain PH_3 after completion the fumigation.

    MeBr

    - Applied methyl bromide from the top of the bin at the dosage of 32 g/cu.m. 24 h.
    - Measured concentration at 1 hour after apply the gas and every 3 to 6 hours until the end of the exposure period by mean of interference refractometer.
    - Ventilated methyl bromide after completion the fumigation.

6. Collected tested insects from the silo.

    - Checked the mortality of the tested insects, adults insects were checked 24 hours after treatment and immature stages were checked 3 weeks later to make sure that all the immature stages including egg stage were fully developed to adult.

Table 2. Showed the mortality of different species of tested insects

	LPH_3-Siroflo [1]		LPH_3-Sirocirc® [2]		MeBr [3]		Control	
	dead	% mortality	dead	% mortality	dead	% mortality	dead	alive
Sitophilus oryzae	250	100	350	100	150	100	0	50
S.oryzae Immature stages	300	100	305	100	205	100	0	50
Tribolium spp.	250	100	250	100	250	100	0	50
Oryzaephilus Surnamensis	250	100	250	100	250	100	0	50
Liposcelis spp.	50	100	50	100	50	100	4	26

NB:
1 : 70 ppm. PH_3 (5g/m^3 of ECO_2Fume®) with Siroflo® systems X 15 days
2 : 70 ppm. PH_3 (5g/m^3 of ECO_2Fume®) with Sirocirc® systems X 15 days
3 : 32 g/ m^3 MeBr X 24 hours.

Table 3. Showed gas concentration on head space of the silo after exposure

Time after exposure (hours)	Gases Concentration		
	PH_3 - Siroflo® (ppm)	PH_3 - Sirocirc® (ppm)	MeBr (g/m^3)
0	0	0	0
1	11	13	40
3	32	37	36
6	49	56	32
12	57	65	30
24	66	71	26
2 days.	73	71*	-
3 days.	67	68*	-
4 days.	69	67*	-
5 days.	69	70*	-
6 days.	70	73*	-
7 days.	72	79*	-
8 days.	71	70*	-
9 days.	73	64*	-
10 days.	71	69*	-
11 days.	70	72*	-
12 days.	69	71*	-
13 days.	72	71*	-
14 days.	72	71*	-

* The average of recirculating PH_3 concentration from head space of SILO is 47 ppm.

1.4.1.2 Sealed Stack Fumigation : PH_3 tablets

Sealed stack fumigation is another method of fumigation that the storage keeper wants to storage the rice for a period of time. This method will provide the protection for insects to reinfest in the rice. The concept for this kind of fumigation is to fumigate in a sealed or gas tight enclosure which will provide the enclosure to hold the gas inside the enclosure all the exposure period. This method will prevent the leakage of the gas and kill all the insect pests.

Method

- Clean the floor, wipe all the dust and dirt to prevent the puncturing the sheet.
- Place the floor sheeting with 1.0 meter longer and wider than the base of the stack.
- Stack building for 125 tons of rice.
- Tailored made the sheet to fit the size of the stack with an extra 1.0 m. on each sides.
- Sheeting the stack that will cover the whole stack and apply silicone to patch the floor sheet and cover sheet together.
- Inspection the sheet to look for the holes and tears these then were patched.
- Pressure testing for gas tightness of the rice stack by using manometer.
- Cut the slit in the skirt of the cover 10 cm. long.
- Calculate the amount of phosphine tablets at the dosage of 2 g of PH3 / m3.
- the total usage of PH3 was 320 tablets.
- Place phosphine tablets on the paper trays then insert into the rice stack.
- Sealed the slit by using patches and glue them all together.
- Collected tested insects from the stack. Checked the mortality of the tested insects, adults insects were checked 24 hours after treatment and immature stages were checked 3 weeks later to make sure that all the immature stages including egg stage were fully developed to adult.

Fumigants :

- PH_3 tablets , active ingredient is 57% Aluminium Phosphide with 1 g PH_3 each. Target PH_3 concentration = 2,000 ppm.

Exposure period : 5 days.

Table 4. Showed the mortality of different species of tested insects

	PH_3 tablet		Control	
	dead	% mortality	dead	alive
Sitophilus oryzae	100	100	5	45
S.oryzae Immature stages	200	100	8	42
Tribolium spp.	250	100	0	50
Oryzaephilus Surnamensis	250	100	3	47
Liposcelis spp.	50	100	9	21

Table 5. Showed PH_3 concentration after fumigation inside the stack.

Time after exposure (hours)	Gases Concentration (ppm)
0	0
3	800
12	1100
24	2200
48	1800
72	1100
96	800
120	700

1.4.1.3. Bagged Rice Fumigation under gas proof sheet : PH_3 tablets VS. MeBr.

Bagged rice fumigation under gas proof sheet is the traditional way of fumigation . This is the method to compare the efficacy of different method of fumigation and fumigant.

Method

- Cover the stack of rice with PVC sheet. All the tears and holes were patched with masking tape.
- The margin of PVC sheet at the floor level was 1m around the stack
- Place sand snakes all around the stack .
- Apply methyl bromide in one stack and phosphine tablets in the other stack.
- Access the mortality of tested insects.

Fumigants &Exposure

- PH_3 tablets , active ingredient is 57% Aluminium Phosphide with 1 g PH_3 each. Target PH_3 concentration = 2,000 ppm. X 5 days.
- MeBr 32 g/m^3 X 24 hrs.

Table 6. Showed the mortality of different species of tested insects

	PH_3				MeBr			
	Treat		Control		Treat		Control	
	Dead	% mortality	Dead	Alive	Dead	% mortality	Dead	Alive
Sitophilus oryzae	100	100	0	50	50	100	0	50
S.oryzae Immature stages	200	100	5	45	200	100	0	47
Tribolium spp.	250	100	0	50	250	100	0	50
Oryzaephilus Surnamensis	250	100	4	46	250	100	0	50
Liposcelis spp.	50	100	7	23	50	100	6	24

1.4.1.4. Lighter Fumigation for Tapioca : PH_3 tablets VS. MeBr.

Lighter fumigation is another method of in transit fumigation which will save the time for the exposure period before unloading to the vessel.

Method

- Measure the size of the lighter.
- Calculate the amount of fumigant use.
- Loading the tapioca into the lighters.
- Cover the tapioca with PVC sheet and seal the sheet attached to the side of the lighter by using masking tape.
- Apply fumigant into the lighters.

Fumigants &Exposure

- PH_3 tablets , active ingredient is 57% Aluminium Phosphide with 1 g PH_3 each. PH_3 concentration = 2,000 ppm. X 5 days.
- MeBr 32 g/m^3 X 24 hrs.

Table 7. Showed the mortality of difference species of tested insects.

	PH_3				MeBr			
	Treat		Control		Treat		Control	
	Dead	% mortality	Dead	Alive	Dead	% mortality	Dead	Alive
Sitophilus oryzae	100	100	0	50	50	100	0	50
S.oryzae Immature stages	200	100	5	50	200	100	0	50
Tribolium spp.	250	100	0	50	250	100	0	50
Oryzaephilus Surnamensis	250	100	2	48	250	100	0	50
Liposcelis spp.	50	100	3	27	50	100	0	21

Table 8. Comparison Variable Cost of Phosphine and MeBr Treatment per tons rice.*

Cost (Baht per 1 tons rice)	Stack Storage		Silo Storage	
	PH_3 tablets	MeBr	ECO2fume w. Siroflo®	ECO2fume w. Sirocirc®
No. of working staffs.	3-4	3-4	1	1
Fumigant / tons rice	7	35	20	11

Results

According to the demonstrations of fumigation which are controlled the key success factors [fumigant concentration and exposure period], no alive insects were found in all of the tests. The efficacy of the fumigation will reach its best to kill all of the stages of insect pests.

Best practice of fumigation is to keep fumigant concentration along the period of fumigation. To take good care of fumigation is necessary.

Best practice of stack fumigation should be

- Stack piling should be on steel or plastic pallet for completion of fumigant circulation.
- PVC sheet must be in good condition, tears and holes must be patched.
- Place sand snakes properly to keep the stack well seal.
- Final check for the possibly leakage such as holes, tears.
- Monitoring gas concentration during the exposure period and add more fumigant in case that the concentration is below standard level.
- Apply fumigant and seal those openings. People who are working with fumigants must wear gas mask with a proper canister for the gas that is used.
- Place warning signs on each side of the fumigated stack.
- Leakage checking with the proper tools, in case of MeBr check with halide detector lamps etc.
- Unauthorized person should not enter the fumigation areas or premises.
- Do wear proper personel protection when airing the gas and recheck with detector tubes to ensure that it is safe to work before in that pile.

The best practice of lighter/barge fumigation should be

- Closed and sealed all openings that are not necessary used during the fumigation with masking tape to ensure that no leakage in the holds.
- Covers the commodity with PVC sheet, which is in good condition, tears and holes were patched.

- Sealed PVC sheet on the sides of the lighter with the masking tape.
- Apply fumigant and seal those small opening. People who are working with fumigants must use the respirator with a suitable canister.
- Do not overnight or stay in the place that gas may leak.
- Put warning signs on each side of the fumigated stack.
- Premises under gas must not be entered.

The concept of the effective PH_3 fumigation to kill all stages of insect is quite reasonable but it is impractical to Thai stored product grain owners due to its longer exposure, which will increase their holding cost , together with Thai traditional fumigation with phosphine mostly take only 3-5 days and to measure the fumigation effectiveness from dead mature insects. This impractical fumigation will be causes of insect resistant to phosphine.

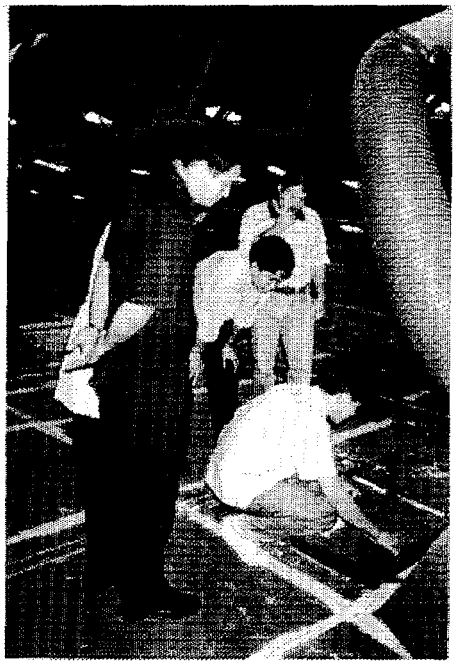
To match with tradition fumigation style, We run the demonstration with 180 ppm PH_3 from $ECO_2Fume^{®}$ using $Sirocirc^{®}$ for 5, 7 and 10 day respectively. We found that all mature stage of Rice weevils[*Sitophilus oryzae*] and Saw-tooth grain beetles [*Oryzaephilus surnamensis*] were dead. There were no alive insects found in the infested rice samples that we used to determine the immature stages of insects.

Conclusion

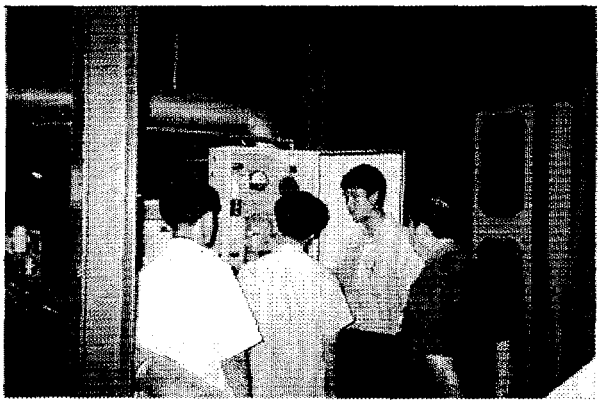
Anyhow, fumigation is not the final answer to control insects in the storage. Good management, sanitation, hygiene in the warehouse is the key to success to reduce the outbreak and treatments like fumigation or pesticide sprays is the supplement for insect control .

Silo Fumigation : $ECO_2Fume^{®}$ VS. MeBr

ECO_2Fume Storage



Silo Pressure Test

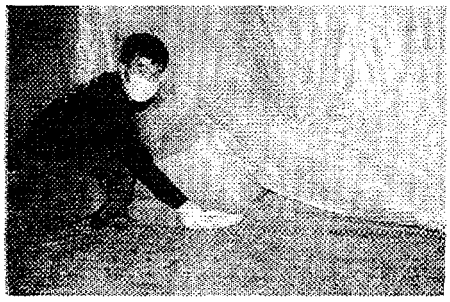


Commissioning & Trainning to CRC staffs

Bagged Rice Fumigation under gas proof sheet [PH_3 Treatment]

Covered Stack with PVC sheet

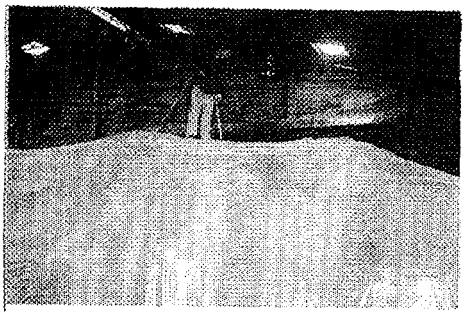
Use sand snakes to seal stacks



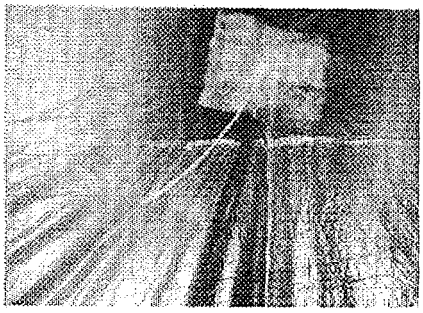
Put PH_3 under gas proof sheet

Bagged Rice Fumigation under gas proof sheet [MeBr Treatment]

MeBr Use



Put MeBr into the stack

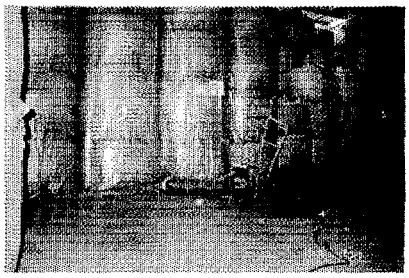


Sampling Point for checking gas concentration

Appendix 1 : Pictures of the demonstrations

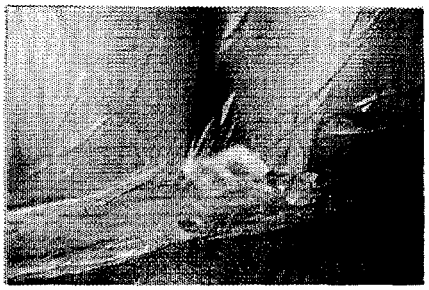
Sealed Stack Fumigation : PH3 Tablets

Sealed PVC sheet with Silicone Adhesive



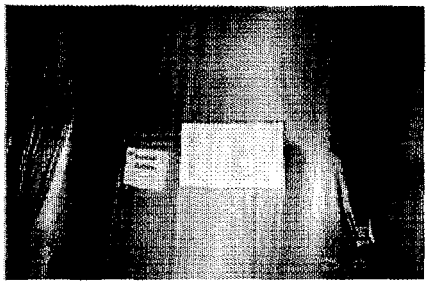
Vacuum Stacks for leakage test

Stack was sealed and gas tighted



Insert PH3 tables

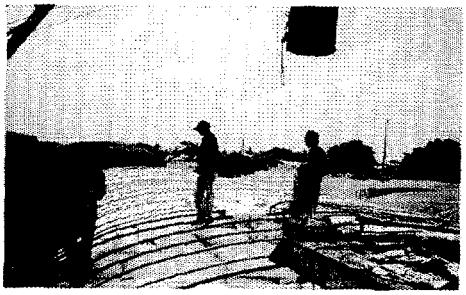
Sealed floor again after put in PH_3 tablets



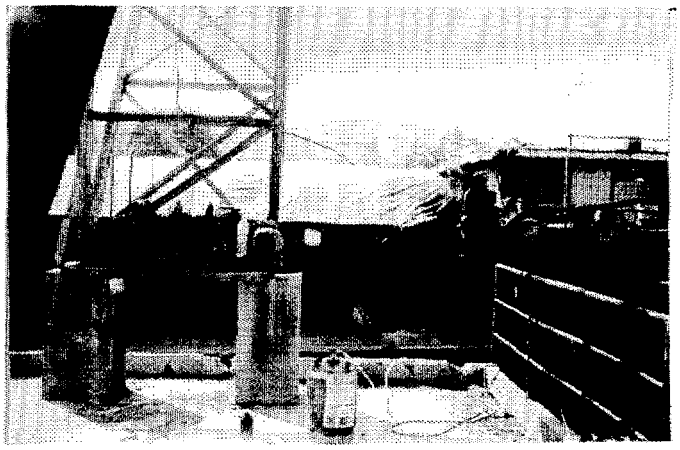
Warning Signs

Lighter Fumigation for Tapioca : PH_3 VS MeBr

Tapioca before fumigation



Cover with PVC Sheet



Applied MeBr