CHEMICAL ENGINEERING TRANSACTIONS
VOL. 39, 2014
A publication of AIDIC
The Italian Association of Chemical Engineering
www.aidic.it/cet
Guest Editors: Petar Sabev Varbanov, Jiří Jaromír Klemeš, Peng Yen Liew, Jun Yow Yong

ISBN 978-88-95608-30-3; **ISSN** 2283-9216
DOI: 10.3303/CET1439075

HAZOP Method in Identification of Risks in a CPFR Supply Chain

Piotr T. Mitkowski*[a], Dominika Zenka-Podlaszewska[b]

[a]Poznan University of Technology, Faculty of Chemical Technology, Department of Chemical Engineering and Equipment, pl. M. Sklodowskiej-Curie 2, PL 60-965 Poznan, Poland.
[b]Poznan University of Economics, Faculty of International Business, Department of International Logistics, al. Niepodleglosci 10, PL 61-875, Poznan, Poland.
piotr.mitkowski@put.poznan.pl

This paper presents the successful transfer of hazard and operability studies (HAZOP) method from the process industry to the area of supply chain management (SCM), more specifically to supply chain risk management (SCRM), with objective on identification of risks in organizations modelled with the Collaborative Planning, Forecasting and Replenishment (CPFR) model.
The specific findings are the possible combinations of guide words and parameters characteristic for supply chain. Therefore the structural identification of feasible risks in CPFR is feasible. As a result of this work various events (e.g. deviations, possible causes and consequences of the deviations) are suggested for specific part of supply chain (SC) with the participants determining whether and how the event could occur and whether the event creates any form of risk in case of implemented CPFR business model. In doing so, the research is creating a benchmark for whole supply chains, especially for these organisations which are using CPFR. The paper could also be used as a roadmap of how to use HAZOP in a supply chain risk identification and management.
The details of risk identification will be presented only for the first process, out of eight, in CPFR model, namely collaboration arrangement. The research is continued, however, the research implication is showing, that the method like HAZOP, designed to identify hazards in other fields (i.e. chemical engineering) can be successfully used in SCRM.

1. A short background on hazard and operability studies and supply chain risk management

In science hazard and risk differ significantly from each other. Hazard is defined as a physical situation with a potential for human injury, damage to property, damage to the environment or some combination of these. Such definition is actually in contradiction with concept of risk, which is the likelihood of a specified undesired event occurring within a specified period or in specified circumstances. Due to above presented differentiation, in this work we are dealing with risk identification. Although the HAZOP method is intended to hazards identification in process industries, in field of SC it will deal with risks.
In 1960s, it has become evident that accident prevention basing on learning from historical accidents in booming process industries was insufficient in terms of costs related to accident compensations, process delays and reengineering (Swann and Preston, 1995). With this background HAZOP was developed at that times (Elliott and Owen, 1968). Since then advantages of HAZOP have been recognized and now HAZOP is widely accepted in chemical and process industry (Crowl and Louvar, 2011). In process industry applications of HAZOP and its modifications are subjected to intensive studies (Gilardi and Gotti, 2013).
The majority of studies in the field of supply chain management (SCM) have basically suggested how to manage a logistic network once it has built up, so that planning methodologies, performances indices are assessed along with its modelling and optimisation (Cigolini and Rossi, 2006). Complementary to the SCM, the area of Supply Chain Risk Management (SCRM) focused mainly on risk management tools and its uncertainties is developing (Waters, 2011). Although, there are successful attempts of utilizing ontology

Please cite this article as: Mitkowski P.T., Zenka-Podlaszewska D., 2014, HAZOP method in identification of risks in a CPFR supply chain, Chemical Engineering Transactions, 39, 445-450 DOI:10.3303/CET1439075

in SC on finding out the most appropriate collaboration level within a given SC (Silvente et al., 2013), there is limited knowledge on identification of hazards and risks in SCRM in advance. Therefore, in this work authors are presenting results of transferring HAZOP to SCM modelled with CPFR model with goal of showing the method which is able to identify risks in structured manner, avoiding only ad-hoc results.

2. Hazard and operability studies

In order to perform the hazard and operability studies a team composed of various specialists related to investigated area is required. In process industries a cross-sectional team can consist of such specialists as plant manager, senior process designer, laboratory, technical and safety professionals, and if appropriate other specialists (e.g. IT specialists). In SCRM is the same situation that we need various specialists like: logistic manager, marketing specialist, sale representatives, production managers and others. The HAZOP method used in this work was performed according to the procedure described below within eleven steps, which is a modification based on procedure provided by Crowl and Louvar (2011):
1. Gather the team consisting of appropriate specialists.
2. Define and assure understanding of guide words. The list of possible guide words, transferred from process industry, is provided in Table 1. Only some of typical guide words could be applicable in SCRM.
3. Begin with detailed flow sheet of process and break into a number of process steps and list process parameters.
4. Select process parameter.
5. Combine a guide word with selected process parameter.
6. If the combination of a guide word and a process parameter is feasible this suggests possible deviations. For each feasible deviation determine possible causes.
7. Evaluate the consequences of the determined deviation.
8. Recommend action in order to deal with deviation but with keeping in mind causes and consequences.
9. Record all information and proceed to next guide word, repeat steps 5 to 9 until all combinations of guide words with selected parameter are used. Obtained information can be stored in the form of Table 2.
10. Go to step 4 to select next appropriate parameter and repeat steps up to 9 until all parameters are analysed.
11. Move to next process step (step 3) and continue until all parts of model are analysed.
A large process might consists of several dozen parts or even more. Therefore, risk identification with use of HAZOP could take enormous amount of time. In such case, duration time of meeting has to be kept at level which ensures a continuous interest of participants in performed analyses.

3. Supply chain risk management

According to Waters (2011) supply chain risk management is the process of systematically identifying, analysing and dealing with risks to supply chains. Norrman and Janson (2004): “Supply chain risk management is to (collaborate) with partners in a supply chain apply risk management process tools to deal with risks and uncertainties caused by, or impacting on, logistics related activities or resources”. In this paper the CPFR model is considered. Juettner et al. (2002) and later Norrman and Jansson (2004) suggest organizing risk sources relevant for supply chains into three categories: (1) External to the supply chain; (2) Internal to the supply chain; (3) Network related. In this paper we concentrated on network related risks. As Norrman and Janson (2004) say, network-related risks arise from interaction between organizations within the SC, e.g. due to insufficient interaction and cooperation. As we are concentrated on network related risks, we take a close look in 5^{th} part of the paper only on the processes, which are done in the CPFR model jointly by the manufacturers and retailer. The SCRM in the literature is divided into steps. Norrman and Janson (2004) presented 4 steps model in which they indicate risk identification, assessment, treatment and monitoring. Furthermore there exist incident handling and contingency planning. Juettner and Ziegenbein (2009) distinguish 3 steps model: Identification of Supply Chain Risks, Assessment of Supply Chain Risks, Supply Chain Risk Mitigation. Waters (2011) – 4 steps, as in Figure 1, but he adds also a step – preparation. We decided to consider the 4 step model: Identification, Analysis, Response and Monitoring, see Figure 1.

4. CPFR

According to Seifert (2003) Collaborative Planning, Forecasting and Replenishment stands for: “initiative among all participants in the supply chain intended to improve the relationship among them through jointly managed planning process and shared information”. Voluntary Interindustry Commerce Standards (VICS) Association defines the model as: “a business practice that combines the intelligence of multiple trading

Table 1: Guide words used for the HAZOP (based on (Crowl and Louvar, 2011) and own elaboration)

Guide words	Meaning	Possible parameters in CPFR
No, Not, None	The complete negation of intention. No part of intention is achieved.	Setting the business goals for the relationship.
More, Higher, Greater	Quantitative increase. Applies to quantities such as flow rate and temperature, and to activities such as heating and reaction.	Defining the scope of collaboration.
Less, Lower	Quantitative decrease. Applies to quantities such as flow rate and temperature, and to activities such as heating and reaction.	Assigning roles.
As well as	Qualitative increase. All the design and operating intentions are achieved along with some additional, such as contamination of process stream.	Assigning responsibilities.
Part of	Qualitative decrease. Only some of the design intentions are achieved, some are not.	Setting the business goals for the relationship.
Other than	Complete substitution. No part of the original intention is achieved. The original intention is replaced by something else.	Defining the scope of collaboration.
Sooner than	Too early or in the wrong order.	Assigning roles.
Later than	Too late or in the wrong order.	Assigning responsibilities.

partners in the planning and fulfilment of customer demand" VICS (2004). CPFR was created already in nineties of previous century, but in 2004 the model was rebuilt (Voluntary Interindustry Commerce Standards, 2004). In this paper the light is shed on the SCRM in supply chains using CPFR and application of HAZOP. Therefore SCRM is treated as a new functionality in CPFR. First model of CPFR was described in nine steps (Blanchard, 2010). The exhibit showing the first version of CPFR model can be found e.g. in Seifert (2003). As the VICS Association decided to improve the model in 2004, the description of the process have been changed. Main aim of the change was to show the focus on the final customer of the supply chain. After the modification the model contains of four main parts.

The concept of the CPFR with SCRM model utilized in this work is presented in Figure 1 in circle on the left hand side. The first shell represent four main parts of CPFR model in which manufacturer and retailer perform their own sub-processes which are essential for collaborative processes (presented in arrowed shell) with aim of delivering the best performance on consumer. In this work we focus on the first part of CPFR model, namely "Strategy and Planning", which describe the process of establishing the principles of collaborative relationship with respect to such issues as product mix and placement, and event plans for the period. Within this part, two main joint processes are distinguished: 1. Collaboration arrangement, and 2. Joint business plan. Manufacturer and retailer perform corresponding sub-processes to each process which can be easily called as a part of SCRM. In more details, manufacturer execute respectively account and market planning whereas retailer, vendor and category management.

5. Identification of risk using HAZOP in CPFR supply chain

As already mentioned in section 3, the purpose of identification of risk in SCRM is creating the list of risks, without assessment of probabilities of occurring those risks. The HAZOP method, covers not only identification of risk, but also some part of its analysis (see Table 2 – "possible consequences"), and also next step of risk management – response to risk (i.e. "action required" in Table 2). Figure 1 presents the relationship between CPFR model and SCRM, with example based on collaboration arrangement process, developed by us and used to conduct the analysis in this paper. To the standard CPFR model we added the supply chain risk management part. The second novelty is using HAZOP to identify the risks. HAZOP analysis for the collaboration arrangement process, with its process parameters is shown in the core of the right hand side circle.

The collaboration arrangement process in the CPFR supply chain consists of 6 process parameters: (1) setting the business goals for the relationship, (2) Defining the scope of collaboration, (3) assigning roles, (4) assigning responsibilities, (5) assigning checkpoints and (6) escalation procedures. Due to the space limitation and keeping the transparency of this paper, Table 2 contains the representative sample of the

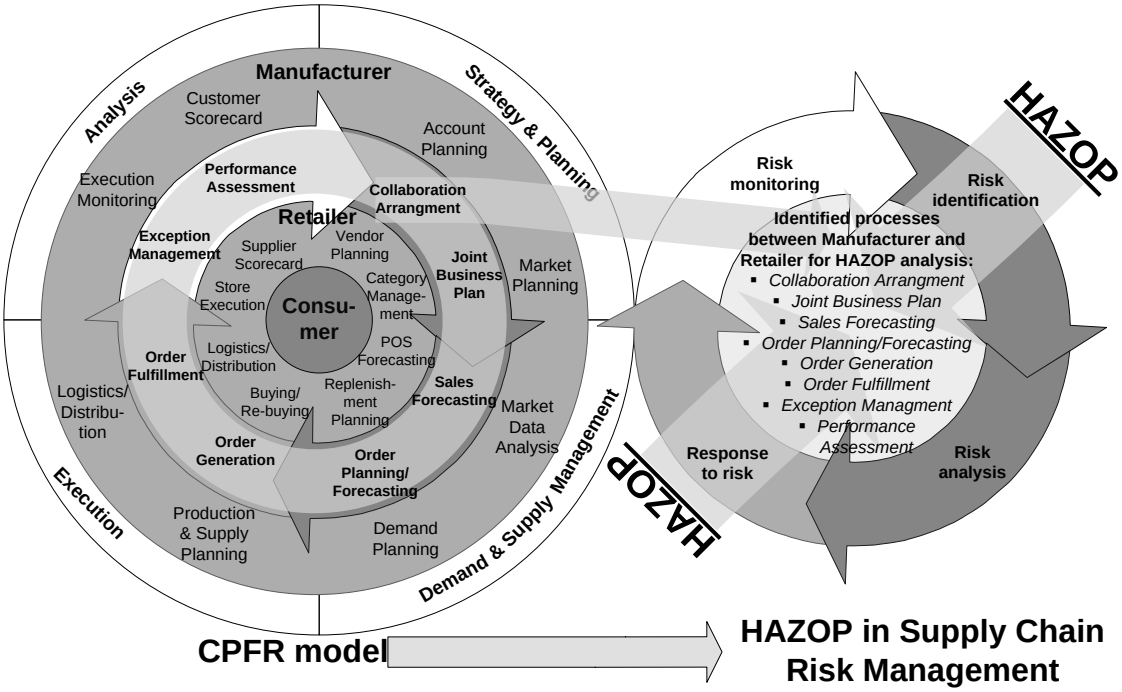

Figure 1: HAZOP analysis as the method in Supply Chain Risk Management of CPFR model (own preparation based on (Voluntary Interindustry Commerce Standards, 2004))

conducted HAZOP analysis for identified risks for the first parameter: setting the business goals for the relationship. As described in section 2, we combined a guide words taken from the process industry with selected process parameter from CPFR model. If the combination of a guide word and a process parameter is feasible this suggests possible deviation or deviations. For every possible deviation (understood in supply chain management as a risk) according to the procedure we were looking for possible causes, consequences and required action(s). The identified risks are listed in column number 3 (deviations) of the Table 2. Columns number 4 & 5 belong to analysis of the risk, incomplete however, because there is no frequency or a probability. Column 6 (required action) is representing response to risk (compare Figure 1).

As an example of analyses workflow let's consider the guide word "no, not, none" (see Table 2). Combined with process parameter "setting the business goals for the relationship" gives deviations "no business goals for the relationship settled". The possible causes found by us are chaotic and lack of collaboration. The possible consequences of that deviation with respect to possible causes are: no operational goals and lack of CPFR implementation. Foreseen required actions which can be taken in order to avoid that deviation are: need of negotiation, regular meetings and better communication.

Not every guide word can be combined with every process parameter. We discovered that "part of" and "less" key words means here almost the same – the difference is that "part of" is according to us a proper guide word in case of aware limitation and "less" is in unaware limitation. "More" is understood as "too many/too much". Use of "where else" during the analysis has been considered if it is applicable or not but with great doubts. The guide word "reverse" which means: "the logical opposite of…" during the analysis also turned out to be improper for SCRM and CPFR model. In case of a few process parameters also single guide words were not applicable. Table 3 shows the matrix of identified valid guide words and process parameters in the first part of CPFR model: strategy and planning.

6. Conclusions

In present volatile world the supply chain risk management is a great need since more and more organisation foreseen challenges in this field. The most significant output of this paper is the successful transfer of HAZOP analysis from process industry to SCRM. The HAZOP is a relatively easy tool in

Table 2: HAZOP table. Sample of analysis for setting the business goals for relationship (own elaboration)

Guide word	Deviation	Possible causes	Possible consequences	Required action
No, Not, None	No business goals (b.g.) for the relationship settled	Chaotic collaboration	No operational goals	Need of negotiation, regular meetings
		Lack of collaboration	Lack of CPFR implementation	Need of better communication
More Higher, Greater	Too many b.g.	Lack of experience	Inefficient introduction of CPFR model	Need of coaching
		Lack of benchmarking	Repeating the same mistakes as others	Need of benchmarking
Less, Lower	Too less b.g.	Poor understanding of CPFR	Partial implantation of CPFR (CPFR Lite)	Better understanding of CPFR model
		No understanding of supply chain	Impossible implementation (e.g. tremendous increase of risk in SC)	Need of management training and benchmarking
		Poor understanding of business goals between trading partners	Difficulties with implementation, so-so results	Need of partner meetings oriented on improvement of information flow
As well as	Setting the b.g. as well as loss of independence	Inadequate business partner	Loss of market share	Appropriate selection of business partners
	Setting the b.g. as well as revealing of business know-how	Inadequate employees	Loss of market share and reputation	Appropriate selection of involved employees
		Inadequate defined processes in companies	As above	Clear and process oriented structure
Part of	Part of b.g. has been settled	Poor understanding of business goals between trading partners	Difficulties with implementation, so-so results	Need of partner meetings oriented on improvement of information flow
		Execution, analysis and demand and supply management mistakes (after previous implementation of CPFR)	Partial or no implementation, so-so results	Better understanding of execution, analysis and demand and supply management processes in CPFR model
Other than	Other than setting the b. g., some negative consequence for one of the sites	Discrepancy of business strategies	Hostile business takeover, vertical integration, loss of market place	Adequate initial knowledge about business partner and market trends setting up the cooperation
		Too big difference in scale of business	As above	As above
Sooner than	Setting the b. g. too early	Urgent requirement of close collaboration.	Partial implementation, so-so results	Monitoring of our market place and trends
Later than	Setting the b. g. to late	Too long decision process	Partial implementation of CPFR, loss of market share, loss of business partners	Process oriented structure of both companies
		Undefined decision process and unclear decision makers	As above	Process oriented structure of both companies

Table 3: Valid guide words and parameters for CPFR model in HAZOP methodology (own elaboration)

Parameters	1	2	3	4	5	6	7	8	9	10
Strategy and Planning: Collaboration Arrangement										
Setting the goals	x	x	x	x	x	NA	x	x	x	NA
Defining the scope	x	x	x	x	x	NA	x	x	x	NA
Assigning roles	x	x	x	NA	x	NA	NA	x	x	NA
Assigning responsibilities	x	x	x	NA	x	NA	NA	x	x	NA
Assigning checkpoints	x	x	x	NA	x	NA	NA	x	x	NA
Escalation procedures	x	x	x	NA	x	NA	NA	x	x	NA
Strategy and Planning: Joint Business Plan										
Identification of significant events that affect supply and demand	x	x	x	x	x	NA	x	x	x	NA

1 - No, Not, None; 2- More, Higher, Greater; 3 - Less, Lower; 4 - As well as; 5 - Part of; 6 – Reverse, 7 - Other than;8 - Sooner than; 9 - Later than, 10 - Where else

implementation due to transparent philosophy in its background, step-by-step procedure and, moreover, it provides in the end a comprehensive list of feasible risks. Most of the guide words adopted from chemical industry where applicable to the CPFR model and any new has been required. If the guide words are selected properly, the tool discovers all possible deviations and risks, which in brain storm analysis could be easily omitted. However, there are two main drawbacks which we found while performing HAZOP analysis. The first one is a relatively time consuming documentation process. The second disadvantage is that, that the results are as good as a team which performed analysis, therefore HAZOP team should consist of cross-sectional specialists. Although that only part of performed analysis has been presented in section 5, these results should be treated as a benchmark, how to use the HAZOP in SCRM.

Acknowledgment

This work was supported by Ministry of Science and Higher Education, Poland, through grants 32-451/14 DS-MK and DS-PB 32/368/13.

References

Blanchard D., 2010, Supply Chain Management: Best Practices. Second ed. John Wiley & Sons, Hoboken, New Jersey, USA.

Collaborative Planning, Forecasting and Replenishment, <www.vics.org/docs/committees /CPFR_ Whitepaper_Spring_2008-VICS.pdf> accessed 19.01.2013.

Crowl D.A., Louvar J.F., 2011, Chemical Process Safety. Fundamentals with Applications. Third ed., Pearson Education, Inc., Boston, USA.

Cigolini, R., Rossi, T., 2006, A note on supply risk and inventory outsourcing, Production Planning and Control, 17, 4, 424–437.

Gilardi, C., Gotti, M., 2013, Semi-Quantitative HAZOP Methodology Applied to Upstream Oil & Gas Activities, Chemical Engineering Transactions, 31, 229–234.

Elliott D.M., Owen, J.M., 1968, Critical examination in process design, The Chemical Engineer, 377-383.

Jüettner U., Ziegenbein A., 2009, Supply Chain Risk Management for Small and Medium-Sized Businesses, in: Supply Chain Risk. A Handbook of Assessment, Management, and Performance, ed. Zsidisin G., Ritchie B., Springer, New York, USA.

Norrman A., Jansson U., 2004, Ericsson's proactive supply chain risk management approach after a serious sub-supplier accident, International Journal of Physical Distribution & Logistics Management, 34, 5, 434-456.

Seifert D., 2003, Collaborative Planning, Forecasting, and Replenishment. How to create a Supply Chain Advantage, AMACOM, New York, USA.

Silvente J., Crexells G., Zamarripa M., Muñoz E., Espuña A., 2013, Use of Ontological Structures for Integrated Supply Chain Management, Chemical Engineering Transactions, 32, 1165-1170.

Swann C.D., Preston M.L., 1995, Twenty-five years of HAZOPs, Journal of Loss Prevention in the Process Industries, 8, 6, 349-353.

Voluntary Interindustry Commerce Standards, CPFR: An Overview of the Model, May 2004.

Waters D., 2011, Supply Chain Risk Management. Vulnerability and resilience in logistics, Kogan Page, London, Philadelphia, New Delhi, USA.