Analysis of Hazards and Control Measures in Chemical Workplace "Pharmaceutical Industry"

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Abstract— Chemical hazards are a major occupational health and safety issue in Pharmaceutical as well as chemical industry. Management of chemical hazards requires the combined efforts of occupational health and safety specialists, including generalist OHS professionals, occupational hygienists, and occupational health practitioners. This Research is about analysis of Hazards and their developed Control Measures in industrial chemicals, the manner in which their toxicity is assessed and the use of such assessments in regulatory decision-making. It begins with general points concerning toxicological data availability and hazard identification, then moves on to risk assessment and occupational exposure limits, and finally looks briefly at some standard specific toxicological issues, where the science is far from resolved after brief consideration of the historical context of chemical reactivity and toxicity issues, acute and chronic exposure, chemical hazard classification systems, and the identification, risk assessment, and control of chemical hazards.

Keywords: Chemical and Laboratories Hazards, Occupational safety and health analysis (OSH), Hazard Identification & Risk Assessment (HIRA), Failure Mode and Effective Analysis (FMEA), Practical approaches, Hazard and Risk calculation, RPN Number calculation

I. INTRODUCTION

The production of Bulk drugs involves usage of many chemicals which are both hazardous and toxic in nature. The risks associated with the pharmaceutical / chemical industry are commensurate with their rapid growth and development. Apart from their utility, chemicals have their own inherent properties and hazards. Some of them can be flammable, explosive, toxic or corrosive etc. The whole lifecycle of a chemical should be considered when assessing its dangers and benefits. In order to ensure the health and safety of persons at or near the facilities, Govt. has approved some regulations.

Pharmaceutical landscape is in a constant change as markets are growing and merging with big companies. In order to be in lead and to gain a competitive advantage these companies needs to be more specialized and flexible. Therefore, the importance of project management especially the risk management in new product development cannot be ignored to bring a successful product to the market.

The regulation requires Employers to consult with employees in relation to:

1) Identification of major hazards and potential major accidents
2) Risk assessment
3) Adoption of control measures
4) Establishment and implementation of a safety management system
5) Development of the safety report

The involvement of the employees in the identification of hazards and control measures enhances their awareness of these issues and is critical to the achievement of safe operation in practice. In order to comply with regulatory authorities, UNICHEM Laboratories Ltd. [1] have entrusted Team Labs and Consultants, Pithampur to review and prepare Hazard analysis and Risk assessment for their facility along with an approach to on-site emergency preparedness plan as required under the acts and rules.

Fig. 1: UNICHEM [1]

A. Scope and Application of Study

This guide can be used in the development of processes to effectively integrate the identification or recognition of hazards and the evaluation of the risks, with the aim of using this information to formulate a plan to minimize or manage the risks prior to the start of work. This guide also provides strategies for:

1) Identifying and responding to changing conditions that can affect a hazard evaluation.
2) Implementing processes in an institution not accustomed to the use of the techniques outlined in this guide
3) Assessing implementation of hazard identification and evaluation methodologies.

This guide was written for researchers without deference to the stage in my postgraduate thesis for departmental chairs for implementation in a scientific research laboratory of the industry. Consideration was given to the variable nature of research in the preparation of this guide and in the presentation of the techniques provided. Furthermore, this guide provides assessment approaches that are intended to be relatively easy to implement and use. While research laboratories and researchers are the primary audience for this guide, other readers may find it equally useful.

B. Hazard Identification

Identification of hazards in the proposed jetty is of primary significance in the analysis, quantification and cost effective control of accidents and process. Definition of hazard states that, hazard is in fact the characteristic of system/process that presents potential for an accident. Hence, all the components of a system need to be thoroughly examined to assess their potential for initiating or propagating an unplanned event/sequence of events, which can be termed as an accident.

S. No	Hazard Types	Examples
1.	Agent	Carcinogenic, teratogenic, corrosive, pyrophoric, toxic, mutagenic, reproductive hazard, explosive, nonionizing radiation, biological hazard/pathogenic, flammable, oxidizing, self-reactive or unstable, potentially explosive, reducing, water reactive, sensitizing, peroxide forming, catalytic, or chemical asphyxiate
2.	Condition	High pressure, low pressure, electrical, uneven surfaces, pinch points, suspended weight, hot surfaces, extreme cold, steam, noise, clutter, magnetic fields, simple asphyxiant, oxygen-deficient spaces, ultraviolent radiation, or laser light
3.	Activity	Creation of secondary products, lifting, chemical mixing, long-term use of dry boxes, repetitive pipetting, scale up, handling waste, transportation of hazardous materials, handling glassware and other sharp objects, heating chemicals, recrystallisations, extractions, or centrifuging

Table 1: Examples of Hazards Commonly Identified for Research Activities [8]

"Risk" has become a ubiquitous term in contemporary society, but is used in such a wide variety of contexts that its meaning has been blurred. The International Organization for Standardization (ISO) defines risk as "the effect of uncertainty on objectives." [11] Indeed, the world is riddled with uncertainty—a necessary byproduct of our inability to foretell the future. In the event the future could be precisely predicted, it could be controlled, rendering all types of endeavors successful.

Unfortunately, this is not the world we live in, nor the world in which businesses operate. As such, "all activities of an organization involve risk [12]. The mere existence of risk does not imply a foregone conclusion of failure, of course; risk can be both defined and calculated, allowing the exercise of some influence in the form of knowledge.2 The magnitude of risk is calculated as the combination of the probability of occurrence of harm and the severity of that harm, exhibited in a simple equation [13].

$$Likelihood \times Severity = Risk$$

This calculation captures the main concerns associated with risk—the chances that some undesirable event will occur, and how bad it might be if it does. The level of concern rises as egregious outcomes become increasingly likely, and subsides when consequences are less severe or rarer. In this way, the concept and calculation of risk reflects the general amount of apprehension with which we approach various activities.

It follows that the management of risks is necessary to increase the probability that an identified goal will be achieved. For example, a thrill-seeking sky diver does not blindly launch him or herself out of an airplane; rather, specific safety controls are employed to ensure the jump will be successful. In the context of business, risk management is defined both as "coordinated activities to direct and control an organization with regard to risk" and the "systematic application of management policies, procedures and practices to the activities of communicating, consulting, establishing the context, and identifying, analyzing, evaluating, treating, monitoring and reviewing risk [14].

Using the latter definition, risk management is universally acknowledged as a process consisting of the identification of risks, the analysis of risks to determine their criticality (using, for example, the risk equation listed above), and the disposition of risks based on organizational objectives.

II. LITERATURE REVIEW

Tao Zeng et.al [17] the increasing demand for chemical products has driven the construction and development of chemical industrial areas, or so-called 'chemical industrial parks' (CIPs), but this has intrinsically raised the risk of major accidents. Therefore, it is significant and urgent to summarize the state of art and research needs in the field of CIP safety.

S. Fairhurst et.al [18] this paper is about industrial chemicals, the manner in which their toxicity is assessed and the use of such assessments in regulatory decision-making. It begins with general points concerning toxicological data availability and hazard identification, then moves on to risk assessment and occupational exposure limits, and finally looks briefly at three specific toxicological issues, asthma, chronic toxic encephalopathy, and ''low toxicity'' dust effects on the lung, where the science is far from resolved.

Igor Kozine et.al [19] the current paper gives an overview of the legislation and the methods used in safety and risk management in the chemical industry within Europe and in particular within the European Union. The paper is based on a report that has been written for the SOS I project under the Nordic nuclear safety research (NKS I. Safety- and risk-related matters in the process industry, in particular, in chemical, within the EU are subject to consideration at three levels: (1) EU legislation, 2) European/international standardization, and 3) socioeconomic analysis.

David J. Leggett et.al [20] the combination of hazard evaluation and risk analysis is an organized effort to pinpoint weaknesses in the design and operation of facilities that could lead to accidental or unintentional chemical releases, fires or explosions. These studies assist organizations with the goal of improving safety and managing the risk of operations.

Amol Paithankar et.al [21] for any industry to be successful it is to identify the Hazards to assess the associated risks and to bring the risks to tolerable level. Mining activity because of the very nature of the operation, complexity of the systems, procedures and methods always involves some amount of hazards.

III. COMPANY DOMAIN

Unichem Laboratories was founded in 1944 by Late Mr. Amrut Mody, a pioneer in the Indian pharmaceuticals business. With a rich tradition of unwavering quality and reliability, Unichem brings together a unique blend of modern, value-added research and deep knowledge of the Indian pharmaceuticals industry.

Fig. 2: UNICHEM LABORATORIES [27]

Unichem's global presence and experience in different markets allow the company to extend its expertise to clients in product technology, filings and much more. Today, Unichem is a globally preferred and reliable external manufacturing partner, leveraging its assets, expertise, and capabilities to deliver high-quality products. Specialized in contract research, development, and manufacturing, Unichem has strategic alliances with large pharmaceutical companies and MNCs.

Strong infrastructure including globally certified GMP compliant manufacturing facilities at six locations across India and an R&D center (Center of Excellence) in Goa for developing APIs as well as formulations meet global norms and stringent quality standards. Areas of expertise:

1) Immediate-release dosage forms
2) Extended-release dosage forms: matrix and pellets
3) OROS technology
4) Dry powder injections and syrups
5) Novel drug delivery systems
6) Technology transfer and documentation

IV. REQUIREMENT OF STUDY

Pharmaceutical manufacturing operations utilize physical processes, machinery and drug substances that present risks of fire, explosion, and injury or illness to people, plant and environment. These risks can only be properly managed by the application of thorough engineering analysis and mitigation of the hazards by knowledgeable and qualified professionals working as a team to review all aspects of the design of a new process. To do less invites an incident or disaster that can have serious financial effects on the company through interruption of manufacturing, destruction of physical plant and injury to people.

1) Risk Assessment
2) Risk identification
3) Risk analysis
4) Risk evaluation

It is the sharing of information about risk and risk management between the decision makers and others. The output/result of the quality risk management process should be appropriately communicated and documented. The included information might relate to the existence, nature, form, probability, severity, acceptability, control, treatment, detect ability or other aspects of risks to quality. The approach described can be used

- Thoroughly analyze products and processes to ensure the best scientific rationale is in place to improve the probability of success.
- Identify important knowledge gaps coupled with processes that need to be understood to properly identify risks.
- Provide a communication process that will best interface with all relevant parties involved in the Risk Management Plan.
- Make possible to transfer process knowledge and product development history to ease product progression and to supplement generic corporate knowledge.
- Enable the pharmaceutical industry to adopt a risk-based approach to development as described in external regulatory guidance.
- The Risk Management outputs will potentially very as reference documents to support product development and control strategy discussions in regulatory filings.

S. No	Risk management tool	Description/attributes	Potential applications
Basic Tools			
1 [34]	Diagram analysis, Flowchart, Check sheets, Process mapping, Cause/effect diagrams	Simple techniques that are commonly used to gather and organize data, structure RM processes and facilitate decision making	Compilation of observations, trends or other empirical information to support a variety of less complex deviations, complaints, defaults or other circumstances.
2 [35]	Risk ranking and filtering	Method to compare and rank risks Typically involves evaluation of multiple diverse quantitative and qualitative factors for each risk, and weighting factors and risk scores.	Prioritize operating areas or sites for audit/assessment, Useful for situations when the risks and underlying consequences are diverse and difficult to compare using a single tool.
Advance Tools			
3 [36]	Fault tree analysis (FTA)	Method used to identify all root causes of an assumed failure or problem, Used to evaluate system or sub-system failures one at a time, but can combine multiple causes of failure by identifying causal chains, Relies heavily on	Investigate product complaints, Evaluate deviations

		full process understanding to identify causal factors	
4 [37]	Hazard operability analysis (HAZOP)	Tool assumes that risk events are caused by deviations from the design and operating intentions Uses a systematic technique to help identify potential deviations from normal use or design intentions.	Access manufacturing processes, facilities and equipment, Commonly used to evaluate process safety hazards
5 [38]	Hazards analysis and critical control points (HACCP)	Identify and implement process controls that consistently and effectively prevent hazard conditions from occurring, Bottom-up approach that considers how to prevent hazards from occurring and/or propagating, Emphasizes strength of preventative controls rather than ability to detect, Assumes comprehensive understanding of the process and that critical process parameters (CPPs) have been defined prior to initiating the assessment. Tool ensures that CPPs will be met.	Better for preventative applications rather than reactive, Great precursor or complement to process validation, Assessment of the efficacy of CPPs and the ability to consistently execute them for any process
6 [39]	Failure modes effects analysis (FMEA)	Assesses potential failure modes for processes and the probable effect on outcomes and/or product performance, Once failure modes are known, risk reduction actions can be applied to eliminate, reduce, or control potential failures, Highly dependent upon strong understanding of product, process and/or facility under evaluation, Output is a relative "risk score" for each failure mode [40]	

Table 2: Common Risk Management Tools used in Pharmaceutical Industries [33]

V. CALCULATION AND RESULTS

The production of Bulk drugs involves usage of many chemicals which are both hazardous and toxic in nature. The risks associated with the pharmaceutical / chemical industry are commensurate with their rapid growth and development. Apart from their utility, chemicals have their own inherent properties and hazards. Some of them can be flammable, explosive, toxic or corrosive etc. The whole lifecycle of a chemical should be considered when assessing its dangers and benefits. In order to ensure the health and safety of persons at or near the facilities, Government has approved some regulations. The regulation requires Employers to consult with employees in relation to: -

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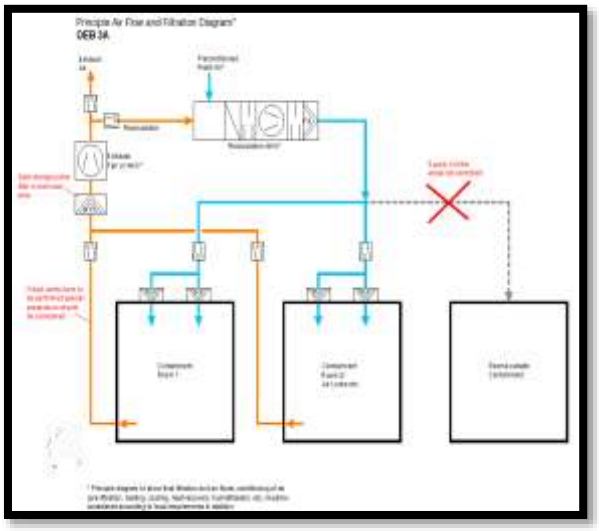

Fig. 3: HVAC OEB 3A

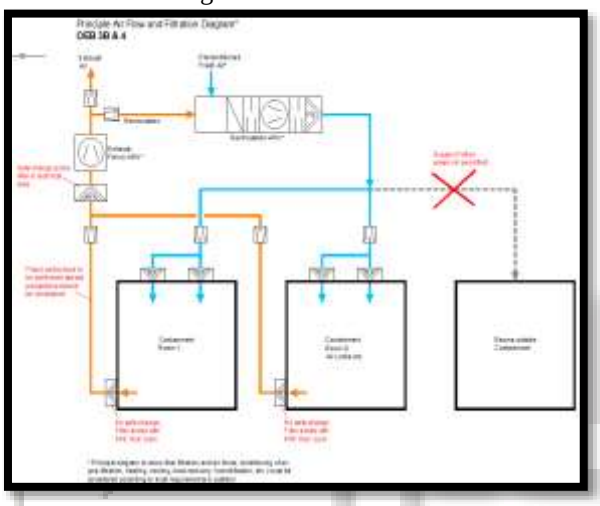

Fig. 4: HVAC OEB 3B and 4

However, failures of storage vessels and those during transportation have been reported more frequently than cases of plant failures. The failure rate of various equipment in a typical power plant is provided in the following table.

S. No	Failure rate	Failures 10-6/h
1	Electric motors (general)	10
2	Transformers (<15 kV)	0.6
3	(132-400k V)	0.7
4	Circuit breakers (general, <33k V)	2
5	(400kV)	10
6	Pressure vessels (general)	3
7	(High standard)	0.3
8	Pipes	0.2
9	Pipe joints	0.5
10	Ducts	1
11	Gaskets	0.5
12	Bellows	5
13	Diagrams (metal)	5
14	(Rubber)	8
15	Unions and junctions	0.4
16	Hoses (heavily stressed)	40
17	(Lightly stressed)	4
18	Ball bearings (heavy duty)	20
19	(Light duty)	10
20	Roll bearings	5
21	Sleeve bearings	5
22	Shafts (heavily stressed)	0.2
23	(Lightly stressed)	0.02
24	Relief valves leakage	2
25	Blockage	0.5
26	Hand- operated valves	15
27	Control valves	30
28	Ball valves	0.5
29	Solenoid valves	30
30	Rotating seals	7
31	Sliding seals	3
32	'O'ring seals	0.2
33	Couplings	5
34	Belt drives	40
35	Spur gears	10
36	Helical gears	1
37	Friction clutches	3
38	Magnetic clutches	6
39	Fixed orifices	1
40	Variable orifices	5
41	Nozzle and flapper assemblies: Blockage	6
42	Breakage	0.2
43	Filters: blockage	1
44	Leakage	1
45	Rack-and-pinion assembles	2
46	Knife-edge fulcrum: wear	10
47	Springs (heavily stressed)	1
48	(Lightly stressed)	0.2
49	Hair springs	1
50	Calibration springs: creep	2
51	Breakage	0.2
52	Vibration mounts	9
53	Mechanical joints	0.2
54	Grub screws	0.5
55	Pins	15
56	Pivots	1
57	Nuts	0.02
58	Bolts	0.02
59	Boilers (all types)	1.1
60	Boilers feed pumps	2.5
61	Cranes	7.8

Table 3: Equipment Failure Rate

We have relied on the status of (FMEA) as a key tool in the identification, severity, impact and detection of risk. In this research, we found that it is best to use this tool to assess and determine the risks and the quality of the pharmaceutical industry (UNICHEM Laboratories) because of the benefits of this method in calculation risks and severity. So the FMEA is implemented by defining the steps in a complex process and then determining the failure patterns for each step, according to use Ishikawa diagram, we therefore worked on the following steps:

Calculate by the following equation:

$$RPN = (O \times S \times D)$$

O = the harmful event or hazard, the cause, the likelihood of occurrence of risk
S = the severity of the effects of the event
D = the delectability of the cause of the event.

It identifies and evaluates these three risks the degree based on a 10-point scale for each risk, with (1) being lowest and (10) being highest. For the calculation of RPN, in this study we will adopt the following measures:

O: - From (1-2) Very Low, (3-4) Low, (5-6) Moderate, (7-8) High, (9-10) Very High.
S: - From (1-2) Very Low, (3-4) Low, (5-6) Moderate, (7-8) High, (9-10) Very High.
D: - From (1-2) Very Low, (3-4) Low, (5-6) Moderate, (7-8) High, (9-10) Very High.

Risk can also be expressed by the number and color code in the matrix which determines the level of risk in this study, as showed, the Green from 1 to 14 (the low risk area appears), the Yellow from 15 to 39 (the medium risk area appears) and the Red from 40 to 100 (the high risk area appears).

SEVERITY	OCCURENCE									
	10	20	30	40	50	60	70	80	90	100
	9	18	27	36	45	54	63	72	81	90
	8	16	24	32	40	48	56	64	72	80
	7	14	21	28	35	42	49	56	63	70
	6	12	18	24	30	36	42	48	54	60
	5	10	15	20	25	30	35	40	45	50
	4	8	12	16	20	24	28	32	36	40
	3	6	9	12	15	18	21	24	27	30
	2	4	6	8	10	12	14	16	18	20
	1	2	3	4	5	6	7	8	9	10

Fig. 5: Matrix of Risk

VI. CONCLUSION

According to the Failure Mode and Effective Analysis FMEA analysis, there is a high, medium and low risk in the production stages. The analysis revealed that a high risk of a red color in the preparation stage. It is a high risk, and it is not allowed. The medium risk of the yellow color was at the stage parting, coating and packaging, as for the stage of pressing, the risk was low and green color. Tables below presents an FMEA model for each of these stages, showing red, yellow and green areas showing the importance of intervention to carry out the treatments. The improvement procedure was identified by the experts. The improvement was oriented towards the elements of the process (worker, machine, material, manufacturing system, and management). The aim of the improvement was to improve quality by reducing risk.

A. Parting Stage:

It determined two failures potential by the experts in the stage, which have potential effects on the effectiveness of the drug which means the level of quality is low, and the level of risk in was the yellow color which is a medium level, the degree of (RPN) it was equal (1350) degree out of index value, and after implementing the required improvement, the degree of (RPN) is dropped into (1010) degrees, in percent of improvement (74.8%). This means that the improvements dropped (340) degrees of RPN index.

B. Preparation stage:

In this they determine it by three cases of potential failure by the experts in production stage, those lead to high-quality risk. The degree of RPN was (2780) on the index scale, and this is the highest degree for risk calculated in these stage (the level of risk in this stage was the red color) this means that the risks are strong and UN acceptance. The cause of the high level of risk this stage resulted from critical stages in production of medicine and require special attention of employees and continuous follow-up of management, at implementing continuous improvement to variables in this stage, the degree of (RPN) dropped in to (1245) degrees with the percent of improving reached (44.7%). This means that (1535) degrees out of index value RPN dropped in this stage, which indicates the amount of improvement that has been achieved.

C. Pressing stage:

At this stage, we identified four potential cases of failure, but it was with simple or weak risk, and their effect on product quality was low, where the degree of (RPN) before the improving reached (1293) and represented in the green color mount the levels of risks, though, This degree represents a certain level of risk and needs reduction to prevent occurrence in the operation, after making the required improvement, the degree of (RPN) dropped in to (1004) degree in the index value, with improvement percent reached (77.6%) this means that the amount of drop is (289).

D. Coating stage:

At this stage, we identified five cases potential for failures, including medium and a low of risks, and that was with yellow and green color analyzing the causes of these risks, it is showed that management of a company depended on machines needing trained of skilled workers on how this machines work The direction of management is to depend on raw material with bad quality caused which raise the scale (RPN) which will reach (1644) degrees, and when the experts implement the issues of continuous improvement on this stage, the degree of (RPN)) dropped about (339) degrees to become (1305) degree, with the percent of improving reached (79.3%). The improvement that happened in this stage moved the level of risks from yellow to a green color.

E. Packaging stage:

At this stage, there are three cases of failure should be paid that most were in yellow color, and this show the existence of medium risks, attention these cases have no effect on the health of the patient, but occurrence is high, this lead to the high degree of (RPN) that reached (1375). The review on the causes of this level of risk, shown that the employees do not have the responsibility of high attention they the importance of packaging of package operation, and its role in product quality, also not they complete the work of periodic maintenance of the machines, which leads to high risk in this stage. After continuous improvement and training for workers, the degree of (RPN) dropped into (688), so the amount of reduction is about (686) degrees from risks, and this shows that the percent of improvement was (50.1%).

We need in this study an international identification organization for both essential risks analysis and estimation

as a helpful tool for improving products quality, risk evaluation face several challenges relates to practical application, including adapting new production processes, either included the essential framework relating human element and refuse or accept risks standards.

We have investigated procedures of determination, analysis, measuring affecting the quality of the product, based on the steps and phases of quality risk management, and using some risk analysis and identification techniques, it provides both researchers and companies basic knowledge and correct practices to address risks, via reducing its impact along with facing it in future as also shown in the charts given by us in the study above.

REFERENCES

[1] Atai, I., & Mutushinda, C. (2010). Health Status Assessment using Reverse Supply Chain Data. Management Research Review, 33(2) 111-122.
[2] Barber, B. M., & Odean, T. (2008). All That Glitters: The Effect of Attention and News on the Buying Behavior of Individual and Institutional Investors. The Review of Financial Studies, 21(2), 785-818.
[3] Berman, B. (2008). Strategies to detect and reduce counterfeiting activity. Business
[4] Horizons, 51(3):191-199.
[5] Cheah, E. T., Chan, W. L., & Chieng, C. L. (2007). The Corporate Social Responsibility of Pharmaceutical Product Recalls: An Empirical Examination of U.S. and U.K. Markets. Journal of Business Ethics, 76(4), 427-449.
[6] Dickinson, J. G. (2001). Most recalls due to FDA inspection findings. Medical Marketing and Media, 36(5), 30.
[7] Fortune. (2017). World's Most Admired Companies: How we conduct the most admired survey. Retrieved from Fortune: http://beta.fortune.com/worlds-most-admiredcompanies/
[8] Harris, V., Hart, D., Hibbard, B., Jurgensen, J., & Wells, J. (2002). Crisis Communication Strategies. Retrieved from The University of Oklahoma Department of Defense Communication Course:
[9] http://www.ou.edu/deptcomm/dodjcc/groups/02C2/Johnson%20&%20Johnson.html
[10] Horvath, P. A. (2005). Liquidity implications of reverse logistics for retailers: A markov chain approach. Journal of Retailing, 81(3), 191-203.
[11] Mollah, H., Baseman, H. and Long, M. (2013). Risk management Applications in Pharmaceutical and biopharmaceutical manufacturing, John Wiley & Sons, New Jersey, USA.
[12] Mukharya, A., Patel, P.U., Shenoy, D. and Chaudhary, S. (2013). "Quality risk management of top spray fluidized bed process for antihypertensive drug formulation with control strategy engendered by Box-behnken experimental design space", International journal of pharmaceutical investigation, Vol. 3 No. 1, pp. 15-28.
[13] Nayak, V.S., Khan, M.S. and Shukla, B.K.S. (2016). "Quality management in risk based monitoring", International Journal of Clinical Trials, Vol. 3 No. 2, pp. 59-63.
[14] Noordhuizen, J.P.T.M. (2008). Applying HACCP-based quality risk management on dairy farms, Wageningen Academic, Wageningen, and Holland.
[15] Nosal, R. and Schultz, T. (2008). "PQLI definition of criticality", Journal of Pharmaceutical Innovation, Vol. 3 No. 2, pp. 69-78.
[16] O'Donnell, K. and Greene, A. (2007). "Failure modes: Simple strategies for improving qualitative quality risk management exercises during qualification, validation, and change control activities", Journal of validation technology, Vol. 13 No. 2, pp. 100-112.
[17] Qing, L., Rengkui, L., Jun, Z. and Quanxin, S. (2014). "Quality risk management model for railway construction projects", Procedia Engineering, Vol. 84 No. 1, pp. 195-203.
[18] Tao Zeng, Guohua Chen, Yunfeng Yang, Genserik Reniers, Yixin Zhao and Xia Liu: A Systematic Literature Review on Safety Research Related to Chemical Industrial Parks, Sustainability 2020, 12, 5753
[19] S. Fairhurst: Hazard and risk assessment of industrial chemicals in the occupational context in europe: some current issues, Food and Chemical Toxicology 41 (2003) 1453–1462
[20] Igor Kozine, Nijs Jan Duijm and Kurt Lauridsen: Safety- and Risk Analysis Activities in Chemical Industry I Europe, Riso National Laboratory: 1975
[21] David J. Leggett: Lab-HIRA: Hazard identification and risk analysis for the chemical research laboratory. Part 2. Risk analysis of laboratory operations, Journal of Chemical Health and Safety · September 2012
[22] Amol Paithankar: Hazard identification and risk analysis in mining industry, Department of mining engineering National institute of technology Rourkela-769008 - 2010-2011
[23] Ashokkumar T C, Dr Muthukumar K, Manojkumar R M: Hazard identification and Risk assessment (HIRA) in Textile Industry, International Research Journal of Engineering and Technology (IRJET): Volume: 07 Issue: 03 | Mar 2020
[24] O. G. Bhusnure, R. B. Dongare, S. B. Gholve, P. S. Giram: Chemical hazards and safety management in pharmaceutical industry, Journal of Pharmacy Research · April 2018
[25] Abdul Hafeez, Shmmon Ahmad, Anjoo Kamboj, Mumtaz Ahmad, Anmar AL-TAIE, Sameera Ali Siddiqui and Isha Talwar: Industrial hazards and safety management in pharmaceutical industry, International Journal of Applied Research 2020
[26] Ruwayd Tawfeeq Alhasadi: Industrial Hazards and Safety Measures in Pharmaceutical Industries, International Journal of Science and Research (IJSR) ISSN: 2319-7064 Research Gate Impact Factor (2018)
[27] Vivian SW Chan Fung: Risk Assessment and Communication in Pharmaceuticals: Recognizing the Differences in Occupational Health and Medication Safety, Journal of Toxicology and Risk Assessment, Volume 5 | Issue 1: 2019

[28] UNICHEM LABORATORIES LIMITED: Unichem Laboratories Ltd. Unichem Bhavan Prabhat Estate, Off S.V.Road, Jogeshwari (West), Mumbai – 400 102.
[29] Sangshetti, J.N., Deshpande, M., Zaheer, Z., Shinde, D.B. and Arote, R. (2017). "Quality by design approach: Regulatory need", Arabian Journal of Chemistry, Vol. 10, pp. S3412-S3425.
[30] Sivadasu, S., Gangadharappa, H.V., Kiran, H.C. and Jose, A. (2017). "Quality risk management: A review", Int. J. Pharm. Sci. Rev. Res., Vol. 44 No. 1, pp. 142-148.
[31] Sonali Mahaparale, G.P., Madhavi Kuchekar & Sneha Walase (2016). "A Review: Quality Risk Management Methods and their Potential Applications", International Journal of Applied Pharmaceutical and Biological Research, Vol. 1 No. 4, pp. 47-66.
[32] Staniec, I. (2011). "Factors that Determine the Functioning of Risk Management Systems", International Proceedings of Economics Development and Research, Vol. 22 No. 1, pp. 87-91.
[33] Tsiga, Z., Emes, M. and Smith, A. (2017). "Implementation of a risk management simulation tool", in Centeris 2017-international conference on enterprise information systems/projman 2017-international conference on project management/hcist 2017-international conference on health and social care information systems and technologies, centeri, Barcelona, SPAIN, Elsevier, pp. 218-223.
[34] Vesper, J. and O Donnell, K. (2016). "Current Challenges in Implementing Quality Risk Management", Pharmaceutical Engineering, Vol. 36 No. 6, pp. 73-73.
[35] Vincent, D.W. and Honeck, W. (2004). "Risk management analysis techniques for validation programs", Journal of validation technology, Vol. 10 No. 1, pp. 235-251.
[36] Waldron, K. (2017). "Managing Risk to the Patient: Recoding Quality Risk Management for the Pharmaceutical and Biopharmaceutical Industries", Doctoral thesis, in the Dublin Institute of Technology, Ireland.

