THE WORKING OF RVNRL PILOT PLANT OF RUBBER BOARD AND IT'S SAFETY DEVICES

L.J.BRITTO R.S.O., E.V.THOMAS
RVNRL Plant, Rubber Board
Kottayam - 686 009, India

ABSTRACT

A pilot plant for producing radiation vulcanised natural rubber latex (RVNRL) was established at Rubber Board, India in 1992. Irradiation is done by a batch process in the plant. The plant has a versatile safety system for safety of operators and people working in and around the plant.

INTRODUCTION

A panoramic wet storage type gamma irradiator plant with maximum source strength of 3.7 PBq.Cobalt-60 was commissioned in April 1992 at Rubber Board, Kottayam for producing radiation vulcanised natural rubber latex. The facility was loaded with 0.37 Pbq Cobalt-60 (8 pencils) initially to standardise the process parameters. The irradiation of rubber latex is done as a batch process in a stainless steel vessel of 1000 litres capacity. Rubber latex is stirred continuously during irradiation using paddle stirrers provided in the product vessel at three locations for ensuring uniform dose distribution. The radiation source is stored in a cylindrical source cage and shielded under water and is brought upto the centre of the product vessel for irradiation by a hydraulic system with two hoist wire ropes. A ventilation system is provided to remove Ozone and Oxides of nitrogen formed during irradiation. A number of safety interlocks are provided to ensure absolute safety of the personnel working in the radiation centre and also to prevent accidental radiation exposure. A concrete biological shield of suitable thickness at different locations are provided all around the irradiation cell. Details of the plant with emphasis on safety aspects are discussed in the paper.

Demineralised Water Plant

The source storage pool is filled with demineralised water. DM - water is essential for the protection of radiation source. The conductivity of the water in the pool has to be maintained at 10 micro siemens/0.01m. This will reduce the possibility of corrosion of the sealed source. The pool is connected to an emergency water tank of at least half the volume of source storage pool for emergency conditions. The low conductivity of the water is maintained by the use of a suitable DM-water plant fitted with conductivity meter and radiation monitor. If the conductivity is greater than 10 micro siemens per 0.01m for long period, source will be corroded and water will be contaminated. Radiation monitor continuously monitors trace amount of activity, if any, in the pool water.

Control System and Plant Operation

The control system ensure complete safety of the plant and personnel. Radiation source, when not in use, remains in shield condition at the bottom of the source storage pool. Raising the source from the shield condition to source exposed condition is the most important parameter of the facility. Source exposed condition is dangerous for operators and other human beings if accidentally get exposed. Therefore, it is important that source exposed condition must have several safety preconditions. These preconditions are basic requirements of control system. Source lowering can be done without any precondition by operating source lower push button. The source can also be brought down manually or automatically in any one of the several emergency conditions.

Preconditions to be Satisfied to Expose Source

1. Pool water level maintained at required level.
2. Power ON.
3. Hydraulic system ON - oil pressure maintained at working pressure ($6.5 \times 10^5 Kg./m^2$)
4. Ventilation system ON.
5. Radiation level in the cell at the preset level (<25 micro Sievert per hour)
6. Service keys, trip wire and emergency push button not operated.
7. Product vessel properly aligned.
8. Search operation completed, cell door closed and door interlock cum latch bar pulled.

Source Operation Disable Situations

The following are the conditions under which the source hoist operation is prevented:
1. Pool water below safe level.
2. Radiation level in the cell/labyrinth above normal.
3. Failure of ventilation system.
4. Hydraulic oil level in the tank below minimum required.
5. Hydraulic oil pressure in the system below working pressure.
6. Source disable switch (Service keys) operated.
7. Product vessel not aligned properly.
8. Emergency trip wire pulled.
9. Search operation sequence not fulfilled.
10. Power failure.

Automatic Source Lowering

The following conditions will bring down the source from exposed condition.
1. Heat sensor/smoke ditector inside the cell gets actuated.
2. Power failure.
3. Ventilation system failure.
4. Hydraulic oil pressure below minimum working condition.
5. Fall in pool water level. An illuminated indicator panel is provided on the wall of the control room to identify the source position whether exposed or shielded. Also clearly visible irradiation status indicators are provided at the control console to indicate source in shield, source in transit, source raised, door open, vessel alignment not O.K., exhaust failure etc. Disunct audio alarms operate during search operation, source transit and emergency situations. In addition to the above, an overall general emergency alarm can be activated from the control room by the operator.

The safety of the operation of irradiation facilities depends on the design features on safety incorporated in the facilities. In gamma irradiation facilities four distinctive considerations are included for analysing the safety of the total system. These are

1. Personnel safety against external exposure to radiation.
2. Personnel safety against any radioactive contamination.
3. Exposure to noxious gases.
4. Industrial safety of operations against fire, smoke, explosives etc.

Important technical specifications of the Plant are given in table 1.

Table 1: Important technical specifications

Facilities	Tecnical specifications
Irradiator overall size	20.6m X 15m
Radiation cell size	4.5m X 4m X 4m (height)
Source storage pool size (long) X (wide) X (deep)	2.6m X 2.0m X6.3m
Radiation source shielding	Water
Biological shield	Concrete wall (2350 Kg./m^3) with 1.8m thick (max)
Roof thickness	1.5m. of concrete.
Max. Source capacity	3.7 PBq. of cobalt - 60.
Product container size	1.2m dia X 1.2m height (Cylindrical vessel)
Venulation system	20 Air changes per hour.
Power supply	440 V, 3 Phase, 10 KW.
Movement of latex container	Container mounted on a trolley moves on rails
Safety	Provided with mechanical, electrical and hydraulic interlock.
Source Assembly	In the form of a cylindrical rack 0.2m dia with 12 positions for the source units
Source specifications	Total length = 0.463m, Total dia = 0.0272m, Active length= 0.4mm, Active dia = 0.0115m
Cobalt-60 slugs size length rods	0.0064m dia X 0.0254m
Classification of irradiator	Class III (Wet storage and mobile source)

The design features/safety interlocks at the RVNRL Plant, Rubber Board are summarised in Figure 2.

1.	Cell door interlock	The door interlock is provided to be raised only if the cell entry door is closed. This interlock also makes sure that the door can be opened only if the source is lowered to the pool and is in shield condition
2.	Pool water level interlock	If the pool water is not maintained to the desired level the source cannot be raised. A level switch (emergency) provided in the pool serves and conveys the signal to the control system. This level switch also act during source exposed condition and lower the source to shield if water level come down beyond the safe limit. If the pool water falls to a level more than 0.3m below the normal level, the emergency water tank gets connected to the pool
3	Radiation detector	A.G.M detector provided in the maze with display near manual entry door is electrically interlocked with manual entry door such that this door cannot be opened when the radiation level inside is higher than a preset level
4	Cell search	Five electrical switches have to be pressed in a given sequence followedby the closing of the manual entry door. The source raise is electrically interlocked such that thesource can be raised only if this operation is carried out in a given time interval
5	Exhaust fan	If the ventilation system is not kept 'ON' the source cannot be raised Similarly, in case the ventilation system fails the source will automatically go to shield position
6.	Fire/Smoke alarms	Provided inside the cell and it is electrically interlocked with source raise system such that it lowers the source into the pool if temperature raises above 55°C
7	Product vessel interlock	If the irradiator trolley is not properly aligned on the pool, the source movement can be obstructed. An electrical interlock ensures that the trolley is properly aligned. A wedge is used to stop the sliding of the product vessel on the rails
8	Water treatment system monitor	A fixed radiation monitor (Gamma Area/ Zone monitor) with an audible alarm is installed in the DM-plant to detect contamination arising from source leakage. This monitor is interlocked with the irradiator control such that the source returns to its shielded position and the water circulating stops if the radiation reach the preset alarm level.
9.	Trip wire	the cell pulling of which lowers the source into the pool by means of an electrical interlock.
10	Wire rope tension interlock	If the tension of the source raising wire ropes are uneven or low, the wire rope stretch lever will activate the micro switch and the source will be automatically lowered to shield position. The tension of the source raising wire ropes can be sensed and adjusted from outside the cell area.
11	Service keys	The hydraulic system used to expose the source is provided with a disconnecting mechanism to enable servicing to be carried out without the danger of the source being inadvertently exposed
12	Emergency stop device Emergency push button is provided at	the control console to terminate the irradiation at any time.

Figure 1: Design features/safety interlocks at the RVNRL Plant

Radiation Safety Aspects

The use of high intensity gamma sources in the irradiators has a potential for radiation hazards to plant personnel and public in the event of any malfunction or failure of safety systems. It is essential to evaluate the hazards likely to arise under normal working conditions, as also under potential accident conditions (e.g) fire, explosion, corrosion, etc.... in order to avoid high doses to personnel. Personnel monitoring and area monitoring devices are commonly used for the evaluation of external radiation hazard.

Personnel Monitoring

RVNRL Plant is included in the TLD badge service conducted by Radiation Protection Services Division, Bhabha Atomic Research Centre, Mumbai. The thermoluminescence Dosimeter (TLD) cards used by the personnel are routinely read by the TLD - badge section of RPSD, BARC every three months and the reports are sent to us.

The quarterly reports of radiation doses received by the staff members have been analysed from 1992 to 1995. The yearly average dose for the personnel have been compute he number of persons monitored, the average dose received by the personnel in different years and number of batch irradiations carried out in each year are given in table 3.

Table 2: The quaterly report of radiation doses from 1992 to 1995

Year	Number of batches irradiated	Number of persons monitored	Total dose in milli Sievert (mSv)	Average dose in milli Sievert (mSv)
1992	7	2	0.00	0.000
1993	13	7	1.00	0.110
1993	13	7	1.11	0.160
1994	4	7	1.05	0.150
1995	6	8	0.60	0.070

Notes:

1) Dose limits recommended by ICRP (1991) for radiation workers.
Whole body (effecuve dose) = 20 mSv per year, averaged over defined period of 5 years with no more than 50 mSv in a single year

2) Dose below measurable level of 0.05 mSv is shown zero.

The analysis indicates that the dose received by personnel are well within the permissible limit. It is found that nobody received any queer dose during the last four years.

Area Monitoring

Routine area monitoring procedure is being adopted in the RVNRL facility during source in shield and source raised condition. Radiation levels at important locations of the facility are tabulated below.

Table 3: Radiation levels at important locations

Sl. No.	Location Shielded	Source exposed (micro Sievert/hour)	Source (micro Sievert/hour)
1.	Cell roof	Negligible	0.2
2.	Steel door	"	0.3
3.	Control area	"	0.1
4	DM-plant room	"	0.3
5	Service room	"	0.1
6.	No occupancy area	"	0.3

Note: 1) Instrument used for the survey = Digirad
2) Expected accuracy = +/- 15%

From the above table it can be seen that the measured dose rate values are well within the permissible limit. i.e., 25 micro Sievert/hour.

In addition to the radiation survey meters, two radiation detectors called Gamma Area/Zone monitors are installed in the facility which can give warning signal in case of abnormal situations. If the source gets stuck up or not returned to shielded position fully, then there will be higher radiation level in the room. This level will trigger the zone monitor to give audio alarm.

ACKNOWLEDGEMENT

The authors wish to express their sincere thanks to Shri.K.J.Mathew, Chairman, Rubber Board for the encouragement and co-operation given in the preperation of this paper and for presenting it at the Second International Symposium on RVNRL at Kuala Lumpur during July, 1996.