Abstract

Risk Management is part of the operational element in an organization to manage their directives towards risks surrounding them. It assists the organization to identify, evaluate and prioritize the risks through risk analysis. The main objective of this work is to identify risk from hazards involved in the work place, so that control measures can be put in place to avoid or minimise the harm it can cause. The risks include hazards from radiation, chemical, biological, physical as well as ergonomic factors. Hazard identification was carried out at two radiation facilities in Malaysian Nuclear Agency that involved radiation safety. ALURTRON and MINTec-Sinagama provide radiation services to commercial industries as well as for R&D purposes. In this paper, every section in risk analysis and hazard identification are discussed.

1. Introduction

Every organization has its own risks that need to be identified at the very beginning of operation. Risks can be identified and managed accordingly prior to the probable occurrence of real incidents. It is good practice to identify the risks including hazards that might affect the operation of any organization. All levels of leadership are strongly encouraged to be involved during this period [1]. Subsequently, by evaluating and analysing the identified risks, organization can plan appropriate control or treatment to decrease the impact of the risks. At the end of the evaluating and analysing process, the organization will either accept any residual risks or continue the process of totally eliminating the risks.

1.1 Risk management

Risks need to be managed effectively for an organization in order for it to operate at its optimum level. When risk identification is correctly carried out, then the risk treatment can be put in place [2]. The process should be continuously handled and maintained at every department and level. It keeps the environment and goal-driven activities in the organization running smoothly. In turn, these activities can bring success to the organization whilst ensuring that the risks are being taken care all the time [3]. Negative and positive impacts from the identified risks will drive the organization along the right path to realise their mission and vision [4].
Therefore, for this purpose, this study carried out risk and hazard identification at two radiation facilities in Malaysian Nuclear Agency namely ALURTRON and MINTec-Sinagama. The main objective of this work is to identify risks from hazards involved in these workplaces. Subsequently, appropriate control measures can be applied to avoid or minimise the harm they can cause.

1.2 Radiation facility: ALURTRON [5]
ALURTRON is one of the radiation processing plants owned by Malaysian Nuclear Agency, located in Bangi, Selangor. It provides electron beam radiation services to industry, especially for wire, cable and tube (tubular product) as well as semiconductor. The purpose of this radiation process is to crosslink the polymer material of the products which can increase the application quality of the products. The most common application of these products is in the automotive industry. These are needed in the engine compartment especially for the brake line. As for treating wafer semiconductor, electron beam radiation can enhance its electrical conductivity.

For the irradiation process, ALURTRON has one electron beam machine, EPS-3000, which works with other supporting equipment and product handling system.

Figure 1. Process in Risk Management.
Figure 2. Left: Capstan drum for tubular product irradiation with scanner horn located in the bunker. Middle: Pay-off equipment for wire under beam handling system (WUBHS) which is integrated to the EPS-3000 machine. Right: Trolley for flat product irradiation.

1.3 Radiation facility: MINTec-Sinagama [6]
Located within the same compound as ALURTRON, Malaysian Nuclear Agency also has a gamma radiation processing plant, known as MINTec-Sinagama. Set-up in 1989, MINTec-Sinagama has since serve the country by treating a diversity of products: from medical devices, raw material of pharmaceuticals products, to food and non-medical products. Depending on the products, the objectives of the gamma irradiation treatment that need to be fulfilled are sterilization, decontamination, shelf-life extension and quarantine.

MINTec-Sinagama has a high radioactive Co-60 activity of approximately 0.3 MCi (1.1 x 10^{13} Bq) (as per September 2019). For product handling equipment, MINTec-Sinagama uses JS 10000 IR 219 tote irradiator system. In addition, irradiation process at MINTec-Sinagama is supported by various mechanical equipment such as compressor, cooling water system and pumps and motors.

Figure 3. Schematic diagram of gamma radiation processing plant in MINTec-Sinagama (courtesy from manufacturer: Nordion (Canada) Inc.)
2. Risk analysis process
Risk analysis comprises identification, description and estimation of risks. During risk identification, ALURTRON and MINTec-Sinagama identified their main risk category with a few fitting into more than one category. Some of the risk category are strategic, compliance, financial, operational and environmental [1]. Based on the recommendation from Institute of Risk Management [2], subsequently the risk description was tabulated as shown in Table 1.

Table 1. Structured format of risk description.

| Item                                | Description                                                                 |
|-------------------------------------|-----------------------------------------------------------------------------|
| 1. Name of risk                     | Qualitative description of the events, their size, type, number and dependencies |
| 2. Scope of risk                    | Eg. strategic, operational, financial, knowledge or compliance               |
| 3. Nature of risk                   | Stakeholders and their expectations                                          |
| 4. Stakeholders                     | Significance and probability                                                 |
| 5. Quantification of risk           | Loss potential and financial impact of risk                                 |
| 6. Risk tolerance/ appetite         | Value at risk                                                                |
| 7. Risk treatment & control mechanisms | Probability and size of potential losses/gains                              |
|                                     | Objective(s) for control of the risk and desired level of performance        |
| 8. Potential action for improvement | Recommendations to reduce risk                                               |
| 9. Strategy and policy developments | Identification of function responsible for developing strategy and policy    |

In order to do the analysis, estimation on risk is needed. The possible impact (consequence) and likelihood (occurrence) are measured depending solely on the past operational experience of the organization [2]. A mixed quantitative, semi-quantitative or qualitative approach was taken. Table 2, 3 and 4 show the table of risk estimation on likelihood and impact as well as matrix of both factors as decided by ALURTRON and MINTec-Sinagama during workshop on risk management. Subsequently, the risk is evaluated.

Table 2. Likelihood or probability of occurrence on threats.

| Level | Descriptor | Description                                           |
|-------|------------|-------------------------------------------------------|
| 5     | Almost certain | Expected to occur in most circumstances              |
| 4     | Likely      | Will probably occur in most circumstances             |
| 3     | Possible    | Might occur in some time                             |
| 2     | Unlikely    | Could occur at some time                             |
| 1     | Rare        | May occur only in exceptional circumstances          |
Table 3. Impact Table - risk estimation on impact of risk.

| Level | Description          | Description                                |
|-------|----------------------|--------------------------------------------|
| 5     | Very critical        | Machine down/closure of facility           |
| 4     | Critical             | Plant closure for 1 to 3 days, high health risk |
| 3     | Moderate             | Risk can cause damage, delay, customer complaint |
| 2     | Fair                 | Risk is real but can be averted fast       |
| 1     | Risk accepted        | Impact is very low                         |

Table 4. Matrix likelihood x impact table. Different colors scheme was used for easier visual inspection.

| LIKELIHOOD | IMPACT |
|------------|--------|
| 5 | 1 | 2 | 3 | 4 | 5 |
| LOW | 5 | 10 | 15 | 20 | 25 |
| MEDIUM | 8 | 12 | 16 | 20 | 20 |
| MEDIUM | 6 | 9 | 12 | 16 | 16 |
| VERY LOW | 2 | 4 | 6 | 8 | 10 |
| VERY LOW | 1 | 2 | 3 | 4 | 5 |

3. Findings and results
Possible risks involved in the work activities of ALURTRON and MINTec-SINAGAMA were explored. A few techniques were utilized – such as SWOT (Strengths, Weaknesses, Opportunities, Threat) analysis and PESTLE (Political, Economic, Social, Technical, Legal, and Environmental) analysis. Brainstorming was also applied at two workshops and in a few discussions among staffs together with the Director of both facilities. Risk analysis and findings from the above activities are tabulated in Table 5 and 6.
| CATEGORIES                        | ISSUES                                | RISKS IDENTIFICATION                  | RISKS ANALYSIS & VERIFICATION | RISKS TREATMENT PLAN                        | PIC               |
|----------------------------------|---------------------------------------|---------------------------------------|-------------------------------|---------------------------------------------|-------------------|
| PRODUCT RECEIVED & INSPECTION    | Quantity of product not tally          | Disruption during payment process     | Thorough Inspection           | Length counter (to purchase)                | Admin/ OP         |
|                                  |                                       | Interrupted operating schedule        | Thorough Inspection           | NA                                          | QC inspector/    |
|                                  |                                       |                                       |                               |                                             | executive OP      |
| DOCUMENTATION & HANDLING PROCESS | Handling of document tagging/revision  | Record not updated                    | Review of document            | Document check once a year                  | Executive QA     |
| IRRADIATION PROCESS              | CCTV damage                           | Product stuck in irradiation room/    | Old CCTV                      | Black and white CCTV procurement            | SV OP            |
| EQUIPMENT CALIBRATION & MAINTENANCE| Chemical hazard to worker health      | Testing equipment performance not     | Service record                | Provide checklist for maintenance by        | Executive QA     |
|                                  | (fumehood)                            | being checked                         |                               | BKJ                                         |                   |
| QA TEST - Gel Content            | Employee health affected due to waste | Delayed test                          | Report to WASTECC for disposal| Disposal programme                         | SV QA / next     |
|                                  | storage overload                      |                                       |                               |                                             | disposal circle  |
| QA TEST - Dosimetry              | CTA dosimeter low in stock            | Disturb & delay in work process       | Procurement when left 2       | NA                                          | Lab Assistant    |
|                                  |                                       |                                       | batch                         |                                             |                   |
| PRODUCT RELEASE                  | Delivery                               | Delay release product                 | Target 5 days delivery (QC   | NA                                          | Executive OP     |
|                                  |                                       |                                       | objective)                    |                                             |                   |
| CUSTOMER SERVICE                 | Delivery                               | Delay & loss of customer              | Target 5 day delivery         | Customer service - Follow up                | Admin            |
| PUBLIC ACCEPTANCE (IP-community) | Public complaint                      | Termination of operation              | Awareness programme (Open day)| NA                                          | UKK              |
| PAYMENT TO SERVICE/ PRODUCT      | Delay payment                          | Blacklisted                           | Purchasing procedure          | Follow up with BKT                         | PIC procurement  |
| PROVIDER (IP-supplier)           |                                       |                                       |                               |                                             |                   |
| TRAINING AND EXPERT SERVICES     | Access to information                 | Complaint                             | UKK management                | UKK program & PR admin                      |                   |
| (IP-NGOs)                        |                                       |                                       |                               |                                             |                   |
| COLLABORATION & CONSULTATION     | Access to information                 | Access to information                 | Website & PR tool             | Programme by PR admin                       | Director         |
| (IP-investor, NGOs)              |                                       |                                       |                               |                                             |                   |
| STAFF WELFARE (IP-worker)        | Safety & health at work               | Accident                              | Training & awareness program  | Monitoring & continual training              | BKS              |
| IMPLEMENTATION OF ACT/ISO/       | Not having enough understanding       | License/ certificate revoke           | Training & awareness program  | Monitoring & continual training              | BPA & ALURTRON   |
| LEGISLATION/ GUIDELINE (IP-standard Body) |                      |                                       |                               |                                             |                   |

Table 5. Risk analysis for ALURTRON.
| CATEGORIES/ PROCESS | ISSUES | RISKS IDENTIFICATION | CURRENT CONTROL | LIKELIHOOD | IMPACT | RISKS TOTAL = LIKELIHOOD X IMPACT | RISKS TREATMENT PLAN | RECOMMENDATION ACTION / ADDITIONAL CONTROL | PIC |
|---------------------|--------|----------------------|----------------|-----------|-------|-----------------------------|----------------------|---------------------------------|-----|
| **PRODUCT ARRIVAL AND RECEIVING INSPECTION** | Product Damage | Product handler attitude | Use trained product handler | 3 | 3 | 9 | MEDIUM | Reminder procedure of product figure/condition to send to MINTec-Sinagama | QA |
| | Integrity of product | Dangerous goods, corrosive, dirty | Memo to customer | 3 | 3 | 9 | MEDIUM | | QA |
| | Customer submit false information | False identification of product in RSP1 | Any false declaration under customer responsibility | 2 | 5 | 10 | MEDIUM | Discussion with customers / regulators | QA |
| **PRE-IRRADIATION PROCESS** | Documentation | Negligence due to the workload | Get more staff | 3 | 2 | 6 | LOW | Train the new part-time operator | Manager |
| **DOSIMETER PLACEMENT** | Error in dosimeter location | Negligence due to the workload | NA | 2 | 5 | 10 | MEDIUM | Get more staff | Manager |
| | Dosimeter broken during placement | Incident, more dosimeter needed | NA | 3 | 5 | 15 | MEDIUM | Design dosimeter hold | QA |
| **PRODUCT LOADING** | PLP configuration is wrongly managed | Irradiation is not valid | Provide updated summary PLP at loading platform | 1 | 4 | 4 | LOW | Recognized product that registered PLP | QA |
| | Negligence of operator on handling the operating system | Disturb and delay in work process | NA | 3 | 4 | 12 | MEDIUM | NA | Operation |
| | Tote and conveyor system | Conveyor not working properly | NA | 4 | 3 | 12 | MEDIUM | NA | Operation |
| | Barcode detection | Scanner not working properly | NA | 4 | 3 | 12 | MEDIUM | NA | Operation |
| | Lack of permanent staff | Disturb and delay in work process, no replacement | Workload divided among staffs and part-time | 4 | 4 | 16 | HIGH | Get temporary staffs when needed | Manager |
| **PRODUCT UNLOADING** | Dosimeter broken during collection | Incident, cannot provide irradiation data reading | Put extra dosimeters and locations | 3 | 3 | 9 | MEDIUM | NA | QA |
| **DOSIMETER ANALYSIS** | Reduction in dosimeters stock | Disturb and delay in work process | Request to SSDL when two batches are left in stock | 4 | 4 | 16 | HIGH | Explore new dosimetry system | QA |
| | Mistake discovered in Certificate of Irradiation (CoI) | Customer complaint | Double checked by superior | 4 | 3 | 12 | MEDIUM | NA | QA |
| **FINAL INSPECTION** | Product Storage | Warehouse condition | Pest control monitoring and fortnightly housekeeping | 3 | 4 | 12 | Medium | | Operation |
| **PRODUCT RELEASE** | Mistake discovered in RSP 15 | Customer complaint | Double checked by superior | 3 | 4 | 12 | LOW | | QA |

Table 6 Risk Analysis for MINTec-Sinagama.
4. Conclusion and recommendations
As a conclusion, managing risks is an important aspect at the workplace and needs to be done continuously [7]. Every factor that contributes to the risks is identified according to the activities involved in the work flow of the irradiation process. Only then can the risks be reduced to as low as possible (ALAP) even though the risk factor is low. The risk treatment is towards ALAP instead of ALARP (as low as reasonably practicable) practices.

Therefore, as a way forward, work on Risk Treatment Plan will be continued. Reviews and actions taken on recommendations in Risk Treatment Plan will ensure its continual improvement. It will be important to explore more actions as well as assessing any new risks in future analysis.

5. References
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